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FORMAL RESEARCH NETWORKING FOR RESULTS: AN EMPIRICAL STUDY

THESIS SUBMITTED FOR THE DEGREE OF PH.D.

2011

RUSLAN RAKHMATULLIN

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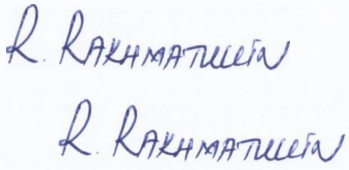

Ruslan Rakhmatullin

May 2011

SUMMARY

The European Union (EU) is continuously increasing its support to a range of formal networking research (FNR) programmes of pre-competitive nature. This study brings together the fields of performance theory and research management with an aim to investigate the added-value created through researcher participation in such *funded formal networking research projects*. It builds a theoretical framework that reflects the objective of the proposed research which is to understand the nature of formal networking research funding scheme supported by the EU. This thesis selects COST (European Cooperation in Science and Technology) as an example of such a funding scheme. It explores the extent to which funding providers (progress assessing experts) expect specific FNR outputs to be achieved by FNR participants. It further examines the extent to which the specific research outputs are actually achieved by FNR participants and if their results correspond with expert expectations. Thirdly, this research suggests that participation in a FNR project assumes development or improvement of networking (collaborative) skills and improved researcher productivity. Data collection for this study included a number of methods from process observation and assessment to surveys. As this study primarily utilises a survey methodology, the empirical data is gathered in three cross-sectional surveys. This study further provides a comprehensive overview of the statistical test results conducted with the collected survey data. Next, this research explores the relationships between the different types of FNR productivity and other variables. Statistical analyses such as Principal Component Analysis technique and Multivariate Regression are conducted to investigate some of the relationships between these variables in depth. This study provides contributions of a methodological and theoretical nature. As researchers are still in the process of consolidating a general theory of collaboration, this study contributes to the body of knowledge by helping to further defragment pertinent studies.

This research contributes to science management theory and practice. Despite a dearth of investigation on the role of research collaboration, the issue of FNR programmes has been found to be largely underexplored. This research develops an improved understanding of the role of FNR projects on the research productivity of individual participants involved in such projects. In terms of theoretical contribution this thesis provides new insights into FNR projects by applying two complementary theoretical approaches: the resource-based view (RBV) and the social capital theory. This research employs both these theories to explain why researchers take part in FNR projects. It further applies social capital theory to explain the incremental build-up of the researcher's readiness to network (a capability to accept practical advantages of offered research networking opportunities) and any incremental improvement in participant research productivity over the lifetime of the projects. Unlike most RBV researchers, this thesis applies the RBV at the level of the individual researcher. The use of the social capital framework to investigate individual outcomes from participation in FNR projects is expected to advance the existing knowledge of the links between social interaction between peers in collaborative projects and individual researcher productivity, and any improvements in this productivity as these areas have been given very limited attention to date.

The multi-angle approach of this study provides further empirical and methodological contributions. The study's data collection process takes the form of three surveys. They address three categories of respondents in order to gain complementing perspectives. This research is also one of the few studies that utilise surveys

aiming to investigate the same phenomenon from several complementary perspectives: (1) potential participants and their motives for participation in FNR projects, (2) expert-evaluator expectations of research outputs from FNR participants, and (3) participants of FNR projects and the results they attribute to their participation in these projects. In addition, this research has found only a limited number of studies that attempt to develop a measure of the outputs and associated research productivity. This thesis identifies a need for such a new measure of FNR productivity and develops new instruments for its measurement. This study proposes several measures of productivity associated with researcher participation in FNR projects. The developed measures include both tangible and intangible outputs generally associated with participation in research projects. Among others this thesis tests a hypothesis that time spent by a researcher in FNR projects is positively related to their FNR productivity. A number of other propositions examine whether other factors (such as the researcher's academic experience, professional background, geographical location, etcetera) have any impact on FNR productivity. The use of a combined approach helps to take an advantage of different approaches by simultaneously including their respective strong aspects such as the reliability of quantitative measurement and concepts such as user empowerment and participation.

Overall, this research develops a number of conclusions contributing to both practice and science management theory. More specifically, the results of the study suggest that the motives driving researchers to join FNR projects depend on researchers' experience of FNR projects and tend to change over time. This thesis identifies several important patterns relating to the change over time in researchers' stated motivation for their participation in FNR projects. However, the conducted research shows that these motives can differ depending on the researcher's circumstances. The results of the study also suggest that experts (who generally evaluate FNR projects) tend to set high expectations in terms of research outputs on all the outputs in question. Their expectations tend to be significantly higher than what is generally achieved by the average participant. In addition, the results of the study suggest that FNR participants tend to achieve upscaling outputs and, to a lesser extent, upgrading, upstreaming and upshifting outputs. The results of this study further suggest that research productivity in FNR projects does not depend on the participant's research experience, their attained level of education plays a more determining role. However, achieving results through *networking research* activities should also be viewed as a specific skill that can be learnt or improved. While no statistically significant differences have been found between junior and senior researchers in their scholarly outputs, this study found that researchers involved in FNR projects gradually increase their FNR productivity. This finding suggests that FNR participants learn to network over time as indicated by the fact that their productivity improves over time. By viewing networking as a resource, this research argues that productivity can be improved to an extent by instructing participants to network. On the other hand, researchers who engage in more than one FNR project seem to be more likely to achieve higher research productivity overall.

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ABBREVIATIONS

Abbreviation	*Explanation/Description*
ANOVA	An analysis of variance
ARIMNET	Coordination of Agricultural Research in the Mediterranean
À la carte participation	Another COST principle suggesting that flexible participation in COST projects is open to participants from all COST Countries under flexible structure with easy project implementation and management of the research activities
BMBS	Biomedicine and Molecular Biosciences (COST Domain)
Bottom-up approach	One of the important COST principles – 'bottom-up approach' – allows researchers themselves to propose their research ideas
Candidate EU Countries	Candidate EU – Turkey, Croatia, The Former Yugoslav Republic of Macedonia (source: http://ec.europa.eu)
Capacities	An FP scheme, which aims to support horizontal actions and addresses the regional needs for clustering and networking
CERN	The European Organisation for Nuclear Research
CIP	The Competitiveness and Innovation Framework Programme focuses primarily on businesses as well as related institutions such as business centres, knowledge transfer centres, and other forms of knowledge producing agencies in advanced regions
CMST	Chemistry and Molecular Sciences and Technologies (COST Domain)
CNC	COST National Co-ordinator
Cooperation	One of the four specific FP7 programmes (Cooperation, Ideas, People and Capacities), which support some form of international collaborative work. Cooperation is primarily aiming to facilitate a number of forms of international cross border research activities with a budget of just over EUR 32 billion
Coordination Actions	Another key FP instrument (formerly known as concerted actions/thematic networks)
COST	European Cooperation in the field of Science and Technology (in French: Coopération européenne dans le domaine de la Recherche Scientifique et Technique), (see www.cost.eu)
COST Actions	Research projects funded and managed by COST
COST Cooperating State	Israel has a status of a Cooperating State, which implies non-voting membership in the COST Committee of Senior Officials (CSO) and in the Domain Committees as well as full member rights on networks level
COST Member States	The 34 Member States include all 27 EU Member States (Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom) plus Croatia, Iceland, Norway, Serbia, Switzerland, Turkey, and Former Yugoslav Republic of Macedonia
COST/ESF Office	COST/ESF Office is formed and sustained under a special agreement between the CSO and the ESF. It supports the scientific activities, e.g. the DC and Action activities, as well as it implements CSO decisions
CSO	Committee of Senior Officials within COST
Current Participants	In the study, these are participants who were involved in COST Actions as individual researchers
CV	Control Variables
DC	Domain Committee
DG RTD	European Commission General Directorate on Research
EC	European Commission
EMBL	European Molecular Biology Laboratory
ENP	European Neighbourhood Policy
ERA	The European Research Area (ERA): a border-free zone for research, in which scientific resources will be better deployed to create more jobs and to improve Europe's competitiveness
ERA-NET	The objective of the ERA-NET scheme is to step up the cooperation and coordination of research activities carried out at national or regional level in the

Abbreviation	*Explanation/Description*
	Member States and Associated States
ERA-ENVHEALTH	Coordination of National Environment and Health Research Programmes – Environment and Health ERA-NET
ERI	European Research Infrastructures
ESA	European Space Agency
ESF	European Science Foundation (www.esf.org)
ESF Network Projects	Formal research networking projects which have been run by ESF
ESFRI	The European Strategy Forum for Research Infrastructures established by the EU Member Countries and the European Commission in 2002
ESRF	European Synchrotron Radiation Facility
ESSEM	Earth System Science and Environmental Management (COST Domain)
EU	European Union
EUREKA	A Europe-wide Network for Industrial R&D - European Research Coordinating Agency
EUROCORES	European Collaborative Research Scheme is a framework offered by the European Science Foundation (ESF) to promote collaborative research, networking and dissemination while targeting broad and complex topics of research across all scientific domains at the European level and in a global context
EUROCOURSE	Europe Against Cancer: Optimisation of the Use of Registries for Scientific Excellence in Research
EU15	The Member States of the EU until 2004, when 10 more countries joined the EU
FA	Food and Agriculture (COST Domain)
FNI	FNR instruments
FNR	Formal Networking Research
FP	RTD Framework Programmes: Multiannual programmes establishing, for a given period, the scientific and technological activities to be funded by the Community, their budget and the detailed rules for their technical and financial implementation.
FPS	Forests, their Products and Services (COST Domain)
FP5	Fifth Multiannual Framework Programme for Research, Technological Development and Demonstration (1998-2002)
FP6	Sixth Multiannual Framework Programme of the European Community for Research, Technological Development and Demonstration Activities aimed at contributing towards the creation of the European Research Area (2002-2006)
FP7	The Seventh Framework Programme for research and technological development (FP7) is the European Union's chief instrument for funding research over the period 2007 to 2013. It bundles all research-related EU initiatives together under a common roof playing a crucial role in reaching the goals of growth, competitiveness and employment
GDP	Gross Domestic Product: The total market value of all final goods and services produced in a country in a given year
GERD	Gross Domestic Expenditure on R&D
ICT	Information and Communication Technologies (COST Domain)
IE	Interdisciplinary Exploratoria (COST Domain)
iMERA-Plus	Implementing Metrology in the European Research Area Plus
IPs	Integrated Projects: Instrument designed to achieve ambitious, clearly defined scientific and technological objectives of a European dimension
ISCH	Individuals, Societies, Culture and Health (COST Domain)
ISP	Involvement in more than one FNR project at the same time
ITER Fusion Project	ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power
JAF	Working Party on Legal, Administrative and Financial Affairs within COST
JTIs	Joint Technology Initiatives are a form of a public-private partnership organised at the European level with a particular objective to address research questions and areas of particular importance to the EU Competitiveness globally
LIP	Length of time involved with FNR projects

Abbreviation	*Explanation/Description*
MoU	Memorandum of Understanding
MRI	Magnetic Resonance Imaging
MC	Management Committee of a COST Action
MPNS	Materials, Physical and Nanosciences (COST Domain)
NETWATCH	Development of a Central Information Platform for ERA-NETs under ERAWATCH (preparatory phase)
NIS	Newly Independent States (former republics of Soviet Union)
NMS2	Bulgaria and Romania
NMS10	New Member States which joined the EU in 2004
NoE	Networks of Excellence: Instrument aimed at creating substantial and lasting integration of the research activities of the network partners, thus directly tackling the fragmentation of research activities in Europe in a given area
Non-COST Country	A country which is not a COST Member State or a COST Cooperating State
NSERC	Natural Sciences and Engineering Research Council of Canada
OECD	Organisation for Economic Co-operation and Development
PCA	Principal Component Analysis
People	One of the FP7 programme which specifically focuses on the support for researcher mobility (both incoming and outgoing) with a budget of EUR 4.75 billion
Potential Participants	In this study, these are applicants who submitted application proposals for collaborative funding provided by the organisation
RBV	Resource Based View
R&D	Research and Development
RRDCs	Regional research driven clusters
RTD	Research and Technological Development
RTD Instruments	Different types of projects defined by the FPs. Each instrument addresses specific objectives and involves particular participation arrangements
SMART objectives	Specific, measurable, achievable, relevant and timed objectives, as defined by the EU Financial Regulation
SMEs	Small and medium-sized enterprises: Enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million
SPSS	Statistics for Social Scientists – a statistical software package
SSAs	Specific Support Actions have an objective to contribute to the implementation of the FPs, the analysis and dissemination of research results, or the preparation of the future activities
S&T	Science and Technology
Scientific Experts	DC (TC) Members and Experts
STSM	Short Term Scientific Mission
STREPs	Specific Targeted Research Projects
TC	Technical Committee of a COST Scientific Domain
TCD	Trinity College Dublin
TUD	Transport and Urban Development (COST Domain)
UPGS	Upgrading, Upstreaming and Upshifting research outputs
UPSC	Upscaling research outputs
VIF	Variance inflation factors
WAP1	Web Assisted Personal Interviewing format

Chapter 1. INTRODUCTION

1.1 Background to the Research

This research thesis is set in the context of formal research funding schemes supported by the European Union (EU). These funding schemes aim to facilitate cross-national trans-disciplinary research in the European Research Area (ERA) through a dedicated financial support of research networking activities. More specifically, this research investigates what motivates individual researchers to become involved in such formal research networks despite the associated additional workload. Furthermore, this thesis examines the expectations of project assessors in relation to the research outputs expected of participants during its life cycle. In addition, this thesis explores to what extent specific research outputs are actually achieved through participation in such projects. Finally, this research develops a new measure of research productivity associated with participation in formal networking research (FNR) projects. In particular, the author examines whether individual research FNR productivity tends to change over the period of the researcher's involvement in FNR projects.

The initial stage of this research project was spent learning about collaboration and cooperation in industry and academia. The author of this thesis spent a further three years working at the research site - one of the major networking funding providers in the ERA (COST/ESF[1] Office in Brussels). While at the COST/ESF Office, the author was further exposed to a wide range of different aspects related to both management and administration of EU-funded research networking projects (COST Actions). Participation in some strategic studies funded by the COST Office (mainly assessing potential and actual impact of COST networking projects) helped to further focus this research project. Instead of focusing purely on collaborative research projects in general, the author of this thesis realised that there is an important lesson to be learnt from funding provided to researchers by COST. COST funding is a very specific type of research funding, which does not support any actual research activities, as it covers only the expenses and costs directly related to networking activities carried out by researchers. The extended exposure to vibrant research networking environment created by COST allowed narrowing down even further the study's research problem: *Do researchers involved in scientific network teamwork actually learn to achieve 'better' research outcomes,* or *is it just a bureaucratic novelty?* However, having reviewed additional literature on collaborative innovation and science management, the author realised that this study should answer further questions: *what is the researcher's motivation to participate in such formal networking research (FNR) projects? Which specific research outputs and to what extent are expected from FNR participants* by the experts assessing these projects? *Which of these specific outputs are achieved by FNR participants*? Finally, *do researchers learn to network while they involved in FNR projects*?

During his three years at the COST/ESF Office, the author of this research thesis realised that while there is strong support in the research community for such networking funding, the existing research literature on formal collaborative research projects was extremely limited and highly fragmented. In fact, the existing

[1] COST/ESF Office – the COST (European Cooperation in Science and Technology) Office in Brussels is provided by the ESF (European Science Foundation)

literature only offered incomplete empirical evidence to support the claim that the taxpayers' money spent by the EU and national governments was, and is, being spent on productive scientific networking and not on '*scientists socialising*'. Managers and administrators of many funding schemes are expected or required to provide some evidence of the added-value produced in the projects financed by them. Often, this evidence is limited to some form of success stories. As a result, one important element in the overall picture was still missing – some documented empirical evidence validating or rejecting the claims that the funded networking research projects facilitate creation of added-value. A strong sense of research curiosity further led the author through the last few years to put together answers to these research questions in this research thesis. This study brings together the fields of performance theory and research management with an aim to investigate the added-value created through researcher participation in funded formal networking research projects. It builds a theoretical framework that reflects the objective of the proposed research which is to understand the nature of formal networking research funding scheme supported by the EU. This study provides contributions of a theoretical and methodological nature. As researchers are still in the process of consolidating a general theory of collaboration, this study contributes to science management theory and practice by helping to further defragment pertinent studies. In terms of theoretical contribution this thesis provides new insights into FNR projects by applying two complementary theoretical approaches: the resource-based view (RBV) and the social capital theory. The multi-angle approach of this study provides further empirical and methodological contributions. This research is also one of the very few academic studies in the research and science management field that attempts to investigate the same phenomenon from several complementary perspectives. In addition, this research is one of the few studies that attempt to develop specific measures of the outputs and associated research productivity.

1.2 Research Rationale and Focus

Throughout the private, public, as well as governmental and non-profit sectors, there is a sense of increased interest in the use of alliances, partnerships, networks and other cooperative arrangements. Until recently, serious discussions regarding the value of scientific cooperation were discussed only in the business or industrial context (Eggert, Ulaga & Schultz, 2006). Yet, different forms of collaboration in research are also becoming increasingly widespread among scientists across all scientific domains (Li-chun, Kretschmer, Hanneman & Ze-yuan, 2006). In fact, scientific cooperation and collaboration in their different forms are maturing to a new level. Governments in many countries are increasing their support to a range of programmes of collaborative, pre-competitive nature (Quintas & Guy, 1995). The most recent EU Framework Programme 7[2] (EU FP7) committed to provide a significantly increased budget of EUR 51 billion to research in the European Community States (CORDIS, 2007). The biggest component of the Programme is *Cooperation Programme,* which received 64 percent of the overall FP7 budget. One of the more specialised instruments included in the FP7 Cooperation Programme budget is known as *European Cooperation in Science and Technology* (also known as COST). The core activity of this intergovernmental institution is the facilitation of pre-competitive scientific networking projects across all scientific domains.

[2] The Seventh Framework Programme for research and technological development (FP7) is the European Union's chief instrument for funding research over the period 2007 to 2013. It bundles all research-related EU initiatives together under a common roof playing a crucial role in reaching the goals of growth, competitiveness and employment.

These COST networking research projects, formally known as COST Actions, allow researchers to work jointly on specific scientific issues through formally coordinated research activities.

Under the latest EU Framework Programme 7, COST received an increased budget of 210 million euros to support its activities. COST's budget under the former FP6 Programme was around 80 million euros. The significant increase in EU funding is seen as a strong vote of confidence towards the COST programmes as well as a recognition by the European Union of the importance of scientific networking to the academic community (COST, 2007b). When it comes to justifying the investment made in COST, the European Commission officials as well as the researchers involved in COST Actions tend to mention a number of points. On the one hand, the results generated by the scientists involved in COST Actions are frequently presented at high-level conferences worldwide. These conference presentations are often followed by peer-reviewed journal publications or books. There is also a long and regularly updated list of so-called *success stories*. These are stories of how certain COST Actions generated significant research results that led to new knowledge, patents, industrial applications, etc. (COST, 2003). This list is frequently used to support the arguments why networking instruments such as COST are important to the European Research Area. On the other hand, COST Open Calls repeatedly confirm a steady strong interest of the European scientific community in COST activities. The almost 500 preliminary proposals submitted for the third collection date (30 September 2007) of the COST Open Call, from which some 25 new COST Actions were selected, was certainly an overwhelming response of the European scientific community (COST, 2007c). This persistently strong response to the Open Calls suggests a need for an effective and efficient tool to network and coordinate research activities at project level, bringing good scientists together under light strategic guidance and letting them work out their ideas, thus contributing to reducing fragmentation in research investments in Europe.

Different forms of collaboration and cooperation are frequently considered and increasingly promoted as the answer to a range of challenges. In practice, this view is based on the assumption that collaborative arrangements allow partners to gain results exceeding what could have been generated through alternative organisational configurations. In evaluation literature this is known as *synergistic rewards*, where such collaborative results are greater than the total sum of what individual partners contribute (Brinkerhoff, 2002a). However, existing literature falls short of providing a clear answer as to whether or not such collaborative formations in the field of research actually boost project performance. In general, while researchers advocate the significance of scientific networking, the literature on the added-value of scientific networking proved to be both scarce and fragmented. Related research confirms that while there is a large body of literature on interorganisational relations (Levine and White 1961; Pfeffer and Nowak 1976; Wiewel and Hunter 1985), researchers have somewhat ignored scientific and research collaborations as objects of inquiry, and have focused instead on production, service, government, and non-profit organisations (Chompalov, Genuth & Shrum, 2002). One important question remains unanswered. What are the intellectual implications of this new model of cooperative research? *Why should governments and other funding sponsors support formal research networking? How does it contribute to learning and innovation?*

Historically, governments and the general public enthusiastically and faithfully accepted scientific values and, surprisingly, only in the last decade the evaluation of publicly funded scientific outcomes has become a

routine reality (Corley, 2007). With science budgets reaching new unprecedented levels, it is imperative to provide evidence to justify the distribution of the funds and the choice of programmes that receive research funding. This thesis aims to provide new insights into advantages and possible consequences of the formal pre-competitive scientific networking among researchers. Although there is some consensus that increasing levels of collaboration amongst academics produce 'better' results (which generally mean higher quality), the issue of research collaboration and its impact on research outcomes remains a contentious area with a wide variety of views as to what role such collaboration plays and its general implications for scientific performance (Rigby & Edler, 2005). This thesis seeks to address the gap in existing literature by answering the following research question: *what is the added-value created in formal networking research (FNR) projects? Do FNR participants actually learn to achieve 'better' research outcomes, or is it just a bureaucratic novelty?*

This study brings together the fields of evaluation and performance theory, and science and innovation management by investigating added-value creation through researchers' participation in *formal pre-competitive networking research*. It is proposed to position this study within the settings of COST Actions. The choice of the COST Actions for this study is justified by a number of reasons. One is the fact that these Actions are characterised by an intensive and well-structured approach to networking. COST Actions involve a large number of researchers, and, as a result, these projects cover a wide range of scientific disciplines. The second reason is the significantly increased financial commitment made by the European Commission (the greater demands for accountability) to the COST activities under the FP7. As formal scientific networking is touted and perceived by many as an added-value activity, this research will attempt to search for evidence that will either support or reject this claim. This study will therefore build a theoretical framework that will reflect the objective of the proposed research, which is to understand the very nature of formal networking research funding scheme supported by the EU. In particular, this research will examine what motivates researchers to engage in FNR projects, what research outputs are expected from them and which of these FNR outputs researchers actually achieve through their participation in such FNR projects. In addition, this thesis explores whether researchers participating in formal networking projects learn to network (in terms of learning to take advantages of the formal research networks) and whether this is reflected in improved performance and research outcomes. Based on the reviewed literature, a number of specific research questions and propositions will be developed. First, this research will review which research motives are behind researchers' decisions to participate in collaborative research projects (despite increased workload associated with such participation). The study will then examine which of these motives are behind researchers' decisions to apply for FNR funding. In particular, it will examine whether this motivation changes as researchers gain experience of participation in such FNR projects.

Secondly, participation in FNR projects assumes working towards achieving certain research outputs. This thesis will develop a set of the FNR-associated research outputs. Funding sponsors have specific research output requirements and expectations of FNR participants. This thesis will attempt to establish to what extent funding providers (progress assessing experts) expect these FNR outputs to be achieved by FNR participants. It will further examine the extent to which the specific research outputs are actually achieved by FNR participants and if their results correspond with the experts' expectations. Thirdly, this research suggests that participation in a FNR project assumes development or improvement of networking (collaborative) skills and

improved research productivity. To examine this assumption, this study will propose a new combined measure of productivity associated with participa tion in FNR projects – FNR productivity. Among others, this thesis will test a hypothesis that time spent by a researcher in FNR projects is positively related to their FNR productivity. A number of other propositions will address whether other factors (such as the researcher's academic experience, professional background, geographical location, etc.) have any impact on FNR productivity.

1.3 Overview of Objectives and Intended Research Contributions

Identification and statement of the research problem and research questions are linked directly to the objectives for the proposed study. One primary level objective for this study is to understand the added-value of EU-funded formal networking research (FNR) projects in terms of the research productivity at the level of individual FNR participants. However, addressing this objective requires a greater understanding of (1) which motives drive potential researchers to apply for new FNR funding, (2) to what extent specific FNR outputs are viewed as attainable by the experts who generally set the assessment criteria for new and existing FNR projects, as well as (3) which research outputs are actually achieved by individual researchers in the process of their participation in FNR projects. These three questions will translate into several secondary level objectives. This research also pursues another primary level objective, which is to explore whether researchers involved in FNR projects learn to network as could be evidenced and measured by their research productivity levels. However, prior to tackling the primary-level research objectives, this study will focus on addressing the secondary level objectives.

At a later stage, there is a discussion of the research contributions achieved by this thesis. However, some contributions were anticipated from the beginning. First, this research intends to contribute to both science management theory and practice. There is a dearth of research on collaborative arrangements, and more specifically on the role of collaboration in R&D and innovation in general. However, the issue of formal collaborative research programmes (and in particular formal networking research (FNR) projects) has been found to be largely underexplored. Therefore, before continuing to answering the main research questions, this study must develop a new perspective on the subject in the science and innovation management fields. Furthermore, this research plans to develop an improved understanding of the role of funded FNR projects on research productivity of individual participants involved in such projects. This research provides contributions of a methodological and theoretical nature. The reviewed literature suggested that researchers are still in the process of consolidating a general theory of collaboration (Wood & Gray, 1991). This study, however, contributes to the body of knowledge in the field of collaborative innovative structures (networks) by helping to further defragment related studies. In terms of theoretical contribution, this thesis aims to provide important new insights into formal networking research projects by applying two complementary theoretical approaches: the resource-based view (RBV) and social capital theory. This research employs both the RBV and social capital theory to explain why researchers take part in formal networking research projects. It further applies social capital theory to explain the incremental build-up of the researcher's readiness to network (a capability to accept practical advantages of offered research networking opportunities) and any incremental improvement in participants' research productivity over the lifetime of

the projects. In addition, most RBV researchers tend to investigate collaborative arrangements on the organisational level (van Rijnsoever, Hessels & Vandeberg, 2008). However, this research thesis is one of the few studies applying the RBV at the level of an individual researcher. The use of the social capital framework to investigate individual outcomes from participation in FNR projects is expected to advance the existing knowledge of the links between social interaction between peers in collaborative projects and individual researcher productivity, and any improvements in this productivity. These areas have been given only very limited attention to date. The author of this thesis could not identify a published study that has investigated researchers' participation in formal networking research projects (which provide only networking funding) despite the fact that one such programme – European Cooperation in Science and Technology has an astounding budget (EU-funded) of 210 million euros under the Framework Programme 7 budget and has been running since 1971.

The multi-angle approach of this study provides further empirical and methodological contributions. The study's data collection process took a form of three surveys. These surveys addressed three categories of respondents in order to gain complementing perspectives. This research thesis is also one of the few studies that utilise surveys aiming to investigate the same phenomenon from several complementary perspectives: (1) potential participants and their motives for participation in FNR projects, (2) expert-evaluator expectations of research outputs from FNR participants, and (3) participants of FNR projects and the results they attribute to their participation in these projects. In addition, this research has found only a limited number of studies that attempt to develop a measure of the research outputs (and associated research productivity). Furthermore, this thesis not only identifies a need for such a measure of FNR productivity, but it also develops a new instrument for its measurement (FNR Researcher Productivity). The developed measure includes both tangible and intangible outputs generally associated with participation in networking research programmes.

1.4 Research Approach and Methodology

The use of a combined approach can commonly be found in the evaluation research. It can help to take an advantage of different approaches by simultaneously including their respective strong aspects such as the reliability of quantitative measurement, and concepts such as user empowerment and participation (Parry, Gnich & Platt, 2001; Pawson & Tilley, 1997). When deciding on whether to go for a quantitative or qualitative research, researchers should not be motivated solely by their philosophical beliefs but by whichever design and methodology are best suited to tackle their specific research objectives. This thesis applies survey methodology. The purpose of surveys is to produce quantitative descriptions of some aspects of the population by asking people structured and predefined questions using a sample of the population (King & He, 2005; Pinsonneault & Kraemer, 1993). These assumptions led the author of this thesis into the boundaries of the positivist paradigm (Lee & Baskerville, 2003). When deciding on the appropriate research design for this study, the author considered the questions raised by the thesis. The study intends to explore and evaluate different aspects of formal networking research programmes. In particular, this research is concerned with the motives and outcomes associated with specific formal research networking programmes (at the level of the individual researcher which was overlooked by previous research), as well as to understand whether researcher productivity (in terms of achieving these results) improves over the term of an

FNR project. Such studies generally fall into the category of applied or evaluation research that generally applies non-experimental survey research design. The study takes the form of exploratory outcome evaluation research and is focused on an investigation of outcomes that have been previously neglected. A particular form of evaluation inquiry - values inquiry - can be helpful in the development of criteria for oversight and compliance (whether the programme is following specific rules or is meeting expectations). Values inquiry can be also suitable for programme improvement when there is uncertainty about programme mission or there is some disagreement over the mission objectives (Mark, Henry & Julnes, 2005).

As mentioned in the earlier sections of this chapter, this mainly quantitative evaluation study employs a multiple survey methodology. The study collects data from several categories of respondents. A number of large-scale surveys will address three categories of the stakeholders of the formal research networking instruments funded by the European Union. The data from these surveys was analysed and the analysis was further balanced with other data sources such as additional documentation as well as observation of some of the actual research networking processes. To increase the likelihood of the main study, a pilot study was undertaken as a mini version of a fully-scaled study (although a pilot study does not guarantee success in the main study). It also was used to detect potential weaknesses in the study design and instrumentation (Cooper & Emory, 1995; Teijlingen & Hundley, 2003). The surveys consisted mainly of closed-ended questions that primarily used quantitative ordinal scales. Further, the study interpreted these findings in light of the research questions, or with theory-building research, determined if the results are consistent with developed propositions and theories. In comparison with other research methodologies with controlled settings, survey research allows the researcher to examine the phenomenon in question in a wide variety of natural settings (King & He, 2005; Pinsonneault & Kraemer, 1993). As a research method, surveys allow collection of information from a sample of individuals which results in the data being used to describe the larger population of which the sample individuals are members. One of the disadvantages of this approach is that its results do not lead to conclusions on cause and effect, but can lead to conclusions about associations (Sproull, 1995). As a result, surveys can potentially produce generalisable research results which can then be applied to those larger populations, even if it requires careful assessment and design considerations (King & He, 2005). This study employs web-based surveys. The use of the Internet for surveys can also be justified economically as such web-based surveys are generally significantly cheaper than other modes (for example, the paper-and-pencil mode) and are more efficient as entered data is generally available straight away (Van Selm & Jankowski, 2006). Some other advantages to using web-based surveys include the absence of interviewer bias, removal of the need for data entry, and convenience for respondents (Medlin, Roy, & Ham Chai, 1999; Mehta & Sivadas, 1995; Smith, 1997; Van Selm et al., 2006). In terms of possible disadvantages of web-based surveys, the author considered some of the following disadvantages identified in the literature (Kumar, 2005): the risk of low response rate, a self-selecting bias or that web-surveys cannot generally be supplemented with other information (for example, real-time observation of respondents) etc.

The study was conducted in cooperation with the COST/ESF Office whose database includes previous and existing (as well as potential) research project participants in addition to the contacts of scientific experts who are generally involved in evaluation of the research projects. The surveys were conducted as a part of a comprehensive large-scale evaluation study conducted by the COST/ESF Office in compliance with ESF's contract obligations with the European Commission. The COST/ESF Office was required to setup and

administer a number of evaluation studies and the author of this thesis was involved in the management and administration of some of these strategic studies. The first study in the series took the form of a participant satisfaction survey in 2005. While the results were deemed satisfactory and encouraging, the Mid-Term Evaluation, conducted by a high-level expert panel, among its recommendations stressed the importance of repeating the customer satisfaction survey to ensure adequate levels of service quality monitoring and service responsiveness. Preparation for a new study and the actual surveys took place between 2006 and 2007. This survey study was seen not just as a contractual requirement between the EU Commission and ESF, but also as a great opportunity to extend the study to address some other questions too. It was anticipated by the COST management and its stakeholders that the findings from the studies would feed a valuable input in the discussion on further development of COST.

The author of this thesis at the time had an opportunity to contribute to the original objectives of the study (customer satisfaction survey) while additionally pursuing a number of research questions related to this thesis. The author was involved in all stages of the study preparation and administration including planning of studies, expert recruitment, tender organisation, selection of the contractors for the studies, as well as the actual design of surveys, and the general facilitation and support of survey (and related) activities. Involvement in these processes put the author at the very epicentre of the study. It allowed for a thorough exposure not just to the internal organisational culture but also to the actual research collaborative projects. Data collection for this study includes a number of methods from process observation and assessment to surveys. As this study primarily utilises a survey methodology, the empirical data was gathered in three cross-sectional surveys among researchers participating in formal networking projects across European countries, potential participants and experts, who are generally involved in the assessment, monitoring and final evaluation activities in relation to these research projects. This study further provides a comprehensive overview of the results of statistical tests conducted with the data collected in three surveys (categories 1, 2 and 3). The author first deals with the socio-demographic data of the respondents in all three surveys. Next, the author analyses (1) the motives for applying for research networking funding as reported by potential project participants, (2) research outputs as reported by actual research project participants as well as (3) the perceived research outputs reported by research experts involved in evaluation and monitoring of these research projects. Next, this research explores the relationships between the different types of formal networking research productivity (FNR productivity) and other variables. Statistical analyses such as Principal Component Analysis technique and Multivariate Regression are conducted to investigate some of the relationships between these variables in more depth.

1.5 Scope and Limitations

This study has a strong focus on European, and primarily the European Union (EU) countries and therefore it did not focus on similar research instruments operating in other parts of the world. The author reviewed a number of other research funding mechanisms collaborative research programmes financed by the EU and national governments and available across the European Research Area (ERA). The focus of this thesis is on a particular type of research funding – that which is provided for formal networking research (FNR) projects in the EU. More specifically, this thesis will examine COST (European Cooperation in Science and Technology) scheme as an example of such funding. COST is the oldest European instrument that primarily

provides funding for the expenses associated with participation in research networking activities. The actual data for the analysis was derived from the surveys conducted by the COST/ESF Office. The research projects that are supported by COST – COST Actions – will not, however, be compared to any other networking schemes. A number of limitations are a result of this choice:

- Only *active* COST participants were involved in the study. The surveys were sent out only to those project participants (in the database managed by the COST/ESF Office) who have been reimbursed by the COST/ESF Office at least once during the four-year period prior to the first survey.
- The rules of participation do not require researchers to participate in COST Actions to the same degree or extent, and the study did not distinguish between very active participants and those who are not as active;
- Some respondents were no longer actively involved in COST Actions at the time of the surveys. The study did not explore the reasons why researchers decide not to continue with their participation in formal networking projects.

This study focuses on examining closer motivation for participation in FNR projects and research results (outputs/outcomes), which individual project participants attribute to their participation in FNR projects. The focus of the study furthermore does not cover the following:

- The study does not investigate the impact of any possible links between the COST Actions and other research projects in which COST participants may be involved;
- The study does not evaluate the effectiveness of the funding scheme or its overall administration;
- The study does not investigate the outcomes attainable by the participating institutions, as its focus is only on the individual level outcomes;
- The study does not investigate the objectives that are set by the projects administrators (such as the COST/ESF Office) and whether their anticipated outputs match the actually reported outputs.

Among other research objectives, this study investigates which of the identified research outputs are expected from the FNR project participants by the experts involved in FNR project evaluation, monitoring and assessments. While there are some templates used to evaluate current projects, this study does not focus on whether these templates are adequate and comprehensive. This study's other objective is to determine whether researchers involved in FNR projects learn to network, and whether their FNR productivity improves over the time they spend on the programme. This project, however, does not aim to investigate whether such learning has any long-term effect and what its other long-term potential impacts could be.

1.6 Outline/Structure of the Report

Chapter 1 of this thesis introduces the background to the research, explains the research rationale and the focus of this study, in addition to providing a brief overview of the contributions made by this study. Chapter 2 offers an overview of the environment of scientific collaborative networks, general research collaboration motives and factors, researcher productivity in terms of research outcomes and outputs. In particular, it develops an understanding of collaboration by looking at its dimensions in terms of complexity, closeness, formality, etc. Chapter 2 further reviews related management literature on scientific collaborative networks and proposes a further discussion of different types of research networks in terms of their heterogeneity and

formality. A concept of researcher productivity is then presented including different aspects of research outputs and outcomes.

Pertinent findings in the science and innovation management literature are further summarised. First, the author attempts to understand the types of organisations that tend to be involved in research and to understand the principles of such collaborative research. Chapter 2 then moves to a discussion of general motives for collaborative research, and in particular, the motives behind collaborative research in science. The reviewed literature suggests focusing not only on these motives but also on the factors (external and internal to science). These factors generally serve as antecedents of the research community's pro-active interest in collaborative scientific activities. The review further focuses on the concept of researcher productivity presented in management literature, the main components contributing to it (such as outputs and outcomes of research collaboration), and discusses a need for an improved performance measure, which should combine collaboration-specific research outputs.

Chapter 3 selectively reviews a number of theories explaining collaborative research efforts as identified in the existing body of literature. Firstly, there is a focus on resource-based view and social capital theory with their explanation of collaborative research arrangements. Emphasis is placed on the motivational side of the collaborative process in order to understand what puts social actors in a position where they not only consider but also actively use their collaborative options. Secondly, the social capital theory literature was further utilised to understand whether social actors can potentially improve their research productivity through participation in formal networking research (FNR) projects. As a result, it is proposed to develop a new FNR productivity construct. Following this discussion of dominant theories, an integrated framework is presented. Based on the proposed framework, a number of specific research questions and related hypotheses are further suggested.

Chapter 4 reviews related literature on collaborative research in the European Research Area (ERA). In particular, this Chapter discusses the concept of the European Research Area (ERA) and identifies trends in science and technology cooperation in the ERA. The Chapter then moves to a discussion of the European Union Framework Programmes (FPs) and research instruments made available to European researchers under the FPs. Some of the specific collaborative instruments under the current Framework Programme (FP7) are further examined. Further, the focus moves to formal programmes supporting research networking in the ERA: some of the schemes available under the FP7 (such as Networks of Excellence and ERA-NETs) and some schemes that are not managed by the European Commission (such as ESF Network Projects and COST Actions). It is then proposed to focus this study on the formal networking research (FNR) projects.

Chapter 5 provides an overview of the details of the research focus and a philosophical approach; it then presents the details of the chosen research design, methods and procedures. The first part of this Chapter provides a discussion of the philosophical assumptions, which support the issues addressed by this thesis. This discussion of methodological choice further guides the investigative focus of the second part of Chapter 5 that examines the details of how this research is carried out in terms of data collection and analysis. In particular, this Chapter provides a justification for the methods chosen for the study and the overall research design. It discusses in detail the main elements and stages of the chosen survey methodology, including

development of the surveys (its core steps of population, sampling frame, sample design, sample size and so on), as well as their administration and analysis. The weaknesses of the chosen survey methodology (in particular those applicable to the web-based surveys) are also briefly discussed and applicable criteria of rigour are suggested. At the end of Chapter 5, it is proposed to set this study in the context of COST Actions so that the research is able to test empirically the conceptual framework and propositions/hypotheses developed in earlier chapters. It is followed by Chapter 6 that provides additional information on the settings for this research – research projects coordinated and financed by COST within the scope of the EC Framework Programmes. In particular, Chapter 6 provides additional detailed information about the very setting of this study – COST, in terms of its nature, procedures and operations.

The following two chapters (Chapter 7 and Chapter 8) jointly deal with the data analyses and draw conclusions based on the collected data regarding the phenomenon of researcher performance associated with FNR projects. Chapter 7 provides a comprehensive overview of the results of the statistical tests conducted with the data collected in three surveys. There are several major sections to this chapter: one dealing with the socio-demographic data of the respondents in all three surveys, with another section analysing the motives for applying for research networking funding as reported by potential project participants. This is then followed by an analysis of research outputs as reported by actual research project participants as well as the perceived research outputs reported by research experts involved in the evaluation and monitoring of these research projects. The next section further explores the relationships between the different forms of formal networking research productivity (FNR productivity) and other variables. Statistical analyses such as Principal Component Analysis technique and Multivariate Regression Analysis are conducted to investigate some of the relationships between these variables in more depth. In addition, the last section analyses the results of several hypotheses tests. Following several methodological recommendations in the literature, Chapter 7 presents both patterns of results and the analyses for their relevance to the research issues and hypotheses (Lindsay, 1995; Perry, 1998). However, an overall discussion of all results of this study (drawing on all methods employed) is presented in Chapter 8 that deals with the data results and their analysis in the context of the study objectives. Chapter 8 also focuses on interrelationships between the variables in relation to the FNR projects in general through further integration of the information into a meaningful whole, so that conclusions and recommendations can be developed. In this final Chapter, conclusions are drawn from the research results with regard to the objectives of the study (each research question and hypothesis). The limitations of the study are then identified. To conclude the study, research recommendations and implications for theory and future research are then offered.

1.7 Summary

Chapter 1 has provided an explanation of the rationale to investigate individual research productivity attributable to participation in formal networking research projects. In addition, it has examined contributions expected to be delivered as a result of this research project, as well as its limitations. This was followed by an overview of the structure of this research thesis. Chapter 2 will further provide a review and critique the field of research and collaboration that framed the work within this research.

Chapter 2. A REVIEW OF LITERATURE ON RESEARCH COLLABORATION

2.1 Introduction

Together, Chapter 2 and Chapter 3 aim to build a theoretical groundwork for the proposed research by reviewing pertinent literature. Figure 2-1 below presents a schematic 'mind-map' of the structure of these two chapters. Chapter 2 will discuss the concept of collaboration and related concepts within the related management literature. Definitions of the main concepts will be developed. This will be followed by a further discussion of the collaborative management literature in section 2.2.

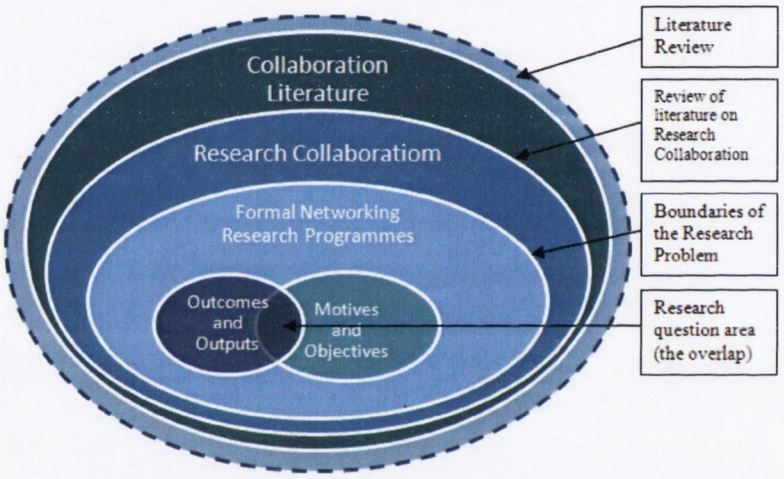

Figure 2-1: Literature Review 'Mind Map'

Section 2.3 will discuss a number of main concepts related to scientific collaborative networks: definitions, factors, structures and typology of network ties. Chapter 2 will systematise existing literature on collaborative motives with a particular focus on collaborative arrangements (such as research networks) in science. Subsequently, Chapter 3 will identify the dominant theoretical perspectives that explain collaborative behaviour observed at the level of individual researchers. Following this discussion of dominant theories, an integrated framework will be proposed.

2.2 Understanding Collaboration

Building upon the collaborative literature, this chapter deals with the terminology related to management of collaborations with an interest in formal research networks. The use of terms such as cooperation and collaboration will be discussed and explored. In this section, the author establishes similarities and distinctions between the terms. Additional attention will be paid to collaboration as it most specifically addresses issues relevant to scientific networking. Similarities and differences among the terms will be discussed. From these observations, a definition of collaboration and networking in science will be discussed. In conclusion, the need for precision within the co-operative model will be argued.

The following section will examine the terminology used in the field of collaborative management. The initial literature review points at the fact that most of the time researchers tend to use the terms 'cooperation', 'collaboration' and 'partnership' interchangeably. To establish the nature of the relationship between these terms, the chapter will start by examining their definitions.

2.2.1 Defining Collaboration

Generally collaboration is defined as the process of either individual parties or institutions pooling both resources and responsibilities in order to set up, manage, and evaluate projects to achieve common goals (Plummer & FitzGibbon, 2004). A number of definitions can be found in most dictionaries. According to one, the word 'to collaborate' could have one of the following meanings:

1. To work jointly with others or together especially in intellectual endeavour;
2. To cooperate with an agency or instrumentality with which one is not immediately connected;
3. To cooperate with, or willingly assist, an enemy of one's country and especially an occupying force (Merriam-Webster, 2007).

Generally, some of the following terms can be considered as synonyms for the word collaboration: *teamwork, partnership, group effort, association, alliance, relationship* and *cooperation.* This list suggests that a collaborative process is about multiple parties sharing a mutual interest. There is a general increase in the use of different forms of collaborative arrangements, alliances and networks, and this is not exclusive to any one single scientific field. Forms of collaboration occur in a range of fields and as a result the term has been widely used even though there is no explicit agreement on it. Initial literature review suggests an idea that a large number of researchers use the terms such as cooperation, collaboration and several other forms of this phenomenon interchangeably. In fact, Brinkerhoff (2002b, p. 20) notes that this is a common situation as '*while many embrace the notion of partnership and stake a claim in its promotion, there is little agreement on what partnership means*'. This lack of consistency in the literature is further highlighted by Mintzberg et al. (1996) according to whom collaboration is viewed by economists as *collusion*, lawyers classify it as a *contracting process*, psychologists consider it one of *negotiation*, scientists and researchers perceive it in terms of *technology transfer*, and sociologists who treat it as *networking*.

The idea of knowledge (technology) transfer is supported by Bozeman and Corley (2004) who interestingly suggest that research collaboration can also be seen as a way in which researchers can both acquire and deploy scientific and technical human capital, which they define as the sum of researchers' professional network ties and their technical skills and resources. Therefore, one can argue that collaboration is about advancing the objectives of individual participants while still creating knowledge flows among researchers, and allowing individual scientists to gain access to new 'capital' (Li-chun et al., 2006). An important comment by Beaver (2004) stresses that collaboration between researchers is not just any one stage of the knowledge creation process but that collaboration occurs throughout the entire process of knowledge generation. Beaver (2004, p.402) sees the collaborative process similar to peer review, and that '*collaborative research introduced the context of justification into the context of discovery*' and therefore, collaborative research stands somewhere between the context of discovery and the context of justification (Rigby & Edler, 2005).

Collaboration is not just about gaining access to new capital when working on the same project. A collaborative process is also a way in which multiple parties are jointly learning through work on the same project. The fundamental objectives for research collaboration are (a) the construction of new learning, (b) the construction of new learning tasks and (c) the recognition of learning at the individual level (Sky-McIlvain, 2004). This implies that a collaborative process encourages sharing information among co-learners. This collaborative process is the way researchers exchange information, share knowledge, merge diverse perspectives, engage in various roles, coordinate their efforts in solving a joint task, or make use of technological tools while the involved institutions maintain their institutional identity, strategic decision making and remain separate entities (Forero, 1999; Hans, Anne, Nikol & Sabine, 2005; Spada, Meier, Rummel & Hauser, 2006). Such formal collaborative projects seem to require individual parties to be able to commit substantial amounts of time and resources. Importantly, coordinating such a project, putting together all involved activities is central to an efficient collaboration process.

Members of the academic community are traditionally open to such collaboration and have always viewed it as a way of sharing information and coordinating their research efforts. However, the actual process of coordinating collaborative project efforts is still perceived as a core challenge preventing researchers from sharing efficiently each other's ideas and expertise (Cummings & Kiesler, 2004). Dillenbourg et al.(1995) quote Roschelle and Teasley (1995) that collaboration is a '*coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem*'. Chompalov et al. (2002) suggest that even though scientific collaborative projects are often seen as informal and collective, such views about the social organisation of collaborative projects in science are primarily based on a narrow examination of the high-energy physics field, which has become highly involved in collaborative research in the course of the 20th century. The authors strongly believe that arguments for scientific collaborative projects are '*informal, free-wheeling formations, without hierarchical structures or clear leadership, that utilize strong communitarian organisation are only partially true*' (Chompalov et al., 2002).

2.2.2 Cooperation and Collaboration

Yet, another term deserves extended attention as it is often used interchangeably with the term '*to collaborate*'. This term is '*to cooperate*' and is defined by the Merriam Webster dictionary (2007) as '*to act or work with another or others: 'act together or in compliance*' or '*to associate with another or others for mutual benefit*'. A 2005 U.S. committee report on strengthening U.S. and Russian cooperative nuclear non-proliferation suggests:

> *In case of scientific cooperation it involves the development of new technologies or the establishment of technical feasibility for technologies that have not yet transitioned from the realm of basic and applied research to the realm of engineering development. The personnel involved in scientific cooperation are often scientists (generally applied scientists), with broad perspectives of multiple technologies that range from unproved laboratory ideas to off-the-shelf components. It is often not possible to specify the technological approach in all detail at an early stage; rather, iteration between goal-directed applied research and engineering development is necessary.*

(U.S. Committee on Strengthening U.S. and Russian Cooperative Nuclear Nonproliferation, National Research Council, Russian Committee on Strengthening U.S. and Russian Cooperative Nuclear Nonproliferation & Sciences, 2005).

As in the case with collaborative arrangements, researchers recognise that scientific cooperation enables relationship building and fosters trust between individuals and organisations (Skolnikoff, 2001). While researchers do often use these two terms as synonyms, some authors believe it is important to distinguish between them. According to Sky-McIlvain (2004), cooperation tends to be both goal-directed and concrete, while collaboration is more about sharing and adapting ideas and opinions. Behind collaborative projects are the answers to questions like 'why', 'what if' and 'how does' and such phrases as 'tell me', 'explain it to me', and 'what do you notice' (Sky-McIlvain, 2004).

Not only can the difference between cooperation and collaboration be blurred, but also the very term 'collaboration' is frequently defined as inclusive of 'cooperation'. Frequently, cooperation is more of an informal arrangement in which the researchers and institutions retain their individual mandates and responsibilities, but do some work together to meet a common goal. As collaboration involves parties to come together, it also fundamentally changes their individual approaches to a goal as a prerequisite for shared use of resources (Waugh, 2005). It is the level of formality between the involved parties that allows scholars to distinguish between cooperation and collaboration. According to another view, the difference between collaboration and cooperation is not about whether or not the joint task is shared. The difference is in the way in which this common task is shared (Dillenbourg et al., 1995). While under cooperative arrangements this task is divided into independent subtasks, in collaboration the involved processes are not only split, but often these are also intertwined. Coordination constitutes an important part of collaboration; however in cooperation coordination is only needed when there is a need to bring together some partial results (Dillenbourg et al., 1995).

The reviewed literature suggests four important lessons. First, researchers and officials commonly use the terms 'cooperation' and 'collaboration' interchangeably. Second, it is important to distinguish these terms in certain contexts. Third, the main difference between the terms is due to collaboration seen as '*mutual engagement of participants in a coordinated effort to solve the problem*', while cooperation should be seen as a '*division of labour, each person responsible for portion of work*' (Dillenbourg et al., 1995; Roschelle & Teasley, 1995). Fourth, researchers should keep in mind that '*collaboration is a philosophy of interaction and personal lifestyle whereas cooperation is a structure of interaction designed to facilitate the accomplishment of an end product or goal*' (Panitz, 1996).

2.2.3 Collaboration as Knowledge Diffusion Channel

As such, collaborative arrangements are frequently perceived as channels facilitating knowledge creation, transfer and sharing across different sectors ranging from academia, civil society, government, industry and private sector (Archibugi & Coco, 2004). In academia and research this can be a result of increasingly deepening specialisation with individual scientists specialising in narrow and very specific fields of expertise (Frenken, Hölzl & Vor, 2005). Hennart (1988, p. 366) suggests the idea that knowledge is '... *more efficiently*

transferred if the transferor and the recipient are linked through common ownership'. To facilitate such transfer and integration of these different pieces of knowledge research institutions and individual researchers often tend to resort to some form of collaboration.

In cases where collaborators view a problem differently, a collaborative process would allow involved parties to understand these differences and to identify alternative ways out. This approach not only is a generally more constructive approach to problem-solving, but it can often facilitate achieving greater results through a more complex analysis of the problem (Gray, 1989). Research collaboration seems to dominate in some mainly applied sciences where it is common to combine the individual theoretical and practical knowledge and skills to create new knowledge and skills (Adams, 2004; Gibbons et al., 1994). Another study illustrates through the use of patent data that the greater technological distances (these are differences in firms' knowledge bases) tend to increase the likelihood that firms participating in alliances will draw upon the knowledge stock of each other (Rosenkopf & Almeida, 2003).

Collaboration can be seen as a way of facilitating the integration of knowledge (needed due to narrow individual specialisation in research), but it can also be seen as a way to take advantage of potential economic benefits such as economies of scale. Collaboration often allows involved scientific parties to benefit from joint use of specific or rare equipment or training facilities (Frenken et al., 2005; Katz & Martin, 1997). The role of collaborations as an important knowledge sharing and integration channel is also supported by the growing number of partnerships involving research institutions, private businesses, government bodies and academic centres (Archibugi & Coco, 2004).

2.2.4 Dimensionality of Collaboration

The role of collaboration is widely accepted and advocated across academia, industry and business worlds. In recent years, researchers and policy makers became increasingly interested in research collaboration. They now generally perceive collaboration as an important instrument, which should be promoted and supported (Katz & Martin, 1997). This increase of interest in collaboration has been at least partially facilitated by multiple collaborative programmes supported by the European and national governments. Many of these collaborative programmes have been instigated specifically with the aim of developing such research collaboration and increasing the involvement of different parties such as business, industry, academy and policy makers.

This research undertakes a review of dimensions, which are often applied to collaboration in collaborative and co-management literature. The first finding of this review is that collaborative arrangements of different types and nature have been studied for some time. The reviewed literature on collaboration is very theoretical in nature and is mainly concentrated in the fields of public policy, environmental management and planning. To date, the research within collaborative literature mainly focused on a few dominating themes: lack of historical record, conflicting goals, complex politics and power, multiple roles, and client identity (Ackermann, Franco, Gallupe & Parent, 2005). On the other hand, existing literature suggests that there is still a lack of clear understanding of the overall taxonomy or typology of collaborative dimensions. Such typologies provide a theoretical framework, which can be used to understand the phenomenon and to explain

some of its characteristics from new perspectives (Yin & Moore, 1987). Development of such theoretical frameworks will later help with the choice of analysis levels at which collaboration can be studied. The importance of typologies should not be overseen. It should be viewed as a set of major blocks that can be used to build a theory. These theoretical blocks reduce and simplify reality to explain the main dimensions relevant to the phenomenon in question (Yin & Moore, 1987). This taxonomic approach is especially important since the conceptual elements of collaboration receive very little theoretical support mostly because of their somewhat pragmatic nature (Brinkerhoff, 2002b; Plummer & FitzGibbon, 2004).

2.2.4.1 Complexity of Collaboration

Viewing research collaborations as knowledge diffusion channels allows understanding the existence of different typologies applied to collaborative arrangements. The earlier literature review pointed out that collaboration can often be seen as a complex concept and it does not necessarily mean the same thing to everyone as it can take different shapes. In addition, collaborative arrangements can take on different shapes and function at varying levels of abstraction (Katz & Martin, 1997).

In recent years, an entire range of collaborative forms appeared as a response to the differences in sought objectives and benefits. The complexity of goals determines largely both the form and the mode of the collaboration. Existing literature in the field suggests that organisations employ a rich range of collaborative arrangements from joint research centres and strategic alliances to enable an informal exchange of scientific information (Chompalov et al., 2002; Mintzberg et al., 1996). These collaborative forms can be seen as an attempt by organisations to meet the objectives and as a response to the increasingly challenging work environment (Ackermann et al., 2005). This section of the thesis will look closer at a number of descriptive and theoretical studies in the collaborative and co-management literature in order to systematise some of the collaborative dimensions.

2.2.4.2 Closeness of Collaboration

Collaborative forms can range depending on the closeness of partners from very close and intensive arrangements to very loose and distant contacts with some other forms in between these two opposites. According to Quintas and Guy (1995), collaboration modes under this perspective change from *close collaboration* to *'no real' collaboration* with shared parallel work and *loose collaboration* in between them.

2.2.4.3 Levels of Formality and Complexity

The variety of collaborative forms also exists due to factors such as formality and complexity of collaboration. Some collaborative choices are further determined by a wide variety of factors such as inter-institutional structures, levels of formalities in the networks, alliances and covenants, as well as collaborative forms for sharing expensive or scarce (scientific) resources and equipment (Bozeman & Corley, 2004; Mintzberg et al., 1996; OECD, 2003). Mandell (1999a) further examines the issue by placing collaborative arrangements on a continuum from interactive contacts to a network structure addressing actions, which are interdependent. Depending on the levels of regulation and formality, collaboration can vary from highly formal forms such as ownership, licensing, joint ventures, alliances, and networks to the less formal

behaviours of negotiation, teamwork, and networking (Mintzberg et al., 1996). Collaborations range from strategic alliances and joint ventures between business organisations (Doz & Hamel, 1998) to less formal and institutionalised collaborations among a wide variety of stakeholders to address issues of common interest (Gray, 1989). The least complex form includes collaborations *between individual researchers* such as exchange of letters or joint co-authorship (OECD, 2003).

Research collaborations in science and research are not limited to these types of collaboration (collaboration between individual researchers or scientists), they also occur on the level of *research institutes* (Frenken et al., 2005). Collaborations concerning individual organisations and institutions are not highly complex forms. They often do not involve or require significant financial injections or commitment and often exist with little or no exchange of funds. These two forms are followed by some of the more complex arrangements that require serious financial support and operational funding. Such forms of international collaboration (strategic agreements between organisations from different countries and academic collaborations among researchers from different countries) represent two main channels of international collaboration for sharing know-how (Archibugi & Coco, 2004).

While some of these complex research collaborations can be based on existing facilities, in some cases they can require establishment of a completely new structure. In some relatively rare cases, complex collaborative projects (such as the ITER Fusion Project[3]) can require a new capital facility that is outside the capability of a single partner country (OECD, 2003). A recent example of such multi-country projects is the above-mentioned ITER Project. The ITER budget was projected to be 10 billion euros and is a joint project between Europe, China, India, Japan, South Korea, Russian Federation and the United States. This joint supervision of the project not only allows for sharing of the building bill but also facilitates international collaboration for sharing know-how.

2.2.4.4 National and International Collaborations

Collaborative arrangements occur on *national* as well as *international* scales. Global and regional problems present opportunities for large-scale cooperation on common problems in such areas as global warming, biological diversity, and spread of disease (Skolnikoff, 2001). The ITER project is only one example of the level of the scientific problems that require international collaborations among institutions from different countries. Such international collaborations can take a range of forms from joint research centres and academic exchange of staff and students to the sharing of scientific information. These collaborations often focus on the problems that display strong dependence on scientific and technological factors. Since both the underlying processes and generated outcomes often differ significantly, it is important to distinguish between *place-based research* and research carried with the involvement of *geographically spread participants* (Stokols, Harvey, Gress, Fuqua & Phillips, 2005).

It has been estimated that the share of international collaborations increased by 100 percent between 1987 and 1997 to account for 15% of world publications in 1997 (Wagner, 2002). This trend continues largely due to the global use of internet and other communication and transport channels, use of the English language as

[3] ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power (see www.iter.org).

a standard language for most scientific disciplines. However, despite the presence of the above-mentioned global factors, the physical distances between collaborators presents a significant bottleneck in the process of international scientific knowledge diffusion (Frenken et al., 2005).

A recent study concluded that according to the evidence for the European Union, the majority of collaborations take place only on the national level, and that this tendency only slowly declines (Frenken, 2002). This bias towards collaboration on the national level suggests that geographical distance affects the probability of collaboration. In a recent review of such research studies, Frenken et al. (2005) examined three studies which all measured collaborative projects on *sub-national level*. According to one study, the patterns of scientific collaboration are strongly determined by the distance between the participating partners (Liang & Zhu, 2002).

Other reviewed studies suggest that the collaboration decreases exponentially with the distance, and that collaborative arrangements such as exchanges (mostly short-term research exchanges) to other institutions are often concentrated around a few centres (Danell & Persson, 2003; Katz, 1994). These studies suggest that as such geographical distance (or proximity) can often be a very good predictor for the frequency and intensity of collaboration between research institutes (Frenken et al., 2005). In addition, researchers involved in most global issues (such as global warming, energy or security research) become frequently involved in international politics and decisions on policy options and choices. This increase in the involvement of scientists in global collaboration projects can be at least partially explained by a strong new stand for international scientific collaboration represented by a growing number of international organisations, which are often specifically concerned with science and technology-related questions (Skolnikoff, 2001).

A different perspective on international collaboration was offered by Archibugi and Coco (2004) who argue that collaborations can be used as an indicator of the vitality of national knowledge systems and that the collaborations are beneficial for the country as a whole. If a country possesses an attractive knowledge base (technological distance), it will present an attractive knowledge base for other potential collaborators based in other countries. Furthermore, collaborations allow participants to connect to the knowledge sources from other countries, enabling national participants to benefit from the competencies of other collaborating parties (Archibugi & Coco, 2004; Cantwell, 2003).

2.2.4.5 Intra- and Inter-organisational Collaborations

The term 'collaboration' naturally refers to a shared project by more than one party. An organisational lens enables conceptual examination of the process of collaboration as an emergent organisational process (Gray, 1989). In line with this view one can distinguish collaborative forms depending on whether collaboration takes place *within an organisation* or involves *a number of organisations*. *Intra-organisational collaboration* involves individual people (members of teams, task forces and committees) and units (within the same organisation). In another study, Ellinger, Keller, and Ellinger (2000) examined the relationship among smaller organisational units such as departments internal to organisations. They explored the relationship between interaction (meetings and information exchange) and collaboration (teamwork, sharing, and the achievement of collective goals), and associated performance. Their research showed that while both

collaboration and interaction display positive association with performance, it is collaboration that facilitates the relationship between the other two: interaction and performance (Brinkerhoff, 2002a; Ellinger et al., 2000).

In contrast to intra-organisational collaboration, there is *inter-organisational* (or *multi-institutional*) collaboration, which displays certain patterns of organisational diversity (Chompalov et al., 2002; Gray, 1989). Four main forms of inter-organisational collaborations include upstream collaboration (e.g. collaboration with suppliers), and downstream collaboration (e.g. with franchisees). The other two forms are governmental collaboration and lateral collaboration (as in a shared research project) (Mintzberg et al., 1996). Essentially, the actual interdependence (e.g. in results and other outcomes) among participants within the four forms of inter-organisational collaborations can be seen as one of the factors determining whether the organisations become involved in collaborative projects. Functions and possible outcomes subsequently permit differentiation within collaborations as *exploratory*, *advisory*, *confederate*, and *contractual* (Plummer & FitzGibbon, 2004). In the beginning of a collaborative relationship this interdependence can motivate participating organisations to look for mutually acceptable solutions (Majumdar, 2006). As a result, the interdependent collaborating organisations, which realise the value of their interdependence, are able to minimise the need for any other formal agreements.

2.2.4.6 Collaboration across Sectors

Collaborative forms can also be classified depending on whether the work is done entirely within one sector or between two or more sectors. In recent years, some policies were specifically developed to improve working links between sectors (especially in science and technology) (Katz & Hicks, 1997). Such cross-sector collaboration occurs on different levels and across different sectors ranging from academia, civil society and government to industry and private sector.

In general, organisations resort to such collaboration (often in the form of sharing/linking and joint use of information, resources, activities, capabilities) to achieve results, which players within one sector are unable to achieve without involvement of parties from other sectors (Bryson, 2006). Such inter-sectoral and cross-sectoral partnering serve as a process of creating and implementing joint projects, which will connect these different sectors and will potentially create conditions for mutually beneficial development (Charles & McNulty, 1999). With communications and transportation, business and financial infrastructures constantly developing and moving towards one complex worldwide system there are more opportunities for collaboration. These collaborative contacts seem now less unique as a source of interaction and motivation; yet the increased globalisation opens many more new sources of conflict (Skolnikoff, 2001).

Collaboration can be *intra-sectoral* (for example, public-public collaboration in case of two governments or government organisations collaborating) or *inter-sectoral* (for example, public-business collaboration in case of collaboration between government and private businesses). With reference to this classification, Prefontaine et al. (2000) further develop a structural perspective in application to collaboration. According to this view, collaborations between these actors may be considered horizontal (with agreements between several government organisations at the same level of government) or vertical (with partnerships between

governmental structures at different levels). Different forms of cross-sectoral collaboration (and the impact they can have on scientific research) has received increased attention over the last two decades. One of the mechanisms for enhancing the economic applicability of scientific research was developed under the 'Triple Helix' model (Chompalov et al., 2002). This model represents a new mode of interaction between governments, the academic community and the private sector. Research with such complex features is then described as 'Mode 2' research (Gibbons et al., 1994). This framework operates on a macro-level of analysis with a focus on innovation, technology transfer and other mechanisms for transferring scientific results.

2.2.4.7 Other Dimensions to Consider

Other dimensions for consideration include the scale, scope, funding arrangements, operational practices, top-down/bottom-up or response mode of the research and the degree of disciplinary interchange (i.e. whether the research is interdisciplinary, multi-disciplinary, pluri-disciplinary, or trans-disciplinary). Other factors are the identity of the research initiators, the extent to which the work is pure or applied, the geographical and locational properties of the interactions (locus of control), and the communication media involved within the interactions (Rigby & Edler, 2005; Selin, 1999).

The fundamental nature of collaboration should be studied along additional dimensions such as intensity (power and process), and the degree of agreement and acceptance (Bramwell & Sharman, 1999). These additional dimensions are important since issues of inclusion, power and decision-making prove to be central to collaborative research and are present in discussions of collaboration (Plummer & FitzGibbon, 2004). Selin (1999) suggests to consider additionally to the aforementioned dimensions those of legal basis, organisational diversity, size and timeframe. The timeframe dimension is particularly interesting since often collaborations themselves need to be seen as temporary (Mintzberg et al., 1996). This literature review suggests that collaboration is a broad concept in scope and that collaborative arrangements of different types and nature have been studied for some time, however very little theoretical attention was directed towards understanding the overall structure of their dimensions. This thesis has therefore reviewed a number of descriptive and theoretical studies in the collaborative and co-management literature in order to systematise the dimensions that can be identified in the review of these studies (see Figure 2-2 below or the extended version in Appendix 37).

An earlier section of this work focused on the differences between collaboration and cooperation. This section of the thesis further explores different forms of collaborative arrangements. The list of dimensions identified and discussed earlier in this section is not finite. However, there are three main dimensions, which will define the framework of the proposed study of formal collaborative arrangements (formal collaborative research networks). First, this work will distinguish between *intra-organisational and inter-organisational collaboration* (Chompalov et al., 2002; Ellinger et al., 2000). Second, one can distinguish between *national and international collaboration* (Rigby & Edler, 2005). Third, *cross-sectional and inter-sectional* collaboration can be distinguished (Frenken et al., 2005). These dimensions, for theoretical reasons, should not be expected to be fully independent from one another or to be fully overlapping (Frenken et al., 2005).

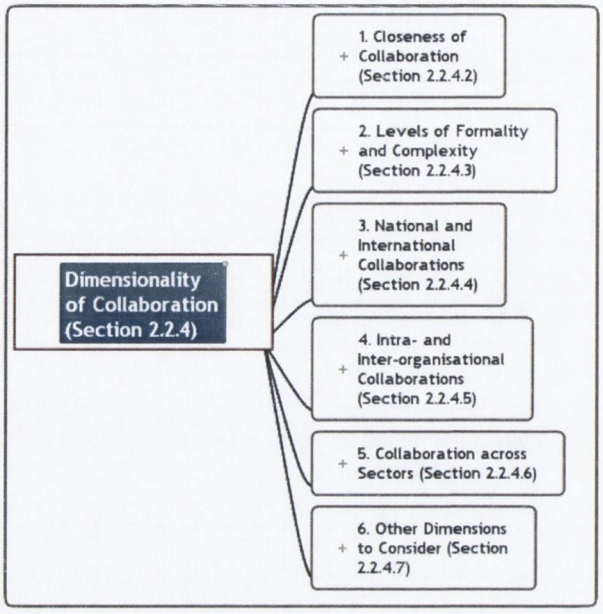

Figure 2-2: Dimensionality of Collaborative Forms

2.3 Scientific Collaborative Networks

The purpose of this section is to examine pertinent literature across a range of research fields in an attempt to develop a better understanding of the concept of research networking and its place in the overall framework of collaboration. Initial findings suggest that the interest in collaborative arrangements and particularly in networking has been incrementally increasing during recent years. Creech & Willard (2001) propose a number of fundamental drivers explaining the timing of this popularity. Firstly, the emergence of ICT (information and communication technology) over the last two decades facilitated global networking. Secondly, Creech & Willard (2001) argue that the ever-increasing complexity and connectedness of all major problems (global economic, environmental, etc.) and unsuitability of long-established processes to address these issues (such as global warming or energy security) created a 'sense of urgency' and made such collaborative learning arrangements an unavoidable necessity. Thirdly, some community and scholarly players feel the exclusion of many research projects from meaningful participation in society and, as a result the lack of impact that such research has on public policy. Lastly, the interest of public organisations in knowledge management has been further fuelled by a more active use of it within the private sector.

The growing theoretical base across all types of collaborative arrangements is generally positioned within the literature on consensus building, conflict resolution, group dynamics, and facilitation (Margerum, 2008). However, even with the increasing popularity of research on collaboration and relationships, research still has to understand the dynamics of social networking to realise the full value of research collaboration (Ehret, 2004). The following part of the review chapter will focus on definitions of social networks, which will be followed by a discussion of the role of knowledge factors in networking. This study will further examine the activities within research networks. It will also develop a typology of ties found in collaborative networks. This research will then propose to distinguish between formal and informal collaborative structures.

2.3.1 Defining Social Networks

Some of the first studies that examined social networks include works of a German sociologist Ferdinand Tönnies (1855-1936). Tönnies was a major contributor to theory and field studies in sociology. Tönnies distinguished between two membership groups: Gemeinschaft (often translated as *community*) and Gesellschaft (often translated as *society*) (Tönnies, 1887). Gemeinschaft groups form around essential will (the one that is the underlying, organic, or instinctive driving force), in which membership is self-fulfilling. Gesellschaft are the groups in which membership was sustained by some instrumental goal or definite end and which are formed around arbitrary will (which is deliberative, purposive, and future (goal) oriented). Family can serve as an example of Gemeinschaft, while the city or the country can be used as examples of Gesellschaft (Truzzi, 1971). Later, during the early 1930s, American theorist J.C. Moreno introduced the idea of '*sociogram*'. In this first formal attempt to describe and analyse a group of people from the point of view of their relationships Moreno views a sociogram as a cluster of individual nodes, which were interconnected by straight lines (Moreno, 1934). Sociograms were later used by other researchers in order to identify and classify categories of actors (van der Aalst, Reijers & Song, 2005).

The actual term '*social network*' has been around since the 1950s when another researcher J.A. Barnes coined this term for the first time. In his anthropological work on different groups within a Norwegian island parish he used the term 'social network' to describe the concept of social life as a set of nodes which are joined by lines to form a total network of relationships (Barnes, 1954). The definition of a 'social network' was later re-introduced by Chandler (1962) who believed social network was a structure crucial to knowledge transfer. According to this author's definition a social network is an organic structure connecting an open set of individuals either governed or ungoverned by the organisation's management (Mintzberg, 1973; Tichy, 1981). In more recent years a number of network researchers and practitioners attempted to define networking, however in general their definitions appear to depend on the objectives and goals of their networks (Nelson & Farrington, 1994). In general, a social network is *a collection of people* or other entities that are related to each other in some way. Plucknett et al. (1990) view it as an *association* of primarily independent individuals and organisations which share a common objective, all of whom share information and resources as well as participate in two-way exchanges and communication. Wasserman and Faust (1994) add that a social network is *a discrete set* of actors linked together by a *discrete set of relationships*.

Engel (1993) suggests that if networks are about actors and the ties between them, networking is about *building working relationships* with other parties to work on different common problems. Social networking is generally seen as a *process of forming new forms of social groups through establishing* a *mutually beneficial link* with other people and organisations. Social groups can therefore exist as *direct personal ties* that connect individuals who share either values and beliefs or impersonal, formal and instrumental social links. As such, social networks can take a range of forms and can be found on several levels (from interpersonal to international). In fact, any social institution (whether it is a small network or a large international organisation) can be both a network in itself and an actor in a larger social network. However, some networks are formed primarily with the purpose of facilitating the exchange of information. Workers who share professional and research interests often organise themselves into groups within an organisation (Allen, James & Gamlen, 2007). Such groups (which can be physical or virtual) allow participants to share

information and experience. Such networking can be described as a *collaborative process* during which interested parties actively *exchange information around a central theme* (Nelson & Farrington, 1994). Based on the reviewed definitions a general *social network* can be described as a *social structure made of nodes* (actors who can be either individuals or organisations, countries, etc.) which are connected to other nodes by one or more specific types of inter-dependency (these 'ties' can represent values, financial flows or trade, community relationships, divergences, ideas.). However, under the social network analysis human (individual) attributes and features are not as important as their ties with other actors. Social networks in this case are viewed as *relational patterns,* which are created as a result of conscious efforts to build relationships with other parties (Engel, 1993). According to this definition, networking is the *actual result* of conscious efforts to build relationships with other parties. Furthermore, in this case, a primary objective of these efforts is not to create new products but *social learning*, *communication* and the *making of meaning*.

Coming up with a single definition which would fit with all these notions seems rather challenging. Most of the identified definitions underline that networking involves individuals (or groups) and organisations who are working through a collaborative effort on a common problem or concern (Creech & Willard, 2001; Li-chun et al., 2006). However, for the purpose of this research networks will be viewed as structures composed of different units (such as individual people, institutions and organisations, entire countries, events, documents, projects, etc.) and ties between these entities, which can be of a different nature as it can involve flows of information, financial resources, goods, etc. In the world of complex global problems, where the need to share practices and information together with other factors (such as the intentions of civil society actors to improve their performance as well as their involvement and influence on policy making) present well established reasons for supporting knowledge networking (van Zee & Engel, 2004).

2.3.2 Knowledge Factors and Networks

As networking and collaboration are generally about knowledge transfer, it is important to make a distinction between how this transfer is organised and carried out in reality (Allen et al., 2007). Networking knowledge is formed not just during meetings, conferences and workshops. As the networks transform into learning spaces for innovation, learning and experimentation, contemporary research networking becomes about a variety of sophisticated strategies for identifying and sharing ideas, knowledge, skills and experiences. Such research networking also allows participants to learn systematically from it for generating innovative proposals and policy options (van Zee & Engel, 2004). Existing literature confirms that today's collaborative practices are generally based on knowledge factors such as creation, sharing, exchanging and integrating knowledge (Hagedoorn, 1993b). New knowledge can be created both within the organisation as well as from external organisations and individuals. In many R&D and scientific fields with numerous issues becoming increasingly multidisciplinary, it is often not possible to rely solely on internal expertise. In this environment, knowledge management improves both research efficiency and effectiveness as well as it provides other benefits to research related organisations (Parikh, 2001). Under these circumstances different collaborative arrangements such as alliances and networks present new (even if often insufficiently explored) ways to facilitate internal innovation processes. Organisations improve their innovating capabilities through collaborative projects by creating knowledge flows, uniting other partner organisations, suppliers, distributors, governmental organisations and others into one or several networks. Similar interaction within

an organisation (as well as interaction between external parties) facilitates creation of a greater body of knowledge.

A number of studies suggest that in knowledge intensive fields individuals and organisations can improve their competitive positions (and sustain their continuous development) through the utilisation of *science and technology driven networks* (Ahuja, 2000; Creech & Willard, 2001; Freeman, 1991). Civil society actors *upgrade* their performance through collective actions when they perceive lack of access to relevant knowledge as a critical factor preventing work from being done. In this case the networks are stable as they fortify creative and critical thinking through mutual sharing and exchange of information and knowledge (Engel, 1993). However, an organisation's competence is dependent not only on the its ability to share and exchange information and knowledge, but also on the ability to capture and absorb implicit knowledge, which can be gained from other collaborators in network projects (Cohen & Levinthal, 1990). A *knowledge network* can be defined as a group of expert institutions collaboratively working on a common issue/problem in order to fortify each organisation's R&D and communications ability. In knowledge networks, these participating parties take advantage of each other's expertise and come up with the answers and solutions to these common issues/problems that adequately address the decision-makers' objectives at the national and international level (Creech & Willard, 2001). As knowledge is widely spread across organisations and individuals and acquiring this fragmented knowledge provides organisations with a competitive advantage, such a knowledge network can be seen as *the locus of innovation* allowing participants to find the important balance between managing internal expertise and acquiring timely access to required external knowledge sources (Powell, Koput & Smith-Doerr, 1996).

Another possible explanation as to why such cross-sectoral partnerships are so common can be linked to an important difference in incentive structures between different sectors: for example, while academic actors work on maximising diffusion of their knowledge, industrial actors attempt to minimise diffusion of theirs. According to Ponds et al. (2007), such complexity makes it difficult to spell all the possibilities in the form of a contract, so often these networks rely on less formal arrangements that reduce the risk of opportunism. The authors believe that this is another reason why cross-sector collaborations (for example projects involving academic and non-academic participants) are often built with the principle of geographical proximity that is supportive in establishing thriving collaborations between institutions with significantly different structural backgrounds. Bozeman and Corley (2004) propose the term '*scientific and technical human capital*' to define the sum of researchers' professional network ties and their technical skills and resources. Only a very few individuals within an organisation engage in knowledge sharing positions, the ties between these sector groups to some extent exist only due to these key expert-level researchers who are involved in several types of networks; therefore these individuals possess the highest S&T human capital (Allen et al., 2007). While their involvement can take different forms (such as joint publications, consulting, expert panel and advisory board membership, licensing, patenting of property rights, start-up companies etc.) this arrangement allows for a transfer of knowledge between several fields and ensures application of research advances (Murray, 2002). Another sub-form of networks is known as *partial* as these are networks that are built upon scientific contacts of a single individual or upon entire networks where no one single actor is privileged (Pappi, 1987).

2.3.3 Research Network Activities

Similar to other social networks most collaborative knowledge networks are undirected networks where nodes represent the scientists and the links represent the collaborative relationship on some common task (for example through a joint publication) (Li-chun et al., 2006). Research networks as institution-based communicational links (either physical or virtual) are built to improve knowledge creation by exchanging mostly codified knowledge (along with focal knowledge) (Maggioni & Uberti, 2006). Such networks are often organised with a purpose of sharing solutions where participating institutions exchange knowledge and other resources solely to come up with a solution to a specific issue in their environment. As a result, knowledge networks are often dynamic by nature and change over time. This is often the result of a turn-over of people as well as the changes in practices of scientific collaboration etc. (Hou, Kretschmer & Liu, 2008). The networks are also dynamic, as organisations at different stages of their development tend to build their relationships with academic partners very differently. Networking can be pursued by both start-up companies lacking *resources* as well as experienced organisations lacking innovative ideas or research *personnel* (Murray, 2002). Many start-up companies involved in science and technology driven fields have interesting promising ideas that however often lack experimental support, proof of concepts, and scale up. On the other hand, a more experienced organisation can have an interest in attracting and creating new ideas and external scientists without upsetting its current research operations; in this case, this company can be more interested in other strategies such as hiring external researchers or consulting.

Collaborative R&D involving external parties compliments internal R&D efforts. Internal expertise allows organisations to contribute to other network participants' learning and to assess and where possible learn from any research developments carried out by other parties externally (Powell et al., 1996). Murray in his 2002 work argues that the very nature of the interaction between research and business communities has to do with the stage of development of a given idea and the maturity of the scientific field in question. Consequently, closer collaboration would be required when working on newer and riskier topics as it would allow external experts and the inventor to share risks. However, in the less innovative and less risky processes (working on more incremental ideas) the inventor might be less central to the process of bringing the idea to market. Additionally to the above mentioned benefits, cross-sector networks (academy-business) enable network building, which would also *endorse new products*, which would later serve as an approval rubber stamp to investors (Murray, 2002).

Engel (1993) suggests that *societal networking* can be characterised by four types of activities. These activities are: (1) the provision of services and training, (2) management, (3) advocacy and (4) learning together. Here, the *provision of services and training* are about the network communications infrastructure. This can be facilitated through either a centralised information point with regular newsletter updates or even a common data centre (website or database) for sharing information, knowledge and skills. Additionally, the networks mostly feature a *management* unit whose particular objective is in facilitating the actual networking process. The operations of this management group generally include improvement of the communication in the group, assessment, monitoring and evaluation of activities and outputs, as well as networking with other external parties.

Advocacy includes the activities that can improve the position of network participants in both getting involved and influencing public and development policy discussion. *Mutual learning* enables networking actors to increase their understanding of the common problem(s). This can take a form of meeting, institutional exchanges, training schools and workshops. Some of the common elements here are joint diagnosis, exchange, comparison and synthesis (Engel, 1993). Other authors additionally point out the importance of face-to-face communications. Allen et al. (2007) showed that physical location can have certain effects on the relationships between the participants of such networks as those collaborative projects, which had more frequent meetings (face-to-face) tended to perform (achieve their project objectives) with a higher success rate when compared to less frequent and more distant communications (Allen et al., 2007). However, different categories of personnel search for information in different ways. For example, when searching for answers to work related questions, engineers and other technical employees are more likely (up to five times compared to other members of staff) to turn to a person rather than any other source of information (Allen, 1977).

2.3.4 Types of Network Ties

Networking readiness (ability to develop and manage one's personal networks) is an important social skill and the ability to manage relationships with other actors has long been seen as a crucial competency for any business-minded institution. Being members of a society, most people rely on the collaboration with other members of that society in both personal and professional dimensions. In response, current society is continuously changing into a network society that is also generally more aware and is more capable of taking advantage of the benefits related to collaboration through networks. Such collaborations often allow sharing of costs and risks associated with complex projects as well as allowing one to keep up-to-date with the latest developments in the field and continually changing information (Castells, 2000). On the other hand, as competition among organisations grows, networks also turn into gatekeepers to ensure the very survival of the organisations. As a result, when previously the basic units used to be organisations, in the modern world often the basic units are networks (Lindgreen & Wynstra, 2005).

Modern organisations frequently take advantage of the recently introduced information technologies that create new communication channels. Related research shows that modern organisations are drawn into enormous webs of contacts and other ties connecting individuals (Cross, Nohria & Parker, 2002; De Meyer, 1983). These connections in reality are responsible for disseminating knowledge and information between individuals and form informal social networks which are critical to the functioning of scientific and technological personnel and the overall ability of the organisation to conduct R&D (Cross & Parker, 2004).

2.3.4.1 Arm's Length Relationships

Lawrence et al. (2005) propose to distinguish between three types of relationships traditionally employed by organisations (and individuals): arm's length ties, socially embedded and virtual embedded ties.

Arm's length ties represent the purely economic relationships between individuals (or institutions) who otherwise are not connected and often are rather rational and independent connections, as characterised by Adam Smith (Lawrence et al., 2005).

2.3.4.2 Socially Embedded Relationships

In contrast, the *socially embedded ties* are economic relationships that are defined by direct social ties among the individuals involved. These are usually relationships involving professional or social acquaintances, friends, neighbours, family relations, ex-colleagues. These ties are generally developed over time through repeated interactions and face-to-face contacts including social events such as joint meals, sports games or professional events such as conferences and workshops. Lawrence et al. (2005) point out that socially embedded ties are focused not just on the business transaction (as it is in the case of arm's length ties) but also on the social interaction of individuals.

2.3.4.3 Virtually Embedded Relationships

Additionally, it is possible to differentiate between embedded ties and virtually embedded ties. *Virtually embedded ties* generally represent economic relationships which are facilitated and maintained through the use of electronic technologies, this minimises the risks associated as well as increasing transparency and information sharing (Lawrence et al., 2005). An organisation needs to understand the benefits and advantages which the three types of ties can provide in different situations. In the business world, a combination of all three types of connections can be required in order to stay competitive since none of the three types of relationships presents the most successful or useful way to create and maintain connections with the external parties (Lawrence et al., 2005). Such a knowledge production system can be conceptualised as an 'evolving communication system' in which computer mediated communication technologies play an increasing role (Heimeriks, Hörlesberger & Van Den Besselaar, 2003).

The credit for many of the successful and effective collaborations is often given to a participant's commitment to trust and understanding of mutual goals and objectives (Majumdar, 2006). This generally takes significant time and effort on the part of involved parties to understand each other's values and goals in order to build an environment of trust and openness about their requirements and resources. Lawrence et al. (2005) advocate benefits of *arm's length ties* in situations with a higher risk of opportunism, little uncertainty and minimal complexity, and in other situations the use of either socially embedded or virtually embedded ties should be considered. When deciding on the right combination of the three types of ties one should take into account a range of factors such as opportunism, uncertainty, complexity, network instability, susceptibility to industry restructuring, need for outside information and so on (Lawrence et al., 2005). Finding the balance in these questions would allow the measuring of effectiveness and efficiency of such networking activities. These players (similar to the players within any network) have to work on building necessary collaborative relationships. In other words, the knowledge production system is increasingly becoming a hybrid network characterised by heterogeneous collaborations between different actors, and by heterogeneous communications using an increasing number of different media.

2.3.4.4 Types of Research Networks

Collaborative social networks are generally dynamic by nature. Scientific and technological progress often originates and takes places in three types of networks: commercial technological groups, purely scientific research groups and in networks combining several sectors. Collaboration between academic institutions is

often perceived as the most important form of collaboration in science, however collaboration between governmental and academic organisations and between academic organisations and other types of institutions (business/industry, government, etc.) is also frequently occurring (Ponds et al., 2007). An objective for such cross-sector networks is to facilitate interdisciplinary research (in terms of both developing ideas and communities of researchers) through advancing interaction between the research community and other scientific, technological and industrial stakeholders. This aims at creating and transferring experimental methods and promoting mobility of researchers and scientists.

2.3.4.5 Heterogeneity of Knowledge Networks

Examples of heterogeneous knowledge networks include those involving non-governmental and governmental organisations, academic institutions, policy makers and other stakeholders who seek partnerships with others in order to facilitate exchange of information, knowledge and experiences, build collaborations and to implement these new ways of working. Research argues that these networking efforts result in formal and informal networks, which in turn are a part of social innovation (Alders, Haverkort & Van Veldhuizen, 1993). Other groups can be considered as heterogeneous due to the international dimension of their collaboration as discussed in an earlier section of this chapter[4]. It is not surprising that both the creation and emergence of heterogeneous networks present some of the most crucial results of any scientific activity, making it important to further uncover the rules governing the formation, structure and functioning of knowledge networks (both formal and informal) as these are crucial to their success (Callon, 1994).

2.3.5 Formality of Network Structures

People invest time and resources in building networks that can improve their standing in society as well as to increase individual's social scientific and technical human capital. This networking ability requires its continuous management. In the business world, networking is recognised as an important factor determining one's achievements and long-term progress. Generally, the most successful organisation leaders are able to influence events and other people's decisions.

Furthermore, depending on the type of networking activity and the level of effort put into creating and maintaining these networks, one can further distinguish between formal and informal networks. Formal and informal structures are two distinctly different systems. An organisation's formal structure is defined by its managerial systems, and its informal structure is the processes by which the organisation's individuals communicate between themselves and external parties on the issues not overseen by the organisation's management (Burns & Stalker, 1961). According to Chandler (1962) a *formal social network* is one that is generated and enforced by management, and usually directed according to its corporate strategy and mission.

2.3.5.1 Formal versus Informal Networks

Formal networks generally have more explicit and visible structures and are organised with very well defined mission, philosophy, membership principles and funding criteria. Formal networks often function through panels, boards, associations, conferences and discussion groups. In contrast, *informal networks* are

[4] Section 2.2.4 on dimensionality of collaboration

unsanctioned and ungoverned organic structures connecting an open set of individuals built around one informal goal, which often involves informal give-and-take exchanges of information and resources (Chandler, 1962; Mintzberg, 1973; Tichy, 1981).

Informal networks have implicit structures and often take the form of a casual get-together or an informal networking event or session. These informal networks do not have formal explicit rules and regulations; access to the network is often through one's personal contacts. However, the emphasis in informal networks is on a *one-to-one collaboration* as opposed to an *organisational system* that defines the formal network. Generally, informal networks are driven and organised around strong leaders who ensure the members of their informal networks interact closely despite the lack of formal structures. Informal networks can exist within the organisations. Furthermore, informal networks can also connect individuals in these organisations to individuals elsewhere. Frequently, such informal networks are represented by work-related associations, collaborations and knowledge exchanges between these individuals, which are often not found in their formal organisational structures. However, these informal networks are mostly the result of employee personal interaction (Cross & Parker, 2004). Some of these informal networks form due to the company's employees, while other networks form due to other external parties. These external individuals or organisations are willing to learn and acquire new knowledge by having the company's employees as members or experts on different panels and professional bodies, or professional researchers at associated academic institutions (Allen et al., 2007).

Informal networks often keep together some of the cross-functional process-improvement initiatives, alliances and mergers (Cross et al., 2002). Informal networks as a type of social network are critical in knowledge-based industries. At the same time, these social networks are not always visible to organisations. Furthermore, some informal networks are not fully recognised by these organisations, even in cases where these networks are crucial to their existence. Therefore, one such recognised reason for the neglect of these informal networks at the managerial level is due to the poor visibility of these networks and lack of clear ownership (Cross et al., 2002).

2.3.6 Conclusion

The reviewed research is unclear on whether heterogeneous formal research networks achieve originally intended results to a lesser degree than homogeneous research networks. However, it does suggest that the level of heterogeneity in a formal research network can be seen as an impeding factor in achieving research objectives. A possible source of unproductive conflicts lies in the differences in ideas, research interests and cultural specifics (Bammer, 2008). The highly heterogeneous research networks can be more open to failing their original objectives than lesser heterogeneous networks (Putnam, 2007). The reason for this suggestion lies in higher risks and in lower levels of trust, which lead to lesser involvement of partners in networking activities. Lesser active participation can result in less active social learning and research outcomes that are smaller than expected in the beginning. Additional risks are further added when the working practices, methods or cultural skills of participants differ significantly. The evidence for the European Union confirms that the majority of collaborations take place only at the national level, and that this tendency only slowly declines (Frenken, 2002). The bias towards collaboration on the national level suggests that the geographical

distance affects the probability of collaboration. This bias can also be at least partially explained by higher coordination costs associated with collaborated research (Cummings & Kiesler, 2007).

Despite the observed variations in interests, personalities and ideas, highly heterogeneous networks (international and cross-sectoral) can provide participants with unprecedented opportunities and exposure to new thinking and ways of conducting research. It is in the process of collaboration where scientists are most likely to bond their differences and similarities in knowledge and thinking (Stephan, 1996). Such large-scale international collaboration can promote new approaches to global or complex research issues. It has also been noted that both the creation and emergence of heterogeneous networks present important results from any scientific activity, making it important to further uncover these knowledge networks (both formal and informal) (Callon, 1994).

2.4 Research Collaboration Motives and Factors

Literature on research collaborations can be grouped into several general topics according to the following broader research problems dealing with:

- Organisations engaging in research;
- Factors and motivation behind collaborative research and sources of collaboration, propensity to collaborate;
- Assessment of the outcomes and impact of collaborative research forms.

The following section further reviews existing research literature with a particular focus on these question groups.

2.4.1 Organisations in Research

Most research organisations can be grouped under three ideal-typical headings: knowledge seekers, research contractors and service providers (see Table 2-1 below) (Wilts, 2000). This study focuses primarily on the scientists involved in organisations classified as knowledge seekers. Knowledge seekers are organisations, which are primarily concerned with the production and creation of new knowledge. Organisations which realise the importance of collaboration also have to decide on the format of such collaboration and on the choice of a partner. There are certain criteria that are used in this decision-making process. Among others, these include trustworthiness and reputation of potential partner organisations, or any existing personal relationships between the top managers of the organisations.

These organisations are required to share certain values. Once these are established and clear, such collaborations must be institutionalised. Many types of contractual arrangements cannot easily be duplicated. As a result, there are only a few types of collaborative research arrangements that are open to organisations. The most common R&D agreements range from the basic coordination of research activities to cost and information sharing joint ventures, with the actual scientific and technical cooperation coming at the R&D or production stages (Silipo, 2008). However, there are substantial differences between these forms of research collaboration. In the case of *coordination* of R&D activities, the link between the involved organisations is weak. These organisations decide on the specific details such as the level of investments, yet they do not

collaborate on their R&D activities. These organisations can conduct their core R&D activities independently from each other in cases where they are market competitors.

Table 2-1: Types of research organisations

Types	*Definition*	*Comments*
Knowledge seekers	Organisations with a guaranteed access to necessary action resources and a warrant of their independence in identifying organisational goals and priorities	Organisations of this type are not dependent upon maintaining direct external relations with economic and political practise for acquiring necessary action resources such as basic research funding
Research contractors	Organisations constituted by formalised and externally acknowledged autonomy, yet dependent upon the successful marketing of research results for gaining full access to necessary action resources	Their constitution thus provides concrete incentives for these organisations to structure their internal decision-making procedures in such a way that the research efforts of individual members are adequately constrained towards organisational goals and priorities
Service providers	These organisations lack a constitution that warrants their institutional autonomy	Strongly depend on funding decisions by their principals in order to gain access to necessary action resources and can do so to such an extent that it may still be difficult to recognise them as independent research facilities

Adapted from Wilts (2000)

Some stronger forms of collaboration (such as licensing agreements) take organisations to a level of sharing both results and information. While such sharing leads to obvious knowledge spillovers, this particular form of collaboration does not prevent organisations from replication or duplication of their R&D efforts, as they still conduct their research in separate labs. Silipo (2008) points out that a joint research venture is a more advanced form of R&D collaboration. Such joint research ventures would allow the sharing of critical knowledge, avoiding the duplication of research costs, and reducing both development and market uncertainties. The choice between these collaborative forms should be based on the analysis of anticipated profits of each member organisation, but it should allow each member to achieve profits higher than it would have earned through independent R&D efforts (Silipo, 2008).

2.4.2 Collaborative Research

The following section reviews existing research literature to identify potential explanations of the growth in popularity of collaborative arrangements in research. Why do organisations and individual researchers engage in collaborative research? A growing body of literature examines the motives that bring organisations to collaborative research. These reasons are generally discussed very briefly and only some authors focus on the motives and motivation behind collaborative research arrangements. The motives for participating in collaborative research generally fall into one of two motive categories. On the one hand, through collaborative efforts, companies increase their revenue. Inter-organisational collaboration can be beneficial as it allows collusion with some competitors against other competitors. Alternatively, such collaboration transforms competitors into allies (Porter, 1986).

In addition, organisations and individuals can gain access to resources, skills, knowledge and capabilities; and through such access, they can improve their competitiveness in the field. On the other hand, inter-organisational collaboration and networking can also be popular as a means of reducing costs. Such cost reductions can be a result of economies of scale or scope. This is often carried out through collaborative R&D, marketing or even production. Less commonly, organisations may choose to go for a collaborative

arrangement as a means of economising costs related to coordinating their core activities (Hennart, 1991). Collaboration can therefore present a cost-effective way of gaining access to important know-how that otherwise cannot be accessed (Dyer, 1997; Madhok & Tallman, 1998). In addition, inter-organisational collaboration can serve as a shortcut to required skills allowing organisations to learn in the most efficient and timely manner (Ahuja, 2000; Bougrain & Haudeville, 2002; Breimer, 1996; Calvert & Patel, 2002). The following sections of this paper discuss a range of factors and motives in an attempt to systematise perspectives identified in the reviewed literature.

2.4.3 Factors Determining Research Collaborations in Science

The following two sections of this thesis explore a range of factors and motives determining the involvement of social actors (organisations as well as individual participants) in collaborative research. This section focuses on the factors leading scientific researchers to collaborative arrangements. The reviewed literature demonstrates that the growth of international collaboration in science did not go unnoticed by researchers. Furthermore, related research provides an excellent list of convincing reasons why social actors engage in collaborative research activities. In one such attempt to analyse factors explaining this recent strong growth of international collaboration in science, Wagner and Leydesdorff (2005) propose dividing these factors into internal and external to science. These factors will be discussed further in the following section of this thesis.

2.4.3.1 Factors External to Science

Existing literature distinguishes between factors external and internal to science with *scientists' interconnectedness*, growth of *information and communication systems* and *research funding* falling into the external factors group (Wagner & Leydesdorff, 2005). The following chapters will discuss these factors in detail.

2.4.3.1.1 Interconnectedness of Scientists

According to Wagner and Leydesdorff (2005), one external science factor is related to the general *interconnectedness* of researchers. Some explanations of the emergence of collaborative knowledge creation are linked to comprehensive social and economic changes, or in particular to the *mass availability of higher education and scientific research*, as well as the transformation of knowledge into production factors in knowledge intensive industries (Gibbons et al., 1994). The worldwide growth of scientific capacity enhances interconnectedness internationally. However, this global capacity growth does not explain why researchers from developed countries become increasingly interested in collaboration with researchers from elsewhere. Yet this trend can, at least to some degree, be explained by either *historical relationships* (such as colonial ties), *geographical proximity* (for example, countries within European Union), or *cultural closeness* (i.e. Ireland and the UK).

Geographical proximity suggests that collaboration between geographically dispersed partners is a possible way to ensure sharing of important research data, knowledge and information as well as resources such as laboratory equipment, tools and other infrastructure. According to one study, the patterns of scientific collaboration are strongly determined by the distance between the participating partners (Liang & Zhu,

2002). While other studies find that the collaboration decreases exponentially with distance and the collaborative arrangements such as exchanges (generally short-term exchanges) to other institutions are often concentrated around a few centres (Danell & Persson, 2003; Katz, 1994). These findings point out that geographical proximity can predict both the frequency and intensity of collaboration between research institutes (Frenken et al., 2005).

2.4.3.1.2 Growth of Information and Communication Technologies

Historically, some dispersed forms of collaborative arrangements were difficult due to geographical distance between the researchers. Geographical distance has a negative impact on the likelihood of collaboration between these researchers as well as on the success of such geographically dispersed collaborative efforts (Allen, 1977; Cummings & Kiesler, 2004). However, in collaborative arrangements such as research networks, participating researchers may collaborate through mail or email, discussions, meetings, conferences, and by exchange visits. In some cases, researchers can perform parts of research independently and then combine their results at a later meeting (Bozeman & Corley, 2004). The development of information and communication systems has further facilitated such forms of collaboration. While the growth in collaborative arrangements is often credited to the spread and development of information and communication systems, it has also been shown that most collaborations still start from face-to-face interactions (Laudel, 2001). So even if information and communication systems do facilitate international collaboration in science, they do not cause it (Wagner & Leydesdorff, 2005).

2.4.3.1.3 Increasing Costs of Conducting Research and Importance of Research Funding

Some larger organisations can access unique know-how owned and developed by smaller companies. On the other hand, smaller players can benefit from economies of scale and the support of larger corporations and their innovative capabilities. Such research collaboration allows researchers to take advantage due to economies of scale as they can share expensive and rare equipment or infrastructure (Katz & Martin, 1997). Similarly to businesses collaborating on research, one of the reasons researchers in science engage in collaborative research is the ever-increasing cost of conducting research work. With often limited state funding, universities tend to look towards industry for additional support. On the other hand, even with some of the bigger firms not being self-sufficient in their knowledge creating capabilities, industry players are (as in the earlier described case of biotechnology) dependent on the university sector for a significant portion of their innovative work.

Davies (1996) points out that the strength of academic institutions is in their science base and this is well recognised by most industrial actors as the key to securing both their survival and sustainable development. Both types of organisation can certainly benefit from such collaborative activities. While universities can hire new staff members and buy additionnal equipment for new projects, this increase in personnel and infrastructure also results in increase in the universities' resources and expertise. On the other hand, industry is responsible both for recognising the potential of funded research findings and for its early commercialisation (Davies, 1996). Existing literature lists a number of motivational factors determining the tendency of academic researchers to engage in external research activities as a way of *increasing their income*. There is also a trade-off between this perspective of achieving extra income through commercial

arrangements and the inherent research objectives of working towards scientific achievements (Arvanitis, Kubli & Woerter, 2008). As many academic institutions are interested in the transfer of research to industry participants, in some universities there are even liaison personnel responsible for dealing with industry (Davies, 1996).

2.4.3.2 Factors Internal to Science

This section examines some of the internal science factors which determine an increase in collaborative research in science. Some of the internal factors that are discussed in the following section are lagging in expertise or resources (centre-periphery perspective), internal disciplinary differentiation of science and increased professionalisation of scientific institutes (Wagner & Leydesdorff, 2005).

2.4.3.2.1 Lagging in Expertise or Resources (Centre-Periphery Perspective)

According to this factor, researchers from the countries lacking in particular expertise or resources would be willing to engage in collaborative research with researchers from leading countries. *Centre-periphery theory* developed by Wallerstein (1979) to some extent explains how this factor works. This theory is often used to explain the movements (in the economy) within and between different countries due to market forces. The capitalist world is somewhat heterogeneous in political and economic terms with some countries at different stages of development. When applied in the context of scientific and technical collaboration in the European Research Area, this theory suggests that a range of formal pan-European research programmes can be used to narrow the technological gap between countries with high technological development (core – the EU10 states) and other less developed EU Member States (periphery - new EU countries). Such programmes can provide Eastern European researchers with access to academic researchers, equipment and other infrastructure in the 'core' EU countries. Another example is different international collaborative projects that produce outputs such as publications or industrial applications. These collaborative outputs also allow all participating researchers to raise their own research profile (as well as the research profile of their institution). This perspective is reiterated on a different level by Archibugi and Coco (2004) who argue that collaborations can be used as an indicator of the vitality of a national knowledge system and that the collaborations are beneficial for the country as a whole. If a country possesses an attractive knowledge base (technological distance), it will present an attractive knowledge base for other potential collaborators based in other countries. At the same time, collaborations allow participants to connect to the knowledge sources from other countries, allowing national participants to benefit from the competencies of other parties (Archibugi & Coco, 2004; Cantwell, 2003).

2.4.3.2.2 Research Field Specific Characteristics

Some fields (such as physics or mathematics) have been historically active in collaboration, while other fields are relatively new to it. A recent study empirically explores the factors determining the propensity of research institutions to engage in collaborative research arrangements with external institutions (private corporations) (Arvanitis et al., 2008). The researchers concluded that research institutions with an applied research focus have a stronger interest and are more inclined to be involved in collaborative research projects with external organisations (Arvanitis et al., 2008). It also confirmed that institutions with previous experience of such

external industry collaborations generally are characterised as possessing a higher share of external funding in their institution's budget. The authors further found that research institutions from some applied fields (mainly such fields as natural sciences, engineering and economics/management) have an above average propensity to participate in such collaborative arrangements (Arvanitis et al., 2008).

2.4.3.2.3 Internal Disciplinary Differentiation of Science

Increased specialisation within the fields of science can be considered as one of the factors determining growth in international collaborations in science. Frenken et al. (2005) explain the increased popularity of collaborative research in science by increased division of labour among scientists. Similar to research-based industries, science gradually develops into various research fields and sub-fields. New knowledge is frequently created through integration of researchers' work from these fields and sub-fields. Such research collaboration has become the primary form of problem-solving across many scientific fields (especially applied sciences) (Frenken et al., 2005). As a result, new solutions are often the result of combined application of many pieces of knowledge and competencies. Research collaboration is increasingly motivated by quality enhancement with collaborative networks serving as vehicles for knowledge flows (Frenken et al., 2005). However, even though there are certain advantages derivable from shared expertise and infrastructure, such multi-party research collaborations do impose significantly higher coordination costs than in the case of projects involving a single institution, as these costs have strong institutional and geographic origins (Cummings & Kiesler, 2007).

2.4.3.2.4 Professionalisation of Scientific Institutes

As discussed earlier, research collaboration in science can take many forms similar to collaboration in other fields ranging from consultancy to active involvement in global research projects. These collaborative contributions can be significant as well as minor. In some of these collaborations, some participating researchers would be seen as crucial collaborators, while in other collaborative arrangements, they can be simply mentioned as a co-author for providing required data or other information (Bozeman & Corley, 2004). Public support of science is often justified by its benefits to society as it is expected to contribute to society's technological and economic improvements in all aspects (Small, Kushmerick & Benson, 2008). Therefore, researchers and research institutions participating in collaborative research projects that are able to show tacit research outputs (such as industrial applications that can be applied on national or international levels) would be considered to contribute to the country's standing. Researchers' capacity to have an impact on important policy issues (both national and international) is perceived as an important research outcome. One reason lies in the impact of scientists and their work on policy issues. According to Skolnikoff (2001), researchers' impact in some fields (such as foreign policy issues) has been decreasing even though scientists have a legitimate role in the policy process.

2.4.4 General Motives for Collaborative Research

Review of related research over the last twenty years provides an important insight into the motivation behind collaborative research. This section aims to analyse the motives determining general principles of collaborative behaviour, while the following section further examines which motives are applicable within

the particular setting of this study – formal collaborative research projects. Traditionally, many stereotypes link innovation with individual scientists developing new revolutionary ideas (Bougrain & Haudeville, 2002). Bright individual researchers certainly deserve the credit for their innovative ideas. Yet, in the modern world, many scientific discoveries are the result of many interactions and contributions, rather than the sole work of a few individuals. In fact, many successful breakthroughs are the result of a series of '*trials and errors, uncertainty and compromises*' involving multiple participants (Bougrain & Haudeville, 2002, p. 735).

The scientific and technological environment and its rules have changed significantly over the past few decades. In the current environment, it is well understood and accepted that critical knowledge can be created both internally within an organisation, as well as being externally acquired (McAdam, 2000). Individual networks are claimed to be known for contributing to scientific and technical progress and innovation, which are also characterised by the significance of organisations and communities as well as their practices (Murray, 2002). Such networks or alliances can involve various types of participants interested in collaboration. Arora and Gambardella (1990) give an example of innovation in the biotechnology field, which depends on three types of agents (academia, small and medium research intensive organisations, and large corporations). These types of research organisations can provide crucial and often complementary resources critical to research, development and commercialisation of new products (Arora & Gambardella, 1990). Frequently, it is these institutions and communities that determine the path for certain breakthrough ideas and innovations with their performance linked to their position in the research networks (Murray, 2002).

2.4.4.1 Strategic Research Collaborations

A categorisation of motives for strategic research collaborations has been suggested by Hagedoorn (1993c), who identifies four main groups of reasons for research collaboration: to reduce development costs, to minimise the risks in environments prone to risk, to achieve economies of scale and to speed up the innovation process. This categorisation confirms that as with many strategic decisions in the business world, decisions about collaborative strategies are frequently determined by answering the following questions: how to reduce costs, research and development costs, how to minimise product and market uncertainty, and how to minimise risks associated with these research activities. In the modern global world, intense competition and the ever-increasing cost of research (with organisations interested in retaining their technological competitive advantage) make joint collaborative efforts an important and often the only realistic answer to these problems (Barnes, Pashby & Gibbons, 2006).

Increased complexity and inter-sectoral nature of new technologies represent another important motive behind collaborative behaviour (Hagedoorn, 1993a). As organisations are frequently engaged in multi-disciplinary fields it is often highly challenging (and in some cases even impossible) to achieve a sustainable high-level expertise in all crucial knowledge areas. Increased complexity and the inter-sectoral nature of new technologies and with scientific and technological knowledge being fragmented and scattered across many organisations, research-based institutions rarely have choices other than to build collaborative networks. As these organisations turn to collaborative research, researchers notice that such networks also tend to achieve greater results when alliance parties differ in their knowledge bases (Rosenkopf & Almeida, 2003).

Raymond (1997) further contributes to the explanation of the ever-rising popularity of collaboration in the academic community previously suggested by some researchers. Raymond suggests a framework (similar to the one offered by Hagedoorn (1993a)) in that global collaborative research systems become critical due to a number of global changes in the nature of scientific problems and nature of the environment. These include *recurring shared problems* with recognised importance (i.e. air pollution), *new classes of problems* – inherently international problems such as climate change, *new collaborative modes* (for example, new electronic communications systems), *deepening capacity* – with the scientific and technological capacities of the research community are diversifying across nations, and *role of multinationals,* which often seek international alliances especially with academic researchers. Raymond (1997) further identifies three more changes in the global environment for the support of collaborative research: *geopolitical shifts*, *rising international competition*, and *private sector growth*.

2.4.4.2 Competition by Collaboration

Competition through collaboration is also a new generation of R&D management for innovative businesses (Rogers, 1997). Historically, the most complex technological breakthroughs and innovations are the result of intensive in-house research and development. However, in the last three decades the increasing complexity and multi-disciplinarity of science and technology leave even some large organisations unable to internalise all necessary resources. As a result, there is a change in the innovative process from in-house research to networked research involving several independent research parties who possess the required know-how and other critical resources (Arora & Gambardella, 1990). Over the years, research collaboration was relatively rare and limited mainly to the private sector. While businesses are generally required to compete at all costs within their immediate field, these businesses are not always able to meet the increasing global demands without making use of a collaborative advantage. In some cases, organisations cannot win when others lose. In these cases, collaboration and cooperation would allow businesses to come to a win-win situation in order to gain certain competencies, which they otherwise would not have. In fact, even organisations with advanced technical competencies are often put in a position where they require external support (Numprasertchai & Igel, 2005). For example, some industries such as biotechnology rely largely on the research services provided by external players (importantly including academic community). Bougrain and Haudeville (2002) note that not only scientific disciplines are strongly intertwined, but also that developments in new research fields such as biotechnology are critically important to researchers in other fields (chemical or pharmaceutical industries). Similarly to the described field of biotechnology, in other knowledge-intensive areas there are analogous developments.

Researchers promoting the use of collaborative networks increasingly agree that an organisation's competence and its competitive position strongly depend on its ability to capture and absorb the tacit knowledge that is created throughout collaborative networks (Cohen & Levinthal, 1990). Bozeman and Corley (2004) argue that many collaborative paths are determined by a range of factors from inter-organisational structures and informal research networks, research alliances and collaborative arrangements for sharing certain limited scientific and technical tools and infrastructure. Such collaborative arrangements allow social actors to capture their partners' knowledge, or in some cases, they even allow the transfer of critical technologies. In other research settings, social actors with an acquired access to scarce knowledge or

critical know-how can significantly shorten product life cycle by reducing the period between invention and market introduction (Hagedoorn, 1993a).

Collaborative arrangements such as alliances and networks are increasingly seen as important sources of innovation. Some of these innovative networks can be organised within the organisation's supply chain. According to one study, companies in the business world can increase the number of innovative partnerships through sharing knowledge and expertise with their supply chain members (Nonaka & Takeuchi, 1995). Collaborative research within its supply chain can present organisations with an opportunity to work on the reduction and sharing of uncertainty in R&D with other chain members. This collaborative philosophy also means that organisations can improve their knowledge creation potential through increasing interaction among members (Numprasertchai & Igel, 2005). Other organisations form innovation networks directly with their suppliers, distributors and other partners; and via these collaborative arrangements they enable the flow of knowledge across their networks. Such organisations can achieve an even higher accumulation of knowledge through this very interaction with other organisations.

2.4.4.3 Additional Power through Collaborative Research

Another motive leading organisations to collaborative research lies in the additional powers that these organisations share as a network. In some diverse and fragmented industries, collaboration is seen as a means of achieving a greater support for policies within these industries. Vernon et al. (2005) suggest the tourism industry as an example of such industries. In theory, such collaborations are expected to ensure both a more democratic and inclusive set of processes when compared with regular processes of planning, management and government (Vernon et al., 2005). However, in the real world, such collaborative arrangements can be somewhat problematic and challenging when it comes to their effective organisations or even evaluation of the efficacy of their outcomes (Bramwell & Sharman, 1999; Vernon et al., 2005). While the above-discussed motives explain collaborative strategic behaviour within industry, it is important to examine how these motives explain engagement of individual researchers in collaborative research.

2.4.5 Individual Researcher Motives

While it is generally assumed that organisations make conscious, intentional decisions to form an inter-organisational relationship for explicitly defined reasons, there are still some theoretical models (such as ecological and random choice theoretical models) that suggest an organisation's motivation can also be irrelevant or even misdirected (Oliver, 1990). The earlier discussed contingencies explain why collaborative relationships occur at the organisational level. The same contingencies to some extent explain the motivation for the formation of collaborations at lower levels (for example, individuals) (Oliver, 1990). While many studies examine questions as to why research organisations become involved in inter-organisational networking, there is little research dealing with the same collaborative issues at the level of individual researchers. Yet in reality, individual researchers are behind many interorganisational collaborative arrangements. The following section of this thesis will examine which motives are behind individual researchers' decisions to engage in collaborative research projects.

2.4.5.1 Access to Key Resources

Within the understanding of the resource-based view and exchange theory, collaborating researchers can improve their research performance by gaining access to resources, skills, knowledge and capabilities. In practice, collaborative behaviour often allows scientific parties to benefit from joint use of specific or rare equipment or training facilities (Frenken et al., 2005; Katz & Martin, 1997). Most individual researchers are not self-sufficient in terms of research resources. Resources critical to sustaining research activities include access to equipment and other research infrastructure. However, one of the most basic and scarce resources in the field of research is research funding. In fact, most research activities depend on continuous funding to cover the cost of managing projects, cost of equipment and all project-related personnel costs, including travel and subsistence, etc. Researchers in most fields traditionally depend on their governments to fund their research activities. In a study of Canadian universities, Polster (2007) suggests that research grants are increasingly becoming an important source of income for academic researchers. In fact, the old academic rule 'publish or perish' is being displaced by another – 'provide or perish' (Polster, 2007, p.601).

Similarly to organisations, individual researchers tend to engage in external research activities to secure additional income or research funding. However, there is a trade-off between this perspective of achieving extra income through commercial arrangements and the inherent research objectives of working towards scientific achievements (Arvanitis et al., 2008). Furthermore, funding is available to a different extent in different research fields. Laudel (2005) argues that academic research fields, which are unable to offer research results applied to industrial innovation, can find it difficult or even impossible to be funded by either industry or many specialised agencies responsible for promotion of industrial innovation. Furthermore, most research activities are highly sensitive to changes in turbulent environments and even to economic recessions as these t often have an impact on the availability of public money (Sanz-Menéndez & Cruz-Castro, 2003). The ever-increasing competition for research funding results in external funding being used as a key performance measure. It is used in many countries across many levels: from performance-based assessments of universities to research and academic job interviews (Laudel, 2005). As a shortage of research funding can seriously hinder research activities and overall progress (Abu-Zidan & Rizk, 2005), one can argue that pragmatic researchers would consider research funding to be a key resource required to pursue a sustainable and active research agenda.

2.4.5.2 Access to Peers

Many researchers can perceive and utilise participation in collaborative projects as channels facilitating knowledge creation, transfer and sharing (Archibugi & Coco, 2004) or as a shortcut to the required skills allowing them to learn in the most efficient and timely manner (social exchange and social learning theories) (Ahuja, 2000; Bougrain & Haudeville, 2002; Calvert & Patel, 2002). Some theories, such as knowledge-based theory, view knowledge to be the most important resource (Aversi, Dosi, Fagiolo, Meacci & Olivetti, 1999; Devetag, 1999; Penrose, 1959). In fact, researchers are most likely to join their differences and similarities of knowledge and thinking through participation in collaborative projects (Stephan, 1996). Research networks in this case are stable as they strengthen creative and critical thinking through mutual sharing and exchange of information and knowledge (Engel, 1993). According to Waddell (1994a), among

other resources, collaborating researchers generally provide (and take) specialist knowledge, methodology, research facilities, additional manpower, as well as access to contacts.

Furthermore, active collaboration in the field of research can be a result of increasing specialisation with individual scientists specialising in narrow fields of expertise (Frenken et al., 2005). Similarly to research organisations, individual researchers resort to collaboration with peers in order to transfer or integrate some pieces of knowledge (Hennart, 1988). Research collaboration can be seen dominating in some applied sciences, where it is common to combine the individual theoretical and practical knowledge and skills to create new knowledge and skills (Adams, 2004; Gibbons et al., 1994). In cases where research peers view a problem differently, a collaborative project can allow the involved participants to view and understand these differences and to identify alternative ways out. Complex and vital problems are examples of problems where large-scale collaboration is critical (Skolnikoff, 2001). Research projects involving international researchers can promote new approaches to global or complex research issues. Generally, collaboration is not only a more constructive approach to problem-solving, but can often facilitate greater results through a more comprehensive analysis of the problem (Gray, 1989).

The role of collaborations as an important knowledge sharing and integration channel is also supported by the growing number of partnerships involving researchers from research institutions, private businesses, government bodies and academic centres (Archibugi & Coco, 2004). Over the years, cross-sector research collaboration was less common as research was often limited to the private sector. Lately, research collaborations involve participants from different sectors. In fact, some policies are specifically developed to improve working links between sectors (in particular, in the field of science and technology) (Katz & Hicks, 1997). Such cross-sectoral collaborations occur on different levels and across different sectors ranging from academia, civil society, government, industry, private sector, etc. In general, researchers resort to such collaboration (often in the form of sharing/linking and joint use of information, resources, activities, capabilities) to achieve results that researchers within one sector are unable to achieve without involvement of collaborators from other sectors (Bryson, 2006).

2.4.5.3 Knowledge Dissemination (from Learning to Legitimation and Advocacy)

Despite some variations in interests, personalities and ideas, highly heterogeneous research networks (international and cross-sectoral networks) can offer participants unprecedented opportunities and exposure to new thinking and ways of conducting research, as well as opportunities to learn and increase further peer recognition in the research field. An important benefit of participation in formal networking research projects can be linked to learning from peers with higher recognition. In line with centre-periphery theory developed by Wallerstein (1979), researchers from institutions (countries) lagging in a particular expertise or resources would be willing to engage in collaborative research with researchers from more leading institutions (countries). Such collaborative arrangements across institutions and boundaries can be seen as important learning processes crucial in the context of sustainable innovation (Bouty, 2000). Other researchers' experience can be an important resource in itself. According to social learning theory, in a collaborative environment, more experienced peers would serve as models of desired and successful performance and

productivity (Bandura, 1977). The behaviour of these experienced peers can be perceived or considered as models, and as a result, such behaviours can be learnt through modelling.

This development within a network can be important as participants can learn by observing the behaviour of their peers and the results of such behaviours. Under the European Neighbourhood Policy (ENP), the EU tries to foster links between researchers from a number of neighbouring countries[5], in case of EU Framework Programmes, such projects aim to involve scientists from these countries under conditions similar to those applicable to EU researchers. The vision is that these countries can be drawn into further integration through international cooperation but without necessarily becoming full members of the European Union. Some of the mechanisms under the Cooperation component of the FP7[6] allow (generally in some form of research funding) researchers from neighbouring countries to learn from the EU (often these are Western and Northern European countries) states through participation in collaborative research projects. Viewing learning opportunities within research networks as a resource in itself can explain to some extent the motives for such collaboration and suggests that participants can learn from peers in such research projects.

On the other hand, recognition in the field can also be achieved through the mentoring of other (generally younger) researchers working in the same field. It is well recognized that such mentoring is important in academic and research careers (Long & McGinnis, 1985). In fact, some research collaborations can aim primarily at the training of new researchers (students) and early stage researchers (Bozeman & Corley, 2004). Other collaborations intend to improve the productivity of individual researchers with some researchers collaborating not for their personal productivity but to provide additional training and opportunities to graduate students and postdoctoral researchers (Melin, 2000). In such collaborative projects, the early stage researchers or students are more likely to benefit in comparison with senior researchers whose performance in contrast can sometimes be impeded.

Public support of science is often justified by its benefits to society as it is expected to contribute to society's technological and economic improvements in all its aspects (Small et al., 2008). Research organisations participating in collaborative projects that are able to show tacit research outputs (such as patents that can be applied at national or international level) would be considered as those contributing to a country's standing. While research projects often generate large volumes of joint research publications in peer-reviewed international journals, books and prestigious conferences, researchers' capacity to have an impact on important policy issues (both national and international) is perceived as an important research outcome. In fact, some of the reasons for the recent growth of interest in networking could be due to certain levels of dissatisfaction among both public and academics as the marginalisation of many research projects, as well as researchers being denied degrees of power resulting in low impact of research on public policy and decision-making (van Zee & Engel, 2004). The majority of global scientific and technological collaborations come with important policy implications (Archibugi & Pietrobelli, 2003). By organising their new or even existing,

[5] The countries covered include all of the Mediterranean shores of Africa and Asia, as well as the European CIS states (with the exception of Russia and Kazakhstan) in the Caucasus and Eastern Europe. Russia insisted on the creation of the four EU-Russia Common Spaces instead of ENP participation.
[6] The Seventh Framework Programme for research and technological development (FP7) is the European Union's chief instrument for funding research over the period 2007 to 2013.

but often fragmented, knowledge and by developing new structures and methods research collaborators attempt to facilitate informed decision and policymaking at all levels.

The majority of global scientific and technological collaborations come with important policy implications (Archibugi & Pietrobelli, 2003). As a result, with many global issues such as global warming, energy or security research, researchers necessarily become involved in international politics as well as in decisions on the policy options and choices. This increase in the involvement of scientists in global collaborative projects can be at least partially explained by a new standard for international scientific collaboration represented by a growing number of international organisations which are often specifically concerned with science and technology-related questions (Skolnikoff, 2001). In the world of complex global problems, where the need to share practices and information together with other factors (such as the intentions of civil society actors to improve their performance as well as their involvement and influence on policy making) present well established reasons for supporting knowledge networking (van Zee & Engel, 2004). As suggested by Engel (1993), advocacy includes the activities that can improve the position of network participants in getting involved and in influencing public and development policy discussion. Relationships developed within such networks can then help solve other problems such as difficulties with regulation, as well as problems with opportunism and legitimisation (Coleman, 1988; Wiewel & Hunter, 1985). Social capital can serve as a policy resource, as social groups have a much higher power to influence policy and decision-making than any individual scientist has.

Existing literature provides examples of when networks were organised expressly to represent particular communities with aims such as to influence decision-making and public policy, as well as to provide dedicated forums for critical analyses and evaluation of new and existing practices and experiences (van Zee & Engel, 2004). Governmental funding of research still plays an important role, but even though the overall share of direct governmental funding is decreasing, governments in many EU Member States are increasingly using indirect policy measures to encourage higher business R&D expenditure (EC, 2005b). Such increases are often the result of new national public policies developed with the involvement of research groups. However, research impact in some fields has been decreasing even though scientists have a legitimate role in the policy process (Skolnikoff, 2001). Some community and scholarly actors increasingly feel excluded from meaningful participation in society and a lack of impact of their research on public policy (Creech & Willard, 2001). As a result, more and more researchers are building research networks to facilitate informed decision and policymaking at all levels through development of new structures and methods, by organising their new (or existing but often fragmented) knowledge.

2.4.6 Understanding Researcher Motivation

Often collaboration and networking are about learning together, understanding lessons and developing specific proposals, as well as pursuing advocacy (van Zee & Engel, 2004). The previous section of this thesis reviewed three major groups of motives behind the decision of researchers to participate in collaborative research projects. In line with the reviewed categories of collaborative motives, this research paper suggests focusing on three major sets of motives: *access to additional funding*, *meeting peers through cross-border networking* and *disseminating research results*. This research combines these motives into a research

motivation pyramid by applying the logic used by Maslow (1954) in developing the hierarchy of needs (see Figure 2-3).

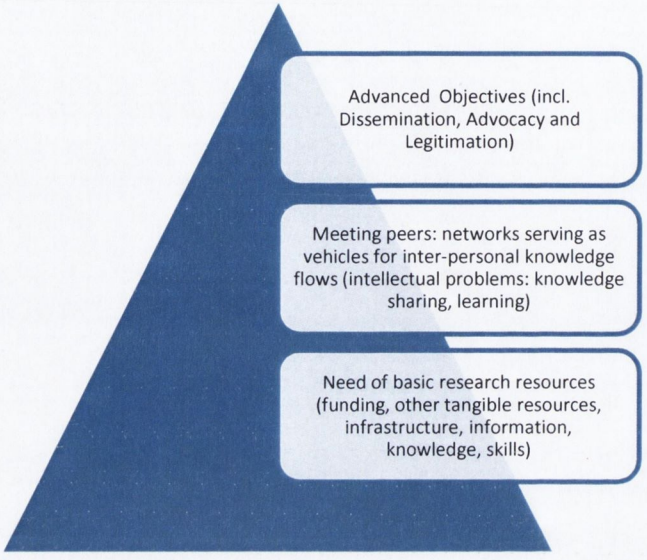

Figure 2-3: Pyramid of individual research motives

In the context of this study, this logic suggests that researchers go through several stages related to the research process. Firstly, researchers are motivated to satisfy their basic research needs of sufficient resources for conducting research (i.e. primarily research funding). Within the context of formal research networks, this means that individual researchers can view participation in funded collaborative research projects as an opportunity to gain access to additional research funding available to their personal research objectives. As discussed earlier, research funding can facilitate (sometimes already ongoing) research activities, or in some cases even enable them, otherwise researchers might be unable to pursue their research interests. Secondly, once the most basic needs of research resources are satisfied, scholars are concerned with the immediate research objectives of their activities, which require or can benefit from collaborative work (i.e. knowledge-sharing for solving complex problems). Sometimes, research activities end soon after the project. Not all projects foresee further dissemination of their research outcomes due to limited resources, time or lack of planning. Frequently it might not be seen as a priority. As a result, this thesis places motivation to achieve more complex applied research objectives (increased impact on policy-making, facilitation of learning and training of researchers, etc.) as the last (top) phase of research process related motives (needs).

Not surprisingly, individual researchers' motives behind their participation in collaborative scholarly activities are close to the motives behind interorganisational research collaboration. Motives are broad statements of why collaborative research interests potential collaborators, and as such, these motives can be rather unclear. Some of the discussed motives determining inter-organisational collaboration confirm the significance of external environmental constraints and institutions. However, individual researchers' choices are often determined by the individuals themselves (Bozeman & Corley, 2004). While project participants in EU-funded research projects formally represent their home institutions in the projects, in reality, individual members in organisations frequently seek to maximise their personal aims (Cyert & March, 1963). In fact, many formal collaborative research projects (such as COST Actions) develop from existing research networks of original proposal convenors. Van Rijnsoever, Hessels et al. (2008) further argue that the reasons

behind collaborative behaviour in research very often relate to the individual researcher's personal resource stock. While certain motives can be behind researcher's collaborative behaviour, these may not be the actual outcomes of collaborative research activities. The following section of this thesis will further examine which collaborative research outputs and outcomes are generally expected in the context of formal collaborative research.

2.5 Researcher Productivity, Outcomes and Outputs

Collaborative outcomes generally associated with research projects can be utilised to evaluate collaborators' research productivity. The term *productivity* generally refers to metrics and measures of outputs from different production processes. Collaborative processes are generally expected to improve the process of knowledge production (Adams, Black, Clemmons & Stephan, 2005; Katz & Martin, 1997). With the general assumption that scientific networking processes are good for scientists it is still unclear if participation in formal research networking programmes in fact improves the productivity of the participants.

Furthermore, the actual relationship between research networking and productivity is not evident (Lee & Bozeman, 2005). Some argue that certain forms of research collaboration can even have a negative impact on the level of outputs (Landry, Traore & Godin, 1996). One reason behind this is that research collaborations unavoidably take up additional time and the resources of participating collaborators (Landry & Nabil, 1998). This additional burden does not necessarily ensure the success of the collaborative project. In addition, not all collaborative arrangements will meet original expectations and objectives. Yet another potential problem for international research networks lies in the heterogeneity of their participants as has been already discussed in an earlier section of this review. Generally, a good place to start identifying research gaps is through a review of earlier research literature. In case of formal research networking, this does not seem to be as straightforward mainly due to a limited number of studies on these issues within this particular field.

2.5.1 Impact and Outcomes of Funded Collaborative Research

Despite the identified increase in academic enquiry into the issues linked to research collaboration, only a few studies focus on the productivity of research collaboration at the individual researcher level. These studies tend to focus on the impact of general research funding on collaborative outcomes or the impact of collaboration with other researchers on the research performance and their scholar productivity (Arora & Gambardella, 1996; Conn, Porter, McDaniel, Rantz & Maas, 2005; Defazio, Lockett & Wright, 2009; Durden & Perri, 1995; Godin, 2003; Gonzalez-Brambila & Veloso, 2007; Lee & Bozeman, 2005; Rigby & Edler, 2005; Shelton, 2008). Many of these studies examine the impact within the context of general research collaboration, rather than in the context of formal research networking. Other authors focus on the importance of industrial funding to researchers in terms of their research performance (Bozeman & Gaughan, 2007; Klenk, Hickey & MacLellan, 2010). An examination of the impact of research environment on the productivity of the academic faculty is provided by Conn et al. (2005). Conn et al. (2005) follow a transformational development which brought an academic unit from a low research productivity level to a greater productivity. General findings from the study also suggest that certain research environments and

infrastructures can significantly improve one's research standing. It is further argued that among other factors it's the newly formed peer support that allows the development of new research cultures (Conn et al., 2005).

In a recent analysis of collaborations between US universities funded by the US National Science Foundation, Cummings and Kiesler (2007) examine the impact of collaborative research on the productivity of participants. The authors explore the coordination activities and project outcomes of 491 such research collaborations in terms of division of responsibilities, knowledge transfer and predicted project outcomes such as production of new knowledge or training of researchers. By applying the knowledge-based view of the firm, Cummings and Kiesler (2007) extend it based on the geographical dimension of collaborations. Findings from the study suggest that a larger number of participants in a collaborative project would mean fewer coordination activities, which results in fewer research outcomes. In fact, the researchers link the coordination activities within a collaborative project (especially division of responsibility for tasks and knowledge transfer among investigators) with the research productivity as measured by short term outcomes (Cummings & Kiesler, 2007). However, Cummings and Kiesler (2007) examine only the outputs directly related to participation in collaborative projects but not any other opportunities, which could have been opened up through this participation. Cummings and Kiesler (2007) also specifically focus on inter-university collaboration and therefore only analyse the outcomes at the institutional level.

A different view on researcher productivity in collaborative research is offered by Landry, Traore & Godin in their 1996 paper. The findings from their article closely relate to the questions of the impact of collaborative research on *academic productivity*. In fact, according to the authors, research collaboration (both cross-sectional and intra-sectoral) can indeed improve or facilitate researcher productivity (Landry et al., 1996). The data suggests that the biggest impact on researcher performance is in the case of collaborations with industry, rather than with peers or other academic institutions. Interestingly, productivity also varies according to the collaborators' geographical closeness and their research discipline (Landry et al., 1996). While these findings do suggest that research collaboration may increase productivity, they do not confirm if this impact holds true for a non-academic environment (such as industry or a governmental institute). Landry et al. (1996) came to two important conclusions. Firstly, academic researchers are generally motivated by operational reasons rather than strategic or organisational. Secondly, collaborative research can and should be encouraged by university administrators and public decision makers by providing researchers with financial resources or other forms of incentives (Landry et al., 1996).

A number of studies examine the relationship between levels of funding and researcher productivity (mostly employing bibliometric analysis). One such study is Godin's (2003) paper, which investigates whether there are relationships between levels of NSERC[7] funding[8] and researcher productivity measured by a number of applications. One assumption is that all research papers from funded researchers are attributed to grants when in fact some scholars receive funding from several sources. Godin (2003) further finds that the volume of research papers grows with the level of funding, at least in the case of those researchers who are in receipt of higher levels of funding. Another interesting observation is that high-calibre researchers (as measured by the volume of papers) tend to be the ones who apply for university-industry funding (Godin, 2003). However,

[7] NSERC stands for the Natural Sciences and Engineering Research Council of Canada;
[8] NSERC administers a program of grants (Discovery Grants Programme) which fund Canadian researchers and their general research activities rather than any specific individual research projects (Godin 2003);

younger researchers' productivity increases steadily as soon as they obtain research funding and over time tends to compare favourably with that of more established researchers (Godin, 2003). In addition, the productivity of researchers whose grant applications have been rejected tends to stagnate subsequently. In agreement with Godin (2003), the literature offers additional evidence of a relationship between researchers' performance and the availability (or size) of research funding (Lee & Bozeman, 2005). Furthermore, this relationship is influenced by the researcher's professional experience (research stage) (Arora & Gambardella, 1996; Godin, 2003).

The identified results strongly relate research productivity to researchers' status or academic field. In line with the Matthew effect, there is a suggested link between productivity levels early in a career and later levels of productivity (Merton, 1968). Bonzi (1992) notes that the research productivity of full professors increases to a greater extent than that of assistant or associate professors. Among other findings, Bonzi (1992) mentions that an increase in productivity for males is lower than that of females. In addition, different research fields display differences in productivity improvements over time. Certain research fields tend to display a greater improvement in research productivity than other scientific domains (Bonzi, 1992). Porac and et al. (2004) argue that individual outputs (productivity) of collaborative projects positively relate to the *duration* of these projects. Researchers' productivity especially increases in most collaborative networks but the increase is generally higher for more heterogeneous networks (Porac et al., 2004). A research study conducted by Bonzi (1992) points out some trends in scientific productivity over time.

A work by Lee and Bozeman (2003) is based around modelling grants as a mediating factor between collaboration and researcher productivity. The study established that there is a relationship between research funding (i.e. grants), collaboration and individual research productivity. Lee and Bozeman (2003) further identify a relationship between funding and collaboration as well as between funding and productivity. However, the study by Lee and Bozeman (2003) does not examine the relationship between funded collaboration and research productivity. Other researchers suggest that the impact of collaboration can be further augmented through an increase in collaborative funding for team projects (Adams et al., 2005; Katz & Martin, 1997). However, while in some cases funding can also decrease a team's research performance, such collaborations on the other hand can be impossible without funding (Arora, David & Gambardella, 1998). Overall, Arora et al. (1998) point out that a funding opportunity does represent a strong motive for collaboration even if it does not ensure an increased impact (Defazio et al., 2009).

Another discussion examines the balance between the size and scale of such collaborative projects. Firstly, a greater number of collaborating researchers in a network can improve participants' individual chances to access specific and scarce knowledge sources (Defazio et al., 2009). Secondly, large networks can suffer from the crippling procedures and impeding complexity of processes involved in both knowledge creation and sharing (Defazio et al., 2009). In addition, existing research empirically confirms a correlation between the number of research collaborations and the levels of individual researcher performance. The higher the number of collaborative projects a researcher is involved in, the greater their productivity (Pravdic & Oluic-Vukovic, 1986).

In a related research study, Defazio, Lockett and Wright (2009) examine the relationships between collaborative incentives and researcher productivity in the context of EU FP[9] funded research networks. The findings from this study indicate that the presence of research funding has indeed an influence on collaborative behaviour. By looking at 294 researchers across 39 EU research networks over a 15 year period, Defazio et al. (2009) found that while generally there is a positive relationship between the impact of funding and researcher productivity, the overall impact of such collaboration within the funded networks is less significant. However, when the authors distinguish between the pre-, during- and post-funding periods they identified important differences. Firstly, collaboration during the funding period does not result in an increase of research productivity. However, in the post-funding stage, the impact of collaboration on productivity is both positive and significant. An important conclusion drawn is that while collaborations (formed specifically for exploiting funding opportunities) are not effective at improving researcher productivity in short-term, they have a good chance in promoting effective collaborations in the long-term.

However, there are specific differences between research funding and research networking funding. Historically, researchers rely on government funding to support their research (Bozeman & Gaughan, 2007). While research funding generally covers either particular research projects (generally multi-organisational or multi-participant) or individual research activities, there is a new form of funding that covers a particular form of collaboration – research networking. While Defazio et al. (2009) investigate funded research networks, the findings of their study are limited to scholars who receive full research funding. There is an important difference between research collaborations reviewed by Defazio et al. (2009) and formal networking research (FNR) funded projects (such as COST Actions) which are the focus of this thesis. The researchers in networks reviewed by Defazio et al. (2009) are availing of *general* research funding[10], while those participating in collaborative Actions funded by COST do not receive any funding for conducting research, as they only receive funds for facilitating research networking (meetings, exchanges, training schools and etc.). Therefore, while existing literature suggests a link between funding and researcher productivity, there is little evidence to support the existence of the same link in the case of formal research networking programmes and researcher productivity.

2.5.2 Outputs and Outcomes of Research Collaboration

Formal networking in research (FNR) is a relatively under-explored phenomenon. With this phenomenon going large-scale, a more comprehensive approach for assessing its influence and impacts is required. While other forms of collaborative research have been studied at least to some extent, a particular form of it - formal networking in research - is still a relatively new area for research. Not surprisingly, the attempts to assess and evaluate formal networking research (both as a process and a result) are perceived as challenging due to both their newness and a general lack of confirmed indicators (Charles & McNulty, 1999). There is a general expectation that collaborative research should normally generate higher value than research carried out by individual researchers. This assumption suggests that through collaborative work researchers achieve greater

[9] EU FP – European Union Research and Technological Development Framework Programmes

[10] In the research projects reviewed by Defazio et al. (2009), funding support covers the costs of the project (the cost of managing the project, the cost of equipment, and all project-related personnel costs, including their travel and subsistence. Other research networks were in receipt of a grant up to 100% of the cost for hiring early stage researchers, for organising conferences and meetings that involve the other partners of the network (Defazio, 2009).

quality when compared with their individual work. Furthermore, Rigby and Edler (2005) suggest that the differentiation related to the extent of collaboration within research teams determines the research results and achievements. Clearly, collaboration on its own is not a panacea for research management problems. Some academics study research collaboration as an end in itself, others view collaboration as a means to an end (Koontz & Thomas, 2006). An important question regarding research collaborative activities remains unanswered and often unasked: *what are the outputs and outcomes associated with the research collaboration and research networking in particular?* The following section will examine the outcomes and outputs that are generally achieved by participants through their involvement in collaborative projects, and which can be further analysed in the context of FNR projects.

2.5.3 Need for Improved Performance Measure(s)

Organisations and individual researchers decide on forms and models of collaboration based on the possibilities they offer. This flexibility gives them a degree of freedom to choose models from alliances to joint projects and ventures, as well as allowing them to respond quickly to changes in the research field, market or industry conditions. Even with a wide variety of available collaborative forms, most of them are structured around exchange of knowledge and information among the collaborators (Butcher & Jeffrey, 2005). However, the actual outcomes, impact and effectiveness of such knowledge and information exchanges are still perceived as difficult to evaluate and measure (Polt, Rammer, Schartinger, Gassler & Schibany, 2001).

This section further examines pertinent evaluation literature with a particular objective to identify a range of metrics applicable to assessments of collaborative performance on both macro (network or organisation) and micro (individual researcher) levels. The literature review suggests that there is a significant amount of existing research dealing with different aspects of how and why individuals and organisations collaborate. Pertinent literature also questions which outputs and outcomes can be attributed to collaboration, and the connection between these collaborative results and the collaborative process (Koontz & Thomas, 2006). In spite of the increased academic interest in collaborative management, there is very little information about the impact of collaboration on the environment or the impact on participants themselves (Koontz & Thomas, 2006). While a sole assessment of a project based on its outcomes is certainly a possibility and has been explored at least to some extent, it is still vague as to the impact participation in collaborative research projects has on individual researchers involved in these projects. What do participants achieve through their participation in FNR projects? Should future assessments be based on the outputs, outcomes or possibly a combination of these?

Related studies on collaboration (especially collaborative arrangements involving interaction with industrial science) confirm the importance of collaboration in generating scientific and technological outputs, and suggest that such collaboration is capable of providing both individuals and organisations with benefits outweighing its costs (Katz & Hicks, 1997; Oliver, 2004; Rigby & Edler, 2005). Therefore, this analysis starts with an assumption that most research collaborations enable an improvement in creativity through opinion exchange and constructive dialogue such as different forms of peer-reviewing. This is often one of the reasons why researchers collaborate (van Zee & Engel, 2004). The peer-review process is intrinsic to

research collaborations. It can be found throughout research collaborations as opposed to being placed only at one single point in time (Beaver, 2004; Rigby & Edler, 2005). The relation between research collaborations and outputs (including their nature, scale and quality) has also received some attention from researchers.

The general understanding shared by some of these scholars has been that joint publications are a result of collaborative research and that such joint publishing is in itself a result of collaborative work (Katz & Martin, 1997; Rigby & Edler, 2005). Based on this understanding, many assessment studies generally build performance assessments of collaborative research projects around a number of tangible outputs such as publications and, less frequently, applied outputs such as patents. Some scholars in the field of research policy still maintain a strong assumption that joint publications are the best indicator of research collaboration, however there is now a growing realisation that the phenomenon of research collaboration has only been studied on the macro level, and rarely on the micro level (Rigby & Edler, 2005). Reviewed literature shows that while publications and patents certainly are popular measures of research performance, these are often insufficient alone. Often these outputs can be applicable only in particular research domains, so in other scientific fields, for example in the humanities, one would rarely expect to develop an industrial application. In fact, many formal collaborative research programmes are often officially labelled as pre-competitive as in reality they are far from near-market research (Chen, 1997).

Some studies on performance measurement of collaborative activities focus on different aspects related to information generation and dissemination. Research collaborations are generally based on the flow of information between collaborating partners. In a specific case in the field of technology transfer, it also refers to either *patents*, *technology licensing* or even the formation of *academic start-ups* (Philbin, 2008). Other commonly observed benefits derivable from collaboration are joint learning, consensus and the accommodation of mutual requirements, field orientation and importantly, improvements in networking skills together with improvements in scientific and technological skills. Many research collaborations can result not only in joint publications, but in a large variety of other research outputs from proprietary benefits, new instrumentation, methodologies to *prototypes*, *patents*, *IPRs*, and *start-ups*, as well as technological innovation, continued support of research programmes, student exchanges and projects, and graduate student recruitment (Barnes, Pashby & Gibbons, 2002). Another indicator of collaborative performance would be the level of *commitment* expressed by industrial partners. In fact, intention to renew membership is a classical measure of participants' satisfaction with the outputs and outcomes of the project and has been previously used in a number of studies (Koontz & Thomas, 2006). In addition, there are other outcomes such as policy implications, legitimation of the individual's activities or even the enhancement of their research profile. The discussion of these outcomes suggests their high importance to the process of research collaboration.

Even with this variety of outputs and outcomes, it is challenging to select and use one single measure to assess the entire range of research collaborations (Butcher & Jeffrey, 2005; Calvert & Patel, 2002). It is proposed to maintain a distinction between collaborative outputs and outcomes. However, developing a universal numerical measure of collaboration has proved to be complex (Philbin, 2008). The review of existing literature has identified a need for strong performance related data in order to carry out evaluation of research collaborations on a new level (Philbin, 2008). This need for basic performance data, which would include both tangible research outputs along with some other project performance measures, is shared by

both academic and non-academic collaborators. In fact, what is often missing is some holistic assessment of research collaborations and their impact (Philbin, 2008). Improved performance measures are becoming especially important due to the ever increasing accountability of research organisations to their funding sources and other stakeholders (Papenhausen & Einstein, 2006). The use of balanced scorecards can potentially address this need for metrics when assessing the performance of research collaboration (Philbin, 2008).

Research carried out by Koontz and Thomas (2006) further stresses the need for tangible and intangible measures in performance management as this can help identifying enhancements in knowledge and social development. During the interviews carried out by Koontz and Thomas (2006), participants were asked to discuss any additional measures which could assist in improving existing collaborations. Many participants (including academics and managers) expressed a strong interest in measures and indicators including quantifiable parameters of less tangible aspects of collaboration such as social networking between collaborators, improvement in tacit knowledge or customer satisfaction. Koontz and Thomas (2006) conclude that due to their very nature these intangibles are mostly difficult to measure and therefore they present a performance measurement challenge. The following sections continue reviewing pertinent literature in a further attempt to explore outputs and outcomes resulting from collaborative research projects.

2.5.4 'Publish or Perish'

Cummings and Kiesler (2004) use a number of possible project outcomes such as the creation of new fields or areas of research, achieving new grants or spinoff projects, newly developed methodologies, recognition with award for contribution to field, creation of new software or hardware, generation of new data, submission of new patent applications. However, often component indicators used in official evaluation reports for composite indicators of performance in knowledge-based economies included among others number of patents per capita as well as the number scientific publications per capita (both used as indicators of S&T performance) (EC, 2005b).

In recent years, the use of publications (generally such as joint publications in journals or books) as a measure of scientific quality and research productivity has become increasingly popular. First of all, publications are often the output of changing processes of knowledge production with changing patterns of communication and collaboration (Heimeriks et al., 2003). Publications are also some of the most frequently occurring research outputs from collaborative projects (Barabasi et al., 2002). Active publishing seems to have an impact on both the ranking of individual researchers and that of particular research institutions. In many cases, comparative analysis of the research performance of universities (or individuals) and non-academic organisations is carried out using publication activity and citation impact to solve the problem of differentiating their research profiles (Thijs & Glänzel, 2008).

Many collaborative research arrangements comprise solely of academic players. Yet, there are other forms of collaboration such as the ones involving representation of other parties such as governmental institutions and commercial enterprises. Often, it is the increased funding provided by the government that facilitates increased popularity of interdisciplinary collaborative research involving both academic and industrial

researchers (Rigby & Edler, 2005). While collaborations involving governmental organisations are rare, other forms of collaborative research involving industry and other firms are more frequent. Ponds et al. (2007) suggest that often these (non-academic) types of research collaboration do not lead to any joint publications.

Practitioners involved in joint research projects, like academics, publish their results in scientific journals (Charles & McNulty, 1999). Some analysts have attempted to answer the question why firms publish their results (at least some of them) in scientific journals. It seems that investment in scientific research is frequently justified by the organisation's absorption capacity as by conducting research firms are better able to benefit from research undertaken outside the firm (Cohen & Levinthal, 1990). However, these arguments can explain to some extent why firms engage in scientific research but not why they opt to publish in scientific journals (Charles & McNulty, 1999). The involvement of non-academic organisations in academic circles (i.e. through active publishing) can prevent these organisations from being excluded from some highly specialised knowledge networks (Rosenberg, 1990 in Charles and McNulty 1999). Internal knowledge production brings new knowledge and further brings organisations to a level where they can learn from external parties (Cohen & Levinthal, 1990). This internal capability to create knowledge and external collaboration in order to acquire external knowledge should be seen as complementary to each other (Cohen & Levinthal, 1990). A possible answer can be found in the ways firms realise their profits through production and publication of scientific knowledge. An early lead in the field can help the firm to achieve a unique position (Rosenberg 1990; Pavitt 1984 in Charles and McNulty 1999). Through collaborative research involving academic institutions, firms can gain access to critical research infrastructures in addition to some highly specialised human resources (Charles & McNulty, 1999). Through such collaborative participation, organisations obtain opportunities to access complementary external knowledge and other resources since collaboration with external partners provides the firm with access to knowledge it could not produce internally (Lundvall, 1992; Ponds et al., 2007). This is often the case in knowledge-intensive industries or industries where knowledge of several research fields is required. Therefore, a single firm would find it challenging or even impossible to keep up with the latest developments in all related fields. In such complex environments learning from external sources often can only be ensured though active involvement in the work of research centres and other institutions. Once an organisation is a member of such a network, it would secure its own position in the field through publications of scientific research carried out in this research community (Cockburn & Henderson, 1998). Ponds et al. (2007) note that for a firm participating in a collaboration with universities or governmental research groups, there is no other way around it. Interestingly, according to another study in France, joint publications are the most frequently reported outputs of research collaboration between French academic institutions and private firms (Goddard & Isabelle, 2006).

Publications are frequently seen as an important part of the three communication systems (the systems of co-production, collaboration, and dissemination of knowledge) in three dimensions (actors, network, content) as proposed by collaboration (Heimeriks et al., 2003). From the perspective of actor-network theory (Tatnall & Gliding, 1999), a knowledge network consists of interconnected heterogeneous knowledge actors. From a social perspective, these individual actors can be viewed as members who create and maintain relationship links among themselves as a result of joint interaction and collaboration. Physical and virtual forms of these collaborative transactions can be observed (Amritesh & Sarkar, 2008). With the development of new technologies allowing distribution and dissemination of information and knowledge, the opportunities for

development knowledge-based networks, knowledge dissemination further improves the productivity of research work (Amritesh & Sarkar, 2008).

From the network perspective of knowledge transfer, there are two models of knowledge management. These models are known as the cognitive model and the community network model (Scarbrough & Hislop, 1999). The cognitive model is built around the information and knowledge located inside people's heads and how this information is identified and captured with the use of external tools such as IT tools. Two considerations of particular importance within the context of the cognitive model are ensuring general continuity and the preservation of delicate individual knowledge. This community approach promotes knowledge sharing through active networking both within and between different groups (Amritesh & Sarkar, 2008). On the other hand, the community network model gives more weight to the role of collaboration and trust in these active networking processes. In comparison, the cognitive model places additional importance on the external tools used during the process of knowledge sharing (Amritesh & Sarkar, 2008).

For many social actors, dissemination of knowledge is an important part of the R&D function together with knowledge creation and exchange (Allen et al., 2007). Research suggests that both the design and facilitation of the learning process together with sharing lessons learnt require systematic attention from the networks involved (van Zee & Engel, 2004). Participating actors should provide some support to facilitate the exchange of ideas and knowledge with the active involvement of other stakeholders. Network members can further ensure promotion of the use of alliances through validation and dissemination of their experiences and lessons learnt. Another key to success can be linked to the monitoring of the results of public policies through the development of strategic alliances with other stakeholders and parties (van Zee & Engel, 2004). The use of bibliometric data can be used as an indicator of links between industries and academy (Katz & Martin, 1997), with some researchers using bibliometric indicators to measure research collaborations (Herbertz & Müller-Hill, 1995; Marshakova-Shaikevich, 2006; Thijs & Glänzel, 2008). Other researchers use bibliometric data to analyse cross-sectoral and cross-disciplinary relationships or even collaborative patterns displayed by researchers or research organisations (Butcher & Jeffrey, 2005; Rigby & Edler, 2005). Yet, even with the growing acceptance and use of publications as an indicator of collaboration, it is not clear whether there is a relationship between the researcher's involvement in collaborative research and research quality of publications.

The study of the effect of collaboration on scientific quality (with an assumption that joint publications present the best indicators of collaborative performance) has been carried out by Rigby and Edler (2005). In particular, their study examines the relationship between the processes involved in collaboration and the variability of the quality of papers produced (Rigby & Edler, 2005). According to other researchers, the publications resulting from such collaborative research (particularly in the case of international collaboration) are considered to be of a greater quality and to provide somewhat greater value to the research field (Mandell, 1999a; Rigby & Edler, 2005; Valderrama-Zurián, González-Alcaide, Valderrama-Zurián, Aleixandre-Benavent & Miguel-Dasit, 2007). With the growing body of research carried out on collaboration, the view that it is always good has been questioned a number of times. It has been noted that interdisciplinary research while being inherently collaborative does not necessarily produce research of higher quality when compared to research outputs from non-interdisciplinary research collaborations (Rigby

& Edler, 2005). In fact, Rigby and Edler (2005) suggest that there is evidence showing that collaboration does not necessarily result in greater impact and that high-citation impact papers often are not the result of collaborative efforts.

The impact of other external factors (such as funding) on the output of publications has also been examined (Adams & Griliches, 1996). Formal statistical techniques were applied to estimate scientific outputs such as publications from research investments and human resources based on the production techniques used by economists (Adams & Griliches, 1996). The results suggest that research investments have a greater impact (in terms of produced publications) rather than the number of researchers involved. In addition, research shows that government investments are much more important than industrial investments (Shelton, 2008). Even though the use of bibliometrics for evaluating collaboration is somewhat widely accepted, there are certainly some disadvantages in using this approach. Butcher and Jeffrey (2005) identified in the existing literature different situations which suggest that bibliometric indicators can never be more than a partial indicator of research collaboration performance. On the one hand, many collaborations do not necessarily result in a publication and so these collaborations would therefore not be detected by bibliometric indicators (Katz & Martin, 1997). On the other hand, it is possible that there are joint publications that did not involve adequate research collaboration. Bibliometric data also does not provide research with any information on the type of relationship between the authors, nor can it tell much about the factors which influence the collaborative process, nor even how the researchers communicated information, etc. (Butcher & Jeffrey, 2005; Katz & Martin, 1997; Qin, Lancaster & Allen, 1997). As a result, one has to combine bibliometric measures with other quantitative and qualitative indicators when evaluating research collaborations.

2.5.5 Applied Research Results

As discussed earlier, scientific and technological collaborative arrangements and agreements turn into a crucial channel for transferring knowledge internationally. However, some researchers believe these knowledge flows are mostly invisible and leave no traces by which they can be measured (Krugman, 1991, p. 53), while others report that some knowledge flows can be measured with the tracking of patents (Jaffe, Henderson & Trajtenberg, 1993; Maggioni & Uberti, 2006). Patents, together with publications, are among some of the most often used indicators in official evaluation reports for composite indicators of performance (EC, 2005b). They present important key information that should not be taken lightly. However, due to the differences between scientific publications and patents the results from purely patent studies may not bear the same meaning to the evaluators as scientific publications. Historically, patents represent a system of social institutions protecting intellectual property over technology. The very existence of such institutions became a reason for publicising research knowledge (Forero, 1999). While the owner of the patent can collect business-related rents from the patents, others can also build on this knowledge. Patents and IPRs can be used in a number of ways: one is to prevent everyone else from accessing this knowledge, another way is to prevent potential competitors from directly obtaining rents from it (Forero, 1999). On the downside, this prevents researchers from using large portions of already existing social knowledge as input for their research work. Some patent owners may choose to keep their knowledge secret from wider society. However, having several different intellectual property rights can lead to '*the paradox that weakening a property right may be in the benefit of society, because it drives agents towards the use of another property right (a patent) that*

forces disclosure and the ensuing positive externalities for knowledge production by others' (Forero, 1999, p.4).

Related research generally supports the view that participation in scientific networks can lead to effective innovations and such interaction with the scientific community can be crucial for one's ability to incubate and commercialise new ideas (MIT, 2002). Economies of scale and rationalised innovation process are among some of the other reasons for such R&D networking (Miotti & Sachwald, 2003). As research collaborations often involve a range of non-academic participants, it should be noted that for all participants to achieve mutual benefit they must ensure an appropriate balance between academic objectives and non-academic (industrial or business) priorities (Barnes et al., 2002). In particular, it is crucial to consider proprietary benefits, which is at least ensuring benefits proportionate to investment, as well as planning for the achievement of tangible outputs during the early stages of the project (Barnes et al., 2002). Furthermore, it requires effective management of research collaborations, including work on maintaining the interests and commitments of different categories of participants (academy, industry, government, etc.).

Across economic sectors, many industry-academy collaborations are of a research nature and mainly involve applied firm-specific research with industry providing funding in exchange for intellectual contribution from academic counterparts to the project (Butcher & Jeffrey, 2005). Barnes et al. (2002) report a case that contains examples of frustration expressed by the industrial participants who perceived as slow the progress within a project. In fact, these participants frequently perceived their academic counterparts as not concentrating enough on tangible outputs. Some industrial participants often equate tangible outputs with actual progress, where tangible outputs are seen as a means of increasing motivation (Barnes et al., 2002; Dawson, 1997). The need to justify their own and their partners' investment of resources and time in the project (through an early confirmation of project's value) often leads to much disappointment expressed by the industrial participants. This dissatisfaction also implies the importance of planning for tangible outputs at an early stage of the collaborative project as a possible measure of maintaining the interest of non-academic partners (Barnes et al., 2002).

Business and industrial partners are generally interested in opportunities to commercialise newly created knowledge. In fact, the important question is how to commercialise the science. According to Murray (2002), the scientists establish new spinoffs to take their patented ideas to the next step – commercialisation. This is a universal phenomenon, although there is a relationship between the likeliness of inventions being patented based on the geographical location. Related statistical data suggests that up to 94 percent of all patents in 2000 were registered in advanced western countries (Archibugi & Pietrobelli, 2003). However, with the increased popularity of collaborative arrangements there is a growth in the number of patents registered elsewhere too. A patent study carried out by Breschi (2000) shows that the geographical concentration of innovative activities across the European Union is highly dependent on the sector.

Recent data on science and technology in the EU confirms that the S&T knowledge bases are highly diversified in the EU (EC, 2005b). It also suggests that the S&T outputs (when measured by scientific publications and patents) are significantly more diversified in the EU than in the US or Japan both in terms of scientific disciplines and industrial fields (EC, 2005b). Yet, scientific research does not produce applied

outcomes to the same extent as solely industrial R&D does, and it would range across scientific disciplines (Frenken, 2002). While the majority of patent applications are still submitted by businesses, there is a new trend involving academic institutions. In 1980, universities in the US were given the right[11] to patent inventions (funded by the government). This newly acquired right resulted in a significant increase in patents and, in particular, in licensing of university patents (Adams, Chiang & Starkey, 2001).

Another study attempted to measure the intrinsic relational structure of knowledge flows through variable, which among other components includes co-patent applications as an indicator of marketable innovations (Maggioni & Uberti, 2006). Furthermore, by examining R&D in the field of biotechnology, existing research suggests that research collaborations involving both industry and universities tend to yield a higher ratio of patents to R&D than internal R&D efforts (2001). Research provides many examples of the use of patents in the evaluation and assessment field (Arvanitis et al., 2008; Jaffe et al., 1993; Markman, Gianiodis, Phan & Balkin, 2005; Rycroft, 2003; Tijssen & Korevaar, 1997; Weck & Blomqvist, 2008). Patent-related statistics are now generally accepted and are often used as an important indicator of technological capability. However, in another study Coombs and Bierly (2006) examined the effectiveness of some technological measures using patent citations, and came to a conclusion that the total number of patents is not usually a valid measure of technological capability. Previous research based on patent analysis suggests that in case of firms, the usefulness of research and development collaborations tends to increase when firms differ significantly in their knowledge bases (Frenken et al., 2005).

Arora and Gambardella (1990) argue that while patents can be considered a valid measure of codified knowledge, they do not necessarily capture all the dimensions of internal knowledge (mainly due to elements of non-codified knowledge). This is addressed by Murray (2002) proposes a new methodological approach, which uses a patent-paper pair rather than using patents and publication as separate indicators. The pair transcribes the same idea but within different texts as a 'paper describes experimental results, while a patent defines utility and makes claims on inventiveness' (Murray, 2002, p.1392). Patents and publications only reflect the formalised component of scientific and technological knowledge and formalised knowledge-generating institutions do not necessarily represent the only existing component of technological change. Archibugi and Pietrobelli (2003) suggest that the making of national S&T capabilities needs the ability to learn or maybe even imitate the knowledge created in other countries. Recent numbers of applications for international patents show a significant increase in international exploitation of nationally created knowledge (Edler & Boekholt, 2001).

An earlier discussion shows that similarly to patents, scientific publications are frequently used to measure the outputs of scientific and technological capability. However, both published papers and patents often occur at different research stages of a project (Coombs & Bierly, 2006). Publications are a measure of basic forms of research. At the same time, patents measure outputs of later stages of collaboration and therefore are more useful as indicators for evaluating collaborative processes resulting in development of new products or more efficient processes (Narin, Noma & Perry, 1987). Some believe that the best output measure of scientific and technological capability would be the number of new products and improved processes (Coombs & Bierly, 2006). However, this measure is somewhat difficult to implement as it is not always easy to differentiate

[11] *The Bayh-Dole Act of 1980*

truly new products from other changed products and the information about the new products may not be openly available because of the certain degree of secrecy surrounding many production processes (Coombs & Bierly, 2006). In other cases, research results can be utilised to some extent, yet they never become full patents or industrial applications. Different research results are often utilised at different project stages. Furthermore, not all S&T research activities lead to patents, as some projects lead to results in forms such as industrial applications. Other instances of utilisation of R&D results (including industrial application of some form) can also serve as a measure of basic forms of research as they measure outputs at the earlier stages of S&T collaboration. As a result, it is possible to suggest that these outputs (different forms of utilization of results at some level and industrial applications) can complement the use of patents as indicators for evaluating R&D processes resulting in development of new products or even improved processes.

2.5.6 Legitimation and Policy Impact

Sharing a common vision is critical for the success of many heterogeneous research projects. While it is important for collaborative partners to be clear about mutual goals and approach, this is still a common challenge due to the differences in participants' individual visions and perceptions. Successful collaboration is about good management of relationships. Many international S&T collaborations (in academic and industrial contexts) seem to benefit all members through significant increases in access to knowledge and other resources (Creech & Willard, 2001). Similarly, some countries have certain advantages in becoming centres of scientific and technological knowledge. To become involved in these S&T collaborative projects, a country has to have appropriately skilled research organisations with the skills or knowledge sought by other potential partners. In certain cases, some partners may be offering more than the other parties can provide in return. Participants with the greater knowledge have more to offer, but they are also probably faster (or better equipped) at learning from the others.

This approach is central to overall EU research policy. The EU Framework Programmes promote international cross-sectoral collaboration across its member states. For example, in projects with some participants from countries with less expertise in a particular field (Country A), these participants would be provided with greater learning possibilities with the participation of members from other countries with finer expertise in the research field (Country B). In a collaboration of this type, the more experienced party (an institution from Country B) has an option to steer research in a particular direction according to its own research interests as it is unlikely for an inexperienced party (from Country A) to define the agenda. As the newly learnt knowledge (or skills) can be disseminated among other institutions in Country A, it makes sense to increase the number of local networks in that country. However, this will not normally be possible without dedicated policies to support and promote this new knowledge transfer, nor will it be possible without active local organisations or researchers. Furthermore, even if research collaboration is perceived as beneficial to all partners, participation in a research network can and often is limited to outsiders. These limits can exist for a number of reasons: larger networks can be more difficult to monitor and administer, or because of limited funding, where the addition of a new member would mean a decrease in funding per existing member. Any access to such a network would generally require support of the existing group members. For a new person (organisation) to become a member of the group, some persuasion would be needed; as such membership should benefit the entire group.

While the earlier discussed publications and patents are often used as indicators for assessing and evaluating collaborative projects, a number of additional measures have been also discussed in literature. Some of the measures are linked to building one's research profile. It is generally assumed that the most interesting partners to collaborate with are those who can potentially contribute the most to the project (either in terms of specialised knowledge or access to other resources) (Archibugi & Coco, 2004). Pertinent research explores possible connections between the nature of some relationships, inputs and outputs for research collaborations (Shelton, 2008). One such study closely examines the failure of the EU to capture adequate benefits in patents and high-technology market share despite its leadership in scientific publications in certain research fields (Tijssen & van Wijk, 1999). Collaborative partners tend to become highly sought after when they develop a strong knowledge portfolio (Archibugi & Coco, 2004). Following this logic, when a particular country has a stronger repute in a particular research field, research organisations from this country are perceived as highly sought after. A strong research profile determines rankings of individual scientists as well as research organisations. In fact these rankings are keenly used for comparative analysis of collaborators' performance (Thijs & Glänzel, 2008). According to Sgourev and Zuckerman (2006), it is the collaborating member's desire to avoid inferior ranking within the group, coupled with peer pressure, which pushes them to meet performance standards established within the group. The members in such groups generally display a strong interest in increasing their in-group ranking in order to improve their recognition by their peers (Sgourev & Zuckerman, 2006). This competitive environment certainly puts additional pressure on members to ensure they achieve their professional goals. However, participation in the work of a stronger network can boost by itself the individual's research profile.

Existing research suggests that *group cohesion* is one the major factors for the success of R&D networks, and it is a challenge in itself. Research group members generally bind to other members through a network of informal relations and these links assure the group's integrity and loyalty (Sgourev & Zuckerman, 2006). This thinking also suggests that the value individual participants place on their membership directly depends on how other members perceive the importance and value of the network. Such interdependence, once properly channelled, can provide outcomes that will benefit all participants (Sgourev & Zuckerman, 2006). However, it can also turn out to be the weakest link of the group if some of the internal group tensions are not resolved in time (Sgourev & Zuckerman, 2006). Previous relationships and affiliations with other organisations can serve to some extent as resources to a new organisation as they legitimise both the organisation itself and its activities. In fact, both organisations and individuals take full advantage of this resource as in many funding applications applicants often identify themselves with their past organisational affiliations to strengthen their applications (Wiewel & Hunter, 1985). In addition, an individual's membership in a network can provide them with new funding opportunities. Most EU-funded research funding programs (in particular, under Framework Programme 7) encourage or even require applications from groups of collaborators. Furthermore, some funding sponsors require a minimum number of countries before a proposal would even be reviewed. By putting such a proposal together, collaborators not only commit themselves to their group's research objectives, they also facilitate and increase their own funding prospects. Furthermore, researchers' association with a research project can further improve their chances of acquiring further research funding from other sources.

In their 1985 paper, Wiewel and Hunter suggest an interesting discussion of three different forms of legitimation process: effectiveness related legitimacy, representational and nested power legitimacy. According to this classification, acceptance by other actors can be facilitated, if not achieved, when one is capable of delivering, as effectiveness on its own is not always a guarantee for legitimacy (Wiewel & Hunter, 1985). When referring to one's previous projects, or achievements in other organisations, these references can be considered as a credit to the organisation affiliated with them. That is especially important if other collaborators are unable to provide similar required skills. The second form of legitimacy (representational legitimacy) is based on the beliefs of others. As any organisation has a particular structure of authority, it would only be able to carry out some of its functions (such as acquiring needed resources) when other members accept and therefore endorse its authority. Such thinking can apply to both insiders (such as subordinates) as well as outsiders (McNeil, 1978). Many important outsiders such as funding agencies or sponsors are most experienced in dealing with other organisations. Wiewel and Hunter (1985) note that by involving earlier occurred affiliations with known organisations these funding sponsors can become important organisational and community actors. The last form of legitimacy within this classification is one arising from *nested power*, proposed in 1968 by Stinchcombe (1968). Under this concept, legitimacy directly corresponds to the degree to which one has access to important resources or powers as a way of demonstrating one's power (Wiewel & Hunter, 1985).

Other analysts argue that often the core business of networking is in *'joint learning, drawing lessons and elaborating specific proposals, and advocacy'* (van Zee & Engel, 2004, p.8). In fact, existing literature cites examples of when networks were organised expressly to represent particular communities with aims such as influencing decision-making and public policy, as well as providing dedicated forums for critical analyses and evaluation of new and existing practices and experiences (van Zee & Engel, 2004). One example, governmental research funding still plays an important role, but even though the overall share of direct governmental funding is decreasing, governments in many EU Member States are increasingly using indirect policy measures to encourage higher business R&D expenditure (EC, 2005b). Such increases are often the result of new national public policies developed with the involvement of research groups. Among reasons why interest in the process of networking has been growing over recent years, one could mention certain levels of dissatisfaction among both public and academics as the marginalisation of many research projects, as well researchers being denied degrees of power resulting in low impact of research on public policy and decision-making (van Zee & Engel, 2004). The majority of global scientific and technological collaborations come with important policy implications (Archibugi & Pietrobelli, 2003). By organising new or existing (but often fragmented) knowledge and by developing new structures and methods research collaborators attempt to facilitate informed decision and policy-making at all levels.

2.5.7 Combining Outputs and Outcomes

In recent years, practitioners and academics working in the field of evaluation came to a consensus to differentiate between outcomes and outputs resulting from collaborative activities. Collaborative outputs are measurable products (mostly tangible) of activities where the (mostly intangible) effects of these outputs are considered to be research outcomes (Koontz & Thomas, 2006). In other words, *outcomes* are the immediate effects of outputs on external environmental and social conditions and the *output* is what research

collaborators did during the project (Koontz & Thomas, 2006). At the same time, the outcome is why they did it, that is, what result they were really trying to achieve at the end of the day (original project objectives). So while publications, patents, meetings, exchange visits, etc. can be what researchers are trying (or planning) to achieve within the framework of their projects, in many formal research networking projects these results would be considered merely as outputs. There is an understanding that outputs are products of project and programme activities, while changes from these outputs result in outcomes. When assessing one's research performance, one of the most common ways to is to describe the outcomes the social actor is trying to achieve (or has achieved). Since reasons for the project's existence can depend on achieving anticipated objectives, one can argue that the performance of a particular project should be measured in terms of its outcomes. While outcomes are important, to be useful these would have to be quantifiable in order to be measureable and observable over time. Often, as outcomes are not that easily measureable, collaborating practitioners instead rely on measuring project performance in terms of outputs rather than outcomes. A large percentage of project organisers implement a system that tracks *outputs* of the project as a reporting requirement set by their funding organisation.

Many government-sponsored research projects are required to implement monitoring programs. Results of these monitoring programs are later used for decision-making related to future funding approvals by public officials. The EU Framework research projects, for example, generally require regular progress reports to be made available to the European Commission. In some cases, public officials decide on the standards for these measures or they actively collaborate with researchers in the setup of such measures. A clear monitoring system enables the prevention of any potential confusion at a later stage of the project. In many cases, these outputs are discussed at the implementation stage of a project. This enables monitoring and recording the immediate results or 'outputs' of research activities. These are distinguished from the long-term results called 'outcomes', which reflect changes in behaviour, attitudes, policies, etc. Such a formal system for tracking outputs permits keeping track and control of project activities and change. It also allows project managers to be accountable to funding organisations (and other stakeholders) and to understand any lessons learned. It further provides tools for assessing project outcomes at a later (or final) stage. While existing research attempted to measure collaborative outputs, there is a lack of research linking outputs and outcomes. In fact, some researchers argue that the only exception to this is a relationship between collaborative efforts and increased trust and social capital (Koontz & Thomas, 2006). While the distinction between outcomes and outputs is important, in practice both of these can serve as useful measures of a project's performance. Any analysis of project outputs should be seen as strongly linked to the assessment of project outcomes. In many projects, tracking of outputs starts much earlier than tracking its outcomes and may often take place more frequently. It is also important to recognise that any outcome assessments might not be valid until after the project has been running for some time to allow some outcomes to be realised. A good understanding of the project's outputs can generally indicate whether the overall project is on the way to attaining its planned objectives (outcomes). Under normal conditions, practitioners are primarily output-focused as they assess projects in terms of tangible results such as publications, presentations, workshops, etc. However, this might not necessarily be what is needed to achieve particular outcomes required of the projects. Collaborative outputs are often the intermediary causal mechanisms (between processes and outcomes), while in other cases outputs can be considered as the initial outcomes (Koontz & Thomas, 2006).

2.6 Concluding Remark

Chapter 2 provided a review of pertinent literature in relation to the environment of research collaboration, factors and motives behind collaborative behaviour in research, and reviewed a number of aspects linked to researcher productivity in terms of productivity and outputs. In particular, Chapter 2 advanced existing understandings of collaboration by examining collaborative arrangements across dimensions in terms of complexity, closeness, formality, etc. The author reviewed existing management literature on scientific collaborative networks and offered a detailed typology of research networks in terms of their heterogeneity and formality. Relevant findings in science and innovation management literature were further summarised. First, the author reviewed different types of organisations, which had become involved in research and attempted to explore the nature of such collaborative research. Chapter 2 continued with a discussion of general motives for collaborative research, and in particular, motives behind collaborative research. The reviewed literature suggests focusing not just on these motives, but on factors external and internal to science, which generally serve as antecedents of the research community's pro-active interest in collaborative scientific activities. The review then further explored the concept of researcher productivity presented in management literature, as well as the main components contributing to it (such as outputs and outcomes of research collaboration). The author then discussed a need for an improved performance measure, which should include collaboration context-specific outputs and outcomes. Chapter 3 will review a number of theories explaining collaborative research efforts within the scope of FNR projects. An improved understanding of these collaborative research efforts could provide further answers to the research questions, which are further formulated in the following chapter. Based on the reviewed theories, an integrated theoretical and conceptual framework is developed.

Chapter 3. CONCEPTUAL FRAMEWORK

3.1 Introduction

Chapter 2 examined the nature of collaborative arrangements and, in particular, scientific collaborative networks. It also explored different types of research network. The researcher productivity concept was presented along with a discussion of a number of aspects of motivation and research outputs/outcomes. Chapter 3 will selectively review a number of theories, which will serve as a basis for conducting research. Based on the earlier discussion of general collaborative motives in research, Chapter 3 will examine the applicability of several related theories (including the resource-based view and social capital theory) to explain what puts individual researchers in a position where they not only consider but also actively use their collaborative options. Chapter 3 will then employ the social capital theory to examine whether research productivity is associated with the length of time of individual researcher's involvement in FNR projects. Following the discussion of dominant theories, a composition of the reviewed interrelated theories will be developed into a theoretical framework. Having formulated the integrated theoretical framework, the author will finalise the conceptual framework of this research. This proposed conceptual framework will facilitate further operationalisation of the theory.

3.2 Overview of Dominant Theoretical Perspectives

A number of theoretical approaches have been identified with the purpose of assessing the motivations and researcher productivity (outcomes and outputs) associated with, and derivable from, research collaborations and in particular formal collaborative (networking) research programmes. Some of these theories, which will be discussed in more detail, employ a number of approaches to account for motivation, objectives, constitution and categories of collaborative arrangements. This section will focus on the unique perspectives offered by these theories. Recent years have witnessed a remarkable growth in various forms of collaboration across a range of fields. A particularly strong growth has been noticed in collaborative arrangements during the 1980s and 1990s, especially in knowledge-intensive areas such as high technology industries (Breimer, 1996; Hagedoorn, Monitor Programme. & Commission of the European Communities., 1991). Powell et al. (1996) bring our attention to the biotechnology industry, in which it is very rare to find a company without any formal cooperative links to other companies, and in which the overall connectivity of firms has significantly increased.

A similar pattern is apparent in other industries such as the automobile and software industries (Archibugi & Coco, 2004; Jassawalla & Sashittal, 1998; Lee, Pak & Lee, 2002; Leonard, 1998; Prefontaine et al., 2000). These collaborative arrangements take many forms. However, irrespective of the differences, the growth in numbers and variety of practices raised a number of important questions which will be addressed by this thesis. Why do individuals and organisations engage in such collaborative arrangements? What collaborative forms do they choose? What results do they expect to achieve and actually achieve? This section introduces a theoretical framework which explains the emergence of collaborative research arrangements such as formal research networks.

A great number of publications address these and related questions (Bramwell & Sharman, 1999; Calvert & Patel, 2002; Daugherty et al., 2006; Ende, 2003; Fleming & Marx, 2006; Goktepe, 2003; Jones, Bond & Mancini, 1998; Katz, 1994; Katz & Hicks, 1997; Nagpaul & Sharma, 1994). Reviewed literature reveals that to date academics are still in the process of consolidating one general theory of collaboration (Wood & Gray, 1991). This lack of a general theory, however, is not necessarily due to a lack of research interest in the phenomenon. In contrast, it has attracted concentrated attention from a range of fields from Organisational Behaviour (DiMaggio, 1988; Fennell & Alexander, 1987; Meyer & Scott, 1983; Scott, 1987; Tolbert & Zucker, 1983) to Sociology (Gupta & Lad, 1983; Levine & White, 1961; Pfeffer & Salancik, 1978; Zeitz, 1980), Political Economy (Benson, 1975; Zeitz, 1980), as well as Economics (and in particular Micro-economics) (Harvey, 1982; Scott, 1985; Williamson, 1975, 1985) and Environmental studies (Aldrich, 1979; Pfeffer & Salancik, 1978; Schoorman, Bazerman & Atkin, 1981). A significant volume of research examines questions as to why, how, where and when organisations and individuals become involved in collaborative arrangements such as networks. As in other scientific domains, research in this field has developed a number of applicable approaches and theoretical frameworks. While the reviewed contributions can be generally mapped over a large number of theoretical perspectives according to how these works address the preconditions (predictors), motives, processes, and outcomes (outputs) of collaboration, this study focuses on the following theories: the *resource-based view* and the *social capital theory*. Each of these two distinctive theoretical frameworks suggests a different (yet complementary in the context of this study) perspective. The next section will discuss these important perspectives and their applicability in the specific research context of this thesis.

3.3 Resource-Based View Perspective

One of the main arguments of the *resource-based view* (RBV) is that organisations possess certain skills, knowledge and other resources which enable them to achieve a competitive advantage and can lead them to a greater long-term performance. Organisation's resources hold their value only as long as these resources are scarce and they enable that organisation to achieve a competitive advantage. However, this competitive advantage can only be sustained over the longer term under a condition that the organisation is well positioned to protect against any unauthorised resource transfer or replication. The RBV generally argues that the rationale for partnerships is value creation through the pooling of organisations' resources such as knowledge and skills. From this perspective most collaborative arrangements can be seen as a means of maximising this created value through efficient use of partners' complementarities (Das & Teng, 2000; Hagedoorn, Link & Vonortas, 2000).

Application of the RBV to research and science collaborations has not been studied as much as its application to collaborative arrangements in other areas. The RBV theoretical perspective can be appropriate for studying collaborative research since academic organisations have been engaging in collaborative research generally to acquire access to other institutions' or other external resources. Frequently, the RBV is applied at the level of a firm (organisational level) and only in a limited number of studies this theory is applied at the level of an individual (van Rijnsoever et al., 2008). This thesis employs the RBV at the level of individual researchers. Many researchers also agree that individual members and stakeholders in organisations frequently seek to maximise their personal aims (Cyert & March, 1963). It is possible to suggest the applicability of the RBV

theory at the individual level since most research organisations depend on the performance of individual scientists who are generally driven by their personal agendas. In fact, Van Rijnsoever, Hessels et al. (2008) argue that the reasons behind collaborative behaviour in research very often relate to the individual researcher's personal resource stock which can be used to gain a competitive advantage.

Within the understanding of the RBV, there are some explanations how collaborating institutions can improve their research performance. A common explanation lies in sharing unique equipment critical to researchers across several fields. A topical example of such co-use can be the MRI (Magnetic Resonance Imaging) facilities at the Trinity College Institute of Neuroscience (TCIN) which are shared by different groups of researchers from institutions across Ireland as MRI equipment is expensive and not available at most research laboratories in Ireland (TCIN, 2009). Similarly to firms, research organisations and individual researchers adjust their behaviour to balance both exploration and exploitation of knowledge (March, 1991). This knowledge can be created internally or acquired externally. In many cases, collaborative research can be the only way to avail of the scarce (unique) knowledge or skills required to achieve specific research objectives. Collaborating researchers often possess different sets of knowledge and skills which can help them to ensure both a sustainable and competitive position in the research field. Collaborative activities between researchers can result in the creation of some new knowledge which can in turn improve participants' research performance and effectiveness. Collaborative research efforts can be reflected in improved productivity and effectiveness subject to a number of factors such as the motives behind collaboration. However, the RBV falls short of explaining the improvements in research productivity alone. Besides the resource-based view, at least one more approach has been employed in management literature to explain the notion of collaboration in research - *social capital theory*.

3.4 Social Capital Theory Perspective

The concept of social capital has been around for a relatively long time. It was first suggested by Lyda Hanifan in a discussion of rural school community centres and was used to refer to *'those tangible substances [that] count for most in the daily lives of people'* (Hanifan, 1916, p.130). Following Hanifan's pioneering use of this term, it took about 70 years for the term to be used more widely. A number of authors including Granovetter (1973), Bourdieu (1983), and Coleman (1988) opened new discussions of this phenomenon in the social context. These authors propose rather different conceptualisations of the phenomenon. The earlier authors (Bourdieu, 1983; Coleman, 1988) offer conceptualisation at the individual level to reflect the fact that social capital takes place among individuals and therefore should also be studied at individual level. However, a later work by Putnam (1993) suggests the phenomenon of social capital as a new focus for both research and policy discussion. Putman (1993) contributes significantly to viewing social capital at the community level having studied the advantages derived by the community. A decade earlier, Bourdieu (1983) distinguished between three major forms of *capital*: economic, cultural and social, where social capital is the '*aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalised relationships of mutual acquaintance and recognition*' (p. 248).

Other attempts to give a clear definition to social capital focus on the degree to which social capital can be used to benefit individuals or organisations. One such attempt was made by Putnam (2000) who argues that

social capital can facilitate co-operation and mutually supportive actions within networks and therefore can be used as a means of achieving greater results. This is how Putnam (2000, p.19) puts the general idea behind this concept:

> *"Whereas physical capital refers to physical objects and human capital refers to the properties of individuals, social capital refers to connections among individuals – social networks and the norms of reciprocity and trustworthiness that arise from them. In that sense social capital is closely related to what some have called 'civic virtue'. The difference is that 'social capital' calls attention to the fact that civic virtue is most powerful when embedded in a sense network of reciprocal social relations. A society of many virtuous but isolated individuals is not necessarily rich in social capital".*

Even without a clear definition of social capital, there is a general understanding that social capital through sharing norms and values can lead to social collaboration (Fukuyama, 2002). Fukuyama argues that social capital is a precondition for successful development and strong economic growth. Collaboration among social entities can be interpreted as a variety of social capital, that is, a form lying outside of where individuals (and individual organisations) work in isolation. The links among these different social groups could help them enlarge their individual capacity to participate in collective action by bonding with each other. These links could also contribute to conflict resolution by bridging differences between and among them. Social capital should then be seen as the cement holding social groups (and networks) together (Cohen & Prusak, 2001). Many research networks involve individuals who are interested in a particular research topic. Participating members of such networks engage in an exchange of knowledge and resources as a means of developing social capital, stimulating innovation as well as sharing existing tacit knowledge (van Rijnsoever et al., 2008). As a result, such networks can provide individual researchers with access to additional valuable resources. A recognised concept - the *Matthew effect* - explains the observed differences in success among individual researchers. Developed by a sociologist, Merton (1968), this concept states that a certain amount of accumulated capital will lead to an even more accelerated build-up of additional capital compared to scientists who lack this level of original symbolic capital (van Rijnsoever et al., 2008).

3.4.1 Social Capital and Social Value Creation

Coleman (1988) further explores the individual aspect of the definition of social capital. According to this perspective, social capital is in fact anything that facilitates individual action and is generated by networks of relationships, mutual trust and social norms. Coleman's view complements that of Putnam (1993) which suggests that social capital should be considered as the *overall collective value* of all social networks, and as such, social capital presents an important key to building democracy. Furthermore, if social capital is related to a democratic level in a society one could argue that declining levels of civic participation and lower levels of trust could be linked to a decline in social capital. Similarly to the RBV, social capital can lead to increased individual access to information and skills as well as increased power (Uzzi & Dunlap, 2005). These benefits can facilitate researchers' further *career development*. Interaction helps people to build networks, engage in collaborative research, and to build their research communities. However, social capital can often lead to unexpected results if research networks are not based on the principles of democracy as it can easily be overturned by different social subgroups within the network. In the following sections, this research examines (from the social capital perspective) the underlying motives driving researchers to participate in collaborative research projects. Social capital has the potential to be used for the analysis of

value creation in research networks as social capital refers to networked acts of mutual support, norms and trust as well as a sense of mutual obligation (Bankston & Min, 2002; Cohen & Prusak, 2001; Coleman, 1988; Smith, 2007). Furthermore, social capital is about gaining value from being a member of such a network. Members of collaborative networks get access either to limited resources owned by other participants or resources that can only be achieved through collaborative activities. As a result, in some cases collaborators' membership of a network can provide them with improved new *career prospects* or new *funding opportunities*. Many of the EU FP7 research funding programs accept applications only from groups of collaborating researchers (the *necessity* predictor, see Table 3-1, p. 68). In fact, some funding organisations set a minimum number of countries before a proposal will even be reviewed (for example, many of the FP7 lay down conditions regarding the minimum number of participants, or additional conditions on the type of participant or place of establishment[12]) (Smith, 2002). Collaborators, by putting such a proposal together, not only commit themselves to their group's research objectives but also facilitate and increase their own funding prospects.

Social capital emerges in the relationships between individual researchers, and as other types of capital, it stimulates research productivity (Coleman, 1988). The idea of social capital implies that social relationships among researchers can facilitate an accrual of benefits by the individuals. Individual researchers can develop relationships with particular objectives in mind and use them to achieve both tangible and intangible outcomes. In the case of collaborative networks, researchers can purposely organise or join new groups and networks and build these relationships in accordance with their individual research objectives. Relationships developed within such networks can then help solve other problems such as difficulties with regulation, as well as problems of opportunism and legitimisation (Coleman, 1988; Wiewel & Hunter, 1985). Social capital can become *a policy resource*, as a social group has a much higher power to influence policy and decision-making than any individual scientist would have.

3.4.2 Credibility Cycle, Peer Pressure and Learning within Networks

The concept of *credibility cycle* suggests that in order to acquire higher levels of funding and recognition, researchers have to work for recognition by their peers (Latour & Woolgar, 1979). Such peer recognition can lead to a greater level of respect and appreciation in the research field. Individual researchers exchange knowledge and information for this recognition and funding, which can be seen as factors related to researchers' competitive advantage (Hagstrom, 1966; van Rijnsoever et al., 2008). Van Rijnsoever, Hessels et al. (2008) further point out the advantages for an individual researcher that can come with such a competitive advantage: an increase in the number of publications, higher academic positions, and even an improvement in one's chances for securing new research funding.

Recognition in the field can also be achieved through the mentoring of other (generally younger) researchers working in the same field. It is well recognised that such mentoring is important in academic and research careers (Long & McGinnis, 1985). In fact, some research collaborations can aim primarily at the training of new researchers (students) and early stage researchers (Bozeman & Corley, 2004). Other collaborations intend to improve the productivity of individual researchers with some researchers collaborating not for their

[12] 'General provisions for participants', CORDIS (http://cordis.europa.eu/fp7/who_en.html)

personal productivity but to provide additional training and opportunities to graduate students and postdoctoral researchers (Melin, 2000). In such collaborative projects, early stage researchers or students are likely to benefit more than senior researchers whose performance in contrast can sometimes be impeded. Another aspect of research collaboration is linked to learning from collaborators with higher recognition. Other researchers' experience can be seen as an important resource in itself. In a collaborative environment, the more experienced researchers serve as models of desired and successful performance and productivity. This phenomenon has been developed into social learning theory (Bandura, 1977). The behaviour of these experienced researchers can be perceived or accepted as models and as a result, such behaviours can be learnt through modelling. This development within a network can be important as participants learn by observing the behaviour of their peers and the results of such behaviours.

Furthermore, researchers can improve their recognition in research fields by attending conferences. According to one study, most researchers attend conferences with the following top objectives: to learn about new research areas and to keep up with the developments in their research field (Waddell, 1994a). In addition, the interviewed respondents sought to seek new collaborations and to keep up with existing contacts (Waddell, 1994a). Attendance at research conferences can offer participants an opportunity to tackle new complex research issues, increase the visibility of emerging research topics, and importantly, improve researchers' peer recognition. In addition, certain research conferences can come with a political agenda. Yet, while some researchers and scientific organisers recognise and accept that many EU funded projects and events are measures to building and strengthening European collaboration, others argue that research should not have any political agenda (Waddell, 1994a).

Under the European Neighbourhood Policy (ENP), the EU tries to bring closer researchers from a number of neighbouring countries[13], in the case of EU Framework Programmes these projects aim to involve scientists from these countries under conditions similar to those applicable to the EU researchers. The vision is that these countries can be drawn into further integration through international cooperation but without necessarily becoming full members of the European Union. Some mechanisms under the Cooperation element of the FP7[14] allow (generally in some form of research funding) researchers from neighbouring countries to learn from EU (often these are Western and Northern European countries) states through participation in collaborative research projects.

Viewing social learning as a resource can explain to some extent the motives for collaboration and suggests that all participants can learn from each other in such projects. It is therefore possible to suggest that the social capital perspective can help to (a) complement the RBV in improving the understanding of the motivation driving individual researchers to participate in formal networking research projects, and (b) it can help to understand the relationship between participation in such FNR projects and expected changes in research productivity.

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[13] The countries covered include all of the Mediterranean shores of Africa and Asia, as well as the European CIS states (with the exception of Russia and Kazakhstan) in the Caucasus and Eastern Europe. Russia insisted on the creation of the four EU-Russia Common Spaces instead of ENP participation.

[14] The Seventh Framework Programme for research and technological development (FP7) is the European Union's chief instrument for funding research over the period 2007 to 2013.

3.5 Overview of Related Theoretical Perspectives

Additional to the resource-based view and social capital theory, some other theories aim to explain motivation behind collaborative behaviour; however, they come from a different angle. Oliver (1990) offers a new summary of collaborative predictors, under which organisations establish linkages or exchanges with other organisations, and corresponding theories (see Table 3-1). A set of six predictors of inter-organisational collaboration includes necessity, asymmetry, reciprocity, efficiency, stability and legitimacy.

Table 3-1: Collaboration predictors and corresponding theories

Predictors	*Nature of contingency*	*Example(s)*	*Theories*
Necessity	An organisation establishes linkages or exchanges with other organisations in order to comply with necessary legal or regulatory requirements.	Mandates and orders from higher authorities such as government agencies, legislation, industry or professional regulatory bodies.	Resource dependence and exchange theories (Benson, 1975; Gupta & Lad, 1983; Levine & White, 1961; Pfeffer & Salancik, 1978; Warren, Rose & Bergunder, 1974; Zeitz, 1980).
Asymmetry	An organisation establishes relationship with another organisation as it can exercise its power and/or has control over its resources.	A corporation may be motivated to form a director link with a financial institution in order to gain influence and control over sources of capital and to increase its power compared to firms that are also competing for financial resources in this industry.	Theories of political economy (Benson, 1975; Zeitz, 1980); resource dependence (Pfeffer & Salancik, 1978), and financial control (Fitch & Oppenheimer, 1970).
Reciprocity	According to this perspective, organisations collaborate for the purpose of pursuing common or mutually beneficial goals or interests.	A linkage between two joint venture partners that is encouraged by the need or desire to pursue new markets or activities.	Exchange theory (Emerson, 1962; Levine & White, 1961), the reciprocity model of director interlocks (Allen, 1974; Koenig, Gogel & Sonquist, 1979) and the collective strategy framework (Astley, 1984; Oliver, 1988).
Efficiency	In this situation, the formation of an inter-organisational relationship is incited by an organisation's attempt to improve its internal input or output ratio.	Some incentives for establishing partnerships for the purposes of improving efficiency may be the organisation's anticipation of increases in return on assets or reductions in unit costs, waste, downtime, or cost per patient or client.	Transaction cost perspective (Williamson, 1975, 1985).
Stability	In this case, the formation of inter-organisational relations organisations can better anticipate or absorb uncertainty affecting their activities.	Uncertainty prompts organisations to establish and manage relationships in order to achieve stability, predictability and dependability in their relations with others.	Theories of adaptive response and environmental uncertainty (Aldrich, 1979; Cook, 1977; Pfeffer & Salancik, 1978; Schoorman et al., 1981; Williamson, 1985).
Legitimacy	Institutional environments impose pressures on organisations to increase their legitimacy in order to appear in agreement with the prevailing norms, rules, beliefs or expectations of external constituents.	For example, the ability to obtain members of prestigious organisations to sit on a board of directors or the development of a relationship that publicises social responsibility.	Institutional theory (DiMaggio, 1988; Fennell & Alexander, 1987; Meyer & Scott, 1983; Scott, 1987; Tolbert & Zucker, 1983).

Adapted from Oliver (1990)

Another theory that explains certain collaborative behaviour of individual researchers is the *social exchange* theory that has its roots in the fields of economics, psychology and sociology. The social exchange theory, while being fundamentally close to the classical exchange theory, has specific characteristics. When applied in the context of collaborative research networks, the social exchange theory (similarly to the resource-based view) suggests that researchers participating in a collaborative research network enter relationships, which

can be viewed as an exchange of goods, material and other resources (such as approval and recognition). While this explains the relationships among the researchers themselves, it does not fully explain the interaction between them as a group and external participants as the social exchange theory (unlike the exchange theory) views the exchange between different actors (Blau, 1964). Most theories listed in Table 3-1 (including theories of adaptive response and environmental uncertainty, institutional theory and transaction cost perspective) provide only limited explanation of the individual researchers' motivation to commit to FNR projects and the impact of participation in FNR projects on the research productivity of individual researchers.

There are certainly some criticisms of the RBV and social capital theory. A possible criticism of the RBV is related to its treatment of knowledge as a *generic resource* as it does not distinguish between its different categories. This new knowledge can either be created within an organisation or alternatively can be acquired from external sources through collaboration. Certain applicability of knowledge-based theories at an individual level has been analysed by a number of scientists. The *knowledge-based theory* originates from strategic management literature and it is frequently viewed as an extended version of the resource-based view (Aversi et al., 1999; Devetag, 1999; Penrose, 1959). This theory, however, specifically views knowledge as the most important resource available to organisations and individuals. The important difference between these two approaches is that the knowledge-based view (although similar in its logic to the RBV) recognises the role of knowledge in facilitating achievement of a competitive advantage by collaborating entities (Alavi & Leidner, 2001). The knowledge-based view also suggests that inter-organisational projects are not inherently superior to intra-organisational projects but are best justified in situations, where scarce and unique skills and expertise are needed (Cummings & Kiesler, 2007).

While studies of social capital on the level of organisations focus on the impact of research collaboration on competitiveness through the improvement of knowledge and technology, studies at the level of individual researchers could help to explain the role of social capital in research networking among individual researchers. One can argue that in contrast with the resource-based view, social capital theory should not be considered on either individual-level or as a group-level phenomenon, as it occurs between the two levels of analysis as individuals collaborate in networks (Bankston & Min, 2002). The resource-based view, to an extent, deals with this argument. With the RBV perspective applied at the level of an individual researcher, one can view research-networking skills *as a resource,* which allows individual researchers to acquire competitive advantage in terms of research productivity and career development. The resource-based perspective generally views research networks as voluntary collaborative arrangements with aims to allow participants to achieve certain collaborative advantages. The results of these competitive advantages to an extent can be confirmed through an identified relationship between scientific networking and career development or improvements in one's research performance (van Rijnsoever et al., 2008). However, this relationship should be tested in a study that would distinguish between types and levels of networks. The RBV on its own does not fully explain the underlying principles of collaborative research networking. Yet the RBV certainly has the potential to provide some explanations of the phenomenon of collaborative research networking by viewing it as a flow of resources between participating organisations and individual researchers.

3.6 Building an Integrated Conceptual Framework

With science budgets committed by the EU to formal networking research projects reaching new unprecedented levels, it is imperative to be able to provide evidence to justify the distribution of funds and the choice of programmes that receive this funding. In its earlier sections, this thesis reviews a range of existing studies on collaborative research and networking in science in an attempt to understand a particular case of research collaboration – formal networking research (FNR) projects. An example of such research networks include formal research projects funded by the European Union through its EU Framework Programmes. Current EU Framework Programme 7[15] (EU FP7) dedicates a significantly increased budget of EUR 51 billion to research in the European Community States (CORDIS, 2007).

The biggest component of the FP7 Programme is *Cooperation Programme* which was assigned an astounding 64 percent share of the overall FP7 budget. One core element of the EU FP7 Cooperation Programme is linked to the facilitation of scientific networking projects across all scientific domains. Formal international research networks are a good example of heterogeneous groups as they frequently involve a wide spectrum of institutions and individuals from non-governmental and governmental organisations, academic institutions, policy makers and other stakeholders from (at least) several countries. A particular focus of this thesis is on the formal networking research (FNR) projects. Given the impressive financial commitment from the European Union, one would assume that the benefits from such networking projects are well examined and documented. The reviewed literature on added-value of scientific networking turned out to be scarce and fragmented (though it does generally advocate the importance of scientific networking). However, the conducted literature review highlighted an important question: *why should governments and other funding sponsors support formal research networking?*

The reviewed literature suggested several general areas for research enquiry which will be addressed in this thesis: researcher motivation for participation in FNR projects, funding sponsor expectations, attainable FNR outputs and research networking as a resource (knowledge/skills). Due to the nature of theoretical paradigms, it is generally uncommon to see a work that incorporates multiple theoretical perspectives on collaborative research. The above-discussed theories and some other concepts such as theories of adaptive response and environmental uncertainty (Aldrich, 1979; Cook, 1977; Pfeffer & Salancik, 1978; Schoorman et al., 1981; Williamson, 1985), institutional theory (DiMaggio, 1988; Fennell & Alexander, 1987; Meyer & Scott, 1983; Scott, 1987; Tolbert & Zucker, 1983), and transaction cost perspective (Williamson, 1975, 1985) tend to provide a limited explanation of the individual researcher's motivation to commit to FNR projects and the impact of participation in FNR projects on the research productivity of individual researchers. This limitation is particularly evident in the case of formal collaborative research projects, since single theoretical perspectives often can be too narrow for dealing with complex issues such as multi-actor arrangements (Kern & Willcocks, 2001). Therefore, following the review of literature on the subject, a logical conclusion is to develop an integrated conceptual framework (see Figure 3-1 below). An analysis of the resource-based view and the social capital theory confirms that the proposed research could benefit from combining these

[15] The Seventh Framework Programme for research and technological development (FP7) is the European Union's chief instrument for funding research over the period 2007 to 2013. It bundles all research-related EU initiatives together under a common roof playing a crucial role in reaching the goals of growth, competitiveness and employment.

theoretical perspectives. Such a combined theoretical framework would facilitate an explanation of the motivation for participation in formal networking research projects, as well examining researcher productivity as a set of research outputs across the systems of research outcomes identified in the reviewed literature. One important criterion for developing a valid conceptual framework is the requirement for research constructs to be empirically tested and therefore quantifiable. These constructs can then be used to test and determine the effectiveness of the formal collaborative research networking programmes.

The proposed conceptual framework includes both the motivational factors determining collaborative behaviour and the relationship between collaborative networking programmes and participants' research productivity (see Figure 3-1). Figure 3-1 summarises the main constructs of the model. The proposed integrated framework deals with a number of key research issues. Key relationships between individual elements within this conceptual framework and associated research questions are discussed further in the following sections of this chapter.

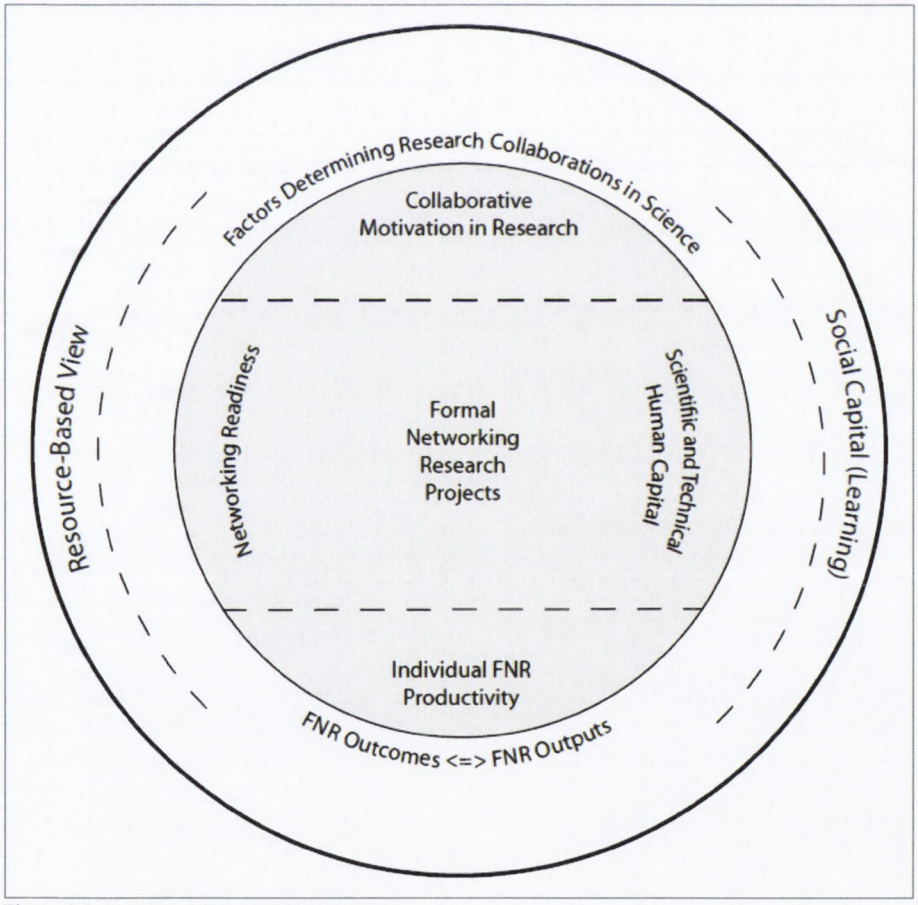

Figure 3-1: Integrated Research Framework

3.6.1 Questioning Researcher's FNR motivation (Research Question 1A)

In recent years, research networks have been considered and promoted as the answer to a range of challenges. In practice, this view is based on the assumption that (similarly to other collaborative forms of research) through networking partners expect to gain results exceeding what could have been generated through alternative collaborative configurations (Brinkerhoff, 2002a). In addition, such collaborative configurations

often provide easier access to otherwise limited and critical resources. On the other hand, pertinent research also suggests that networking efforts can result in new formal and informal networks. These networks are part of social innovation and learning as their participants often seek collaboration with others in order to facilitate an exchange of information, knowledge and experiences and to build collaborations to implement new ways of thinking and working (Alders et al., 1993). To advance current understandings of what drives individual researchers to engage in formal networking research, this thesis develops an integrated theoretical model reflecting these complementing views (resource-based view and social capital/learning). Following an extensive literature review, this framework examines individual researchers' motivation linked to their involvement (expressed through commitment of their time and other resources) in formal networking research (FNR) projects. Among other questions, this thesis is concerned with the researcher motivation in becoming involved in such FNR proejcts. More specifically, this thesis investigates what motivates individual researchers to apply for FNR funding despite the associated additional workload:

Research Question 1A: *What are the motives behind an individual researcher's decision to get involved in FNR projects?*

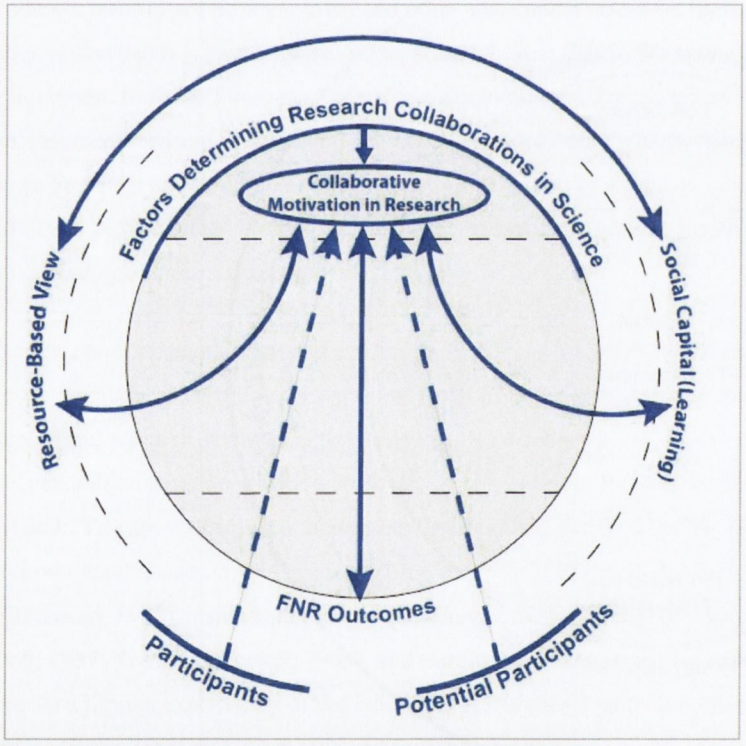

Figure 3-2: Conceptual Model (Version: Research Question 1A)

To answer this question, the developed integrated theoretical model employs a combination of the resource-based view and social capital theory to explain the specific motives behind researchers' involvement in FNR projects (see Figure 3-2). Based on the reviewed literature, this integrated model assumes that collaborative motives for the individual researcher's commitment to a FNR project (similarly to other collaborative arrangements in research as reviewed in sections 2.4.3 and 2.4.5) are determined by a number of collaborative research factors (discussed in section 2.4.3). On the other hand, participation/membership in such formal research networks can potentially result in a number of research (FNR) outputs and outcomes (reviewed in section 2.5).

3.6.2 Questioning Individual Researcher's FNR Productivity and Funding Sponsors' Expectations (Research Questions 2 and 3A)

The developed conceptual model (see Figure 3-1) assumes a link between participation in collaborative research collaborations and research outcomes (and researcher FNR productivity as expressed through individual FNR outputs and outcomes). This research examines individual FNR productivity as a measure expressed through a range of researchers' FNR outputs (as discussed in section 2.5). The model acknowledges that individual researchers' collaborative productivity can be affected by their networking readiness (defined by a number of individual researcher characteristics such as country of work, professional research experience, field of work, age, etc.). This model further assumes a bi-directional relationship between researchers' networking readiness and their productivity in FNR projects. As these researchers take part in FNR project activities, some research outcomes can be attributed to their participation in the FNR projects. On the other hand, funding providers may set different expectations in regard to what results they expect from funded projects (see Figure 3-3). As a result, it is possible to suggest two (related) research issues that remain unanswered:

Research Question 2: *What FNR outputs do funding sponsors expect from FNR participants?*

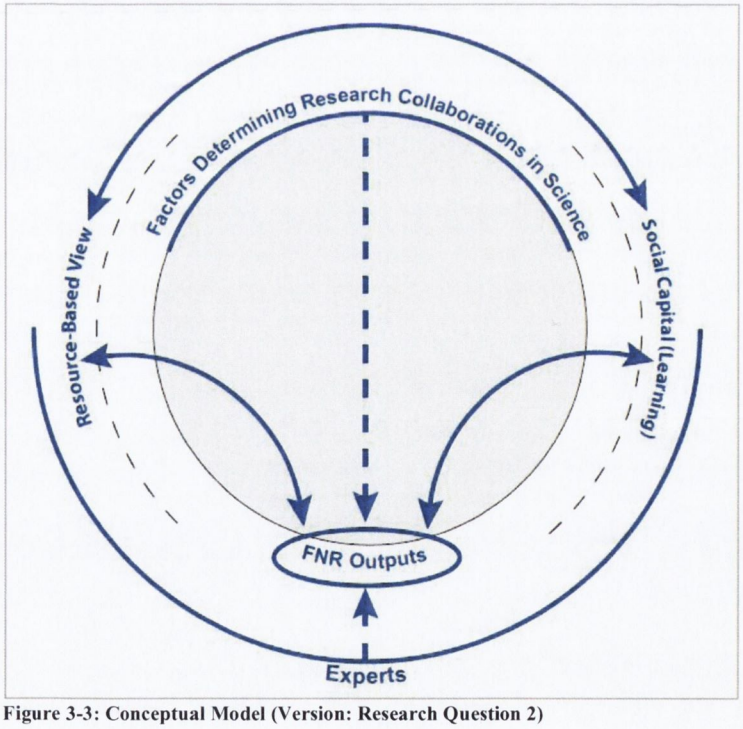

Figure 3-3: Conceptual Model (Version: Research Question 2)

Furthermore, research interaction between participants in a formal research-networking programme may take different forms of knowledge, resource and expertise exchange and sharing. These participants can share these through research meetings, exchange visits, research conferences and workshops, etc. As a result, networking efforts can result in many kinds of tangible and intangible outputs and outcomes; however, the extent to which these outputs are achieved can vary significantly from what is expected by the programme funders (see Figure 3-4). Hence, the next question aims to answer which of the research outputs can be achieved as a result of involvement in FNR programmes.

***Research Question 3A**: Which FNR outputs can be achieved through participation in formal networking research (FNR) programmes?*

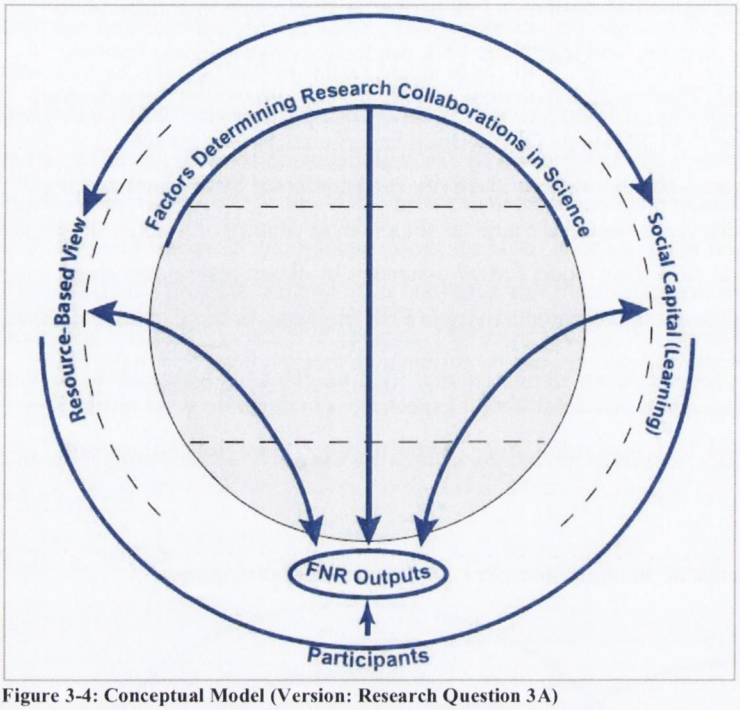

Figure 3-4: Conceptual Model (Version: Research Question 3A)

One should also question if the observed output results are the same for the entire population or whether there are some other possible explanations. As suggested in the reviewed literature, one can anticipate that certain additional variables such as educational level, professional experience, professional background and geographical location (country of work) can also have an impact on a researcher's networking research productivity, and therefore, these variables will be controlled (for) (Bozeman & Corley, 2004; Gaughan & Bozeman, 2002). As a result, the following research question:

***Research Question 3B**: What is the impact of Researcher's educational level, level of experience, scientific domain and professional background and country of work on their research outputs?*

3.6.3 Questioning Learning through Participation in Formal Research Networking

3.6.3.1 Constructing a Measure of FNR Productivity (Research Question 4 and related Hypotheses IA and IB)

Existing research supports the idea that collaborations and funding have a positive impact on research productivity and that more funding often leads to increased productivity (Lee & Bozeman, 2005). However, the identified empirical studies do not explain if the same applies to FNR cases (where researchers who engage in formal research networks only receive financial support for their networking activities and do not receive any support for their general research activities). What is the relationship (if any) between the researcher productivity and the time spent in such networking programmes? This leads to the next research question:

***Research Question 4**: Do FNR participants learn to network over the time of their involvement in FNR projects?*

The developed model (see Figure 3-1) assumes that as a result of participation in FNR projects and exposure to a research networking environment (including learning from their peers), researchers can acquire greater levels of FNR-related networking and research skills (researcher's networking readiness), which can eventually translate into greater FNR readiness. The newly acquired FNR experience can result in a further impact on researcher's competitive standing in their research field, which can have some impact on researcher's future motivation (and needs) for participation in further FNR activities. The theoretical model further integrates social capital theory to explain (anticipated) changes in researcher FNR productivity over the term of the researcher's involvement in FNR projects. The framework also suggests a relationship between FNR experience and FNR productivity. The developed model views FNR productivity as a set of FNR outputs which are associated with the researcher's participation in the FNR project (see Figure 3-5).

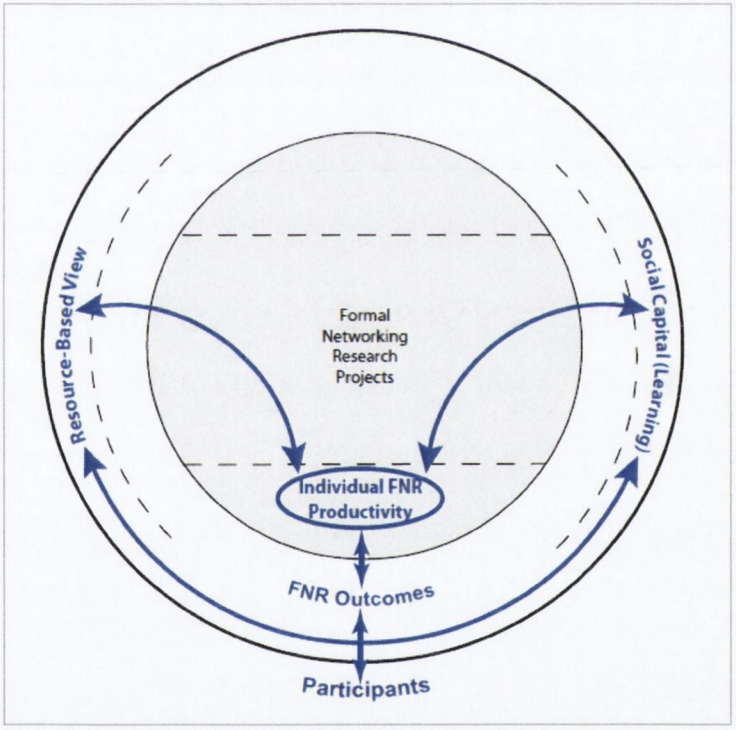

Figure 3-5: Conceptual Model (Version: Research Question 4)

Existing literature does not yet provide a straightforward answer to the question, whether or not such collaborative formations actually boost project performance or in fact, if they even improve the performance or research productivity of involved participants over time. In fact, only a limited number of studies empirically test these assumptions. Moreover, research suggests that research networking can be tricky and that research networks are not always well positioned to achieve their objectives. One possible danger lies in the heterogeneity of such international formal networking research programmes, which has been reported by some analysts (Godin & Gingras, 2000). Existing research suggests that funding and researcher productivity are related. If the European policy in promoting research networking through formal research networking programmes is successful, one should be able to see an increase in researcher productivity resulting from such networking.

3.6.3.1.1 Constructing a Measure of FNR Productivity (Hypotheses IA and IB)

Following the objectives of this thesis, an FNR productivity construct is proposed to include a range of FNR outputs (section 2.5.7). As noted by Porac et al. (2004), in general individual outputs (productivity) in collaborative projects positively relate to the *duration* of these projects. Furthermore, researchers' productivity increases in most collaborative networks but the increase is generally higher for more heterogeneous networks (Porac et al., 2004). Another study conducted by Bonzi (1992) suggests that there are some trends in scientific productivity over time. The findings from the studies by Porac et al. (2004) and Bonzi (1992) generally apply to funded collaborative research. In formal networking research (FNR) programmes where the funding sponsor only finances networking activities (and not the actual research), individual research productivity should improve over time. Based on pertinent studies of research collaboration and participant performance, this thesis hypothesizes that participant's research productivity associated with their participation in FNR projects tends to change over time (see Figure 3-6).

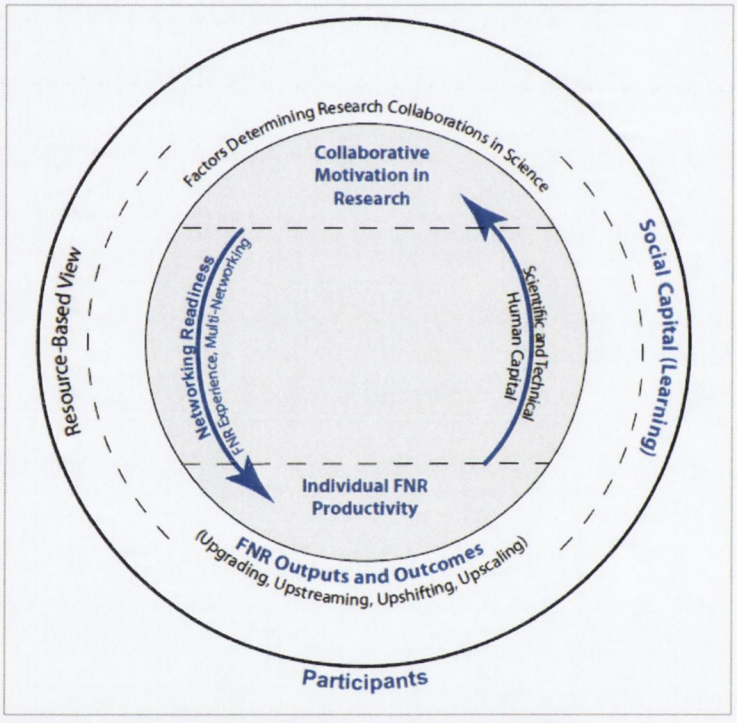

Figure 3-6: Conceptual Model (Version: Hypotheses IA and IB)

Those researchers who participated in programmes over a longer period of time tended to achieve greater research results (as measured by networking research outputs) when compared with other researchers who had been involved in the same programmes for shorter periods. To answer *question 4*, the framework puts forward the following related hypotheses:

***Hypothesis IA**: Individual researcher's FNR Productivity is associated with the researcher's concurrent involvement in multiple (more than one) formal networking research projects (multi-networking)*

***Hypothesis IB**: Individual researcher's FNR Productivity is associated with the overall time researcher is involved in formal networking research projects*

3.6.3.2 Constructing a Measure of UPGS Productivity (Upgrading, Upstreaming and Upshifting) (Research Question 5 and related Hypotheses IIA and IIB)

However, pertinent research suggests to distinguish between several groups of collaborative outcomes: *upgrading* of a researcher's performance through collaborative efforts, *upstreaming* in terms of activities and analysis, and *upshifting* their impact (Creech & Willard, 2001; Engel, 1993; van Zee & Engel, 2004). In the context of collaborative work, upgrading of performance is the result of collaborative use of resources, while upstreaming is the result of joint attempts to understand complex issues. Lastly, collaborative work allows social actors to upshift their impact with a focus on higher policy levels (van Zee & Engel, 2004). In the context of FNR projects, there is an assumption that researchers should achieve primary or operational outputs such as publications (i.e. joint publications in peer-reviewed journals, books), applied results (i.e. industrial applications and patents), and other results (new applications for new EU research funding, etc.). Such research outputs are generally anticipated. They would also be associated with all three categories of above-listed outcomes and they are direct collaborative results of research creativity and critical thinking through dialogue and exchange (van Zee & Engel, 2004). In addition, many formal international research projects (i.e. EU-funded research projects) are built around specific global and often complex research problems with an objective to shape policymaking. Impact on policymaking and decision-making is an important outcome. It can be linked to researchers further upshifting their impact, taking the focus of the work to a different level by allowing them to take part in the public or governmental discussion about developments in their field (van Zee & Engel, 2004). This study further suggests a more specific measure of participant research productivity associated with participation in FNR projects. This summative score (to be abbreviated as UPGS) is to include outputs falling into the three categories: upgrading, upstreaming and upshifting (see Figure 3-7).

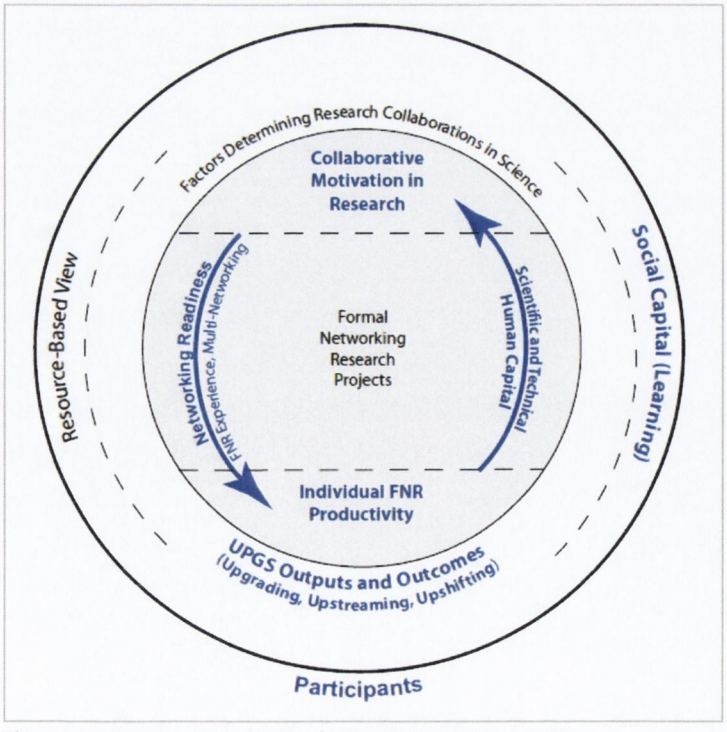

Figure 3-7: Conceptual Model (Version: Hypotheses IIA and IIB)

This leads to the following research question:

Research Question 5: *What is the relationship between the researcher's UPGS productivity and the researcher's multi-networking and the overall time of involvement in FNR projects?*

3.6.3.2.1 Examining UPGS Productivity (Hypotheses IIA and IIB)

To answer this question 5, the framework puts forward two related hypotheses. The proposed hypotheses suggest that UPGS productivity (similar to FNR productivity) will change over the time of the researcher's involvement in FNR projects (see Figure 3-7). It is further suggested that UPGS productivity is related to the researcher's multi-networking.

Hypothesis IIA: *Individual researcher's UPGS Productivity is associated with their concurrent involvement in multiple (more than one) formal networking research projects (multi-networking)*

Hypothesis IIB: *Individual researcher's UPGS Productivity is associated with the overall time the researcher is involved in formal networking research projects*

3.6.3.3 Constructing a Measure of UPSC Productivity (Upscaling) (Research Question 6 and related Hypotheses IIIA and IIIB)

Reviewed research suggests that networks are both a means and an end in themselves (Nunez & Wilson-Grau, 2003). In addition to the above-discussed collaborative outcomes, collaborating social actors can achieve some less implicit secondary collaborative results. Often, these results have a strong link with establishing legitimating research activities. In parallel to achieving expected research outputs, collaborators' involvement in projects can have an impact on their standing. As social actors are motivated to acquire higher levels of funding and recognition (credibility cycle), they have to work for recognition by their peers (Latour & Woolgar, 1979). Participation in projects can contribute to researchers' standing within their field. Under the earlier discussed concept of nested power, legitimacy frequently corresponds to the degree to which one has access to important resources or powers as in a way it shows the individual's power to be effective in cases when needed (Wiewel & Hunter, 1985).

Certain events such as international conferences are organised and attended by collaborating actors in order to raise awareness of developments in the field. Furthermore, participation in such funded international projects involving a wide variety of stakeholders can increase international visibility of research institutions whose personnel are involved in project activities. In turn, by involving high-profile participants, and funding research with a greater degree of impact, funding sponsors improve their international recognition. Following the logic discussed by van Zee and Engel (2004), this research proposes the fourth outcome category (in addition to upgrading, upshifting and upstreaming). The new category (UPSC category) suggests that social actors involved in formal collaborative projects can achieve *upscaling* in terms of peer-recognition and legitimacy. This research further proposes to develop a summative score measure of UPSC productivity, which can be assessed through a set of mostly intangible perceptual outputs such as improved peer

recognition and higher credibility levels (increased international reputation of participating researchers, improved reputation of their home institutions, etc.) (see Figure 3-8).

Research Question 6: *What is the relationship between the researcher's UPSC productivity and their multi-networking and the overall time of involvement in FNR projects?*

3.6.3.3.1 Examining UPSC Productivity (Hypotheses IIIA and IIIB)

In line with the earlier sets of hypotheses (sets I and II), the following hypotheses (IIIA and IIIB) suggest that UPSC productivity is related to both researchers' multi-networking and to the time of researcher's involvement in FNR projects.

Hypothesis IIIA: *Individual researcher's UPSC Productivity is associated with their concurrent involvement in multiple (more than one) formal networking research projects (multi-networking)*

Hypothesis IIIB: *Individual researcher's UPSC Productivity is associated with the overall time the researcher is involved in formal networking research projects*

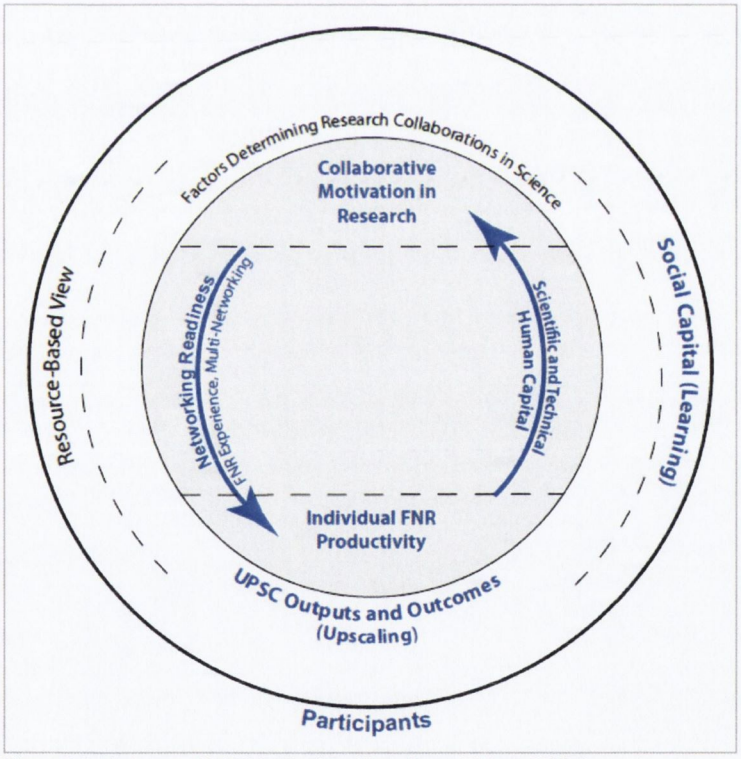

Figure 3-8: Conceptual Model (Version: Hypotheses IIIA and IIIB)

3.6.3.4 Overview of Research Questions and Related Hypotheses

Chapter 3 selectively reviewed a number of theories explaining collaborative research efforts with a focus on resource-based view and social capital theory. Based on the developed theoretical and conceptual framework, a number of research questions and related hypotheses are suggested and grouped into categories:

motivations, programme expectations and productivity. An overview of these questions and hypotheses is presented in Table 3-2 below.

Table 3-2: An overview of research questions and related hypotheses

<table>
<tr><th>Focus Areas</th><th>Research Problems</th><th>Research Questions</th><th>Related Hypothese and Additional Sub-questions</th></tr>
<tr><td>Motivation</td><td>What is researcher motivation in applying for FNR project funding?</td><td>Research Question 1A: What are the motives behind an individual researcher's decision to get involved in FNR projects?</td><td>Research Question 1B: Which individual Instruments associated with Formal Networking most interest Applicants?</td></tr>
<tr><td>Programme Expectations</td><td>To what extent are FNR project participants expected to achieve research outputs?</td><td>Research Question 2: What FNR outputs do funding sponsors expect from FNR participants?</td><td>-</td></tr>
<tr><td rowspan="7">Productivity</td><td>Which FNR outputs are actually attained by researchers involved in FNR projects?</td><td>Research Question 3A: Which FNR outputs can be achieved through participation in formal networking research (FNR) programmes?</td><td>Research Question 3B: What is the impact of Researcher's educational level, level of experience, scientific domain and professional background and country of work on their research outputs?</td></tr>
<tr><td rowspan="6">How does researcher's involvement in FNR projects affect Research Productivity over Time?</td><td rowspan="2">Research Question 4: Do FNR participants learn to network over the time of their involvement in FNR projects?</td><td>Hypothesis IA: Individual researcher's FNR Productivity is associated with the researcher's concurrent involvement in multiple formal networking research projects</td></tr>
<tr><td>Hypothesis IB: Individual researcher's FNR Productivity is associated with the overall time researcher is involved in formal networking research project</td></tr>
<tr><td rowspan="2">Research Question 5: What is the relationship between the researcher's UPGS productivity and the researcher's multi-networking and the overall time of involvement in FNR projects?</td><td>Hypothesis IIA: Individual researcher's UPGS Productivity is associated with their concurrent involvement in multiple formal networking research projects</td></tr>
<tr><td>Hypothesis IIB: Individual researcher's UPGS Productivity is associated with the overall time the researcher is involved in formal networking research projects</td></tr>
<tr><td rowspan="2">Research Question 6: What is the relationship between the researcher's UPSC productivity and their multi-networking and the overall time of involvement in FNR projects?</td><td>Hypothesis IIIA: Individual researcher's UPSC Productivity is associated with their concurrent involvement in multiple formal networking research projects</td></tr>
<tr><td>Hypothesis IIIB: Individual researcher's UPSC Productivity is associated with the overall time the researcher is involved in formal networking research projects</td></tr>
</table>

3.7 Summary

To summarise, Chapter 3 proposed to ground this study in a number of theories by developing an integrated theoretical framework. First, there is a focus on the resource-based view and social capital theory with explanations of important aspects of collaborative research. Secondly, this research examined further applicability of social capital theory literature in explanation of how researchers can potentially improve their research productivity through participation in formal networking research projects. Following this discussion of dominant theories, an integrated framework was proposed. In conclusion, a number of research questions and hypotheses have been further developed.

Chapter 4 will deal with literature on collaborative research in the ERA, identified trends in science and technology cooperation in the ERA. The review will focus on the European Union Framework Programmes (FPs) and research instruments made available to European researchers under the EU Framework Programmes (with a particular focus on the FP7 programme). A number of formal programmes supporting research networking in the ERA will be discussed: research schemes available under the FP7 (such as Networks of Excellence and ERA-NETs) and some other schemes that are not managed by the European Commission (such as ESF Network Projects and COST Actions). Once the conceptual framework and research context are determined, this research will determine what research methods are best positioned to answer the research problem through the proposed framework (Chapter 5).

Chapter 4. COLLABORATIVE RESEARCH IN EUROPEAN RESEARCH AREA

4.1 Introduction

Chapter 3 has provided a review of applicable theories which can be employed to explain formal collaborative research in terms of collaborative motives, research outputs and outcomes. Following the discussion of dominant theories, an integrated framework is proposed. Finally, this research proposed to develop a new research productivity construct based on collaborative research outputs and outcomes. A number of research propositions and hypotheses were then developed. This Chapter will further review pertinent literature on collaborative research in the European Research Area (ERA), which is a particular focus of this research thesis. In particular, Chapter 4 will review trends in science and technology cooperation in the European Research Area. The Chapter will then offer a discussion of the European Union Framework Programmes (FPs) and research instruments available to European researchers under the FPs, with a particular focus on the current Framework Programme 7 (FP7). Finally, this chapter will examine formal networking research programmes: research funding schemes available under the FP7 (such as Networks of Excellence and ERA-NETs) and other schemes that are not managed by the European Commission (such as ESF Network Projects and COST Actions).

4.2 European Research Area (ERA)

In 2000 the European Union decided to move towards building a homogeneous research area across all of its Member States. It was anticipated that by building this European Research Area (ERA) the Union would enable its scientists to move and interact with less effort across the EU, give them access to world class infrastructures, facilitating the development and strengthening of European networks of research institutions on the world level (European Commission, 2009b). The same vision also suggests that the ERA would allow Europeans to create and share new European value-added knowledge, to optimise the existing fragmented research efforts in order to address research questions of a complex nature. Ideally, the ERA should help the European Union to build and maintain stronger links with its partners globally in a way which would benefit Europeans and would contribute to global development, as Europe would take a greater role in international initiatives to tackle global problems (European Commission, 2009b).

The actual concept of the ERA defines the European way to excellence in research. In fact, the ERA is considered a major driver of European competitiveness in the globalised world. Some ERA objectives have taken the form of a single document '*2020 vision for the European Research Area*' (European Commission, 2009a). The most important of these objectives can be summarised in the following way:

1) To modernise existing research, education and innovation systems so that these three pillars of knowledge would interact at all levels and be supported by appropriate EU mechanisms;
2) To improve EU competitiveness in attracting international investments in R&D by creating an area of open innovation and building partnerships between businesses and a European public science base;

3) To provide coordinated support to researchers and research institutions in order to contribute to world-class S&T excellence in Europe, relying on cooperation and coordination where there is clear added-value; such coordination should bring national and regional research systems in line with policy objectives, dissemination, support mechanisms in a coherent manner;
4) To promote Science and Technology capacity-building across the European Union states, so that the entire ERA could build on their strengths while gaining and maintaining access to complementary specialised knowledge and S&T capacities in the rest of the EU;

Once in place, the ERA could provide a seamless area of freedom and opportunities for dialogue, exchange and interaction open to the world. This would help to open circulation of knowledge across national borders. To manage adequate and mutually beneficial collaboration with third countries Europe would have to employ appropriate intellectual property rights management and protection. As a result, the ERA could become the centre of the global networks of S&T leaders in research. However, to facilitate this further, the Europeans would have to allow for interoperable high performance information systems so that scholars could access, manage and share their knowledge. On the other hand, the EU would need to increase the attractiveness of its research institutions to high-level researchers across the globe. New ERA institutions would have to provide highly competitive working conditions for scientists and researchers around the globe and this mobility would be facilitated in the framework of a single labour market with minimal financial and administrative obstacles (European Commission, 2009a).

The best international specialists would be able to enter and continue their research and academic careers in the EU, international investors would be more inclined to increase their investments into EU research, which as a result would contribute to the Lisbon goals and would facilitate further job creation in the EU. Nearly a decade after the commencement of building of the ERA, creation of the European Research Area has become an important key to EU Lisbon Strategy together with other elements such as Single EU Market, the European broad-based innovation strategy and the European Higher Education Area (European Commission, 2009a). Despite many initiatives are widely supported across many EU States, there are still some national and institutional barriers that do not allow the ERA to realise its potential.

Some policy makers argue that research in the European Research Area should be open to non-Europeans too (European Commission, 2007a). With the ERA open to the world, it is important for the EU to work towards a coherent approach to international science and technology cooperation with its partner countries. A number of extremely large research endeavours such as ITER show that Europeans can be both highly motivated and capable of addressing global challenges with collaborators across the globe. While Europeans get involved with crucial initiatives at an increased rate, still this involvement is far from systematic and often is not well coordinated across the EU States. This fragmented and incoherent approach to dealing with highly important issues can often lead to a weaker influence of Europeans on the decision making process. This also means that Europeans as a whole are losing some of their potential impact on the international scene (European Commission, 2007a).

Working on these weaknesses means the EU Member states have to tackle issues related to insufficient project coordination, as well as inadequate research cooperation and collaboration policy across individual

EU countries especially when it comes to working with the third countries. To address these potential obstacles and weaknesses in its current policies, the EU identified three important directions (European Commission, 2007a). First, the EU must establish a wider and more open research area with its close neighbour countries under its current European Neighbourhood Policy. Second, it has to improve its relationship with developing countries in order to strengthen their S&T capacities, and to support their sustainable development (this particular concept is well explained by the *centre-periphery theory*). Finally, the EU has to work closer together with highly developed and industrialised countries across the world with priority given to programmes of mutual benefit and of global importance under principles of reciprocity (European Commission, 2007a).

4.3 Cooperation in Science and Technology in ERA

One conclusion from the Lisbon Summit in 2000 was to bring the European Union to a point where it is one of the most dynamic and competitive knowledge economies globally. The Summit has also identified instruments, which would help to achieve that level of development: science, technology, knowledge and innovation. Since then, these values were also accepted as fundamental elements of European societies. A few years later, at the Barcelona Summit in 2002, it was decided to establish a new high and very ambitious target of increasing the level of funding provided to R&D with an actual target set at 3 percent of GDP by 2010 (EU Council, 2002).

In the corner of the ERA policy is the recognition of the importance of ensuring integration of the European knowledge systems devoted to advancements in science and technology. The green paper published in 2007 introduced a new important focus of this policy (European Commission, 2007a). According to this focus, to ensure that Europe as a whole and its member countries individually are not losing their potential impact on the global scene Europe should bring together both EU nations (and regions) in an attempt to enforce a greater cohesion of the European Union single system of innovation. In line with the earlier policies, the 2007 green paper lists five main research features important to the research community in the European Research Area (European Commission, 2007a, p.2):

1. *An adequate flow of competent researchers* with high levels of mobility between institutions, disciplines, sectors and countries;
2. *World-class research infrastructures*, integrated, networked and accessible to research teams from across Europe and the world, notably thanks to new generations of electronic communication infrastructures;
3. *Excellent research institutions* engaged in effective public-private cooperation and partnerships, forming the core of research and innovation 'clusters' including 'virtual research communities', mostly specialised in interdisciplinary areas and attracting a critical mass of human and financial resources;
4. *Effective knowledge-sharing* notably between public research and industry, as well as with the public at large;
5. *Well-coordinated research programmes and priorities*, including a significant volume of jointly-programmed public research investment at the European level involving common priorities, coordinated implementation and joint evaluation.

However, the biggest change in this policy was an open recognition of the international aspect of science and research. In fact, the 2007 green paper explicitly praised the benefits from ties between the ERA and other international systems (European Commission, 2007a). This international collaboration is especially important as most countries' (or regions') research efforts are limited and therefore the EU is not self-sufficient in its research activities. The need of scientific internationalisation for the first time is central in the EU science and technology policy. As in the FP6, the international aspect at EU-level was praised as important in terms of bringing together European researchers: "*...Generation, diffusion and exploitation of knowledge are at the core of the research system. In particular, access to knowledge generated by the public research base and its use by business and policymakers lie at the heart of the European Research Area, where knowledge must circulate without barriers throughout the whole society...* " (European Commission, 2007a, p.16). The 2007 green paper by the EC explicitly called for the development of '*new channels and innovative approaches for communicating and discussing science, research and technology*'(ibid, p.17). However, the 2007 green paper has also put an additional emphasis on global collaboration efforts by proposing the *6th element* of the new ERA policy (ibid, p.2):

6. *A wide opening of the European Research Area to the world* with special emphasis on neighbouring countries and a strong commitment to addressing global challenges with Europe's partners.

The 2007 green paper resulted in long and wide-ranging debates through a process of public consultation. As a result, the expressed suggestions and recommendations from a range of stakeholders including national governments gave a push to a further discussion and was followed up by an EC-established ERA Expert Group report in relation to the 6th element suggested in the 2007 EC green paper 'international cooperation in S&T' (European Commission, 2008d).

Many research collaborations involve institutions at the same institutional level (European Commission, 2008d). Public participants such as universities are more likely to enter collaborative research arrangements with other academic institutions while business organisations are often inclined to enter collaborative research projects with other businesses. However, such scientific and research activities benefit considerably from collaborations among public and business players. This is especially crucial in emerging research areas where businesses can gain added-value from collaborating with academic laboratories and easily recruit trained young researchers. Such models of research collaboration (in particular in science and technology) are widely recognised by the EC in its European Research Area policy (European Commission, 2008d). Under the FP7 scheme, there are two particular sections: ERA-NETs and jointly implemented national research programmes under Article 169 of the EC Treaty.

4.4 The EU Framework Programmes

Both conducting European research policies and implementing European research programmes is an obligation under a chapter on research and technological development of the Amsterdam Treaty[16]. The Framework Programmes for Research and Technological Development, also known as Framework

[16] The Treaty of Amsterdam amending the Treaty of the European Union, the Treaties establishing the European Communities and certain related acts, commonly known as the Amsterdam Treaty, was signed on 2 October 1997, and entered into force on 1 May 1999; it made substantial changes to the Treaty on European Union, which had been signed at Maastricht in 1992.

Programmes (FP), are funding programmes established by the European Union with a specific objective to support, facilitate and encourage research in the European Research Area. The specific objectives and actions vary between funding periods. From the start of its first Framework Programme in the early 1980s, the European Union has been putting a lot of effort into increasing its market standing against its main competitors (primarily Japan and the USA). The European government strongly promoted the use of research groups and networks involving universities, research institutes, public organisations and private businesses. As a result of this dedicated public funding, more than 17,000 multinational research projects with over 85,000 collaborations by laboratories have taken place across the EU member states (EC, 1992).

Science-related policies also have long been included as an important part of the European integration process. In some principal EU documents (such as the Single European Act or the Maastricht Treaty), the competence in the field of science and technology to a large extent has been given to the European institutions (Breschi & Cusmano, 2004). As a result, a number of dedicated instruments have been developed and implemented. European institutions have been given competence in the area of science and technology and have developed several actions in order to promote and coordinate R&D, create pan-European networks and stimulate the European mobility of researchers (Breschi & Cusmano, 2004).

A wide range of research parties from a number of different countries with diverse scientific and research cultures and agendas in collaborative research explain an EU wide endeavour for some standardisation and alignment of research efforts and methods. There is a consensus in the literature that the EU Framework Programmes promote exchange and diffusion of scientific and technological knowledge through the development of collaborative practices across member states.

4.5 FPs and Defragmentation of the European Research

While the EU overall has a good record of research, this record is a result of fragments of work across many institutions and universities. Many of these research efforts are not synchronised on the EU level, in fact, of all public sector research in the EU only a small share of it takes place at the EU level, the rest occurs at the national or regional levels (European Commission, 1997; Gusmao, 2001). As existing research activities do not take full advantage of the EU setting, the European Commission proposed in 2000 to create a single European Research Area (ERA). Creating such a space is thought to contribute to a greater defragmentation of European scientific and technological activities. This ERA proposal was further endorsed as a part of the Lisbon strategy to improve European competitiveness globally. The EU's Framework Programme 6 (FP6) was highly affected by this policy and was adopted as a crucial element in building the ERA. The FP6 and the following FP7 became the key financial mechanisms in the EU. These Programmes were constructed with the Lisbon strategy objectives in mind. In fact, the title for the initial EC proposal for the FP7 reads 'Building the ERA of knowledge for growth 2007-2013'.

The Framework Programmes for Research and Technological Development are one of the main EU instruments for the support and promotion of research across the EU States and for creation of the common European Research Area. Along with the changes in EU research policy, the structure and activities of these Framework Programmes change from one programme to another. At the same time, some of the underlying

mechanisms supporting research are still the same. Each consecutive Framework Programme is built on strong collaborative principles. With research becoming more high-level, costly and complex, society resorts in many cases to collaboration and cooperation (including the research networking or increased researcher mobility) seen as an essential element of ensuring the overall progress and development in the scientific field (Defazio et al., 2009).

Overall a large majority of Europeans believe national research activities in the EU Member States should be more coherent as 83 percent of surveyed Europeans[17] believe there should be more coordination of these research activities across national EU borders (European Commission, 2007a). Management of state of the art knowledge is certainly central to the success of any research effort. Provision of consistently reliable and affordable access to the results of research activities as well as their dissemination are intended to become the defining principles of the European Research Area. Multiple research results across the EU are necessary in the form of research databases, publications and other research information and results. These can be jointly managed and integrated at the European level, there are some additional potential benefits in linking these with the similar sources of scientific information across the globe. The European Commission proposes to stimulate the sharing of this knowledge across its borders (European Commission, 2007a). As well as being able to manage and share scientific information, there is a need for further effective channels and platforms for discussing these results. These channels are important for the general scientific validation and dissemination of these research results but also they ensure European awareness of, and commitment to, important issues. The current Treaty of the European Union has two major objectives for the Framework Programmes. First, the FPs should strengthen the scientific and technological bases of industry to ensure its international competitiveness. Secondly, the Framework Programmes also work to support European Union policies. Since the beginning of the 1980s, the European Union viewed collaborative research within the FPs as a way of achieving these objectives.

Historically the Framework Programmes has seen a number of important changes since launching. The FP3[18] addressed the challenges relating to the development of the European Internal Market. The FP4 went along with the Maastricht Treaty[19] and the White Paper[20] on Growth Competitiveness and Employment (European Commission, 1993). The next fifth FP had the rising interest in socio-economic values in the background, while the FP6 focused on developing the European Research Area (European Commission, 2007a; FP6 Expert Group, 2006). The common feature of all successive Framework Programmes is in the way they are built on the principles of collaborative research. These very principles have been around since the early 1980s when they were introduced by Commissioner Davignon to assist the competitiveness of the European electronics industry. The FP6 made collaborative research very central to its instruments. As the FP6 proceeded with the ERA in mind, the programme introduced four new major funding instruments, which aim at increasing international research collaboration.

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[17] Eurobarometer: Europeans, Science and Technology, June 2005, http://ec.europa.eu/public_opinion

[18] The early Framework Programme generally ran for 4 years: FP3 from 1990 to 1994, FP4 – from 1994 to 1998, FP5 – from 1998 to 2002, and the FP6 – 2002 to 2006. Only the current FP7 has a longer duration of 7 years – from 2006 to 2013.

[19] The Maastricht Treaty (formally, the Treaty on European Union, TEU) was signed on 7 February 1992 in Maastricht, the Netherlands. It created the European Union and led to the creation of the euro.

[20] European Commission. White Paper on Growth, competitiveness, and employment. The challenges and ways forward into the 21st century, 1993.

The EU funding of different forms of research networking has an objective of tackling the fragmentation of national research activities across the EU Member States through promotion of cross-border collaboration between individual scientists and research organisations (Defazio et al., 2009). In many funding programmes, these networks are expected to provide researchers with opportunities to collaborate with others to create and share new knowledge and scientific information. An EC report suggested in 2005 that the EU does not take full advantage of its scientific base even though the EU is one of the global leaders when it comes to scientific outputs measured in total number of publications and their global share (European Commission, 2005). However, figures from the report also indicated that with the global share at 38.3 percent in 2003, the EU still has a number of patents per capita lower than Japan or the US. Importantly, some individual EU States such as Finland and Sweden performed better than Japan, and the Netherlands and Germany achieved results higher than the US.

The Framework Programmes have been designed to support the very creation and development of the ERA. Since the establishment of the FPs, their budget has been significantly increased, and correspondingly their objectives developed and matured over time. The Seventh FP and other instruments such as the new European Research Council can potentially have an important impact on the European Research Area. The European Institute of Technology (first proposed a few years ago) is yet another important instrument in the process of building world class knowledge and innovation communities (European Commission, 2007a). A number of initiatives have been launched to facilitate the all-European coordination of fragmented research activities and programmes across the EU States. Some such initiatives are the European Technology Platforms and the ERA-NETs. While the European Technology Platforms aimed to develop the long-term visions and strategic research agendas of business values, the ERA-NET scheme targets to bring into one framework fragmented national research programmes in the EU States.

4.6 EU FP Collaborative Instruments

Most funding instruments introduced under the initial Framework Programme in 1984 considered only proposals submitted by collaborative networks of researchers. This tradition continued in all of the following Framework Programmes. These networks do not necessarily have to be established prior to the project's commencement, so as a result most of the research networks consist of people who have collaborated prior to the current project and those who have not. While the Framework Programme instruments require researchers to apply for funding and to conduct research in groups and networks, these instruments do not define any particular structures or forms for such collaboration or networking, nor do they require any particular nature of the linkages prior to the project (Defazio et al., 2009).

These EU-supported research networks are expected primarily to combine scientific and technological information, knowledge and resources. The format of research networking generally allows for sharing of these assets in an organised and coordinated manner and yet it allows partners to interact with mutual benefits. To ensure the sustainability of such a format, networking partners employ a variety of platforms for sharing and joint knowledge creation. Conferences, workshops, seminars and mutual exchange visits are just some of them. Generally, these are expected to deliver an array of outcomes and outputs from joint publications, patents as well as some intangible results such as creating and sustaining collaborative relations.

Defazio et al. (2009) further argue that each research network has its own motivation and history of the working relationships behind it; and that these characteristics have an impact on the way the network functions as well as on its effectiveness and the potential impact.

In the following sections of the Chapter, this thesis will examine some general formal collaborative instruments introduced under the FP6. This will then be followed by a discussion of the recent changes introduced within the FP7 and some of the newest collaborative instruments. After this it will focus on some of the existing formal programmes with a specific focus on research networking within the ERA.

4.6.1 Integrated Projects

The first of formal collaborative instruments (introduced under the FP6 budget), *Integrated Projects* (IPs), are medium to large size collaborative research projects with holistic work-plans with a minimum of 3 partners (from 3 countries) who can later be joined by more participants. The IPs aimed to improve European competitiveness in basic and applied research with a particular focus on addressing major need in society as defined by the FP6 Priority Themes.

Within its 3-5 year life cycle, such a project is expected to deliver its objectives and to involve relevant small or medium sized enterprises as to establish the commercial viability of its research results. Despite this, the EC is particularly keen on delivering commercial results in addition to purely scientific ones, the overall flexibility of the project is somewhat limited. The overall workflow is predetermined largely from the start of the project with the coordinating organisation playing a key role in mediating participation in the project. One other criticism of the IPs is that often they are more modular than collaborative in nature (European Commission, 2007a). The monetary value of the activities integrated by an IP is generally in the range of several tens of millions of euros. The funding, provided by the European Commission in IPs, covers all eligible project related expenses and costs but it generally takes the form of a grant to the budget, as a percentage of the total costs of the project.

4.6.2 Specific Targeted Research Projects

Specific Targeted Research Projects (STREPs), also previously known as 'shared-cost' actions, are yet another FP instrument dealing with objective-driven research. They are limited in scope, since they usually focus on a single issue and, as such, are often mono-disciplinary.

The objectives of the STREPs projects are smaller than in IPs and therefore the scope of activities pursued within the STREPs is usually not as wide as those under the Integrated Projects. STREPs involve a smaller number of participants and focus on narrower research objectives defined in predetermined work-plans. The STREPs can be considered the most typical form of collaborative research traditionally supported by the FPs (European Commission, 2007a). And even though the STREPs are similar to IPs in that they also advance knowledge, the main difference between them is that STREPs focus on a smaller single research problem where the IPs work on the multi-disciplinary complex research issues.

4.6.3 Coordination Actions

Another key FP instrument is *Coordination Actions* (formerly known as concerted actions/thematic networks). Coordination Actions aim to provide researchers and areas of policy application with several different forms of coordination or support. Coordination Actions promote coordination, cooperation or networking a range of research and innovation projects or operators for a specific research objective. They generally aim to achieve improved integration and co-ordination of European research for a fixed period. They do not provide support for research and development. Generally, there is a minimum requirement for the size of the partnership; however, there is no limit on the maximum number of participants per Action.

While the earlier discussed Networks of Excellence have an explicit requirement for durable integration of researchers, Coordination Actions do not set such a requirement. As a result, Coordination Actions by focusing on specific research objectives are seen as a better instrument for achieving standardisation or just coordinating research projects funded from elsewhere. Coordination Actions are also perceived as a lighter framework by industrial participants.

4.6.4 Specific Support Actions

Another instrument that is quite similar to Coordination Actions is *Specific Support Actions*. Specific Support Actions (SSAs) have an objective to contribute to the implementation of the FPs, the analysis and dissemination of research results, or the preparation of future activities (European Commission, 2004b). On the other hand, SSAs are used to stimulate stronger international scientific collaboration, as well as greater involvement of SMEs, plus other research institutions such as research teams from new Member States (and Associated Candidate Countries[21]). Therefore, SSAs are often seen as the first step to the next larger scale research project. In many cases participation in a SSA leads to a new proposal for either Networks of Excellence programme or Integrated Projects. However, as the SSAs have a limited agenda and generally do not include more than several participants these participants receive very limited funding with no provisions for the actual research or development activities.

Even in comparison with Coordination Actions, the SSAs are more limited in scale. While the SSAs are similar to Coordination Actions in the range of activities that they offer (except for the training element), the concepts behind them differ significantly. The SSAs are seen as irregular once-off events with a small number of participants, while the Coordination Actions generally are generally of longer duration, have longer-term workplans and often involve a large number of participants.

4.7 The Framework Programme 7 (FP7)

FP7 is the largest Framework Programme ever with a budget of EUR 50,521 million for the duration of seven years from 2007 to 2013 (European Commission, 2008d). With its recent momentous decision to invest EUR 86 billion in the 7th FP, the European Commission aims to improve European adaptability to change through

[21] All legal entities established in these Associated Countries are eligible for funding on the same footing as legal entities from the Member States. The following countries are presently associated to FP7: Switzerland, Israel, Norway, Iceland and Liechtenstein, Turkey, Croatia, the Former Yugoslav Republic of Macedonia and Serbia, Albania and Montenegro, Bosnia & Herzegovina.

establishment of new (or stronger) infrastructures in forms of technology transfer centres and other R&D infrastructures promoting clusters, networks as well as support for entrepreneurship (European Commission, 2004b, 2008a). With the introduction of the Seventh Framework Programme the overall policy towards cross national scientific collaboration and cooperation moved to a new level. The policy follows a new approach with a particular focus on international collaboration and cooperation. International collaboration in the European case can be complex: it includes research collaboration across internal EU borders and associated countries as well as all the other third countries. While the FP6 also strongly promoted the benefits of the cross-border research collaboration, under the FP7, all of the four specific FP7 programmes (Cooperation, Ideas, People and Capacities) support some form of international collaborative work.

The first of the programmes, 'Cooperation' is primarily aiming to facilitate a number of forms of international cross-border research activities with a budget of just over EUR 32 billion. The 'Ideas' Programme with a smaller budget of about EUR 7.5 billion focuses on bringing scientists from the third countries to conduct research in Europe. The next FP7 programme 'People' specifically focuses on support for researcher mobility[22] (both incoming and outgoing) with a budget of EUR 4.75 billion. The last programme 'Capacities' has a budget of about EUR 1.75 billion and aims to support horizontal actions and other measures. 'Capacities' addresses the regional needs for clustering and networking. Under the 'Capacities' actions, there are two specific programmes, which address needs of the European regions with a dedicated budget of EUR 466 million.

The first of the two programmes '*Regions of Knowledge*' has a budget of EUR 126 million and in particular targets mainly regional research driven clusters also known as RRDCs. The second programme '*Research Potential*' with its budget aims at building new capacities based on the potential of research organisations and institutions in the convergence and outmost regions. Another programme 'The Competitiveness and Innovation Framework Programme' (CIP) focuses primarily on businesses as well as related institutions such as business centres, knowledge transfer centres, and other forms of knowledge producing agencies in advanced regions. Regions of Knowledge, Research Potential with the CIP programme cover a range of researchers from PhD students and individual scientists to research organisations, academic institutions, companies, non-governmental organisations, government organisations and other research infrastructures. Other research instruments that exist in the ERA are Marie Curie actions[23] (under the FP7 People programme), European Technology platforms[24] (ETPs) and a number of schemes under the Article 169 of the EC Treaty[25].

This thesis is primarily focused on formal collaborative programmes supporting research networking within the FP7. Therefore, the following section of this chapter will look closer at some of the funding instruments available under the Programme. As mentioned earlier, the biggest element of the FP7 budget is directed at the programme on 'Cooperation'. The 'Cooperation' programme is designed to support and encourage all types of research activities carried out by different research bodies in international collaboration. The FP7 allocates

[22] This programme 'People' also offers a special track for mobility between the EU and the target countries of the European Neighbourhood Policy (ENP) and third countries with an S&T Agreement with the Community.
[23] For more information see: http://cordis.europa.eu/fp7/people
[24] More information on European Technology platforms see: http://cordis.europa.eu/technology-platforms
[25] For more information on the EC Treaty, Article 169 instruments see: http://cordis.europa.eu/fp7/art169_en.html

EUR 32,413 million to the Cooperation programme, which will go to supporting collaboration and cooperation between academic institutions, industry, research centres, and public organisations both on the EU level and globally.

The actual Cooperation programme is further divided into ten individual themes. Each theme is autonomous but is expected to maintain coherence within the overall Cooperation Programme. Each theme is also expected to ensure that certain joint activities across different themes can be further enhanced through joint calls or other arrangements. These ten individual themes are in the fields of knowledge and technology where research excellence is particularly important to further improving Europe's sustainable development. Across the ten themes, support to international cooperation will be implemented through the following schemes:

1. Collaborative research;
2. Coordination of national research programmes;
3. Joint Technology Initiatives;
4. Technology Platforms;

A significant part of the EU research funding from the FP7 budget goes to collaborative research, with the objective to establish high-level research projects and research networks, which would further attract human and financial resources from within and outside of the European Union. A number of funding schemes have been introduced to facilitate these ambitious objectives:

- R&D Collaborative projects (the earlier covered IPs and STREPs under FP7 became one instrument);
- Networks of Excellence;
- Co-ordination/support actions, etc.;

4.7.1 Coordination between National Research Programmes

The Commission stakeholder consultation on the future of European research argued for a stronger support for coordination of nationally funded research programmes (European Commission, 2004a). The FP7 supports two main instruments, which are expected to reduce its fragmentation in several national and regional research programmes by promoting and supporting the development of joint calls, joint programmes and actions supported together by several Member States as well as the European Commission.

The first instrument, ERA-NET scheme, is expected to improve and strengthen the coordination of national and regional research programmes. The second set of instruments (Actions under Article 169) aims at bringing together parts of national and regional programmes for implementing jointly, together with the Commission, a real European research programme. The actions supported here may cover subjects not directly linked to the ten themes as long as they contribute to the creation of EU added-value. On the other hand, the results from these programmes can contribute to the complementarity and synergy between the Framework Programmes and research activities carried out under intergovernmental structures[26].

[26] Such as EUREKA and COST

4.7.2 Joint Technology Initiatives (JTIs)

Joint Technology Initiatives (JTIs) are a form of public-private partnership organised at the European level with a particular objective to address research questions and areas of particular importance to the EU competitiveness globally (European Commission, 2008c). JTIs were introduced as a new instrument within the Seventh Framework Programme. These partnerships generally take the form of a *multinational* large-scale research project, which bring together both public and private partners and stakeholders in order to define their research project's objectives of high societal importance and to eventually combine funding and research activities to achieve these objectives. Knowledge creation is often expected to result in tangible outputs such as creation of spin-offs across the EU.

Generally, the combination of the European and national levels of research is anticipated to deliver results in areas where most single players such as industries would be able to achieve greater results by joining their efforts with other crucial players in the field. Another expectation is related to creation of added-value by creating additional incentives for increased spending by all players on research and development activities (European Commission, 2008c). Based on a number of criteria developed by the European Commission, there are five areas of research where a JTI can be considered as particularly related: fuel cells and hydrogen, aeronautics, embedded computing systems, innovative medicines and nano-electronics (European Commission, 2008c). While many JTIs are the results of European Technology Platforms, formally, they are established on the basis of an EC proposal by a Council regulation and these initiatives are often approved for a duration of up to 10 years. Their funding will be provided mainly by the Member States and the European Community as well as some[27] non-monetary contributions (such as equipment and personnel) expected from some industry participants; additional funding can be achieved through other sources such as the European Investment Bank, Structural Funds and other forms of private investment.

Practical arrangements are somewhat complex as JTIs are legally established bodies[28] with dedicated budgets and personnel. Such a Joint Undertaking sets a framework for all participants to manage their collaborative work including the process of decision making, although there are often several decision-making bodies. The JTIs are expected to deliver a number of regular reports on their activities to the European Council and the European Parliament, with additional monitoring and assessment activities involving the European Commission.

4.7.3 European Research Infrastructures

The idea of the ERA has been guiding EU's research policy development for the last decade (European Commission, 2008a). An important part of this policy is focused on the European Research Infrastructures (ERIs). As a crucial step on the path of making Europe one of the most competitive knowledge driven economies globally, there is a need to establish some of the world's best research infrastructures in Europe so that these pan-European facilities are used for world class training and research.

[27] Industry contributions cover at least 50% of the total cost of the research projects.
[28] JTIs generally take a form of a Joint Undertaking set up based on Article 171 of the EC Treaty.

The European Strategy Forum for Research Infrastructures (ESFRI) was established by the EU Member Countries and the European Commission in 2002. At the November 2004 Competitiveness Council the European Research Ministers called on ESFRI to develop a European roadmap for the construction of the top research infrastructures. Several years later, in 2006, ESFRI launched the first European Roadmap for Research Infrastructures that consisted of thirty-five projects across all research disciplines. The 2006 Roadmap was only seen as preliminary with the possibility to adjust the list of projects. ESFRI to an extent played an essential role in building this Roadmap, and therefore strongly contributed and shaped ERA policymaking.

Previously the Framework Programmes were seen as the main funding tool, which supported European research networking as well as some other research activities of the cross-European Research Infrastructures. However, the introduction of the European Research Infrastructures scheme achieved a particular goal of ensuring pan-European access for scientists and researchers to the state of the art research facilities. Some EC figures suggest that the ongoing scheme activities give about 30,000 researchers direct access to existing research facilities which are not located in their home countries or regions (European Commission, 2008c). Following the success of these activities under the FP6, the overall budget for their support has been increased under the FP7 from EUR 730 million to more than EUR 1,700 million under the new FP7 budget. Under the FP7, European Research Infrastructures scheme receives additional support from other FP7 schemes (such as 'People' and 'Ideas') to ensure both complementary and full use of the ERIs as well as construction of new ERIs.

In addition to the above discussed programmes there are formal programme financed within the FP budget that are specifically focused on promoting and facilitating networking between researchers within the ERA. Some of these schemes will be reviewed in detail in the following sections of this work.

4.8 FP Research Networks

In some cases, European-wide research networks allow for standardisation and improved compatibility and usability of research existing nationally, as well as these networks allow to advance the body of knowledge in the field, to increase the role of researchers in European policy making, and to increase the quality and impact of research findings originating within the programmes (Engel, 1993). Researchers might also be willing to upstream their activities through a means of teaming up to join forces and work jointly on finding new ways of understanding the surrounding environment and any particular objectives when traditional methods fail. Engel further suggests that researchers can become dissatisfied with their impacts and can decide to network in an attempt to up-shift their impact.

Networking with other stakeholders in this case may allow them to focus on a higher policy level that allows them to participate in the public debate, and effectively may allow them to influence policy making on both the local, national and international levels. Organisations involved in scientific academic research and industrial level research and development have their own two different communities with their own rules and behaviour. Because of different socio-economic structures and the resultant institutional distance between, large scale collaborative projects can take on a bridging role (Ponds et al., 2007). As discussed earlier, many

research networks generally consist of several different organisations and players, both public and private, as well as some non-governmental organisations (Mandell, 1999b). While these individuals and organisations take on specific activities their impact as a network addresses broader tasks that go way beyond their individual objectives. The network structures in place allow the creation of added-value through collaborative research work as well as the coordination of individual research activities. Unlike other forms of collaboration, research networks are established around participants' commitment to joint objectives and their interdependent work. These networks are also different from those collaborations with contractual obligations. Research networks are often built to create and enhance social capital (Coleman, 1990). In many research networks the hierarchical structures are either non-existent or the person/organisation in charge have little power. While some social actors can have greater powers than others, these individual powers do not play the same role within the network.

The overall structure of a network is supported by its members who realise that collectively they are able to achieve greater results and therefore their activities are dependent on those of the others. This interdependency rather than individual participants' levels of power is a distinctive feature of the networks and is sometimes referred to as horizontal management as compared with vertical management (Mandell, 1999b). While there are different arrangements (for example a task force or panel) for managing a network, these structures are not critical. Some traditional coordination and control methods are often not able to support networking structures together. Mandell (1994) introduced a new concept of programme rationale, which is the group mindset that keeps together all separate elements of a network. According to the same author the very strength of these networked communities depends on the extent to which they realise and capitalise on the advantages derivable from the structure of networks (Mandell, 1999b).

Generally, one of the reasons for collaboration on research is to advance the research quality both in individual EU countries and on the European level. It is generally believed that scientific networking leads to more and stronger research ideas that can develop into something more significant such as networks or centres of excellence. Researchers argue that many governments promote and engage in scientific research with the goals, which are often not the advance of science itself but lies merely in the use of the results of this research for society-broad goals (Ponds et al., 2007; Raymond, 1997):

1) Well-defined problems through Informal Research Networks;
2) Complex problems through Centralised Research Facilities;
3) Complex problems through Formal Research Networks.

Two examples of such research networking schemes backed and financially supported by the European government are ERA-NETs and Networks of Excellence.

4.8.1 Networks of Excellence

One of the formal research networking instruments introduced under the FP6 is the *Networks of Excellence* (NoEs). The NoEs have been introduced as a means of strengthening excellence through bringing together fragmented national research activities across the EU States. The main deliverable of a NoE is a durable structuring and shaping of the way thematic research is carried out within the network. The main difference

between the NoEs and the rest of the instruments is in a greater internal flexibility in ways of pursuing its research objectives. The funding provided under the NoEs covers both the research itself and the costs associated with sustaining the networking administration and facilitating active ongoing collaborative efforts.

The NoEs are seen as a longer-term instrument with the average duration of a NoE of about 5 years and a maximum of seven years. They also are more likely to involve less centralised structures as well as they are supportive of outreach collaboration well beyond the originally planned network (European Commission, 2003, 2007a). While it is anticipated that business and industry participants would also take part in the NoEs, they are, however, sometimes reluctant to participate directly in Networks of Excellence. NoEs were initially formed to assist in the 'defragmentation' of the European research as well they were intended to boost the S&T excellence of European research on particular research problems through a combination of needed resources and expertise (FP6 Expert Group, 2006). Under the scheme conditions, at least six partners should be at work on any research project with activities ranging from educational to dissemination. Interestingly, the geographical dimension of the programme is very specific as a large proportion of all NoE coordinators (approximately 48 percent of the total number) are located in France and Italy, which receive 24 percent of NoE funding received by the Member Countries; while there were only two NoE coordinators from the newer Member States (FP6 Expert Group, 2006).

Officially, NoEs were established to strengthen Europe's excellence on a particular research topic by integrating the critical mass of expertise needed to provide European leadership and be a world force through a joint programme of activities. NoEs were aimed primarily at creating a durable integration of the research capacities of the network partners while at the same time advancing knowledge on the topic. So, primarily, NoEs as an FP instrument were charged with tackling the fragmentation of European research which was seen by the European Union as a potential disadvantage of European science. Therefore, the deliverables from NoEs would be expected to take the form of a durable structuring and shaping of how research is carried out in Europe. NoEs are generally allocated significant budgets. An average NoE with about 200 participants over its five year life time would receive about EUR 18.5 million (not including any bonuses for doctoral students) (FP6 Instruments Task Force, 2003). This budget can be used for covering a wide range of research activities, which can be grouped as follows:

1) Integrating activities:
    a. coordinated programming of the partners' activities;
    b. sharing of research platforms/tools/facilities/infrastructure;
    c. joint management of the knowledge portfolio;
    d. staff exchanges, possibly relocation of staff and equipment;
    e. reinforced electronic communications.
2) Joint research activities:
    a. a programme of joint research to support the network's goals.
3) Activities to spread excellence:
    a. training programme of researchers and other key staff;
    b. dissemination and communication.

Additionally, to their defragmentation role, NoEs also have the mission to spread excellence both within Europe and globally. While in the beginning, NoEs were expected to have budgets of millions of euros and were supposed to build on the participation of very few participants, later, this concept has undergone some changes and as a result the NoEs moved towards having many participants in its projects. Eventually, NoEs became somewhat large and strongly academic as there were only very few[29] non-academy participants. Many NoEs conduct research in a manner very similar to research networking schemes found under the COST and ESF frameworks with only a very few NoEs that have achieved a greater level of integration (FP6 Instruments Task Force, 2003). As this brief review showed, the NoEs are generally large-scale research projects with a degree of internal flexibility.

The EC expects that the internal financing structure would create strong incentives for active and ongoing collaborative research efforts. A later survey of the NoE participants suggests that those participated in the NoEs tended to do so because it was a partial requirement in a Call. Most NoE participants engaged and built larger research networks so they could be exposed to more peers and partners from interdisciplinary perspectives. While the impact of these NoEs was assessed generally as higher than what would had been achieved through other FP instruments (such as STREPs), still participants perceived NoEs as a platform for meeting new peers and for writing joint proposals to other instruments rather than for the purpose of conducting actual research together (Technopolis and GHK, 2008).

In the 2006 report, the FP6 Expert Group suggested that while the NoEs were established as an instrument for increasing critical mass within the ERA, it was not fully achieved. One of the possible reasons why the NoEs did not manage to fulfil their original task was the EC's strong desire to bring as many research participants into these networks as possible; as a result such increased participation led to increased fragmentation of ERA research. In the last two decades, many of the EU States invested heavily in their own centres of excellence to minimise national fragmentation of national research. With fewer calls for NoEs in the Framework Programme 7, it was recommended that some of these networks should be continued as Joint Research Initiatives (JRIs). This would require long term support and funding to realign research space and community through the means of research networking, and which should not be limited to small numbers of participants (FP6 Expert Group, 2006). Another 2006 report strongly recommended that the role of NoEs is further extended to include more networking and greater integration of national research schemes and other national technology platforms (ITRE, 2006). As a result, the role of this instrument is shifting from basic integration of partner research activities to collaborative work towards achieving complex research objectives. In addition to the Networks of Excellence, there was one more research-networking programme introduced within the Framework Programme – ERA-NETs.

4.8.2 ERA-NETs

An FP instrument, *ERA-NET* Scheme, was first launched in 2002. This bottom-up programme was built with the support for the coordination of national and regional programmes in mind. ERA-NETs are also expected to contribute to the strengthening of the ERA through the provision of new answers to shared research and scientific problems. The objective is to encourage organisations programme owners and managers of national

[29] Industry obtained only 7.6% of the participations and a mere 4% of the funding (EC, 2006)

and regional research schemes and programmes to take advantage of joint activities including strategy development and in some cases even joint calls for international research (European Commission, 2008b). The difference of ERA-NET as a programme is that participation in it is limited only to programme owners (these are generally national ministries and regional authorities) and to programme managers (for example research councils or funding agencies). This eligibility criterion means that all the rest of research institutions and universities, which are not official programme owners or managers would be ineligible to become partners for ERA-NET actions (European Commission, 2008b).

The ERA-NET scheme works through three different types of actions: Coordination Actions (CA), ERA-NET plus Actions and Specific Support Actions (SSA). Coordination Actions are ERA-NETs (new or in some cases existing actions) wishing to broaden and deepen their scope. Specific Support Actions are expected to contribute to the implementations of the Framework Programmes, and preparation of future Community research. These actions generally have a smaller well-defined objective and often are only take a form of once-off events. ERA-NET plus Actions is a new form of ERA-NETs introduced recently under the FP7. ERA-NET plus Actions are projects in receipt of additional EU financial support to facilitate joint calls for research proposals (between national/regional programmes). They provide additional EU financial incentive to national and regional research programmes that pool financial resources to facilitate joint calls for proposals.

These actions must have a high European added-value and are available only in a limited number of cases (CORDIS, 2009). ERA-NET Plus has three rules – they have to include at least five participants from five different Member or Associated States, their joint call must be at least EUR 5 million, and the maximum duration of these actions is five years. Within the FP6, 26 SSAs and 71 CAs were selected for funding. These involved over 1000 representatives from 38 countries (25 EU Member States; eight Candidate and Associated States; and five 'Third Country' States) (ERA-NET Expert Review Group, 2006). The selected CA Projects spanned four broad 'vertical' areas (Industrial Technologies, Life Sciences, Environment and Energy, and Humanities and Social Sciences) and two crosscutting, 'horizontal' areas (International Cooperation and Fundamental Research). Project representatives were largely from national ministries (38%), funding and other agencies (28%) and national/regional research councils (23%).

The first fourteen ERA-NET Actions were selected under the FP7 call and they represent fields such as health, food, energy and environment with a small number of activities not defined by the Cooperation themes. Examples of these approved ERA-NETs include the following:

- EUROCOURSE: Europe Against Cancer: Optimisation of the Use of Registries for Scientific Excellence in Research;
- ARIMNET: Coordination of Agricultural Research in the Mediterranean;
- ERA-ENVHEALTH: Coordination of National Environment and Health Research Programmes – Environment and Health ERA-NET;
- iMERA-Plus: Implementing Metrology in the European Research Area Plus;
- NETWATCH : Development of a Central Information Platform for ERA-NETs under ERAWATCH (preparatory phase).

The existing literature reviewing the ERA-NETs is limited and fragmented with most of the available reports being the official ERA-NET reviews. One of the few identified papers on the topic is such a report by the ERA-NET Expert Review Group (2006). General understanding is that participants in ERA-NET projects were generally very positive about these projects and the outcome, however, there is certainly some room for improvement in some areas of the Programme. These and some other recommendations of the report by the ERA-NET Expert Group are generally focused on the aspects related to running the operations within the projects and give only limited overview of the Programmes outputs and outcomes. The report however argues that there is a strong demand for an instrument such as ERA-NETs as over 2000 organisations submitted applications. This response by the scientific community suggests that while researchers and scientists are well served by their national and regional programmes there is a strong need for instruments which would bring together '*relative advantages enjoyed by national and regional programmes over their international equivalents*' (ERA-NET Expert Review Group, 2006, p.11). According to this view, the ERA-NET scheme allows the combination of greater familiarity of researchers with their national administrative procedures and personnel and the benefits of international programmes such as access to greater research funds and international expertise.

The report has also recognised the fact that these identified policy benefits are not limited to the ERA-NET programme as there are other policy instruments which also support international research and science in a similar manner. A number of multilateral agreements outside the Framework Programme between governments (such as EUREKA or EUROCORES) also allow ministries and agencies to finance to the international research projects. At the same time, the Expert Group believes that ERA-NET programme managed to fill in a very specific gap for a mechanism (a) to facilitate mutual learning between funding agencies and other programme managers and owners; (b) to encourage these funding bodies to consider developing strategies jointly with other funding bodies on agreed priorities; and (c) to provide new flexible ways to implement experimental joint calls, programmes, thus working towards true transnational initiatives (ERA-NET Expert Review Group, 2006).

4.9 Non–FP Formal Collaboration Programmes

Generally, intergovernmental research organisations assist European cohesion policy activities. The coherence between policies and activities of these organisations and the European efforts is crucial both for the development of the European Research Area as well as for the relationship of the ERA with the rest of the world (European Commission, 2007a). Certain intergovernmental mechanisms such as COST and EUREKA could serve as suitable vehicles further to ensure increased levels of coherence of research activities within the ERA.

The current European Research Area (ERA) policy is aimed at combining different programmes promoting and supporting multilateral research collaboration and networking. The collaborative programmes covered in the earlier sections of this chapter are certainly central pieces of the last two EU Framework Programmes. Additionally there are a number of formal schemes both at the national level and on the EU level which also facilitate collaboration and networking of researchers across the EU. The national programmes in general have a much narrower spectrum of participants and often are only open to applicants from the country.

Research collaboration is also further enhanced by some international collaborative programmes. Some of these programmes are managed by large pan-European research organisations responsible for scientific and technological cooperation, as well as European level programmes allowing combining the benefits of national research projects.

Some of the major research collaboration projects besides the EU Framework Programmes include:

- CERN (The European Organisation for Nuclear Research);
- COST (European Cooperation in Science and Technology);
- EMBL (the European Molecular Biology Laboratory);
- ESA (the European Space Agency);
- ESF (the European Science Foundation);
- ESRF (the European Synchrotron Radiation Facility);
- EUREKA (A Europe-wide Network for Industrial R&D), and etc.

These organisations play an important role in contributing to the Lisbon goals[30] and building the European Research Area through exploitation of complementarities existing in the member states. Under all these instruments, scientific and technological progress is dependent on the collaborative activities involving research groups and teams rather than just on the individual's research advancements. However, in specific fields European programmes can play a different role. Their function is not just in providing incentives for developing new collaborations but rather provision of a platform for coordinating all European research and development efforts in a given field (Gusmao, 2001).

While many of these formal schemes have a particular interest in a narrow research field (for example molecular biology, nuclear research or space related research), some of these formal programmes (such as COST Actions and ESF Research Networking Programmes) are more flexible. These two formal schemes will be discussed in the following section of this chapter.

4.9.1 ESF Network Projects

A number of formal research networking projects have been run by ESF which has been running its Network instrument since 1980s. Each network involves a number of participants – researchers from different countries regularly meet over the life span of the programme (generally once a year) to discuss current developments in their research, to discuss and coordinate their research activities. Generally, ESF networks are established with an objective of coordinating research efforts in a range of fields from Physics and Materials Science to Social Sciences and Humanities. The nodes of the collaboration networks are the organisations involved in the projects.

While a lot of research is often carried out on the national level, the ESF is following its usual role to coordinate these national studies into a pan-European program (Barabasi et al., 2002). In general, such international frameworks provide not just an opportunity for brain storming with similar minded people. It

[30] In March 2000, the EU heads of state and government agreed on an ambitious goal: making the EU '*the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion*' (European Commission, 2000).

also gives an opportunity to gain some high-level cross-domain expert feedback and analysis from researchers (as well as policy makers and other potential stakeholders) as well as sharing knowledge of local and regional contexts, and deepens understanding of global problems (van Zee & Engel, 2004). The network instrument generally covered expenses related to networking activities such as meetings, travel and short term visits of participating researchers. An average network would normally run over three years and would have an average budget of about EUR 30,000 per year. The ESF stopped accepting applications for Network funding in 2004.

Another research instrument introduced by ESF in 1975 – ESF Programmes (à la Carte). These were medium to long-term research projects with very specific themes. Their general objective was to coordinate and develop effective expertise in the identified fields at European level. There were a few important differences between the ESF Networks and the ESF Programmes. First of all, while Networks were financed from the general ESF budget, the 'à la Carte' Programmes were supported by the ESF Member Organisations. ESF was only responsible for dealing with the proposals.

The actual decision to finance a particular Programme was in the hands of individual Member Organisations. Another difference was in the size and the scale of these two programmes. The 'à la Carte' Programmes were generally larger in scale and their duration was longer – on average four to five years. The larger scale was reflected in the Programme's budget. While the budgets also covered a similar range of expenses such as meetings, workshops, training, and visitation grants (although the Programmes also allowed longer visits by researchers), their size was significantly higher than the Network's budget. The annual budget of the 'à la Carte' Programme was set at between EUR 50,000 and EUR 200,000 as compared the Network's maximum annual budget of EUR 30,000 per year.

Recently, these two instruments have been somewhat phased out and currently the ESF offers a relatively new instrument – ESF Research Networking Programmes (RNPs). Officially, a RNP is a formal research-networking programme, which brings together nationally funded research activities for a period of four to five years and which generally addresses major scientific issues or topic at the pan-European level with the aim of advancing the frontiers of science. RNPs are self-coordinating activities both self-managed including the decision making process. These programmes are relatively open and the members of the network are expected to associate with other researchers who can be eligible to benefit from the programme's activities and could contribute to achieving the key objectives of the RNPs:

1) creating interdisciplinary fora;
2) sharing knowledge and expertise;
3) developing new techniques;
4) training of young scientists.

The RNP budget also generally covers expenses related to networking activities such as meetings, travel and short term visits of participating researchers. The programme budget does not, however cover direct research costs linked to specific research activities (e.g. salaries, equipment and consumables) and these costs are supported directly at the national/international levels.

4.9.2 European Cooperation in Science and Technology (COST)

COST (*European Cooperation in the field of Scientific and Technical Research*) is a formal programme for scientific and technical cooperation of nationally funded research projects at European level. COST is an intergovernmental framework facilitating research and scientific networking of nationally financed research. COST, established by a Conference of European Research Ministers in 1971, is the oldest Pan-European Research networking programme. Since then it has developed into one of the largest international frameworks for the coordination of nationally funded scientific networks involved in basic and pre-competitive research and other related activities of European public value. COST is seen as an important and complementary instrument within the European research funding system, which plays an ever increasing role as a facilitator for participation in larger research activities (Technopolis, 2004).

COST currently supports about 200 research network projects at any one time, overall through its projects COST '*reaches out to over 30,000 researchers across Europe*' (COST, 2008a, p.9). Research collaboration in COST is based on these projects known as Actions, which are formal research networks coordinating nationally funded research projects. An Action in most cases runs for about four years and in some cases this can be extended by another year. COST started with a limited number of research domains but over the last three decades it grew into a comprehensive research collaboration framework across all research fields divided into nine scientific domains.

Not all structures can assist public authorities to jointly identify and decide which research questions have the highest societal value and therefore require a pooling of resources and capacities. COST scheme can be a flexible yet efficient tool for networking and coordination of the fragmented nationally funded research projects. A light funding scheme which is built primarily on the proposals coming from the European researchers themselves, could ensure a new and badly needed support for networking and the coordination of research activities. While the main objective of COST funding is only to establish the actual network and to establish the organisational and operational foundation for research, this funding on average only accounts for one percent of the national funds in COST Actions. COST networks in many cases are built around innovative and interdisciplinary research projects. COST explicitly does not support research as such but focuses on the tasks facilitating greater results from the research supported by the individual COST Member States. A standard COST Action is based on an official Memorandum of Understanding (MoU) and it frequently consists of a standard range of collaborative activities such as meetings, conferences, short-term research exchanges (missions) and some outreach activities.

One of the main differences between COST Action financial support and other networking programmes in ERA is in that COST provides only financial support for the actual network coordination related work and activities such as travel costs, expenses related to organisation of meetings, workshops, conferences, researcher exchanges or training schools. The majority of other programmes (discussed earlier in this chapter) generally support both the research itself and the coordination/networking activities.

Often COST, by being a flexible instrument covering areas generally not well represented in the rest of the Framework Programme to an extent, serves a preparatory role to test a range of new research ideas which can

later be introduced to one of the other bigger Framework Programmes. This is often ensured by spreading information across informal and formal research networks as well as by formally communicating research proposals to the EC's DG Research as to avoid any possible overlaps. There are certain similarities with the earlier discussed ERA-NET scheme; however, COST's official mission is in coordinating research activities nationally funded by the EU states. ERA-NETs similarly aim at bringing together research programmes existing at the national/regional level to the European level. Such growing international collaboration on research among national funding organisations is likely to challenge the existing standing of COST especially if more research organisations engage in coordination of pan-European research programmes.

However, despite the similarities, there are also some differences in the way research is coordinated by COST and ERA-NETs. First, COST in practice brings together scientists involved in nationally funded research projects. ERA-NETs work around national RTD programmes and their managers. On the other hand, research networks (created through COST Actions) have a wider geographical dimension. As a result, they can be seen as the next step for research ERA-NETs. COST Actions are generally bottom-up projects initiated by the researchers themselves. Additionally, research in COST Actions often focuses on exploring new directions of research which are under-represented in other research instruments in the ERA. Once established, these research directions can influence other research programmes and ERA priorities. Such COST Actions can be viewed as complementary precursors to other FP instruments and schemes (Technopolis, 2004).

Researchers taking part in these Actions build new relationships and strengthen existing networks through collaborative research efforts which often result in a significant build-up of the European research capabilities. Researchers participating in these Actions can often have better chances of securing research networking at other levels such as the Framework Programme level. The earlier discussed credibility circle contributed to the fact that some of the COST Actions resulted in Framework Programme projects. There is however a different sort of synergy between the two. According to some analysts not only did a number of Actions corresponded directly to the main themes under the FP schemes (such as nanotechnology theme), but these very Actions availed of some of the other FP instruments such as Marie Curie fellowship scheme to address their Actions' objectives (Technopolis, 2004).

The earlier discussed ESF network instruments certainly share some similarities with the COST Actions. Some COST Actions are built around fundamental scientific issues and there are Actions with research interests in applied fields. They function like the ESF RNPs except there is no provision for longer-term visits of researchers to other institutions. Interestingly, ESF legally provides the COST/ESF Office under a contract between the ESF and the European Commission. It has been suggested that one of the reasons why COST and the ESF entered a collaborative arrangement was to develop synergies between these two frameworks. The nature and the structure of this relationship between the COST Actions and the instruments of the ESF were discussed in a 2005 evaluation study conducted by Technopolis. Technopolis further argues:

> *there is significant overlap between the Network and Programme instruments on the one hand and the Actions of COST on the other.... ESF and the scientific community would benefit in terms of improved transparency and efficiency if the two other ESF instruments and the COST Actions were*

merged into a single networking instrument, capable of being operated at a variety of scales and across both fundamental and more applied domains (Technopolis, 2005, p. iii).

In what could be seen as a response to this evaluation report, the ESF introduced some a number of changes to some of its instruments. The Networks instrument was discontinued in 2005 and the 'á la carte' Programmes were transformed into 'Research Networking Programmes'. Furthermore, in the recent ESF Strategic Plan (2006-2010) COST Actions are positioned as complementary objective-driven networks while ESF activities are perceived as more curiosity-driven activities. Moreover, in its 2006 report TEKES further points that COST is seen as one of the ESF's services: *"the ultimate goal is to put in place a single-stop-shop for programmes for cooperation of scientists whose research is funded from other sources: this means putting ESF Programmes and COST Actions on a common denominator, whilst maintaining their specific character..."* (ESF, 2005).

4.10 European Models of S&T Collaboration

Since the launch of Framework Programmes, European Union institutions developed a very specific European model of scientific and technological collaboration and cooperation. The European Union often is still perceived as a collection of national research areas. In recent years, the main stress of the Framework Programmes has shifted from supply side factors to those related to diffusion, creation and sharing knowledge among Europeans (Maggioni & Uberti, 2006). However, the long-term European vision views the European Research Area as a homogeneous research area. While national collaboration has long been promoted by national governments, the same researchers are still finding it difficult to collaborate across borders, even on the European level.

Many modern research organisations are already involved in daily collaboration with other organisations in networking of one form or another. Often this is seen as an organisation's response to increased (global) competition and generally increasing market demands. This is further promoted by policy makers and governments which are keen on further increasing any such collaboration. The reason they are some fond of committing tax-payers' resources to such inter-organisational collaborations is the general assumption that not only does it increase the benefits of any such public funding but it also has a good chance of resulting in benefits many times exceeding the investment in knowledge (Archibugi & Coco, 2004; OECD, 2000). Such a support results in multiple government funded programmes aiming to support research collaboration among academic institutions, industrial players and government organisations. Such programmes exist on national level in many of the EU States as well as they are well supported within the EU science and technology policy whose primary objective is to facilitate the European collaboration on Research and Technological Development (RTD) activities.

The European Institutions have developed comprehensive policies for the support of RTD mainly through promoting research collaboration and viewing it as an outcome of a multi-governmental policy. Europe as a region expressed a need to narrow the scientific and technological gap between the EU and Japan and the US. In many fields, even the strongest and most advanced EU States as Germany, France or Italy would find it close to impossible to compete globally against the US or Japan. With these concerns of European global

competitiveness, EU institutions have established a comprehensive basis for research collaboration as one of the cornerstones of its ERA policy. Collaborative research, European excellence and dissemination of the research and scientific information across all EU States are expected to enhance European competitiveness globally and increased cohesion of research activities within the European Union.

A number of studies based on the data for the EU suggest the importance of geographically localised networks as a large proportion of collaborative projects still take place within the borders of single member states and that this tendency shows only a slow decline (Frenken, 2002). As so many networks involve different types of individuals and organisations (for example, academy–industry–government networks) and the actual collaboration is only partially formalised through the use of contractual agreements, the actual collaboration also involves some face-to-face, informal contacts, as well as exchange of staff. It is argued that both the structure and strength of these collaborations is reliant on geographical proximity between the parties sharing the same or similar institutional environment (Frenken et al., 2005).

Networking (in its forms) for many years now has been seen as a useful path for bringing together EU Member States and for integrating newer Member Countries. The larger research centres have an increasing attraction for smaller research organisations as well as they increase and facilitate researcher mobility across Member States. Networking between researchers in different fields encourages to a degree an exchange and adoption (trial) of new methods, methodologies and techniques from other scientific fields. Additionally, such research networking activities can improve researcher access to complex or scarce research equipment or infrastructures. Results of this networking can outlive many formal research projects as the scientists often maintain their newly created relationships.

Through a range of scientific and technological instruments (including exchange missions between research institutions, provision of easier access to top level research facilities, building new research infrastructures and overall these research strategies strengthen the single European Research Area (Gusmao, 2001). Additionally, those researchers from countries with less expertise in specific fields develop their science and technical capital (the sum of skills, knowledge, and social relations needed to participate in science) through scientific collaboration in these programmes (Bozeman & Corley, 2004).

Pertinent research (Gusmao, 2001; Katsoulacos, 1994) suggests that European research instruments and programmes should be distinguished from other links that form among scientists and researchers in an international scientific environment due to the following three differences:

1) European research programmes projects involve parties from a large number of countries;
2) As a rule, these programmes involve a range of stakeholders from scientists, policy makers, practitioners and other institutions;
3) The collaboration ties under the European research projects generally mean more than traditional academic links and often include exchange of research data, materials, results, software and hardware protocols and prototypes, as well as involvement of technical designers, providers, suppliers and final users.

A number of formal research networking programmes existing in the ERA were discussed in the earlier parts of this chapter. All of these programmes share a number of similarities: they have a strong transnational dimension and generally involve a range of stakeholders. The reviewed programmes differ on a number of points. First of all, some of the reviewed networks run as a part of the Framework Programmes (ERA-NETs, Networks of Excellence), while others (COST and ESF networking schemes) are placed outside the FPs (even if they are part-financed under the FP budget as it is in the case of COST). Also, this thesis recognises that there is a long list of specialised collaborative programmes (e.g. CERN, EMBL, or ESA) not mentioned in this review, however, these schemes have a very narrow scientific focus or are concerned with a particular aspect of collaboration other than research and science (e.g. EUREKA, which is an industry-led initiative with an interest in applied R&D). One of the most fundamental differences between the reviewed formal programmes is in the funding they provide.

4.11 Focusing on FNR Projects

Formal Networking Research (FNR) programs are viewed by this research as knowledge diffusion channels. Based on the earlier reviewed literature FNR schemes can be characterised based on earlier identified collaboration dimensions: closeness of collaboration, levels of formality and complexity, national/international dimension, inter/intra-organisational dimension, cross-sector and some other dimensions. Depending on the closeness of partners, FNR projects can be placed somewhere in the middle of the 'close collaboration' to 'no real collaboration' range (Quintas & Guy, 1995). The specifics of the funding available to participants generally dictate the structure of how work is organised inside FNR projects. Many FNR projects emerge as a result of existing connections between researchers.

On the one hand, in FNR projects researchers maintain rather loose and distant contacts with each other due to the nature of the project which is often only an additional item on their research agenda. On the other hand, these researchers share motivation, objectives and work packages determined by the conditions attached to the funding application. FNR projects benefit from such mutual interests and create benefits for all of their participants. Frequently, networking is viewed as a less formal type of collaboration due to its generally low levels of formality (Mintzberg et al., 1996). However, FNR projects are a highly formal and regulated style of networking with a focus on research activities. Research funding generally stems from a source within the Framework Program, and as a result, there are formal conditions and a certain administrative burden attached to the projects. FNR projects only provide participants with networking funding as participants are expected to have also secured national funding for their actual research activities. Therefore, FNR projects (involving both individual researchers and research institutions) can be classified as a relatively complex form of collaboration which not only re-uses existing infrastructure facilities but also requires national governments to commit to additional financial support (Archibugi & Coco, 2004; Frenken et al., 2005).

Many of the FNR participants become involved in research projects through their so-called socially embedded ties which are generally relationships between professional or social acquaintances (Lawrence et al., 2005). Some researchers learn about research projects only after they commence as information about the project spreads through their existing contacts. These ties are developed over time through repeated interactions and contacts such as through previous joint research projects. A large number of researchers,

however, join through specific formal procedures without any socially embedded ties prior to joining the project. Their initial relationships with other researchers in the project can be defined as arm's length ties that are purely rational and independent connections. In contrast, the *socially embedded ties* are economic relationships that are defined by direct social ties among the individuals involved. These are usually relationships developed over time involving professional or social acquaintances, friends, ex-colleagues, etc.

Lawrence et al. (2005) point out that socially embedded ties are focused not just on the business transaction (as it is in the case of arm's length ties) but also on the social interaction of individuals. In many cases, these initial arm's length ties develop into new forms such as the socially embedded, while in some cases they turn into virtually embedded ties where relationships are facilitated and maintained mainly through the use of electronic technologies (Lawrence et al., 2005). Development of any working relationships can take significant time and effort by the involved parties in order to understand each others' values and goals, however, once in place, participants' commitment to trust and understating of mutual goals and objectives these relationships can be credited with many successful and effective collaborations (Majumdar, 2006).

FNR projects are largely a platform for international collaboration on common problems although the majority of participants in many of these FNR projects work in the EU Member States or EU Accession States. A number of instruments are available to researchers within the framework of FNR projects such as inter-organisational exchanges of staff and students. Such instruments facilitate sharing of scientific information to address problems with a strong dependence on scientific and technological factors in projects involving a large number of geographically spread participants (Stokols et al., 2005). Some of the FNR schemes (such as COST) in the ERA allow involvement of researchers and experts from outside Europe under the condition that such participation is of benefit to all parties. Such involvement of researchers in FNR projects provides participants (both European and non-European) with an access to the knowledge base in Europe, as well as it provides Europeans with benefits of access to the competencies of other parties (Archibugi & Coco, 2004; Cantwell, 2003).

FNR projects generally can be described as inter-organisational or multi-institutional forms of research collaboration, which display certain patterns of organisational diversity (Chompalov et al., 2002; Gray, 1989). This diversity of FNR projects results in the participation of very different stakeholders and generally defines the degree of their interdependence. Collaboration in FNR projects often is not restricted to any particular sector (academia, government or industry). In many research fields, such inter-sectoral and cross-sectoral partnering in FNR projects can be seen as a process of implementing joint research objectives which will connect these different sectors and create conditions for mutually beneficial development (Katz & Hicks, 1997).

On the other hand, FNR projects often involve researchers and participants from only one or two sectors, and in order to maximise the impact of the project, efforts are made to ensure adequate involvement of stakeholders and parties to ensure both horizontal and vertical collaboration (Prefontaine et al., 2000). Heterogeneity of formal research networks such as FNR projects (for example, on the cross-sector and international dimensions) presents questions regarding creation, functioning and maintaining, as such scientific activities result in formal and informal networks, which in turn are a part of social innovation

(Alders et al., 1993). Participation in FNR projects can allow researchers who invest their time and resources in building their networks to improve their standing in society as well as increasing their individual social scientific and technical human capital. While FNR projects in many cases are convened by participants related to each other with some form of socially embedded ties, their further join participation in approved FNR projects is governed by certain formal policies and structure generated and enforced by the project management and the funding sponsor. Introduction of these more explicit formal structures often goes along with the introduction of well-defined missions, philosophy and funding criteria.

These membership principles introduced within often pre-existing research networks allow classifying these FNR projects as formal research networking projects (Chandler, 1962). The pertinent literature is unclear on whether heterogeneous formal research networks achieve the originally intended results. However, it does suggest that the level of heterogeneity in a formal research network can be seen as an impeding factor for achievement of research activities. Some of the potential sources of unproductive conflicts lie in the differences – differences in ideas, research interests and cultural specifics (Bammer, 2008). This research, however, aims to explore whether highly heterogeneous formal research networks fail to achieve their research objectives.

4.12 Summary

Chapter 4 reviewed existing literature dealing with different aspects of collaborative research in the European Research Area (ERA). In particular, this chapter identified trends in science and technology cooperation in the ERA. The Chapter then discussed the European Union Framework Programmes (FPs) and research instruments available to European researchers under the FPs. A closer look was then taken at some of the specific collaborative instruments under the current Framework Programme (FP7). Further, this study focused on formal programmes supporting research networking in the ERA: some of the schemes available under the FP7 (such as Networks of Excellence and ERA-NETs) and some schemes that are not managed by the European Commission (such as ESF Network Projects and COST Actions). It was then concluded to focus this study further on the formal networking research (FNR) projects. The following chapter will present the details of the research focus, the chosen philosophical approach, and details of the selected research design, methods and procedures. The first part of Chapter 5 will provide a discussion of the philosophical assumptions which support the issues reviewed by this thesis. It will further provide a justification for the methods chosen for the study and the overall research design by discussing in detail the main elements and stages of the chosen survey methodology, including development of the surveys, as well as their administration and analyses. The weaknesses of the chosen survey methodology (in particular those applicable to the web-based surveys) will then also be discussed, and applicable criteria of rigour will be suggested.

Chapter 5. RESEARCH METHODOLOGY

5.1 Introduction

Chapter 5 will focus on developing the research design of this thesis and describes the methodology applied to collect the data which will be used to answer the questions posed in earlier chapters. This research design is influenced by the objectives to define, understand and evaluate the relationship between individual participation in formal research networking programmes and their research outputs associated with this participation. As the phenomenon of formal research networking is relatively new and the body of literature on it is limited and fragmented, this chapter will discuss first the applicable philosophical approach and paradigms, and secondly, it will develop methodology to address the objectives of this research. The first part of this chapter provides a discussion of the philosophical assumptions which support the issues reviewed by this thesis. This discussion of methodological choice further guided the investigative focus of the second part of this chapter which examines the details of how this research is carried out in terms of data collection and analysis. After providing an introduction and outline of the chapter, this study continues to discuss in detail the main elements and stages of the chosen survey methodology, including development of the survey (its core steps of population, sampling frame, sample design, sample size and so on), as well as their administration and analyses.

5.2 Research Focus

The earlier chapters of this thesis examined closely a range of formal collaborative research programmes in the European Research Area. One of the conclusions of the literature review was that while such research collaboration is strongly promoted by many players including governments, it is not certain if all collaborative programmes achieve their anticipated results and in some cases it is not evident what the expected outputs are. What is more, in the case of formal research networking programmes the outcomes for individual researchers have only ever been confirmed by anecdotal evidence. Therefore taking into account recently increased FP7 budgets assigned to a large number of collaborative programmes this research posed the question as to why governments and other funding sponsors should support formal research networking schemes. To answer this question, the thesis will investigate whether such formal research networking in fact contributes to learning/innovation and whether there are quantifiable implications of this model of cooperative research to individual researchers taking part in these formal programmes. This research is also keen to test whether the ability to take advantage of such research networking can be seen as a skill that can be acquired through participation in such formal networking projects. Do researchers involved in scientific network teamwork actually learn to achieve 'better' research outcomes, or is it just a bureaucratic novelty?

5.3 Philosophical Assumptions

Some researchers believe that even though it is ultimately the research rigour and impact and not philosophical debate that are used to judge active scholars' work, it is still critical to understand the philosophical conflict that does exist among some researchers (Swanson & Holton, 2005). The authors further argue that the existing differences in these rival philosophical views 'can allow for expansion,

tolerance and inclusion in research thinking and methodology' (ibid, p.18). As with most research studies, this thesis has some underlying philosophical assumptions about what makes 'valid research' and what methods can be applied to achieve these research objectives. These assumptions generally form a paradigm, a set of beliefs and approaches from which a particular research phenomenon is investigated and explained. The etymology of the word paradigm suggests it originated from Greek *paradeiknymai*, which means '*to show side by side*' (Woolf, 1974). Kuhn (1970) uses the term paradigm to describe the dominant understanding of a particular phenomenon at a particular time. Research paradigms as research frameworks guiding scientific research are often classified based on three critical questions: ontological, epistemological and methodological (Guba & Lincoln, 1994). The ontological question is that of reality in its most general meaning; it is the question of being, existence or reality. The second, epistemological, question focuses on the certain knowledge of truth (certitude), the basic belief about knowledge and what can be known. Epistemology deals with questions of knowledge and how this knowledge can be acquired. According to Guba and Lincoln (1994) the last, methodological question deals with the researcher's assumptions regarding existing choices of methods, how to explore the phenomenon the researcher believes can be known.

Table 5-1: Comparison between research paradigms

Item	*Positivism*	*Postpositivism*	*Constructivism*	*Critical Theory*
Ontology	Naïve realism – 'real' reality but apprehendable	Critical realism – 'real' reality but only imperfectly and probabilistically apprehendable	Historical realism – virtual reality shaped by social, political, economic, ethnic, and gender values; crystallised over time	Relativism – local and specific constructed realities
Epistemology	Dualist/ objectivist; findings true	Modified dualist/ objectivist; critical tradition/ community; findings probably true	Transactional/ subjectivist; value-mediated findings	Transactional/ subjectivist; created findings
Methodology	Experimental/ manipulative; verification of hypotheses, chiefly quantitative methods	Modified experimental/ manipulative; critical multiplism; falsification of hypotheses; may include qualitative methods	Dialogical/ dialectical	Hermeneutical/ dialectical
Inquiry Aim	Explanation: prediction and control		Critique and transformation	Understanding; reconstruction
Goodness or Quality Criteria	Conventional benchmarks of 'rigour': internal and external validity, reliability and objectivity		Historical situatedness, erosion of ignorance; action stimulus	Trustworthiness and authenticity and misapprehensions
Researcher Voice	'Disinterested scientist' as informer of decision makers, policy makers, and change agents		'transformative intellectual' as advocate and activist	'Passionate participant' as facilitator of multi-voice reconstruction

Adapted from Guba and Lincoln (1994)

Gephart (1999) discusses three rival philosophical paradigms explaining research views of modern day social research scientists: positivistic, interpretative and critical science research. In their 1994 work, Guba and Lincoln also add to the three earlier mentioned paradigms postpositivism. The four paradigms have been summarised by Guba and Lincoln (1994), and to provide a more detailed feel of the paradigms these are adapted in this section as Table 5-1. In this table, the paradigms are compared based on three fundamental questions: ontology, epistemology and methodology. While not always, these paradigms can explain all posed questions, they are accepted as major philosophical paradigms. Kuhn argued that 'to be accepted as a

paradigm, a theory must seem better than its competitors, but it need not, and in fact never does, explain all the facts with which it can be confronted' (Kuhn, 1970, p.12).

The first of the paradigms – positivism – is certainly one of the most dominant research paradigms in social sciences. Positivism is a philosophy that posits that the only authentic knowledge is that based on actual sense experience. According to this, knowledge can only be acquired through experience and can be studied only through observable facts. It is perceived as absolute and therefore equal to the truth (Guba & Lincoln, 1994; Hacking, 1981). As positivists assume the world is objective they generally search for facts and correlations and associations between different variables. When selecting their scientific methods, positivists generally tend to rely on empirical methods, as well as structured and replicable observation, quantification (measurement) as well as some experimental methods, which allow to directly manipulate variables and to observe facts (Gephart, 1999). As a result, positivism tends to employ experimental and quantitative methods that allow it to test and verify research hypotheses. Guba and Lincoln (1994) further suggest that because of real world complexity positivists focus more on falsification rather than verification of their research hypotheses.

Postpositivism can be considered as an evolutionary result derived from developments of positivism. Postpositivists are generally consistent with positivists in sharing the assumption that the world is objective however they accept that the world is imperfect and therefore it might be not readily investigated and understood and that variable relations (including any facts) can be more probable and not deterministic as viewed by positivists (Gephart, 1999). A number of postpositivists also have written on possible biases, which can be unintentionally introduced by the experiment leaders and which can have an impact on a study's results and validity (Cook & Campbell, 1979). In recent years, however, postpositivists focused on developing qualitative methods based on positivistic methods and experimental designs and thus they tend to apply quantitative quasi-experimental and causal-comparative methodological designs. Many positivists and postpositivists rely on survey studies, verification of hypotheses and forms of statistical analysis.

In the late 1900s, some researchers expressed concerns about the dominant positivistic research paradigm as well as the limits of quantitative data and positivistic methods (Swanson & Holton, 2005). While social sciences have become relatively dominated by positivism and postpositivism, their dominance has been challenged by interpretive constructivists and critical theorists who challenged the fundamentals of positivism by providing alternative approaches to research (Gephart, 1999). Researchers in the constructivist (also known as interpretative) camp maintain an assumption that scientific knowledge is constructed by researchers and it is not discovered from the world. Therefore, to understand the world one must interpret it. In contrast to positivists, they argue that there is no single valid methodology and there are other methodologies for social science: qualitative research. The underlying assumption of constructivism is that realities can be learnt and understood through multiple intangible mental constructions. These constructions depend on individuals or groups of individuals for their content and form. As these individuals change, they alter their construction and as a result the associated realities are changed (Guba & Lincoln, 1994). Constructive scientists believe to be linked to the object of their investigation, and as a result, their research findings are created as they proceed with their investigation. To reflect this logic constructivists tend to use

ethnographic prose, historical narratives, first-person accounts, still photographs, life histories, fictionalised facts, biographical/autobiographical materials (Denzin & Lincoln, 2003).

According to the paradigm supported by critical theorists, people can design and reconstruct their own world through action and critical reflection. This reality is shaped by a large number of factors such as political, social, economic, ethnic and gender factors (Guba & Lincoln, 1994). Critical theory generally views knowledge as dispersed but constituted by the individual experience and the social relations that structure these experiences. A number of important observations on critical theory have been summarised by Popkewitz (1990):

- Critical theorists do not separate method of science from the context, in fact, these methods emerge from the research questions;
- Critical theory assumes it is impossible to separate the objective from the subjective as the objective reality is formed by the social environment while subjective reality is the response of the individual's mind to that objective reality;
- The production of knowledge is defined as the production of values. The use of statistics therefore expands the number of research issues that can be of research interest and should be investigated;
- Science itself is a study of the past. Researchers commonly generalise about the present and the future based on data from the past. As a result, since there is only data on the past, predictions can only be treated as statements of rhetoric.

In their methodological choices, critical theorists often adopt the role of a facilitator who both encourages/facilitates the participation and involvement of the research subjects (who are viewed as partners in the research process). Many proponents of critical theory rely on different forms of participatory action research or dialogical methods. Having reviewed these four major research paradigms and associated philosophical assumptions the author of this thesis concluded that they are not necessarily in conflict. There are some fundamental differences between the four paradigms when it comes to how the paradigms treat issues of inquiry arm, nature of knowledge, or even values. Yet some aspects of the paradigms seem to overlap to some extent. In fact, as paradigms change and develop over time they can also change some of their aspects. As Miles and Huberman (1984, p.20) put it:

> *"It is getting harder to find any methodology solidly encamped in one epistemology or the other. More and more 'quantitative' methodologists, operating from a logical positivist stance, are using naturalistic and phenomenological approaches to complement tests, survey, and structured interviews. On the other side, an increasing number of ethnographers and qualitative researchers are using redesigned conceptual frameworks and pre-structured instrumentation, especially when dealing with more than one institution or community."*

Other researchers explicitly appeal to scientists to ignore the paradigm conflict or even argue that scientists should move from one paradigm to another if is necessary (Cook & Reichardt, 1979; Patton, 1982). The idea is that while there are certainly proponents and opponents of each of the discussed paradigms, their differences can only be brought together with the emergence of a new paradigm which would be more incorporating and sophisticated than any of the existing ones (Guba & Lincoln, 1994). Until such a paradigm is formed, researchers can discuss their differences and by continuing this critical dialogue they can share

(give and borrow) some of the strongest points and improve the current understanding of philosophy in science. In the second half of the 20th century there was a great deal of debate over the relationship between paradigm and methodology (Tashakkori & Teddlie, 2003). Some theorists ('incompatibility theorists') believed that constructivism and positivism were fundamentally incompatible, while others ('the compatibility theorists') believed that the differences were over-exaggerated (Cherryholmes, 1992). This debate around the paradigms and applicability of mixed methods continued and resulted in the emergence of another paradigm – pragmatism. Pragmatists strongly recognise the requirement of an alternative to the dominant paradigm which must be able to resolve the anomalies in the conventional approaches. In their 1998 work, Tashakkori and Teddlie strongly reject the forced choice between the camps of positivism and constructivism. The authors proposed a new analysis of four important paradigms used in the social and behavioural sciences in support of their '*Rejection of the Either-Or*' (see Table 5-2).

Table 5-2: Comparisons of Four Paradigms

Paradigm	*Positivism*	*Postpositivism*	*Pragmatism*	*Constructivism*
Methods	Quantitative	Primary Quantitative	Quantitative + Qualitative	Qualitative
Logic	Deductive	Primarily Deductive	Deductive + Inductive	Inductive
Epistemology	Objective point of view. Knower and known are dualist.	Modified dualism, findings probably objectively 'true'.	Both objective and subjective points of view.	Knower and known are inseparable.
Axiology	Inquiry is value-free.	Inquiry involves values, but they may be controlled.	Values play a large role in interpreting results.	Inquiry is value-bound.
Ontology	Naïve realism	Critical or transcendental realism	Accept external reality. Choose explanations that best produce desired outcomes.	Relativism
Causal linkages	Real causes temporally precedent to or simultaneous with effects.	There are some lawful, reasonably stable relationships among social phenomena. These may be known imperfectly. Causes are identifiable in a probabilistic sense that changes over time.	There may be causal relationships, but we will never be able to pin them down.	All entities simultaneously shaping each other. It is impossible to distinguish causes from effects.

Adapted from Tashakkori and Teddlie (1998)

The pragmatic paradigm as a set of beliefs, illustrated above, arose as a single paradigm response to the debate surrounding the 'paradigm wars' and the emergence of mixed methods and mixed model approaches. It is pluralistic based on a rejection of the forced choice between post positivism and constructivism (Creswell, 2003). A number of authors note that the pragmatic paradigm has an intuitive appeal which allows researchers conduct their scientific studies using research methods that are considered as most appropriate as well as allowing researchers to apply their findings according to their (the researchers') value systems (Creswell, 2003; Tashakkori & Teddlie, 1998). The author of this thesis shares the view that these four paradigms are not mutually exclusive. What researchers have to decide for themselves is which paradigm is most appropriate for their particular purposes (Morgan, 2007).

The author of this thesis initially embraced the postpositivist stance as being closest to his own understanding of the philosophical questions of reality when analysed through dimensions of ontology, epistemology and methodology. This thesis is a study of evaluative nature, as it is particularly concerned with the evaluation of quantifiable outcomes from formal research programmes. The design of the evaluation involves surveys and includes a form of 'user participation' in an endeavour to reflect the level of analysis. Methodology generally

associated with postpositivism allows involving some elements of interpretive social science (constructivism) such as the use of heuristic insights, but at the same time, this research leans towards a positivistic epistemological framework (Denzin & Lincoln, 1998). Such a combined approach can be commonly found in evaluation research as it helps to take an advantage of different approaches by simultaneously including their respective strong aspects such as reliability of quantitative measurement, and concepts such as user empowerment and participation (Parry et al., 2001; Pawson & Tilley, 1997). As discussed earlier, when deciding on whether to go for a quantitative or qualitative research, researchers should not be purely motivated solely by philosophical beliefs but by whichever design and methodology are best suited to tackle their research objectives. This thesis applies survey methodology with a definition of the survey's purpose being to produce quantitative descriptions of some aspect of the population in question by asking people structured and predefined questions using a sample of the population (King & He, 2005; Pinsonneault & Kraemer, 1993). These assumptions also eventually lead the author of this thesis into the boundaries of the positivist paradigm (Lee & Baskerville, 2003).

5.4 Research Approach and Outline

When deciding on the appropriate research design for this study the author considered the questions raised by the research. This study intends not only to explore and evaluate particular research outcomes associated with specific formal research networking programmes (at the level of an individual researcher which was overlooked by previous studies), but also to understand whether individual researcher productivity (as expressed in these results) changes during the term of FNR projects. Such studies often fall into a particular category of applied or evaluation research which generally applies non-experimental survey research design. The study will take the form of an exploratory outcome evaluation research focused on investigation of outcomes that have been neglected in previous studies. A particular form of evaluation inquiry - values inquiry - can be helpful in the development of criteria for oversight and compliance (whether the programme is following specific rules or is meeting expectations). Values inquiry can also be suitable for programme improvement when there is uncertainty about programme mission or some disagreement over mission objectives (Mark et al., 2005).

As mentioned in the earlier sections of this chapter, this evaluation research will employ a multiple survey methodology. The study will collect data from several groups of respondents. A number of large-scale surveys will address three categories of experts and participants of the formal research networking instruments taking place in the European Research Area. The data from these surveys was analysed and the analysis was further advanced by other data sources such as available documentation and observation of networking processes. The actual research process came through the following stages:

- An ongoing literature review;
- Identification of the context (selecting an appropriate research networking programme);
- Close process observation to increase understanding of the research programme and research instruments;
- Secondary data collection and analysis;
- Organisation of the surveys; primary data collection, including initial pilot survey;
- Initial data analysis (based on the data from the surveys)

- Combination of results from the conducted surveys;
- Availability and analysis of the final dataset and data results;
- Collection and analysis of supplementary secondary data, additional literature review;
- Integration of the results, write-up.

The following sections of this chapter specify the research design of this study by providing detailed information on its methodological logic and philosophical assumptions. Data collection for the proposed evaluation study will also include process observation and assessment. The study will employ surveys of individual research outcomes attributed to participation in formal networking programmes. Empirical data was gathered in cross-sectional surveys among groups of researchers (actual and potential) and stakeholders taking part in or otherwise involved in work of formal networking projects across European countries. To increase the likelihood of the main study, a pilot study was undertaken as a mini version of a fully scaled study (although a pilot study does not guarantee success in the main study); and it also was used to detect possible weaknesses in design and instrumentation (Cooper & Emory, 1995; Teijlingen & Hundley, 2003).

5.5 Study Overview and Data Collection Methods

While this section will provide a brief overview of the study, the individual elements of this study will be further discussed in detail in the following sections of this chapter. The actual research process proceeded through a number of steps that can be divided into two stages. In arguing for such a two-stage research approach, one can argue that it facilitates learning more about the problem before committing efforts and resources to it (Cooper & Emory, 1995). The first stage had a clear objective to collect initial information about the phenomenon in question. The process involved the following procedures: an extensive review of literature on the subject, process observation of collaborative research projects, analysis of relevant documentation and initial field exploratory interviews with participants or experts in the field. The objective of this stage was to develop an initial understanding of the programme, of its underlying operational principles, as well as an understanding of the complexity of programmes and their structures. During this first stage, the author of this thesis was able to gain firsthand experience in the field that has led to significant changes in the research focus. One of the important things the author observed at that stage was that policymaking processes were often strongly influenced by anecdotal evidence of the benefits derivable from some collaborative research programmes. This lack of empirical evidence supporting the otherwise acclaimed impact of formal research networking programmes (the relationship between the research outputs of individual researchers and their participation in collaborative research programmes) further re-focused the research questions of this thesis. During Stage 1 the author was able to develop research questions, and as a result of further literature analysis, a number of research propositions were developed. The re-focused study was set to investigate whether individual researchers taking part in formal research programmes in fact achieve the research outputs/outcomes that are generally associated with such programmes and (2) whether there exists a relationship between variables: extended (prolonged) participation in formal collaborative programmes and researcher outcomes.

At this stage, the work was strongly influenced by a number of additional elements. During the process of the thesis write-up, interactions with peers and researchers have further pushed this research to re-define its

assumptions, chosen methods and other elements. Another objective for the second stage was to identify researcher outcomes and outputs generally attributable to participation in formal collaborative programmes. The author first developed categories of these results and these lists were confirmed through consultations with experts in the field as well as participants with existing experience of such formal networking programmes. The consultations with informants (participants) took the form of informal semi-structured interviews and confirmed what was already known, and provided the opportunity for learning, as well as allowing for comparisons. The results of these interviews were used to determine the baseline information and the set of values and value centres for each of the indicators. The interviews encouraged participants to begin to reflect on the issues.

In most formal collaborative research programmes, it is often a challenge to measure directly the actual programme outcomes and outputs and to quantify every impact of the participation in such programmes. The process has to be indirectly analysed by interviewing and surveying the people involved in these programmes as well as by analysing any related documentation and archival materials. As very little was known about the sponsoring organisation, data collection included a review of project documentation, reports, observation of management meetings, and analysis of all collected and relevant data. The assessment aspect included an initial summary and analysis, plus interactive feedback and interpretation sessions with partnership actors collectively. Such sessions more directly addressed the developmental aspects of the assessment.

The next step included developing the actual surveys. The first drafts of questionnaires were first pilot-tested in a number of smaller pilot studies in each of the three groups of informants. The feedback from the pilot studies was integrated with the results of the direct interviews with participants and the overall findings lead to slight changes in the original questions. Once the questions were readjusted, a large-scale survey involving researchers with current experience in the funded research networking programmes was the first to take place. Subsequent surveys were informed by the results from the first survey, the earlier agreed indicators and the results of process observation and assessment.

Overall, three surveys (addressing different groups of informants: actual and potential programme participants and programme experts) have been developed and administered as a part of an ongoing evaluation study carried out at one of the major research funding organisations in the ERA. The surveys consisted mainly of closed-ended questions, which primarily used quantitative ordinal scales. During the data collection stage, the data was collected in Microsoft Excel and during the data analysis stage both Microsoft Excel and SPSS were used. Data analysis involved reducing accumulated data to a manageable size, developing summaries, looking for patterns, and applying statistical techniques[31]. Scaled responses on surveys often require the analyst to derive various functions, and relationships among variables are frequently explored after that. Further, the study interpreted these findings in light of the research question, or, with theory-building research, determined if the results are consistent with developed propositions and theories.

[31] During the data analysis stage a number of statistical techniques have been used including some of the following: descriptive statistics, some data reduction techniques (factor analysis), and some comparative analysis statistical techniques such as t-tests, means comparison, ANOVA, chi-square, and some others including measurement index development.

5.6 Survey Approach

Survey research in comparison with other research methodologies with controlled settings (such as laboratory and field experiments) allows the examination of the phenomenon in question in a wide variety of natural settings (King & He, 2005; Pinsonneault & Kraemer, 1993). Surveying is a research method for collecting information from a sample of individuals so to use this information to describe the larger population of which the individuals are members. One of the objectives of this thesis is to understand the phenomenon of formal research networking programmes that play an ever-increasing role in the European Research Area. The other objective is to evaluate the individual researchers' outcomes from participation in such formal collaborative programmes.

One of the disadvantages of this approach is in that its results do not lead to conclusions on cause and effect, but can lead to conclusions about associations (Sproull, 1995). As a result, surveys can potentially produce generalisable research results that can then be applied to those larger populations even though such a potentials requires careful assessment and design considerations (King & He, 2005). As any other data collection method, the survey approach has its advantages and disadvantages. According to Nardi (2005) some of the advantages, which can be attributed to surveys include:

- Their cost-effectiveness in reaching larger samples;
- Surveys allow the use of standardised questions;
- They are less labour intensive to collect data;
- Surveys are suitable for probability sampling and more accurate generalisability;
- Surveys can address several topics in one survey;
- They are ideal for computer and web-based surveys.

Among the main disadvantages of using surveys Nardi (2005) lists the following:

- Surveys allow for a possible gap between what people report they do and what they actually do;
- There is a possibility of low return rates, and therefore this can result in limited generalisability;
- Closed-ended questions can be restrictive and dependent;
- A survey cannot guarantee respondent answering is the person intended to answer it;
- More difficult to generate reliability and validity for one-time-use questionnaires.

The noteworthy position of survey research may reflect the increased attention that researchers place on the abilities of the survey design to achieve its objectives and the generalisability of their research findings (King & He, 2005). As in many applied disciplines research with generalisable results is widely promoted and accepted as it is perceived to generate potential real world impacts (Davenport & Markus, 1999; Zmud, 1996). Nardi (2005) also mentions the importance of the survey design to achieving its research objectives. This can be achieved through consultation with stakeholder groups during the survey design and questionnaire development stage of the research. This thesis employed the method of cross-sectional surveys that are used to gather information on a population at a single point in time. A different cross-sectional survey questionnaire can also be used to determine the relationship between two factors, like participation in collaborative research projects and research outcomes reported by the participants. Like the majority of surveys this survey incorporated the following activities: setting objectives, designing the study, preparing a

reliable and valid survey instrument, administering the actual survey, managing and analysing the collected survey data and, finally, reporting the results (Fink, 1995b). The current chapter is concerned with the methodological choices and their administration. However, the consecutive chapters will deal with the data analysis, interpretation of the results and deriving at conclusions.

5.6.1 Use of Web-Based Surveys

There are several different ways to collect survey data so when deciding on the format of surveying a number of points had to be considered. The population that the surveys were going to address can be characterised as follows:

- The overall population can be enumerated (the funding sponsor is able to provide very comprehensive contact list of participants in each of the survey groups),
- The respondents are highly computer literate (researchers, academicians, research agencies personnel);
- The population is highly international with most of potential respondents spread across the EU Member States and EU neighbour countries; the population is also widely spread across large geographical area;
- The language is generally not a problem as the majority of academic work in Europe is conducted through the use of English language;
- The overall population is generally cooperative when it comes to participation in different forms of research data collection such as surveys.

The Internet is increasingly used as a platform for conducting social scientific studies. The use of Internet for surveys can also be justified by the reason of economic advantage as web-based surveys are generally significantly cheaper than other modes (for example, the paper-and-pencil mode) and more efficient as entered data is generally available straight away (Van Selm & Jankowski, 2006). However, some authors warn that while computer-mediated communication can cut the costs, the start-up expenses associated with setting up web-based surveys (especially expenses related to securing the necessary knowledge and expertise for designing these web instruments) can be considerable (Mann & Stewart, 2000). By choosing to use web-based surveys, researchers can accelerate the response rate. Yet, the use of web-based surveys can result in additional technical issues. In some cases, researchers can spend significant amount of time on resolving technical issues both before and during the implementation of web-based surveys on activities such as checking email addresses, replacing incorrect participant details, explaining procedures to less internet-confident survey respondents (Van Selm & Jankowski, 2006). Some other advantages to using web-based surveys were mentioned in the reviewed literature and include the absence of interviewer bias, removal of the need for data entry, and convenience for respondents (Medlin, Roy & Ham Chai, 1999; Mehta & Sivadas, 1995; Smith, 1997; Van Selm & Jankowski, 2006). Speaking of possible disadvantages of web-based surveys, the author considered some of the following identified in the literature (Kumar, 2005):

- Low response rate;
- A self-selecting bias;
- There is no opportunity to clarify issues causing uncertainty;
- Web-surveys do not allow for spontaneous responses;

- Respondents can consult other respondents;
- Web-surveys cannot generally be supplemented with other information (for example, observation), etc.

One of the main concerns for the study however is in the *self-selecting bias,* as not all approached respondents will decide to take part in the surveys. However, those who do choose to respond may have different characteristics than those who chose not to. As a result, if the response rate is very low the overall survey findings may be representative of the overall surveyed population in focus (Kumar, 2005). Taking into account the characteristics of the population listed earlier and having considered both advantages and disadvantages associated with web-based surveys, it was decided to choose web-based surveys conducted in English. In fact some researchers strongly argue that if the population in focus are 'connected and technologically savvy', the costs, ease, speed of delivery and response, ease of data cleaning and analysis weigh in favour of the Internet as a delivery method for survey research (Sills & Song, 2002, p.28; Van Selm & Jankowski, 2006).

The actual surveys have been conducted through web-based questionnaires. Emails were sent to selected samples of identified populations, with each email including links to the online questionnaires (in a form of an email message containing a hyperlink to an interactive questionnaire available on the Internet). The surveys were written in WAP1 (Web Assisted Personal Interviewing) format using the English language. All survey respondents were sent an email from the funding organisation (signed by one of the organisation's top managers) with an explanation of the objectives for the surveys and informing them of the involved steps and procedures, scope of the study, and additionally provided details of the person in the organisation responsible for its administration. A follow-up email was later sent to participants who had not opened the questionnaire link within five days of the first emails being sent.

5.6.2 Triangulation

While developing their studies, researchers build their research design in a way that enables them to ensure rich, unbiased data valid for further interpretation (Breitmayer, Ayres & Knafl, 1993). The ultimate aim is to develop a study design and a number of procedures decreasing potential biases in order to ensure strong internal and external validity and reliability of their research (Mitchell, 1986; Thurmond, 2001). Some argue that the influence of some of these potential biases can be decreases through the use of triangulation. One of the ways to deal with these potential biases is to use the triangulation approach (Denzin, 1970; Jick, 1979; Kimchi, Polivka & Stevenson, 1991; Oppermann, 2000). Triangulation is the use of several approaches to the investigation of a research question in order to increase the level of confidence in the resulting findings. Denzin (1978) offers four basic types of triangulation: investigator triangulation, theory triangulation, methodological triangulation and data triangulation. *Investigator triangulation* employs a number of research investigators in an attempt to avoid or minimise investigator bias. In practice, in order to increase the credibility of some studies, research design is based on using more than one interviewer (or data analyst) in the research study.

Theoretical triangulation is based on the use of several theories (hypotheses) when researching a phenomenon with an expectation to conduct the study with several research questions in mind (Denzin, 1970). Thus, theoretical triangulation, depending on the study objectives, can assist in finding out whether the perspectives employed by the study are related or are if they are contradictory in nature (Denzin, 1970).

Methodological triangulation is the most frequently used type of research triangulation as it is an attempt to improve validity by combining various techniques in one study (Murray, 1999). This type of triangulation generally takes one of the two sub-forms: within-method triangulation and between (across) method triangulation. The within-method triangulation collects data on from at least two data collection procedures from the same research design approach (Kimchi et al., 1991). The between-method triangulation is often used to validate the research findings generated with the use of one research method by another (Holloway, 1997). The same author further argues that many researchers use the within-method triangulation as it allows them to stay within one single paradigm. In fact, some believe that different research methods originate in different research paradigms and therefore, a researcher cannot follow the views (paradigms) of more than one world at the same time (Leininger, 1992). *Data triangulation* is used when researchers collect their data from different groups, times or locations. By using different groups (persons), times and locations one can further enhance the reliability of the study as it can potentially open up some irregularities in data or it can help to identify certain patterns (Fielding & Fielding, 1986). Thurmond (2001) and Banik (1993) point out that while the nature and amount of data generated constitute one of the main advantages of data triangulation. Data triangulation can take a range of forms depending on how the data is collected: location, informants, setting or even the times when the data were collected (Denzin, 1970; Mitchell, 1986).

One general argument in favour of triangulation is that the same results confirmed by several methods or techniques can increase confidence in these results/outcomes by decreasing the impact of potential biases. For example, certain data bias can be introduced when the survey population has unusual characteristics and so their characteristics can be non-representative of the overall wider population; it is therefore important to cross-validate results collected from one population set with others (Oppermann, 2000). However, there are also several criticisms of triangulation as some authors even note that in certain cases theoretical triangulation does not reduce bias, while in other instances methodological triangulation does not increase validity (Fielding & Fielding, 1986; Oppermann, 2000). Criticisms of triangulation are not limited to those listed above. A number of critiques were proposed in the literature consistently over the last 30 years. Some authors argue for leaving behind the very concept of triangulation (Miller, 1983) while others go even further by suggesting the declaration of a moratorium on the use of the concept of triangulation in social research (Blaikie, 1991, p.131). However, it is important to recognise that generally triangulation is critiqued for its use in the form of a multi-method and/or multi-theory approach and not its use as data triangulation (Oppermann, 2000).

This suggestion to use triangulation for data is defended by some authors because through data triangulation a researcher can achieve its most ideal use as the measurements are be of the same nature and are based on the same ontology/epistemology (Blaikie, 1991; Oppermann, 2000). As such, data triangulation can be used as an important check for researchers to verify their results through the use of multiple data sources such as multiple informants, as a single informant might be a source of reliable yet invalid information (Crabtree &

Miller, 1999). Having analysed the advantages and disadvantages of different forms of triangulation, this thesis employed a form of data triangulation in that it used a number of data sources (multiple informants) to investigate the same research phenomenon (Denzin, 1970). Through application of several groups of informants, this research could crosscheck the results acquired in one data collection study with the data collected from other independent groups of respondents. The triangulation of multiple perspectives on the same phenomenon generally increases the chances of this thesis arriving to a more complete and whole picture and provides both a simple and powerful method of quality control in the analysis of the results (Mariner & Paskin, 2000).

The primary research method for this thesis takes the form of a number of survey questionnaires aimed at different groups of informants (Appendix 4, Appendix 5 and Appendix 6). The results achieved from these surveys are complemented by some additional information acquired from the researcher observation and additional documentation analysis. The surveys of different categories of respondents allow gaining perspectives at different angles at the same research phenomenon (see Figure 5-1) and were highly complementary to each other as well as to other sources of information such as literature and documentation reviews, etc. (Denzin, 1970).

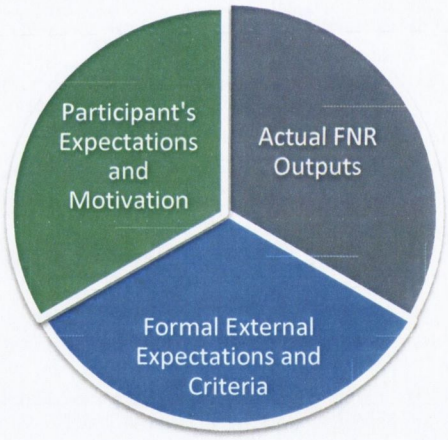


Figure 5-1: Utilising multiple informants to understand FNR phenomenon

5.7 Study Context

Many of the research networking schemes support financially all research-associated expenses. However, two of the reviewed programmes (COST and ESF schemes) only cover the networking-associated expenses and specifically exclude (do not reimburse/cover) any of the actual research expenses. At the same time, the four programmes also differ in the type of stakeholders they involve in their networks. If ERA-NETs aim at research managers and project owners, the COST Actions primarily engage individual researchers and scientists and their institutions. Taking these similarities and differences into account COST Actions were selected as a well-established example of a formal research-networking instrument in the ERA. It was proposed to position this study within the settings of COST Actions. The choice of COST Actions for this thesis is justified by a number of reasons. One reason is the fact that these Actions are characterised by an intensive and well-structured approach to networking. The Actions also involve a large number of

researchers, and as a result they are likely to cover a range of disciplines and scientific domains. Another reason is the increased financial commitment by the European Commission (the greater demands for accountability) to COST activities under the FP7. In one of the following chapters, (see Chapter 6) this research will closer examine COST, its structure, principles and operations, to gain a better understanding of formal networking programmes.

5.8 Role Duality and Implications

This section examines a number of questions associated with the author's on-site location, the duality of his role at the COST Office, and balancing of his closeness to the organisation and maintaining distance.

The author spent overall approximately three years working at the research site – the COST Office in Brussels. During this time at the research site, in his standard organisational role, the author was involved in different aspects of management and administration of COST Actions (FNR projects). The author was also responsible for the coordination of several strategic studies funded by the COST Office. Two of these studies primarily assessed potential and actual impact of COST networking projects, while the third study focused on the assessment of the satisfaction of the COST users and stakeholders (CSS 2007). Such an insider position certainly had its distinct advantages and disadvantages. An overview of some of these reported by (insider) researchers conducting research in their organisations is offered by Coghlan and Brannick (2009) (see Table 5-3 below).

Table 5-3: Insider Researchers Conducting Research Inside Their Own Organisations: Advantages and Disadvantages
Adapted from Coghlan and Brannick (2009)

Advantages	*Disadvantages*
Insider researchers possess preunderstanding of the research setting before they engage in a research programme;	Insider researchers may assume too much and not probe as deeply as outsiders;
Insider researchers have knowledge of an organisation or community's everyday life – its rules and norms;	Insider researchers can find it difficult to gain access to relevant data because of their roles within internal hierarchies. They can be denied deeper access;
Insider researchers can use the appropriate "internal jargon" and draw on their own experience in asking questions and interviewing	The research topic can be considered subversive and is political;
Insider researchers can participate in discussions or observe without others necessarily being aware of their presence;	Role duality can lead to role conflict; possible problems with role identity;
Insider researchers can participate freely, without drawing attention to themselves and creating suspicion".	Involvement in the two roles can affect researcher's relations with organisational members;

First, the author was able *to acquire knowledge of the internal organisational culture* at the COST Office. In addition, such a full immersion in the organisation's daily work life permitted the researcher *to learn the internal jargon* and *to* better *understand its internal norms and regulations*. Coordinating the COST Strategic studies allowed the researcher *to observe the on-going developments* and *to participate in key discussions without drawing any unnecessary attention* to his personal research agenda. Furthermore, this prolonged exposure to the COST environment helped the author *to further focus his personal research project*. Instead of focusing purely on collaborative research projects in general, the author of this thesis realised that there is an important lesson to be learnt from funding provided to researchers by COST. While at the COST Office, the author realised that while there is strong support in the research community for such FNR funding, the existing research literature on formal collaborative research projects was extremely limited. In fact, the

literature at the time only offered fragmented empirical evidence to support the claim that the taxpayers' money spent by the EU and national governments was, and is, being spent on productive scientific networking and not on 'scientists socialising'. Managers and administrators of many funding schemes are expected or required to provide some evidence of the added-value produced in the projects financed by them. Often, this evidence is limited to some form of success stories. As a result, one important element in the overall picture was still missing – some documented empirical evidence validating or rejecting the claims that the funded networking research projects facilitate creation of added-value. A strong sense of research curiosity further led the author through the last few years to put together answers to these research questions in this research thesis. The actual data collection was carried out as an integral part of a larger evaluation study (CSS 2007) conducted by the COST Office in compliance with ESF's contract obligations with the European Commission. In 2006, the author had an opportunity to contribute to the original objectives of the new COST customer satisfaction study (CSS 2007). Preparation for this study and the actual surveys took place between 2006 and 2007. During these years, the author realised the importance of finding the right balance between his COST role and any personal research objectives. Often, any such attempt to sustain simultaneously a full organisational membership and the research perspective could result in a conflict as while the former role requires full and dynamic participation, the latter demands '*a more detached, theoretic, objective and neutral observer position*' (Coghlan & Brannick, 2009, p. 119).

The author was responsible for the coordination of every stage of the CSS 2007 study. These stages included planning of studies, expert recruitment, tender organisation, selection of the contractors for the studies, as well as the actual design of surveys, and the general facilitation and support of survey (and related) activities. Most of these stages presented opportunities for a potential role conflict. The author recounts how a conflict between his two roles arose during the stage when the questionnaires were being developed. On the one hand, in the role of a Scientific Secretary to COST Strategic Studies, the author had to pursue business objectives of developing an efficient and economically viable study. The survey also had to be reasonably brief, so only a limited number of additional questions could be added to the original questionnaires. With an agreement of the COST management, the author *pursued a number of additional research questions* which were central to this thesis. However, the nature of these additional questions had to be contextually (and politically) appropriate as well as they had to be approved by the COST management and the high-level expert panel. Managing stable relations with these stakeholders helped the author to ensure the success of the ongoing research project and the strong top management support. These are some other role duality related advantages and disadvantages are further discussed by Nielsen and Repstad (1993).

It is evident that being an insider in the organisation in focus (the COST Office) offered the author of this thesis a number of distinct advantages in terms of contributing to the research scope, study design and access to data. However, sustaining two different roles simultaneously can result in certain operational or political difficulties. In addition, when conducting research in their organisations, insider researchers should be aware of potential ethical and political implications of their research.

5.8.1 Populations and Samples

The survey is the main method of this research and, in fact, it took a form of several surveys tackling different yet complementing aspects of the research phenomenon and these were addressed to different groups of stakeholders and programme participants involved in formal collaborative programmes as well as some potential programme users. Three major separate survey questionnaires were distributed respectively to three target samples of (1) potential users (see Appendix 4), (2) existing participants of collaborative research programmes (see Appendix 5), and (3) scientific experts (see Appendix 6). The questionnaires differed in some important features because of the intrinsic conflict of interest. Actual project participants have been assumed not to be perfectly neutral judges of the effectiveness of the formal research-networking programme but they have also been assumed to have an advantaged knowledge of the collaborative programme in question and of the possible alternative sources of research collaboration funding available.

5.8.1.1 Survey 1: Potential Participants

This survey was built to address one of the three groups of respondents identified for the purposes of this thesis. The survey was sent out to all of the applicants who submitted application proposals for collaborative funding provided by the organisation. The survey aimed to confirm the anticipated (expected) programme results (outputs and outcomes) as perceived by participants who are not yet in receipt of funding from the programmes. The distinction is made between the applicants with earlier experience of participation in formal research programmes and those without such experience.

5.8.1.2 Survey 2: Actual FNR Participants

This second survey was formed to detect what research-networking outcomes/outputs are achieved by actual participants and whether there is any relationship between these outcomes and the duration of the participant's involvement in the formal networking research programme. The list of outputs was created based on the reviewed literature and was later confirmed by the field experts and participants with experience of formal networking programmes.

5.8.1.3 Survey 3: Scientific Experts

The third group of survey respondents consisted of scientific experts across nine scientific domains. This category was asked to provide their opinion on different research networking instruments and on applicability of research outcomes to the programme in question. The respondents are highly knowledgeable scientists nominated by their home countries to special scientific domain committees. These experts regulate, to some extent authorise and manage formal networking projects. Many of them also have a very thorough knowledge of the research-networking programme in terms of content and procedures. As a result, they can have a different understanding of what can be achieved from the networking projects; in fact, many of them can also establish certain standards for these measures (Koontz & Thomas, 2006). So, surveying these experts can allow for comparison with the results reported by the actual project participants. This involvement of project experts into the study can provide additional insights and perspective on the measurement standards.

Within the context of this research setting (exploring formal research networking programmes participation for individual level research outcomes associated with these programmes), the research surveys in categories 1 and 2 addressed the entire samples in each respondent category with one condition – each person on the respondent list had to be an active participant. Here, an active participant is a person who was in receipt of funding in the five years preceding the study (7,709 people in category 2 (current participants), and 242 people in category 3 (experts)). In the category of potential participants (category 1), every main proposal convener who applied for networking funding in the year preceding the survey was included on the questionnaire recipient list (712 people).

5.8.2 Unit of Analysis

There is a growing realisation of the phenomenon of research collaboration has only been studied on the macro level, and rarely on the micro level (Rigby & Edler, 2005). Other researchers further argue that only little is known about this micro-level as only a very few studies attempted to leave the macro level of analysis (Melin, 2000). Other academics agree that the individual is the most critical level to research since all knowledge is in the first instance created or acquired by individuals (Coombs & Bierly, 2006). This thesis explores the outputs of the individual researcher's participation in a collaborative project primarily based on the output results reported by the individual. To balance these subjective measures the informants are asked about their achievements in terms of both intangible and tangible outputs and outcomes. As the emphasis of this thesis is placed on the results achieved by individual researchers from participation in sponsored formal networking projects, this emphasis is justified on the basis that one's individual decision to take part in the future collaborative projects often is influenced by these subjective perceptions of success and previous project outputs (Barnes et al., 2002). Therefore, the unit of analysis for this research is an *individual researcher* (also see Figure 3-1). These individual researchers may perform differently both across the groups and within the groups depending on some of their individual factors such as age, experience, level of education, etc. The individual researcher as the unit of analysis means that the logic of the research is to investigate how individual researchers vary on the different variables and how that individual-person-variance is related across different variables (Punch, 2003).

5.8.3 Question Identification and Development

This subsection presents an overview of some issues that this thesis faced when constructing the three surveys. A customer satisfaction study (COST CSS) was primarily a contractual requirement between the European Commission and the ESF. The first survey (COST CSS 2005) took place in 2005 and served as an important input to the Mid-Term Review (MTR). The results of the first COST customer satisfaction survey were deemed satisfactory. In June 2005, the high level expert panel which conducted the MTR of COST operations stressed the importance of repeating this study. The panel specifically recommended a full review of customer satisfaction across all groups of users and stakeholders as such a review would be a key input into the further evolution of COST in the ERA. As a result, the starting point for developing and identification of survey questionnaires and associated measurements were the original measurement instruments of the original customer satisfaction survey (COST CSS 2005).

To ensure comparability of these two studies it was agreed to include as many items from CSS 2005 as possible in the new framework without compromising on the new scope of COST CSS 2007. If the CSS 2005 study primarily focused on customer (user) satisfaction with specific COST operations, the scope of CSS 2007 was significantly wider. Three major questionnaires were developed to be distributed respectively to three groups of respondents: (1) potential users (see Appendix 4), (2) existing participants of collaborative research programmes (see Appendix 5), and (3) scientific experts (see Appendix 6). The questionnaires consist of different yet completementing components.

To get the right information one needs to ask valid questions. It was agreed that all questionnaires would be offered in English only, as to have comparable cross-national validity. As longer questions are harder for respondents to process (especially if they are not in the first language of the respondent), it was also agreed to keep the overall questionnaires as brief as possible. In addition, one has to keep questionnaires focused and clear. When developing individual questions, it was also agreed that each question would address a single area of enquiry. A preliminary frame of questions for each questionnaire was drafted during the meeting of the high level expert panel. This list has then been further edited and additional questions were suggested and included with the agreement from the COST management. These questionnaires then were reviewed and pilot-tested by project participants (COST Actions participants in several scientific Domains) to see if there was another way to make them clearer and to avoid any ambiguity. Following the pilot stage, a final list of questions was proposed to the expert panel and was finally approved for execution. The three surveys included three main sections of questions: (1) *Group Specific Questions*, (2) *Customer Satisfaction Questions*, and (3) *General Profile Questions* (see grey cells in Table 5-4 below).

Table 5-4: Survey Sections and Structure(s)

<table>
<tr><th>Sections</th><th>Potential Participants</th><th>Actual Participants</th><th>Scientific Experts</th></tr>
<tr><td rowspan="3">Group Specific Questions</td><td></td><td>Outcomes (The extent to which specific FNR Outcomes are achieved by FNR researchers)</td><td>Outcomes (The extent to which specific FNR Outcomes are achieved by FNR researchers (perception of))</td></tr>
<tr><td>Motivation (to apply for FNR funding)
+ Awareness of alternative sources of FNR funding
+ Future Renewal Intent</td><td>-</td><td>-</td></tr>
<tr><td>Interest in Specific COST Instruments</td><td>Researcher Satisfaction with Specific COST Instruments</td><td>Researcher satisfaction with Specific COST Insturments (perception of)</td></tr>
<tr><td rowspan="2">Customer Satisfaction Questions</td><td></td><td colspan="2">Allocation of funds
to individual instruments</td></tr>
<tr><td>+ Satisfaction with COST (Open Call)</td><td>+ Satisfaction with COST (Operations)</td><td>+ Satisfaction with COST (Networking)</td></tr>
<tr><td rowspan="3">Profile Questions</td><td colspan="3">Age, Gender,
Country of Work, Education Level,
Professional Background</td></tr>
<tr><td colspan="2">+ Research Experience</td><td rowspan="2">Adjustments:
- Research Experience Question was excluded

+ Involvement in COST Actions as an individual researcher</td></tr>
<tr><td>+ Prior COST Experience</td><td>+ COST Experience (in years)
+ Involvement in more than 1 COST Action at a time (multi-networking)</td></tr>
</table>

Each questionnaire started with a general question about the role of COST networking programme in the European Research Area. *Group specific questions* focused on *motivation* (Potential Participants), research *productivity* (Actual Participants), and a *perception of researcher productivity* (Scientific Experts). Questions about research *outcomes* (associated with participation in COST Actions) were integrated into questionnaires for Actual Participants and Scientific Experts. The final list of outputs was created based on the reviewed literature and was later confirmed by the field experts and participants with experience of formal networking programmes. In agreement with the suggestions by the COST Office, the same two groups of respondents (Actual Participants and Scientific Experts) were asked an additional number of questions regarding the current allocation of funding to specific COST Instruments. Questions about motivation for participation in COST Actions, alternatives to COST funding, interest in future grant applications (renewal intent) and in specific COST Instruments were further added to the questionnaire (for Potential Participants).

Importantly, each questionnaire included a large number of (customer) satisfaction questions. The objective here was to learn more about the existing COST operations with a particular focus on (1) possible improvements to the introduced *Open Call system* and associated processes (Potential Participants), (2) on satisfaction with existing COST operations from the participants' perspective (Actual Participants), and (3) on COST as a networking environment from the experts' perspective (Scientific Experts). Finally, each questionnaire concluded with a number of profile questions regarding respondents' *age, gender, country of work, educational level,* and *professional background/sector*. In general, these questions were identical for all groups of respondents with a few minor exceptions. It was agreed, for example, that a question about respondent's research experience would be redundant in case of experts. A number of additional control variables have been further added to the questionnaires regarding respondents' previous/current COST experience (Potential Particitipants, Actual Participants, and Scientific Experts) and their involvement in multi-networking (Actual Participants).

The following subsection of this thesis deals with the identification of specific variables and the development of appropriate measures.

5.8.4 Variables and Measures

This thesis is concerned with several research issues. The first issue is concerned with the motivation behind social actors' decision to engage in formal networking research projects. The second issue explores individual researcher outputs which can be attributed to participation in formal networking research projects funded by the EU. As formal research networking programmes are becoming more common, an approach to assessing individual researcher outputs associated with them is needed. Such formal scientific networking is a relatively new phenomenon and in its earlier chapters, and this thesis identified a lack of literature in this area. The novelty of this phenomenon and the acknowledged lack of established measures further highlight the difficulties in its assessment (Charles & McNulty, 1999). This study proposed to seek to understand this phenomenon by exploring it from three complementary angles:

(1) from the perspective of those researchers who are currently involved in some of these formal collaborative projects,

(2) from the perspective of experts who possess expertise and experience of a different nature to those of currently involved participants, and

(3) finally, the perspective from those researchers who are not yet in receipt of this type of networking funding but who have applied for this funding and who therefore may have different reasons for applying.

The third issue this research is concerned with is whether there is a relationship between the amount of time researchers spend in formal research networking projects and the research outputs which participants attribute to their participation in these projects. To address these research issues, the author has developed a conceptual framework that integrates researcher motivation and productivity. Furthermore, it views FNR productivity as a set of research networking outputs across two dimensions of research outcomes: UPGS (upgrading, upshifting and upstreaming) and UPSC (upscaling). Importantly, these constructs should be quantifiable. The developed constructs can then be used to test and determine the effectiveness of the formal collaborative research networking programmes.

This section will deal with the construction of scales used in the questionnaires. The term 'scale' is commonly used to refer to a measurement instrument developed for the purpose of measuring a theoretical phenomenon that cannot be readily observed or assessed directly (DeVellis, 2003). The scale development process is of critical importance and specific steps should be carried out in order for the researcher to construct a reliable and valid measure and to have any confidence in the construct. Proposed integrated framework assumes an inherent link between the earlier discussed collaborative motives and researcher productivity as expressed through research outputs and outcomes reported by the individual researchers.

The respondents make their decisions on the basis of both objective and subjective data and information (Churchill, 1999). As this thesis employed the survey methodology, its main instruments (questionnaires) were tested to establish conditions for reliability and validity. The questionnaires were developed to include a list of eleven original measures for the variables included in the hypotheses to be investigated (see Appendix 4, Appendix 5 and Appendix 6). These questionnaires were built based on the framework developed in an earlier chapter. The majority of survey questions were newly developed to capture certain constructs due to the newness of the study phenomenon. All of the constructs have been built of multiple items and measured by a multiple item scale (DeVellis, 2003). Using multiple-item scales and summated ratings is a common approach used when individuals aim at quantifying constructs which are not directly measureable otherwise (Gliem & Gliem, 2003). Summated rating scales generally share four common features: (1) they consist of multiple items which can be combined or summed up, (2) they all measure a property of something that can vary quantitatively rather than qualitatively, (3) there is no right answer to any of these items, and (4) each item is presented in a form of a statement in relation to which respondents are asked to give rating (Spector, 1992).

The use of the Likert scale is accompanied by two main discussions in the literature. First, researchers have not yet arrived at a consensus on how to treat Likert scale items. Some argue that Likert items should be considered as interval data, while on the other hand, in some cases they can be treated as ordinal data (Madsen, 1989; Newman, 1994; Schertzer & Kerman, 1985). If the Likert items have only five levels then it

is open to discussion as to whether the respondents perceive these five levels as equidistant. While on the other hand, the use of five levels and the wording of response options suggests a certain symmetry of response levels about a middle level (McIver & Carmines, 1981). In addition, there is yet another discussion about the 'right' number of points to be used in a Likert scale (Armstrong & Overton, 1977; Newman, 1994). Likert scales, while certainly having some disadvantages, are becoming increasingly popular these days due to their relative simplicity and reliability. Yet researchers' main concern when dealing with the Likert scales is their uni-dimensionality, that is, whether all of the items measure the same thing (Oppenheim, 1992). Likert's scale allows survey participants (respondents) to place their answers on the scale continuum for each statement. While constructing scales this study closely followed procedures as outlined by Oppenheim (1992).

For the purpose of this research, the author treats the Likert scale as ordinal as we can assume that the distance between the values on the scale are the same and therefore it is hard to argue that the scale is an interval variable. In the survey addressing *Current Participants* (Category 2), respondents were asked to answer to what extent they have achieved each of the 11 items as a result of their participation in formal networking projects. The respondents were asked to place their answers on the continuum with 5 positions[32] running from '*fully*', '*to a great extent*', '*in part*', '*to a small extent*' and '*not at all*'. A similar scale was applied to the questionnaire addressing the category 3 subjects (*Experts*). They were asked to answer to what extent they believe project participants generally achieve each of the 11 items as a result of their participation in networking projects. In line with the Oppenheim recommendation the five main positions on the chosen Likert scale were assigned simple weights[33] of 5, 4, 3, 2 and 1 for scoring purposes. The sixth position ('not applicable') was assigned zero (0). Having scored each of the items from 5 to 0, the author next added up the item scores to obtain a total (summated) score per each respondent. As there are 11 items on the questionnaire the summated scores can range from 55 (maximum score) to 0 (minimum score). The assumption is that the higher the score the higher the individual's research performance, as measured in terms of research outputs. It is, however, generally possible that some of the items can score in the higher range while others score in the lower range, and some may even not fit well in the particular dimension addressed by the scale.

The next step was to carry out an item analysis to decide what the best items for the developed scale are. It is very rare for researchers to be able to correlate each item with some external reliable criterion (Oppenheim, 1992). By assuming that the best available measure of researcher performance is the total item pool such a construct has been assembled. Further following Oppenheim's logic, by purifying this the items will at least be homogenous and consistent as they are measuring the same thing, and as a result, there is a greater possibility that the scale is valid (Oppenheim, 1992, p.199). Once this assumption is made, the following step involves the internal-consistency method of item analysis - checking correlation coefficients for each of the items and the total score, and keeping those with the high coefficients. Out of 11 items used to build the

[32] Additionally to the five positions generally offered by a Likert scale the author added an additional one - 'not applicable' as some of the items may be domain specific (for example, social scientists generally would not achieve patents or industrial applications as a result of their research work).
[33] These simple weights have been chosen as the more complex scoring methods had been shown to possess no advantage (Oppenheim, 1992, p. 195).

construct of researcher productivity, all 11 items display from moderate to strong positive correlation (statistically significant at the 0.01 level (2-tailed)) with the total score (Fitz-Gibbon & Morris, 1987, p.82).

A similar procedure - internal-consistency method of item analysis was applied to the multi-item scale employed in the category 3 survey (*Experts*). By checking correlation coefficients for each of the items and the total score, and keeping those with the high coefficients, this research has established that out of 11 items used to build the construct of perceived researcher productivity, all 11 items display statistically significant (at the 0.01 level) correlation with the total productivity score, ranging from moderate to strong positive correlation and in two cases very strong positive correlation. In the third survey (category 1 – Potential Participants (applicants)), survey participants were asked to reply to a number of questions. The first group of questions addressed the reasons which influenced applicants' decision to apply for formal networking funding. The survey subjects were specifically asked to rank one of three predefined reasons for applying for funding. Three major reasons were offered to choose from: (1) gaining access to additional funding, (2) meeting peers through cross-border networking, and (3) enhancing the chance of disseminating project results. These three reasons had been established through the review of literature and they were later validated through a number of interviews, a pilot study and a discussion with panel experts. In the next part of the questionnaire, respondents were asked the extent to which they were interested in specific programme instruments (with a provided list of ten instruments and a brief explanation of each if needed). The respondents were asked to place themselves on the scale from 1 ('*not interested at all*') to 10 ('*highly interested*').

5.9 Reliability and Validity

Generally a reliable survey instrument is consistent while a valid survey instrument is accurate (Fink, 1995b). Surveys tend to be weak on validity and strong on reliability. The artificiality of the survey format puts a strain on validity. Since real human feelings are hard to grasp in terms of such dichotomies as 'agree/disagree', 'support/oppose', 'like/dislike', etc. These are only approximate indicators of what we have in mind when we create the questions.

Reliability, on the other hand, is a clearer matter. Survey research presents all subjects with a standardised stimulus, and so goes a long way toward eliminating unreliability in the researcher's observations. Careful wording, format, content, etc. can reduce significantly the subject's own unreliability. Researchers bear the responsibility for the research method's design, including dealing with the questions of their research instrument's validity and reliability (Morris & Fitz-Gibbon, 1978). Since in most cases both groups of people and situations they are in are never exactly the same, the ways of determining an instrument's validity and reliability are multiple (Dunn, 1987).

5.9.1 Reliability (Generalisability)

A reliable survey instrument is expected to be relatively free of measurement error in which respondents score differently to their true scores (scores obtained from perfect measures) (Fink, 1995b). Reliability is the extent to which surveys achieve the same results with every replication or repeat. This ability of researchers to yield consistent results supports their claims about the generalisability of their research findings. The

concept of reliability is considered central to a range of research activities and currently the following three types of reliability in research are distinguished: equivalency, stability and internal reliability.

Equivalency reliability is the extent to which two items measure identical concepts at an identical level of difficulty and largely is determined by two sets of test scores to confirm the degree of relationship or association between them. The correlation coefficient (***r***) is generally used to show the strength of the correlation between a dependent variable and independent variable(s). As a result, the equivalency reliability is dealing with correlational relationships rather than causal. *Stability reliability* deals with measuring instruments over time by repeating a measure of tests on the same research subjects at a future date, comparing the results and correlating them with the results of the initial test. A study's reliability can be to some extent ensured through the provisions of complete descriptions, explanations and full documentation of the research procedures, so that the same study can be potentially replicated using identical research design and logic. Detailed description of steps taken by the author of this thesis would permit other researchers to reproduce this study's steps including the stages of data collection and analysis.

Reliability generally refers to the property of a measurement instrument that causes it to give similar results for similar inputs. Unfortunately, it is difficult and often impossible to establish absolute standards for academic excellence or the meaning of human responses to a survey. It is important to try to establish reasonably consistent scales. The methods available via the reliability analysis procedure are useful for situations in which the true state of the measured objects is unknown. This thesis will therefore apply reliability analysis to determine to what degree the surveys were successful in constructing questions that measure a researcher's opinion in relation to individual *researcher (FNR) productivity* (Survey Category 2). The individual summary statistics seem to indicate that there are three general groups of indicators, those (see Table 5-5):

- that are generally achieved to a great extent by the majority of respondents (with the means in the range of 3 and 4);
- that are achieved to a lesser extent (with the means of scores in the range from 2 to 3);
- in addition, those that are achieved only by a small extent by the majority of respondents (with the scores means in the range from 0 to 2).

Table 5-5: Item Statistics (Researcher productivity indicators – Category 2 Survey)

Individual Items	*Mean*	*Std. Deviation*	*N*
1. International conference of high standard	3.53	1.288	2173
2. Joint publications in high-ranked scientific journals (peer review)	2.73	1.463	2173
3. Publication of a book	2.06	1.737	2173
4. Industrial applications	1.53	1.380	2173
5. Raised the international profile of participant's organisation	3.36	1.114	2173
6. Raised the international profile of participant's own research	3.51	1.095	2173
7. Raised the international profile of the funding sponsor	3.48	1.151	2173
8. Utilisation of COST results at national level	3.07	1.240	2173
9. Patents	0.93	1.105	2173
10. Influence on policy issues (at European level and/or country level)	2.21	1.366	2173
11. Submission of proposal(s) for a new EU-funded project	2.40	1.572	2173

The results of the inter-item correlation matrix based on the individual researcher performance indicators confirm some of the earlier notions (see Table 5-6). The responses for the items (5, 6 and 7) are highly correlated, reaffirming the understanding that researchers who raise the international profile of their own

research will tend to increase the international profiles of their organisations and their funding sponsor. Moreover, there is a positive correlation between questions 4 and 9, which was expected. This correlation confirms that researchers reporting achievements in the form of industrial applications will tend to report patents too. The responses to the majority of other questions also display a degree of correlation. The weakest degree of correlation is between the responses to questions 1 and 9 (0.184) which suggests that while there is certain level of correlation between the researchers involved in development of patents do not necessarily tend to attend international high-level conferences.

Table 5-6: Inter-Item Correlation Matrix (Researcher productivity indicators – Category 2 Survey)

	1. International conference	2. Joint publications in high-ranked journals	3. Publication of a book	4. Industrial applications	5. Raised the international profile of participant's organisation	6. Raised the international profile of participant's own research	7. Raised the international profile of the funding sponsor	8. Utilisation of COST results at national level	9. Patents	10. Influence on policy issues	11. Submission of proposal(s)
1. International conference	1.000	.444	.287	.219	.301	.360	.400	.331	.184	.240	.265
2. Joint publications in high-ranked journals	.444	1.000	.344	.267	.275	.363	.321	.343	.272	.239	.363
3. Publication of a book	.287	.344	1.000	.306	.203	.235	.272	.279	.289	.289	.328
4. Industrial applications	.219	.267	.306	1.000	.285	.242	.302	.312	.533	.316	.322
5. Raised the international profile of participant's organisation	.301	.275	.203	.285	1.000	.660	.528	.487	.197	.342	.302
6. Raised the international profile of participant's own research	.360	.363	.235	.242	.660	1.000	.527	.473	.183	.274	.304
7. Raised the international profile of funding sponsor	.400	.321	.272	.302	.528	.527	1.000	.495	.217	.387	.333
8. Utilisation of project results at national level	.331	.343	.279	.312	.487	.473	.495	1.000	.226	.457	.316
9. Patents	.184	.272	.289	.533	.197	.183	.217	.226	1.000	.319	.341
10. Influence on policy issue	.240	.239	.289	.316	.342	.274	.387	.457	.319	1.000	.369
11. Submission of proposal(s) for a new Action in EU FP	.265	.363	.328	.322	.302	.304	.333	.316	.341	.369	1.000

While there is a lot of information that can be acquired from looking at correlations what is really needed is a single summary statistic that would tell how reliable this survey was.

There are several ways to do this, the most common of which is *Cronbach's alpha*[34]. It states that answers to a reliable survey will differ because respondents have different opinions, not because the survey is confusing (or there are possible multiple interpretations).

[34] Cronbach's alpha (Cronbach, 1951) is a measure of reliability. More specifically, alpha is a lower bound for the true reliability of the survey. Mathematically, reliability is defined as the proportion of the variability in the responses to the survey that is the result of differences in the respondents.

The computation of Cronbach's alpha is based on the number of items on the survey (k) and the ratio of the average inter-item covariance to the average item variance. Under the assumption that the item variances are all equal, this ratio simplifies to the average inter-item correlation and the result is known as the *standardised item alpha* (or Spearman-Brown stepped-up reliability coefficient). The value of Cronbach's alpha is reported in the Table 5-7 (Reliability Statistics) below. It should be noted that the *standardised item alpha* is computed only if inter-item statistics are specified. The coefficient of 0.836 reported for these items is an estimate of the true alpha, which in turn is a lower bound for the true reliability. The internal validity (construct reliability) test has also been applied to the results of the categories 2 and 3 surveys. The Cronbach's alpha results for the constructs developed for these two studies have been achieved at the satisfactory high levels of 0.850 for the category 3 survey and 0.767 for the construct used in the category 1 survey (see Table 5-7).

Table 5-7: Reliability Statistics

Study Type	*Cronbach's Alpha*	*Cronbach's Alpha Based on Standardised Items*	*N of Items*
Potential Participants	0.767	0.773	10
Current Participants	0.836	0.843	11
Project Experts	0.850	0.854	11

To assess further the reliability of the individual items included in the constructs in the questionnaires this research will test them for their internal consistency. *Internal consistency* (construct reliability) provides a measure of the precision between the observers or instruments in a study and it is generally used to predict the value of scores as well as the limits of the relationship among the identified variables. Internal consistency is estimated via the split-half reliability index or coefficient alpha (Cronbach, 1951) index. The split-half estimate entails dividing-up the test into two parts (e.g. odd/even items or first half of the items/second half of the items), administering the two forms to the same group of individuals and correlating the responses. Coefficient alpha represents the average of all possible split-half estimates. This thesis is concerned with development of a questionnaire(s) to explore several aspects of researcher productivity. Therefore, by analysing the internal consistency of the survey items dealing with researcher productivity it will reveal the extent to which items on the questionnaire focus on the notion of researcher productivity. In an ideal situation, to acquire a good estimate of the reliability of a survey, it would be necessary to run the survey twice to the same group of people and then correlate the two sets of survey results. However, this option is often impractical because bias may be introduced in the second set of answers or because respondents may be unwilling or unable to take the survey a second time. One solution is to compute Cronbach's alpha. Another solution is to split the items into two groups and then to compare these groups as if they were two separate administrations of the same survey (see the results in Table 5-8).

Table 5-8: Scale Statistics, Reliability test (Project Experts)

	Mean	*Variance*	*Std. Deviation*	*N of Items*
Part 1	16.72	28.022	5.294	6([35])
Part 2	12.09	19.932	4.465	5([36])
Both Parts	28.81	81.467	9.026	11

[35] The items are International conference of high standard, Joint publications in high ranked scientific journals (peer review), Publication of a book, Industrial applications, Raised the international profile of your organisation, Raised the international profile of your own research.

[36] The items are: Raised the international profile of funding sponsor, Utilisation of FNR project results at national level, Patents, Influence on policy issues (at European level and/or country level), Submission of proposal(s) for a new EU-funded project.

The *Correlation between forms* (0.709) is simply the correlation between the sums of the items in each group (see Table 5-9). Generally, the higher the reliability value the more reliable the measure. The general agreement in existing research is that one should attempt to achieve reliability values of 0.70 or higher (Miller, 2008; Nunnally & Bernstein, 1994).

Table 5-9: Reliability Statistics (Current Participants)

Cronbach's Alpha	Part 1	Value	0.722
		N of Items	6(a)
	Part 2	Value	0.722
		N of Items	5(b)
	Total N of Items		11
Correlation Between Forms			0.709
Spearman-Brown Coefficient	Equal Length		0.830
	Unequal Length		0.831
Guttman Split-Half Coefficient			0.823

As the internal consistency (homogeneity) coefficient is used to measure the extent(s) to which items on the test (instrument) are measuring the same thing then if individual items are highly correlated with each other it is possible to be highly confident of the reliability of the entire scale. The Equal-length Spearman-Brown coefficient (0.830) is then computed using the formula for the standardised item alpha for two items, inserting the '*Correlation between forms*' as the correlation. The Guttman Split-half coefficient (0.823[37]) is computed using the formula for Cronbach's alpha for two items, inserting the covariance between the item sums of two groups and the average of the variances of the group sums.

5.9.2 Internal Validity (Construct, Content, Face)

If the earlier discussed concept of reliability is dealing with the precision of the actually applied measuring instrument or procedure, *validity* is concerned to establish whether the researchers are measuring in fact what they wanted to measure. Therefore, validity can be interpreted as the level of accuracy with which the research concepts are set up and measured. Generally, researchers are concerned with external as well as internal validity. The extent to which results of the study are generalisable is referred to as the external validity (Campbell, Stanley & Gage, 1963). Internal validity in most cases deals with either (1) researcher's rigour in respect to the study procedures/methods, or (2) in case of studies dealing with causal relationships, internal validity will also deal with whether the researcher has considered all other possible explanations for these causal relationships (Huitt, 1998; Singh, 2007). Scholars generally discuss several types of internal validity: face validity, construct validity, content validity and criterion related validity.

Face validity examines whether a measure or procedure appears valid. This type of validity can be established through consultations with other researchers and experts by discussing to what extent the measures are perceived as adequate to depict the research concept in question, and as such face validity does not require any support by any of the established theories (Fink, 1995b; Singh, 2007). By approaching a number of experts in the field and acquiring their feedback on the structure of the study, measures, and the

[37] These different splits of the items produced different estimates of the reliability coefficient. When they are split so that each group contains items that are highly correlated within the group but not between groups (as has been done here), the split-half coefficients will be close to their lowest values. When highly correlated items are paired off and placed into separate groups, then the split-half coefficients will reach their highest values.

applied constructs and individual construct items, the author ensured an acceptable level of face validity. While similar to face validity, content validity goes a little further in its requirements.

Content validity is dealing with the adequateness with which researchers covered for the construct domain or even for the essence of the domain (Churchill, 1979). However, it would seem rather impossible to measure it in an objective and numerical manner. In fact, Emory (1985) further argues that this content validity can be established only in subjective and judgemental manner. To address the concerns linked to the content validity of this study in the research stage prior to data collection, the content validity was established by employing an extensive literature review to build the research instruments. They were further assessed by a group of six experts (academics and policy makers with significant experience in the field). Their comments were taken into account to rewrite the survey questions and measurement items and scales. The final draft version of the questionnaire instrument has been amended and further trialled though smaller pilot studies. Because of this process a number of items were re-written to improve the questionnaire content. The overall feedback collected and applied during these three validation stages allowed a validated survey questionnaire to develop so that all applicable conceptual space has been covered.

Criterion related validity (or instrumental validity) could be applied to demonstrate the accuracy of a measure or procedure by comparing it with another measure or procedure that has been demonstrated to be valid. However, similar to criterion validity, content validity examines specific relationships between the instruments but with a wider perspective (Dunn, 1987). In certain cases where criterion (or even content) is difficult to define, the construct validity can be more important (Cronbach & Meehl, 1955). *Construct validity* deals with the discrepancies between the theoretical concept and a specific procedure or tool measuring it (Carmines & Zeller, 1979). There are two main sub-types of construct validity: convergent validity and discriminate validity. Discriminate validity implies that there is no relationship between the measures while theory suggests these measures are not related. In contrast to discriminate validity when in theory there is an expected relationship between several measures, convergent validity confirms the agreement between these measures.

In other words, the construct validity is the extent to which the individual items in a scale measure the underlying theoretical or even abstract concepts. These theoretical or abstract concepts are generally also known as constructs (Dunn, 1987). The term '*construct*' is used 'to refer to something that is observable, but is literally constructed by the investigator to summarise or account for the regularities or relationships that he observes in behaviour' (Thorndike & Hagen, 1977, p.70). Construct validity is established on the grounds of correlations between the variables in question. In fact, a high level of correlation between these variables (inter-item correlations) is an important prerequisite to validity of the construct (Salzberger, 2008). According to the same author, as these correlations are important to scale development, individual items should be built in a way that ensures or guarantees substantial inter-item correlations. Other researchers suggest that construct validity mainly deals with the question that the research instrument is measuring and that construct validity '*lies at the very heart of scientific progress*' (Churchill, 1999, p. 454). However, to demonstrate construct validity it is necessary to go through three distinct steps. '*First, the theoretical relationship between the concepts themselves must be simplified. Second, the empirical relationship between*

the measures of the concepts must be examined. Finally, the empirical evidence must be interpreted in terms of how it clarifies the construct validity of a particular measure' (Carmines & Zeller, 1979, p.23).

This approach argues for a defined research program using a variety of different methods to gain a further understanding of the construct and its measurement by the evaluation instrument (Dunn, 1987). Research procedures contributing to the understanding and measurement of the construct will also add to the construct validity of the evaluation instrument that is designed to measure the construct. Dunn further notes that a range of procedures is generally applied by researchers to increase construct validity during all research phases from instrument construction to its validation. The adequate procedures which should be considered by researchers, include extensive review of both professional and related literature, content validity and criterion-related validity, forms of descriptive research, multitrait-multimethod studies, as well as factor-analytic studies (Dunn, 1987).

So as to ensure an acceptable level of construct validity the author of this thesis applied additional efforts to ensure the internal consistency between the individual items in question. While developing a researcher performance index the author spent a significant amount of time defining researcher performance (productivity) in order to achieve an acceptable level of construct validity. The developed constructs studied in this thesis have been validated through the application of reviewed evaluation studies to establish the relationships between the items in the concepts. Following this, the author examined the empirical relationship between the items in the constructs.

In addition, by confirming a statistically significant[38] degree of covariance between these items, the author established construct validity. The constructs have been also validated with pilot studies and supplementary interviews with some of the existing users and experts familiar with the phenomenon in question. Data and information such as internal organisation's documentation collected during the project have served as additional sources of construct verification and validation. Finally, the final draft versions of the questionnaires (addressing individual items of the developed constructs) and the acquired empirical evidence have been reviewed by the high-level expert panel employed for the study by the organisation to ensure the coherence, consistency and construct validity of the developed measures.

5.9.3 External Validity

External validity generally defines the extent to which results of the study are generalisable (Campbell et al., 1963). As discussed earlier, surveys potentially can generate generalisable research results that then can be applied to those larger populations even though such a potentials requires careful assessment and design considerations (King & He, 2005). The generalisability of results is in itself a broad concept, which can be dealt with at several different angles (Lee & Baskerville, 2003). One main reason why it is crucial to consider the external validity (generalisability) of the survey results lies in the low response rates which are obtained through some surveys (Radhakrishna & Doamekpor, 2008).

[38] The results of correlation tests confirmed statistically significant (at the 0.01 level (2-tailed)) levels of correlation between all 11 individual items in the construct developed for the category 1 survey (Current Participants), statistically significant (at the 0.01 level (2-tailed)) inter-item correlations between 9 out 11 individual items used in the survey category 2 (Experts), and statistically significant (at the 0.05 level (2-tailed) between 9 out 10 individual items in the construct applied in the category 3 survey (Potential Participants).

A number of authors point out four potential sources of error in survey research: sampling error, measurement error, coverage error, and non-response error (Dillman, 2000; King & He, 2005). *Sampling error* potentially occurs during the process of selecting a sample from an entire population. By increasing the size of the sample it is possible to lessen (but not to eliminate) the impact of this type of error. *Measurement error* is brought on by the composition of the data collection instrument. Researchers can minimise the impact of the measurement error by use of additional measures such pre-testing and pilot testing which help to tackle lack of clarity or possible ambiguity. *Coverage error* is introduced when the frame from which the sample is taken does not fully include all of the characteristics of the population to which conclusions are made (Dillman, 2000). A number of measures can be taken to increase external validity of a study (King & He, 2005; Radhakrishna & Doamekpor, 2008). As one of these measures to enhance external validity of this study the collected data has been reviewed by the members of the high-level expert panel to verify the accuracy of the data. The collected data results have been reported to these experts and their comments provided important feedback on the accuracy of the survey findings.

Coverage error and *non-response error* to a large extent can influence external validity, which in itself is an important determinant of how useful the survey results are (King & He, 2005). The extent to which the sample in question represents the entire studied population can be established (from a coverage perspective) by comparing the sample and population based on a set of key characteristics. Once these procedures are followed it is possible to enhance the external validity of the study (Radhakrishna & Doamekpor, 2008). The information on the sample and the population means of a number of variables were compared for any significant differences. The category 1 survey has been distributed to a group of potential project participants. These proposers submitted applications for networking funding in the year preceding the survey year. The category 2 survey questionnaire was distributed to all current participants taking part (or those who have been active in one of the projects in the four years preceding the survey) in networking projects funded by the sponsor organisation. The category 3 survey was distributed to all current experts registered with the organisation (officially nominated by their home countries). Respondents to these three categories of surveys have been compared with the overall populations. The results suggest that non-response does not appear to be a problem. As there were no significant differences identified between these respondents and non-respondents (populations) on several variables it was possible to statistically conclude that respondents are similar to the population and, therefore, the findings of the surveys can be generalised to the population (Radhakrishna & Doamekpor, 2008).

The decision to generalise research findings to the accessible population or general population had to be clarified in this thesis so that the results can be interpreted with a degree of caution of replicating similar study design and assumptions in similar research settings. It is important to mention that the sample of the study only includes participants of only one type of funded research networking scheme (even though it is a dominant research-networking scheme in Europe) and thus may limit the generalisability of the results. To address these potential limitations they will be reviewed later in the later *Limitations* section of this thesis.

5.9.4 Response Rates

Within the context of this research setting (exploring formal research networking programmes participation for individual level research outcomes associated with these programmes), the research surveys in categories 1 and 2 addressed the entire samples in each respondent category with one condition – each person on the respondent list had to be an active participant. Here, an active participant is a person who was in receipt of funding in the five years preceding the study (7,709 people in the category 2 (Current Participants), and 242 people in the category 3 (Experts)). In the category 1 of respondents (Potential Participants), every main proposal convener who applied for networking funding in the year preceding the survey year was included on the questionnaire recipients list (712 people) (see Table 5-10 below).

Table 5-10: Population size and response rates

Category of Informants	Customers Groups	Number of Invited Respondents	Number of Completed Questionnaires	Response Rate	Number of Questionnaires Not Delivered
Category 1	Potential Participants	712	297	42%	12
Category 2	Current Participants	7,709	2,173	28%	708
Category 3	Experts	242	114	47%	6

It is commonly accepted in research that response rates do not as such directly influence the validity of the statistical analysis of survey data, however these have to be considered as generally low response rates are often associated with small sample sizes (King & He, 2005). In line with the authors' thinking, these small sample sizes may negatively influence statistical power (by not allowing the use of certain statistical techniques) and will lead to an increased size of confidence intervals. Low response rates also influence the risk of non-response-induced errors and therefore can have an impact on the generalisability of the survey results, however the issues related to external validity have been in detail addressed in the corresponding section of this chapter.

The response rates received by the surveys conducted within the scope of this thesis however fall into the middle range of rates for this kind of web-based survey (Cook, Heath & Thompson, 2000; Couper, Traugott & Lamias, 2001). Although these response rates may be perceived as not very high, the number of respondents in the main survey (*n* 2173) is a large enough sample size to permit the use of the collected data to shed light on the relationship between scientists' productivity and participation in formal research networking projects (Landry et al., 1996). One can argue that while certain measures have been taken to increase the response rate the actual response rates have been probably decreased due to length of the survey, and lack of incentives. The following section of this chapter will discuss some of the measures taken to improve the response rates in this study.

5.9.5 Improving Response Rates

In line with the recommendations summarised by King and He (2005), a number of measures have been employed to increase the response rate in to the survey questionnaires. First, a letter of invitation by email was sent to all subjects in the survey samples signed by one of the top managers of the funding organisation. The letter appealed for a more active support and participation from the funding recipients as well as explaining the overall scope and procedures involved in the study. Also in an attempt to increase the response

rates to the questionnaires the invitation email promised[39] to inform the respondents of the final results from the study as this can often be perceived by the respondents as a positive response motivator when a study is well-founded (King & He, 2005).

Emails were circulated to all survey respondents directly by the funding organisation (signed by one of the organisation's top managers) with an explanation of the objectives for the surveys and informing them of the involved steps and procedures, scope of the study, and additionally provided details of the person in the organisation responsible for its administration. Follow-up emails (duplicate survey invitations) were sent to all sampled individuals who did not respond within a reasonable time. These follow-up emails were circulated to participants who had not opened the questionnaire link within five days after the first emails were sent. These follow-up emails were sent separately to the passive non-respondents (individuals who had not clicked the link even once) and active non-respondents (those who had clicked the link to the survey but did not complete the questionnaire).

While the response rates achieved in the study can be interpreted as satisfactory it seems there were several measures which could have resulted in increased rates. One of the possible solutions would have been to provide respondents with methods to fill the questionnaire alternative to the web-based questionnaires. However, when considering minimising survey related costs and the timeframe for the study it was decided that the average subject in the surveyed population can be described as highly technically 'savvy'. Secondly, one of the high-level expert panellists voiced a concern that the timing of the emails to participants was probably not the most optimal to target the population in question (the emails were sent during the last week of January and the first two weeks in February). Thirdly, general survey fatigue, which is one perceived component of respondents' burden often observed in academic circles, may also have taken its toll on the response rates for the conducted surveys (Stephen, Michael & William, 2004).

5.10 Pilot Phase

Even though the objectives of the study were well defined and the questionnaires were specified, these initial questionnaires still needed to be adapted for the three groups of respondents. Pilot studies in survey methodology are seen as an important step since it aids not only with the phrasing of the questions but also assists with procedural matters such as the design of a letters of introduction, the order in which the questions are to be asked, and helps to minimise non-response (Oppenheim, 1992).

While almost all aspects of a survey should be piloted, it was important to focus on the areas that had to receive greater priority. To address these priorities the pilot study was conducted in two stages. The first part took the form of a number of free style exploratory and generally unstructured discussions and interviews with the key informants and field experts (Oppenheim, 1992). These initial talks have been informed by the reviewed literature and resulted in what Oppenheim refers to as a 'hidden agenda', that is a flexible range of issues that need to be addressed within the scope of these exploratory interviews (Oppenheim, 1992, p.52).

[39] Such a report (in a form of executive summary) has been later sent out to the survey participants upon within a few months after the survey has been completed.

These interviews were recorded and analysed. The outcome of this stage was a better feel for the issues being investigated and for the different existing perspectives.

At the next step, the factual survey questions were piloted for their wording and the design of the answer-categories through another set of test questionnaires. An advantage of this step is that the participating respondents can further assist in fine-tuning the questions and answers categories by providing immediate feedback to the interviewer. This way, the respondents who are being questioned can suggest a different interpretation of the questions (in case the questions are ambiguous or vague), different phrasing of questions or even additional categories of answers, which have not been considered during the earlier stages of the questionnaire design.

As the majority in each of the three populations of informants were non-native English speakers, it was also important to ensure the phrasing of the questions was as clear and non-ambiguous as possible. Other aspects that were considered during this first stage of the pilot study concerned the layout of the questionnaires, their format, scales and the actual procedures involved in answering the questionnaires. Once the final draft questionnaires had been developed they were additionally tested for their overall coherence. The questionnaires were circulated to respondents in each of the identified categories: 60 respondents in the category 1, 100 respondents in the category 2, and 30 respondents in the category 3. The results have also suggested that a response rate for the main surveys would fall in the middle range of rates for such a type of web-based surveys.

5.11 Main Instrument Surveys and Procedures

Once the final versions of the questionnaires had been prepared the main data collection stage was launched. To collect the data necessary for this study the design of questionnaires included several sections. The research objective was to collect information across three groups of informants (category 1, category 2 and category 3 surveys). The main survey addressed those in the *category 2* – current participants in formal research networking projects. The first section of the questionnaire focused on the research outputs/outcomes achieved by individual project participants following their participation in FNR projects during the last five years. More specifically, in this section the respondents were asked about 11 research outputs and the degree to which these were achieved. The objective of this section was to collect data which indicates not only achievement of a particular output but also whether the respondents believe certain results are not achievable under their participation in such formal networking schemes.

The second section recorded the perceived usefulness of the major research networking programme instruments and whether the questioned participants were not informed about some of these instruments. In the third part, the participants were asked to identify individual COST instruments that they perceive as valuable and their satisfaction with the instruments they used in their networking activities. This section also focused on participants' perceived satisfaction with some of the organisational and logistical aspects of how the funding sponsor managed the overall organisation of networking projects.

This section also attempted to capture data on whether researcher expectations had been met, whether participation in these projects contributed to their individual research goals, and if the level of participation

by other participants was adequate/sufficient, etc. The final section of the questionnaire dealt with the respondents' socio-professional indicators such their age, gender, the level of education, the level of research experience, their professional background, the level of their experience of formal research networking projects, their country of work and their scientific domain.

The *category 3 survey* addressed a different group of respondents – experts. These are mainly experienced researchers nominated by their national governments to represent their national scientific domains at the European level. Many of these professionals have extensive personal experience in the COST and ESF research networks as well as major EU collaborative research projects. This group of informants generally set the requirements for the new research proposals, as they are responsible for the on-going assessment and final evaluation of any existing research networking projects. The informants are well informed in ongoing EU and national research policies on science and research. They were invited to participate in the survey so that additional information could be collected.

First of all, since these experts are, to a large extent, responsible for the selection of the new research proposals (submitted through a series of Open Calls), it would be important to grasp some of their perceptions of what actual participants should be expected to achieve as a result of their participation in these research networking projects. The informants were asked questions similar to those posed to the current participants. The *category 1 survey* was aimed at yet another category of respondents – potential participants. These researchers (main conveners) have applied for research networking funding, yet not all of them have any experience of this particular research scheme. The questions to this group of respondents fall into three main categories: (1) the main motives for applying for networking funding, (2) the main networking research instruments of most interest to these potential participants and (3) whether they considered alternative funding sources for their proposed collaborative research projects, plus a range of socio-demographic questions.

5.12 Control Variables

In addition to the variables discussed above, another element that can potentially have an impact on the researcher outputs is socio-demographic characteristics of the surveyed subjects. By introducing these control variables this thesis takes another step towards investigating how the independent variables affect the dependent variables (Punch, 2003). As a result, controlling for a variable suggests that this research has to remove its effects.

As the independent variables can be mutually related (interrelated) to each other, this would compound their effects on the dependent variables (Punch, 2003). Control variables can be controlled either by exclusion - that is, by excluding each of the control variables as a source of variation, by holding them constant or by randomisation (Oppenheim, 1992). A number of socio-demographic characteristics (age, research experience, country of work, network position and others) were controlled for the research design and were included in statistical analyses.

5.13 Summary

Chapter 5 has described the research context and settings and provided an overview of the details of the philosophical approach. It has presented details of the chosen research design, methods and procedures. The chapter also provided justification for the methods chosen for the study and the overall research design. The weaknesses of the chosen survey methodology (in particular those applicable to the web-based surveys) have been briefly discussed and applicable criteria of rigour have been suggested. The central piece of this research is a large scale cross-sectional survey (a series of three surveys) organised to test the study's propositions and hypotheses drawn from the proposed research model.

By setting the study within the context of COST Actions this research will be able to test empirically the conceptual framework and propositions/hypotheses developed in earlier chapters of this thesis. The following chapter (Chapter 6) will provide more information about the setting of this study. Chapter 7 and Chapter 8 will deal with the data analyses and will draw conclusions based on the collected data in regards to the phenomenon of researcher performance associated with formal research networking projects.

Chapter 6. COST AS AN ERA INSTRUMENT

6.1 Introduction

The previous chapter described the research context and settings in detail and provided an overview of the details of the philosophical approach; presented details of the chosen research design, methods and procedures. The chapter has also provided justification for the methods chosen for the study and the overall research design. The weaknesses of the chosen survey methodology (in particular those applicable to the web-based surveys) also have been discussed and applicable criteria of rigour have been suggested. Chapter 6 will provide some additional information on the specific settings for this research – COST Actions - research projects coordinated and financed by COST within the scope of the EC Framework Programmes. In particular, it will provide more information about COST, in terms of its nature, procedures and operations.

6.2 Brief History of COST

As discussed earlier, there are a number of research networking programmes in both the ERA and countries outside Europe. One of the important differences that distinguish these networking projects is the type of funding they provide. While the majority of research networks are organised around a pot of research funding, there is another type of research networking programme which financially supports only the very important aspects of research networking such as meetings, exchanges or joint publications. The following section of this thesis examines COST research networking activities. This section of the thesis, however, does not aim to understand the uniqueness of COST but rather views COST as a representative of a particular type of a formal research networking funding programme.

The initial literature review highlighted a remarkable irony. Despite COST being one of the oldest research networking schemes that exist in the ERA there are very few studies focusing on its activities and there are even less research papers focusing on the research networking 'the COST way'. Most of the identified sources on COST are either papers created for evaluation purposes by the European Commission or the COST/ESF Office. Another category of papers is the analysis papers developed by COST stakeholders on a national level. As a result, the description of COST in this chapter follows largely the official information, which COST and its stakeholders (such as the European Commission or the European Science Foundation) communicate to the external world in their formal publications. COST is a framework for scientific and technical cooperation which coordinates fragmented nationally funded research on a European level.

The title COST is the French acronym (Coopération européenne dans le domaine de la recherche scientifique et technique) which translates as *European Cooperation in the field of Scientific and Technical Research*. COST is an intergovernmental framework that facilitates the networking of nationally funded research projects. COST established by a Conference of European Research Ministers in 1971 is the oldest Pan-European Research networking programme. The primary reason for establishing it nearly four decades ago was to '*strengthen Europe in scientific and technical research for peaceful purposes through the support of cooperation and interaction between European researchers*' (COST, 2007a). Since 1971, COST has developed into one of the largest inter-governmental frameworks for the coordination of nationally funded

scientific networks involved in basic and pre-competitive research and other related activities of European public value.

Today, COST is the oldest research co-operation mechanism of its type in Europe and at any time it runs a total of about 200 research network projects and '*reaches out to over 30,000 researchers across Europe*' (COST, 2008a, p.9). Research collaboration in COST is based on these projects known as Actions which are formal research networks coordinating nationally funded research projects. An Action in most cases runs for about four years, and in some cases this can be extended by a further year. One of the main differences between the COST funding scheme and other networking frameworks in the ERA is that COST only provides funding for the immediate network coordination activities such as travel costs, expenses related to the organisation of meetings, workshops, conferences, researcher exchanges or training schools. COST started off with a limited number of research domains but over the last three decades it has grown into a comprehensive research collaboration framework across all research fields divided into nine scientific domains.

Currently there are thirty-five COST Countries including thirty-four COST Member States and Israel as a COST Cooperating State. The 34 Member States include all 27 EU Member States (Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom) plus Croatia, Iceland, Norway, Serbia, Switzerland, Turkey, and Former Yugoslav Republic of Macedonia. Israel's status is that of a Cooperating State which implies non-voting membership in the COST Committee of Senior Officials (CSO) and in the Domain Committees as well as full member rights on the networks level.

6.3 General COST Principles

COST positions itself as a precursor of advanced multi-disciplinary research in bridging and complementing research activities across the European Research Area and building the foundation for the European Networks of Excellence across many important research fields. COST Actions cover basis as well as more applied research initiatives which address '*issues of a pre-normative nature of societal importance*' (COST, 2008c, p.73). One of the important COST principles – '*bottom-up approach*' – allows researchers themselves to propose their research ideas. Another important COST principle, '*à la carte participation*' suggests that flexible participation in COST projects is open to participants from all COST Countries under a flexible structure with easy project implementation and management of the research activities. This bottom-up principle allows COST to adjust its focus on research problems related to the needs and objectives of its participants. As a result, COST Actions cover a wide range of research issues of basic and precompetitive nature.

According to survey data over a quarter of respondents (27 % of COST participants) have been involved in initiating their COST Action (participated in the original application for COST funding) and about half of all COST participants have been approached by other partners in their Actions (Technopolis, 2004). These numbers not only suggest that network participation is strongly bottom-up but also indicate that participation

in COST networks leads to increased number of new relationships. The survey results further suggest that about a third of participants are new to COST while another third have never collaborated with any of their COST Action members prior to joining the Action. The survey authors argue that these findings lead them to believe that COST, with its relatively broad and open access, brings new entrants into international research collaboration.

6.4 COST Actions

As suggested earlier COST is built around research networks known as COST Actions. Actions are research projects which cover all scientific fields. COST Actions can be defined as *a formal collaborative arrangement which coordinates nationally funded research at the European level*. Currently there are over 200 COST Actions running (May 2009). These COST Actions in general focus on basic and pre-competitive research for peaceful purposes as well as activities of public utility. The Actions must be backed-up by researchers from at least five COST Member Countries. COST Actions are not as much research projects as they are networks of individual research activities.

Each COST Action has well defined research objectives, goals, and clear deliverables which are also described in a Memorandum of Understanding (MoU) signed by participating COST Countries. In general, research proposals for new Actions are accepted during the Open Calls, and these require participation of researchers from at least five COST Countries. Until recently all new COST Actions had to undergo their ratification in national legislatures, and as a result the process of initiating a new COST Action was generally perceived as overly slow, complex and unnecessarily formal. However, with the Open Call this process has changed significantly. As soon as a research proposal is accepted by the COST Domain Committee it is forwarded to the CSO for final formal approval. Once the Action is approved by the CSO it is then open to the rest of the COST Member Countries to join the Action by formally accepting the Action's MoU. Only when five COST Countries accept its MoU is the Action officially launched.

Each approved and launched Action is supervised and managed by a Management Committee consisting of nominated representatives from each participating country. In most cases, the aim is to organise a kick-off meeting within the first two months after CSO approval. Once the Action is approved, participants can be involved in the Action on the 'à la carte' principle. The bottom-up principle allows researchers to determine the focus of the proposed Action themselves. COST Actions usually have a lifespan of four to five years. The average annual budget of an Action has increased in recent years from about EUR 60,000 to about EUR 90,000. This funding is generally provided for the support of research networking activities. The work within an Action is generally organised between different Working Groups. The topics for each Working Group (WG) form the proposed Action's Work Plan which normally forms the Technical Annex to the Memorandum of Understanding. Once the Actions have started, new participants from other countries can also join due to the somewhat low level of bureaucracy associated with involvement into an Action. However, the rules are different for participants who decide to join within the first 12 months from the date of signing MoU and for participants who join the Action after the initial 12-month period.

Non-COST countries or international non-governmental organisations can apply to join a COST Action as long as their participation brings mutual benefits. Involvement of non-COST country participants can be perceived as enforcing global research networking. The COST/ESF Office in the last several years switched to a new continuous Open Call for research proposals for new Actions. The Open Call employs a two-stage process. During the first stage, short preliminary proposals are assessed by the relevant Domain Committee and the successful ones are then invited to the second stage to submit full proposals. During the second stage the full proposals go through external peer review and are then further assessed by the respective Doman Committees.

COST is often characterised as a flexible cost-efficient form of research activity coordination. COST Actions are expected to deliver results of scientific importance and contribute to the research literature and research training. A general assumption is that COST Actions act as precursors. COST Actions are frequently the precursors for successful projects in the EU Framework Programme and in particular some COST Actions lead to larger scale EU networking tools such as Networks of Excellence (COST, 2008a). Many COST Actions focus on topics of importance to most European countries and in line with the Lisbon goals[40] COST Actions aim to contribute to European competitiveness. At the same time some COST Actions facilitate increased harmonisation of various norms or standards in order to achieve certain levels of uniformity among European countries and in some cases COST Actions even lead to new small and medium size companies. In fact, pre-normative standardisation is often mentioned as an area in which COST research projects have produced significant achievements (Nissinen & Niskanen, 1999).

A number of COST projects have strongly influenced some of the earlier industry-oriented programmes in the EU such as ESPRIT, RACE, EURAM and BRITE (European Commission, 1996). COST Actions are also promoted as having high '*societal importance in their contribution to knowledge, to its wider dissemination to policy makers and the public at large and also for tackling problems deriving from pressing societal needs*' (COST, 2008a, p.11).

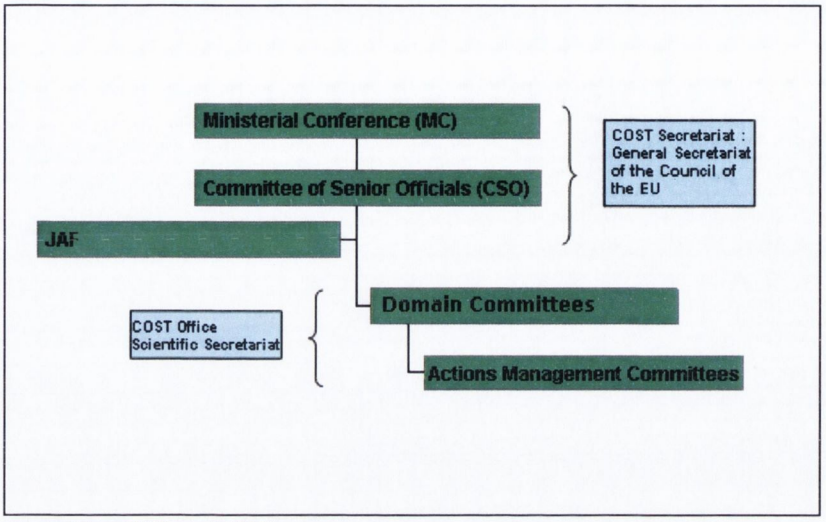
6.5 COST Governance

The COST governance structure can easily be perceived as somewhat complex (see Figure 6-1). However, since its establishment in 1971 at a Ministerial Conference the governance of COST was built to reflect its intergovernmental nature. Currently there are thirty-five COST Countries including thirty-four COST Member States and Israel as a COST Cooperating State. There is also strong participation from non-COST States and some Non-Governmental Organisations. Its intergovernmental and inherently international nature largely determines the multiple layers in its governing structure. The main elements in this governance are:

- The Ministerial Conference;
- The Committee of Senior Officials (CSO);
- The Executive Group of the CSO (JAF);
- Domain Committees;

[40] At the Lisbon summit in March 2000, European Union leaders set out a new strategy the EU Heads of States and Governments agreed to make the EU "the most competitive and dynamic knowledge-driven economy by 2010" in order to modernise Europe. This became known as the "Lisbon Strategy". After initially moderate results, the Lisbon Strategy was simplified and re-launched in 2005. (For more information, see: http://ec.europa.eu)

- The COST/ESF Office;
- Action Management Committees.



Adapted from EU Council (2009)
Figure 6-1: COST Governance structure organigramme

6.5.1 COST Ministerial Conferences and the CSO

From 1971, the key decisions are generally made at COST Ministerial Conferences which are held on average every five years. However, the CSO is the main decision making body in the COST governance. Being a crucial part of the governance structure the CSO is responsible for the oversight and decisions on strategic development of COST. The Secretariat of the CSO is yet another entity provided through the General Secretariat of the Council of the European Union. Each of the COST Countries can appoint two CSO Members and one of them generally will become also a COST National Coordinator (CNC). CNCs are nominated by COST Member Countries. They act both as CSO Members and as the national level liaison between COST, CSO and the researchers and scientists. In addition to the European level, structures are in place in COST Member Countries where national organisations support the work of the CNCs.

The CSO is responsible for the strategic development of COST as well as formally approving the final list of new Actions following Open Calls. The CSO Members are responsible for liaising with the ministries and other governmental offices in their home countries, and with the COST/ESF Office and the COST Secretariat at the Council of EU. The CNCs are responsible for nominating Domain Committee and Management Committees Members, for advising on all COST-related matters. The CNCs also play the role of the liaison between the scientists and institutions in their home countries and COST.

6.5.2 Domain Committees (Scientific Experts)

Each COST scientific Domain is responsible for the scientific activities of Actions (projects) in one of the nine research fields (see Figure 6-2). COST Domain Committees (DC) report to the CSO as they ensure quality control of the COST Actions, assess Open Call proposals and are responsible for the strategic development of their research Domains. Each of the COST Countries can appoint up to two DC Members who are normally senior and reputable scientists. The COST/ESF Office provides the secretariat to these

Domain Committees. An additional domain, IE (Interdisciplinary Exploratoria Domain) was set to provide opportunities for potential high gain networking activities complementing other Domain Committees in response to a need to enhance inter-disciplinarity within COST (COST JAF, 2005). Any Actions that do not fall into any specific research domain due to their inter-disciplinarity are generally assigned into this IE domain.

Figure 6-2: COST Scientific Domains

Domain	*Full Domain Name*
BMBS	Biomedicine and Molecular Biosciences
CMST	Chemistry and Molecular Sciences and Technologies
ESSEM	Earth System Science and Environmental Management
FA	Food and Agriculture
FPS	Forests, their Products and Services
ICT	Information and Communication Technologies
IE	Interdisciplinary Exploratoria
ISCH	Individuals, Societies, Culture and Health
MPNS	Materials, Physical and Nanosciences
TUD	Transport and Urban Development

6.5.3 Action Management Committees

Individual COST projects known as COST Actions are generally managed by their respective Management Committees. Domain Committees (DC) and Management Committees (MC) are generally fully supported by the COST/ESF Office. However, each of these committees also has an elected Chair (Domain or Action Chair), a vice-chair and a number of rapporteurs.

6.5.4 The COST/ESF Office

Another important part in the overall structure is the COST/ESF Office. The actual COST/ESF Office is based in Brussels (Belgium) and it was established by the European Science Foundation (ESF). As COST is funded through the Framework Programmes, the COST/ESF Office is formed and sustained under a special agreement between the CSO and the ESF. It supports the scientific activities, e.g. the DC and Action activities, as well as implementing CSO decisions.

6.5.5 Cooperation between the European Science Foundation and COST

The relationship between COST and ESF is especially important. Since the ESF became the implementing agent for COST which is now responsible for administering the funds provided by the European Commission under the FP budget lines. Up until the end of 2003, the European Commission was directly involved in running COST operations. From the beginning of 2004 the European Commission and the European Science Foundation agreed on a new arrangement under which the ESF took over the entire scientific, technical operations as well as the administrative secretariat of COST. From that year, ESF was also fully responsible for the scientific, technical and administrative secretariat for the COST Domain Committees and Actions. To follow up on these commitments ESF set the COST/ESF Office in Brussels in 2004. Financial support of the COST operations is carried out through a dedicated budget line within the Framework Programme and is regulated by a contract between the EC and the ESF.

The EC decided to involve an external body (ESF) as an implementing agent to manage the COST operations for a number of reasons. First, the administrative workload generated by COST (which can be described as a large number of mainly very small payment transactions) proved to be incompatible with the general operations of the Commission. An external organisation had to be chosen due to the legal status of COST. COST itself is not a legal body and therefore it cannot enter (by itself) any legal agreements with the EC. A number of other alternative arrangements have been considered by the EC and at the end of 2002 the CSO formally nominated the ESF as an implementing agent for COST. A number of measures have been agreed between COST and ESF in the form of the COST-ESF Memorandum of Understanding. An Addendum to the existing MoU sets the objectives not only to strengthen both ESF and COST as separate ERA instruments but also to ensure a crucial degree of synergy between them while maintaining their differences such as their characteristics and complementary roles (Fedi, 2007). This relationship between COST and ESF has been officially considered as successful even though a number of criticisms suggested that this relationship is somewhat complex and the long term impact of such a relationship is unclear (EC, 2005a).

6.6 COST Budget

It is estimated that COST Actions represent over EUR 2 billion in national funded research (COST, 2008a, p.9). COST however brings together this research fragmented funding through its support of less than 1% of this sum. Individual COST Actions on average receive about EUR 90,000 per year and bring together about EUR 10 million in national research funding (Grabert, 2009). As a result, COST Actions are often promoted as a very cost-efficient way to facilitate international scientific collaboration. The primary source of COST funding comes from a specific budget line within the EU Framework Programmes. Annual funding for the entire COST programme has increased from 1998 to 2000 from about EUR 10 million to about EUR 11 million. However, over 2001 and 2002 the funding levels decreased to those of 1998. In the following year, COST operations moved from being carried out directly by the European Commission to being financially supported by the EC but carried out by the European Science Foundation. That year the COST budget nearly halved. However, once the COST/ESF Office has been set up by the ESF, the COST budget reached and stabilised for a number of years at the level of EUR 15 million by 2004 (TEKES, 2006).

The overall EC support of COST during the Framework Programme 6 amounted to about 80 million euros. The most recent Framework Program 7 (FP7) has increased COST funding somewhat significantly to 210 million euros. As the FP7 will run over seven years, annual COST budget during these years will be in the range of about 30 million euros per year. An additional 40 million euros could be added by the EC to the COST FP7 budget if a mid-term evaluation in 2010 is successful. The entire COST budget is generally divided between two types of instruments: COST Actions and COST Exploratory/Strategic Workshops. COST Workshops intend to explore future scientific or societal needs, support policy developments or stimulate new activities. The biggest spending chapter is, however, the COST Actions.

6.7 Instruments for Financing of COST Action Activities

Individual COST Actions receive a financial contribution based on a joint work programme of about EUR 90,000 per year (Grabert, 2009). This budget is provided to cover a range of networking activities such as:

- Science management / working group meetings
- Scientific workshops and seminars
- Research Conferences
- Short Term Scientific Missions (STSMs)
- Training Schools
- Dissemination activities (including publications)

There are two basic models of support currently applied by COST. Under the first scheme known as the Grant System, one of the Management Committee's institutions can receive an annual grant, and as a result the institution[41] is then responsible for administering and funding the activities according to the decisions made by the Management Committee. The second (older) model is the traditional support model. Under this model, the MC agrees on activities which are then funded directly by the COST/ESF Office on an event-by-event basis. Under this 'Pay As You Go' administration, expenses are paid directly to each participant for each Action event. One of the main instruments available to Action participants is *Meeting support*. Researchers across all Actions use it to finance expenses accrued during the process of organising any Action related meetings, workshops and conferences. These events are generally organised by the Management Committee of the Action and can take place in any of the COST countries which have formally accepted the MoU of the Action.

Meetings and other events are generally open to the entire scientific community and are often used to promote the Action and its research activities. Larger events such as conferences and workshops are often organised to take place at the same time as the Domain and Management Committee meetings or in some cases other significant scientific events in the same scientific field so that to increase networking and dissemination of the research results. The largest instrument that can be availed of by the Action researchers is related to reimbursements of their travel related expenses (flights, accommodation, meals and so on) accrued in relation to an Action event. This ensures that all formal Action Members are able to part take in all relevant activities. These meetings do not always target scientific objectives; some of them aim at addressing some administrative agenda points too. Travel and subsistence support is generally available to cover any reimbursement of an Action participant for their attendance of MC Meetings, Working Group meetings, Workshops, Conferences, some strategic events such as Domain Committee meetings and synergy meetings with other research programmes such as EUREKA, ESF, or EC.

Short-term scientific missions or STSMs in recent years have become a particularly important COST instrument. Under the STSM instrument, exchange visits aim to strengthen the existing researcher networks by allowing scientists to visit an institution or laboratory in another COST country. These visits are expected to facilitate greater collaboration, to help with a know-how transfer, to learn a new technique, to access rare research infrastructures or to make measurements using instruments and/or methods not available in their own institution/laboratory. STSMs are predominantly aimed at younger scientists. The duration of an STSM can vary between one week minimum (five working days), and three months maximum (six months for Early Stage Researchers). The Applicant is expected to engage in research activities at an institution of a COST

[41] An overhead can be allocated to the grant holder who carries out these tasks.

Member State which has accepted the MoU of the Action concerned. It is a requirement[42] that both home and host institution are in a COST Member State which has accepted the MoU and participates in the COST Action.

COST *Training schools* are generally aimed at disseminating the results of Action activities and intensive training on a new emerging topic. Often the training schools take place at one of the laboratories of the Action. Most of the participants attending these schools (but not necessarily) are younger researchers, however the training schools can also provide training or even re-training of other researchers. The objectives of such schools are very closely related to the Action topic. *Dissemination* of the researchers' results is seen as central to the success of the COST Actions. COST works at increasing visibility of the research conducted by its networks to ensure that these results serve European society and industry. COST aims both to inform other relevant players about its Actions' research and to involve to a greater extent some of these parties in the work of its Actions.

One of the ways COST currently attempts to achieve this is through an increased number of dissemination channels. Some of the channels financed within Action budgets are publications of scientific articles in the major journals, books and conference/workshop proceedings. Previously COST also facilitated (financially supported) the development of individual websites for the COST Actions. However, this policy has changed lately as the COST/ESF Office now maintains one central website with the information on its Actions. Despite this change in policy, a large number of Actions are still supporting external and therefore independent from the COST/ESF Office websites. It is also important to note that while COST finances research publications there is no obligation for the Actions to produce these. Therefore, often the financial support provided by COST can be perceived as an additional benefit and not a requirement in itself.

6.8 Participation of non-COST Country Institutions

COST is generally a pan-European scheme for research in science and technology. During the last twenty years, COST experienced a significant growth in a number of participations of European researchers as well as those from outside of Europe. There is a strong participation from non-COST Member States and some non-governmental organisations (NGOs). Additionally there are a large number of non-COST Member State institutions in COST Actions with the most active participation of researchers from Russia, Ukraine, USA and Canada. Generally, participants from these countries can join individual COST research networking projects once there is a mutual benefit. Involvement of researchers from non-COST countries normally follows one of the several available routes. Similar to the EU Neighbourhood Policy[43], some of the nearest EU neighbours receive what can be seen as a special treatment. In 2004 the CSO supported the idea of an integration of scientists from the Balkan Region, the Mediterranean Basin countries and the European Newly Independent States (COST, 2005). A year later, Francesco Fedi (the President of COST) issued a COST strategy statement which emphasised COST's role as an active partner in realising the new European

[42] In exceptional cases, a STSM can be approved from a home institution in a participating COST country to a host institution in a non-COST country but not the other way round;

[43]The European Neighbourhood Policy (ENP) was developed in 2004, with the objective of avoiding the emergence of new dividing lines between the enlarged EU and our neighbours and instead strengthening the prosperity, stability and security of all concerned (for more information on ENP see: http://ec.europa.eu/world/enp/index_en.htm)

Neighbourhood Policy (ENP) in addition to its traditional role in the ERA. Under this strategy special support is to be provided for the integration of scientists from the Balkan Region, Mediterranean Basin countries and from the countries of the NIS[44]. In relation to the latter, Russia and Ukraine have two of the largest participations in COST Actions from institutions of non-COST countries.

As a part of the intention of COST to stimulate the participation of researchers from the Balkan regions (not already involved as a COST Member State, i.e. Albania, and Bosnia and Herzegovina), from Mediterranean countries (Algeria, Egypt, Libya, Lebanon, Morocco, Syria, Tunisia, and the Palestinian Authority)[45] and from European NIS countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova, Russia, and Ukraine), COST will finance the participation of researchers at COST Actions meetings. Such participation, however, is generally restricted to one participant per country per year at science meetings and at meetings of Action Management Committees (in the case of participation of non-COST institutes) and at Working Groups.

COST currently has a dedicated budget line (in the region of EUR 100,000 per year in total to all Actions) in the system to facilitate collaborations. Participants from the COST neighbouring countries can avail of this budget to facilitate their active participation in the COST Actions activities. In addition to the earlier budget line, the 157th meeting of the CSO on 4-5 December 2003 agreed to allocate EUR 30,000 from the COST Fund to stimulate and enable further participation in COST activities to Member States from the Balkan countries (Croatia, FYR of Macedonia, Serbia and Montenegro), as well as possible applicant States (Albania, Bosnia and Herzegovina) from that region (COST, 2005). The following countries took advantage of these arrangements as of 2009: Russian Federation (with 50 participations), Ukraine (16), Moldova (3), Bosnia & Herzegovina (2), Albania (1), Azerbaijan (1), Georgia (5), Morocco (2), Tunisia (2), Algeria (3), Palestinian Authority (1) and Egypt (3). In 2008 there was a total of 90 such participations (from the COST neighbouring countries) across 45 COST Actions (Grabert, 2009).

The 2005 strategy statement mentioned earlier highlighted once again the global role of COST in networking scientists from different parts of the world. Participation in COST Actions is not limited to researchers from the COST Member Countries or COST neighbouring countries. Over the years COST proved to network researchers and research institutions from old, new and potential EU member states by working together on joint research projects under a somewhat light and flexible formal framework. However, the recent years showed a slow expansion of COST even towards some countries far outside Europe. There is a significant global participation in many of the current COST projects with 227 participations in 90 Actions from 29 countries (figures for November 2008) (Grabert, 2009). Additional to the existing exchange arrangements COST added two pilot schemes which aim to improve research relationships between European researchers and those from Australia and New Zealand. In these pilot schemes, COST Action with participants from Australia and New Zealand will be eligible to receive additional financial support for short-term scientific exchanges between scientists from these countries. What is important is that the partner countries have also committed similar level of funds in order to secure reciprocity of the schemes.

[44] NIS – Newly Independent States
[45] It was noted that Jordan should be included in the list of countries (COST 2005)

While the further expansion of COST is often seen as an opportunity for greater exchange of scientific knowledge and information the inclusion of research organisations from countries with varying scientific competence levels is also seen as challenging. When the overall network is strongly heterogeneous the actual research collaboration can move from focused collaboration to a mere transfer of know-how and basic networking (TEKES, 2006). In addition, the same report suggests that the expansion of COST can generate new intellectual property rights issues and improve the exploitation of research results as information is exchanged with partners on a global basis. There are already some existing examples of cases when dissemination of research results within the forums of COST has resulted in patenting in the USA (TEKES, 2006). Some analysts believe it is still not clear whether the promoted global strategy is motivated by purely political reasons or if it has an actual impact on the scientific activities (Slowinski & Zerby, 2008; Smeby & Trondal, 2005).

6.9 COST Action Lifecycle

This research study employs a form of data triangulation by using a number of data sources (multiple informants) to investigate the same research phenomenon (Denzin, 1970). Furthermore, this study employs data from several surveys of three categories of respondents: potential COST participants (Open Call applicants), actual COST participants (researchers currently involved in COST Actions), and scientific experts (national members of COST Scientific Domains). The activities of these three categories of respondents overlap as discussed below.

An average Action generally goes through at least four main stages: project initiation, project planning, project execution and project closure. During the first stage of project initiation, researchers (under the influence of internal and external to science factors) consider their collaborative options such as applying for new funding (such as COST Action funding). With the consideration of one or several major motives (as discussed earlier), researchers initiate further planning which includes finding out more about the COST Open Calls, organising a preliminary list of potential Action participants, and writing a research proposal. These proposals are further assessed by the COST Office (scientific experts) and a number of them will receive networking funding. An average Action runs over four to five years. During the first four years of its lifecycle each Action brings together researchers and other stakeholders in work on the same research issues. As a result of their involvement in COST Actions, researchers (current participants) achieve certain research (FNR) outputs and outcomes. These results are assessed throughout the life of each Action with the activities and associated outputs monitored by the COST Office (Domain Committees). Furthermore, research outputs and outcomes are evaluated at the end of each project (Final Evaluation).

As mentioned earlier, once a proposal is submitted to the COST Office it goes through an assessment procedure which is normally carried out by scientific experts (Domain Committee Members). Generally, these respondents are highly knowledgeable scientists nominated by their home countries to special scientific domain committees. These experts regulate, and to some extent, authorise and manage funded formal networking projects (COST Actions). Many of them also have a very thorough knowledge of the research-networking programme in terms of both content and procedures. As a result they can have a different understanding of what can be achieved from the networking projects; in fact, many of them can also establish

certain standards for these measures (Koontz & Thomas, 2006). Surveying these experts can allow for comparison with the results reported by the actual project participants. Among other duties these experts act as COST gatekeepers. Domain Committee Members are responsible for the assessment of all submitted proposals in terms of scientific quality and other criteria. The involvement of scientific experts is not limited to the assessment of new proposals. Domain Committee Members are also involved in the routine monitoring of currently running Actions, as well as in the final evaluation of concluding Actions. Furthermore, some Domain Committee Members are also involved in COST Actions as individual researchers. It is possible to assume that experts' professional experience would play an important role in these decisions. At least to some extent scientific experts compare newly submitted proposals (as well as the reported outputs/outcomes of ending Actions) against their own expectations in terms of outputs and outcomes. The difference in perspectives offered by three groups of respondents is further illustrated by Figure 6-3.

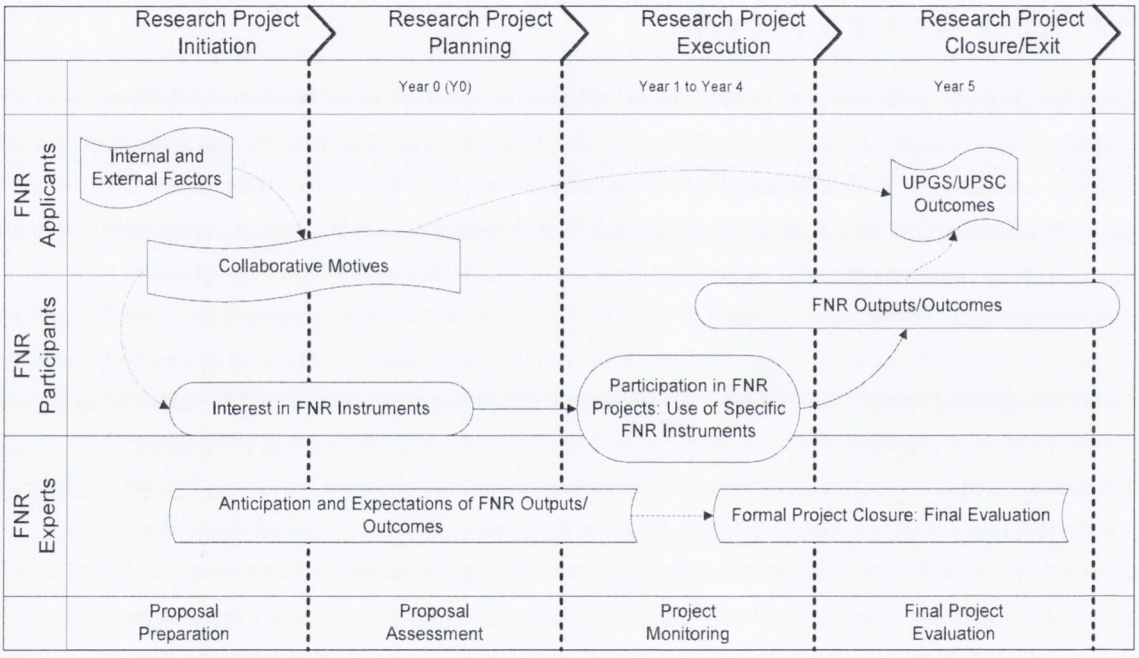


Figure 6-3 : COST Action (lifecycle)

This thesis attempts to improve the existing understanding of FNR projects through exploring the phenomenon from three complementing angles. To summarise:

- Potential participants are well positioned to provide answers in regards to motivation behind individual researchers' motivations to participate in FNR projects similar to COST Actions:
    - Researcher's motivation to collaborate can change over time subject to a number of external and internal to science factors. By comparing collaborative motivation of Applicants without previous COST experience and motivation of those with such experience, this research can gain further insights.
    - Applicants' knowledge of the instruments available can further influence their motivation to apply for networking research funding.
- Surveying scientific experts can provide answers to a number of research questions:
    - What are the implicit expectations in terms of participants' productivity? Which research outputs are expected and to what extent?

- What is the difference in expectations set by experts who are involved in FNR projects themselves, in comparison with experts who are not involved in FNR projects as individual researchers?

- Current participants in FNR Projects (COST Actions) can provide answers to other important questions:
  - Which research outputs can be attributed to participation in FNR projects?
  - To what extent are these outputs actually achieved by different categories of current project participants?

By applying a number of data sources (multiple informants) to investigate the same research phenomenon (Denzin, 1970), this thesis is able to complement and crosscheck the results acquired from one data source (group of informants) with the data collected from other groups of informants. Such triangulation of multiple perspectives on the same phenomenon is expected to increase the chances of arriving to a more complete and whole picture yet it provides both a simple and powerful method of quality control in the analysis of the results (Mariner & Paskin, 2000).

6.10 Examples of COST Actions

The Actions listed below are some examples of COST Actions (see Table 6-1 below).

Table 6-1: Examples of previous (completed) COST Actions

Action	*Description of Actions*
A5	COST A5 on aging and technology explored the conditions for extended autonomy, independence and activity for the elderly with the help of modern technology. COST Action A5 also studies the role of technology in increasing the participation of the elderly in society.
207	This COST Action made a major contribution to the development of the harmonised Pan-European GSM Public Digital Mobile Radio System, which has spread not just across Europe but also beyond Europe
219	COST 219 took the initiative to develop R&D-type activities dealing with telecommunications facilities for disabled and elderly people. It addressed the standardisation and application development in this field;
230	COST 230 on stereoscopic television aimed at developing a three-dimensional television. At its outset, it was the first scientific R&D project in this field but it led to an equally successful 3DTV project in RACE II and later to a further project in ACTS;
30 (301)	The development of electronic traffic aids on major roads (COST Action 30) and of shore-based marine navigational aid systems (COST Action 301);
322	COST 322 on low-floor buses aimed at defining the criteria for vehicles and access-stations at bus stops, especially for people with reduced mobility. It managed to outline guidelines for the vehicle construction, safety and associated infrastructure of low-floor buses;
50 (501)	COST Actions 50 and 501 contributed to the development of advanced high-temperature materials for use in gas turbines and energy conversion systems;
508	COST Action 508 aimed to create better knowledge of the various properties and the rheological behaviour of wood as well as the application of new technologies for wood industries.
61, 64 and 68	The first concerted efforts in the field of environmental protection research (COST Actions 61, 64 and 68, followed-up in COST Actions 611, 641 and 681);
70 (701)	COST 70 led to the establishment of the European Centre for Medium-Range Weather Forecasting, which now plays an important role in the meteorological services of the whole world. COST Action 70, which led to the setting up of the European Centre for Medium-Range Weather Forecasts in Reading (UK);
810	The study of vesicular-arbuscular mycorrhizae in the circulation of matter in soil and in plant nutrition (COST Action 810)

Action	*Description of Actions*
IC0602	This Action proposed new algorithmic solutions for hard decision theoretic problems arising from the use of large amounts of information, the presence of uncertainty as well as of complex structures of data. Action IC0602 also looked at the alternative use of results and concepts from decision theory in order to improve and advance in computer science and artificial intelligence;
P9	Solar Disinfection (SODIS) is a technique for making microbially contaminated drinking water safe. COST contributes to meet the EU's commitments under the Millennium Development Goals (MDG), the EU Water Initiative (EUWI), the Plan of Implementation of the World Summit on Sustainable Development (WSSD)

6.11 COST as a RESEARCH SETTING

A number of research collaboration schemes in the ERA support financially all research-associated expenses. However, two of the reviewed programmes (COST and ESF schemes) specifically cover only the *networking-associated expenses* and expressly exclude (do not reimburse or cover) any of the actual research expenses. At the same time, the four programmes also differ in the type of stakeholders they involve in their networks. While ERA-NETs aim at research managers and project owners, the COST Actions primarily engage individual researchers and scientists plus their institutions. Taking all these similarities and differences into account it was determined to look closer at the COST Actions as an example of formal networking research (FNR) instrument. It was proposed to position this study within the settings of COST Actions. The choice of the COST Actions for this thesis is justified by a number of reasons. First, COST Actions are characterised by an intensive and structured approach to scientific networking with a well-defined research agenda; the Actions also involve a large number of researchers from a wide variety of countries and, as a result, they are likely to cover a range of all disciplines and scientific domains. Another reason is the increased financial commitment by the European Commission (the greater demands for accountability) to the COST activities under the FP7.

6.12 Summary

This Chapter has provided details on the settings for this study – research projects coordinated and financed by the European Cooperation in Science and Technology (COST) within the scope of the EC Framework Programmes. In particular it provided information about COST in terms of its nature, procedures and operations, however, the review of available sources fell short of providing sufficient information about the typical COST Action participant. The following chapter will provide a comprehensive overview of the results of the statistical tests conducted with the data collected in three surveys. Statistical analyses such as Principal Component Analysis technique and Multivariate Regression Analysis will be conducted to investigate some of the relationships between these variables in more depth. Finally, the survey data will be used to test the earlier developed hypotheses.

Chapter 7. ANALYSIS OF DATA

7.1 Introduction

In Chapter 5 the process and methods of data collection for this research are outlined with an explanation of the type of data analyses carried out as well as information on the employed statistical techniques and tests used. Chapter 6 provides additional information on the settings for this thesis – research projects coordinated and financed by COST within the scope of EC Framework Programmes. The current chapter provides a comprehensive overview of the results of statistical tests conducted with the data collected in three surveys (categories 1, 2 and 3). Chapter 7 consists of several major sections: section 7.3 deals with the socio-demographic data of the respondents in all three surveys. The next subsection (7.4.1) focuses on the researcher's motives for applying for FNR funding (as reported by applicants - potential project participants). This will be followed by an analysis of research outputs as reported by actual research project participants (subsection 7.4.1.2), as well as the perceived research outputs reported by experts involved in evaluation and monitoring of these projects (subsection 7.4.3). Section 7.5 explores relationships between the different forms of formal networking research productivity (FNR productivity) and a number of additional variables. Statistical analyses such as the Principal Component Analysis technique and Multivariate Regression Analysis are conducted to investigate some of the relationships between these variables in more depth. Section 7.6 then explores the results of several hypotheses tests. Following the conventional scientific tradition to divide the results from the discussion of their significance, in order to preserve objectivity, most of the data analysis and discussion of results within this thesis have been separated into two chapters (Perry, 1998). First, Chapter 7 refers to the analysis of the major stage of the research project and presents both patterns of results and their analyses for their relevance to the research issues and hypotheses. However, an overall discussion of all the results gathered for this study (drawing on all methods employed) will follow in Chapter 8, which will deal with the data results and their analysis in the context of the study objectives.

7.2 Missing Data

One of the main concerns for researchers dealing with survey results is how to address the potential issue of missing data. As the surveys for the purpose of this study took a form of web-based questionnaires, all of the questions were encoded as compulsory, and as a result the data set is complete and therefore, this analysis will not to have to enhance the data set.

7.3 Socio-Demographical Patterns

To allow further analysis across different segmented groups the following sections will deal with the demographic measures – instruments which aim to measure demographic characteristics such as gender, age and so on (Sproull, 1995). The results are grouped according to three survey groups: Potential Participants (Applicants), Current Participants and Experts (scientific experts).

7.3.1 Socio-Demographics of the Survey Sample 1 – Potential Participants

All probabilities reported are based on two-tailed tests as each comparison had two possible directions. A particular statistical instrument used for demographic measures is the *frequencies procedure* that provides statistics and graphical displays that are useful for describing many types of variables. Frequent summary tables and figures of results are essential as they also help to see patterns in the mass of data presented in this chapter (Perry, 1998). These summaries of variables provide an important first look at the collected data. The statistical procedures will be run on all three groups of respondents: Potential Participants (Category 1), Current Participants (Category 2) and Experts (Category 3).

7.3.1.1 Respondents' Age

The first variable which is to be analysed with the frequency procedure is the age of the respondents who took part in the survey, category 1 (Potential Participants). According to the observed frequencies the youngest respondent in category 1 was aged 27 years old at the time of the survey and the oldest participant was aged 78 years old (see Table 7-1). The centre of the distribution can be approximated by the median (or second quartile) 45 (years of age), and half of the data values is between 39 years and 53 years, the first and third quartiles.

Table 7-1: Respondents Age (Potential Participants)

N	Valid	297
	Missing	0
Mean		46.3
Median		45.0
Std. Deviation		9.5
Variance		90.9
Skewness		0.407
Std. Error of Skewness		0.141
Range		51.0
Minimum		27.0
Maximum		78.0
Percentiles	25	39.0
	50	45.0
	75	53.0

7.3.1.2 Respondents' Gender

The next variable that was analysed with the frequency procedure is the gender of the respondents who took part in the survey, category 1. The respondents in the experts group are predominantly male as the frequencies procedure suggests that 77.1 percent of respondents in category 1 are male, with the rest (22.9 percent) female (see Table 7-2 below).

Table 7-2: Gender (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Male	229	77.1	77.1	77.1
	Female	68	22.9	22.9	100.0
	Total	297	100.0	100.0	

7.3.1.3 Respondents' Educational Level (Doctoral Level)

The following variable is the educational level (on the PhD level) of the respondents who participated in the survey, category 1 (Potential Participants). The results of the frequencies procedure suggest the 90.6 percent of respondents in the category 1 hold a doctoral degree or equivalent and less than one tenth of the respondents (9.4 percent) reported that they do not hold a PhD degree (or equivalent) (see Table 7-3).

Table 7-3: Educational Level (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Yes	269	90.6	90.6	90.6
	No	28	9.4	9.4	100.0
	Total	297	100.0	100.0	

7.3.1.4 Respondents' Professional Experience

The following variable is the professional experience of the respondents who participated in the category 1 survey. The results from the frequencies procedure suggest the 92.9 percent of respondents in category 1 position themselves as senior researchers (with four or more years of research experience). Further, 2.0 percent of subjects position themselves as junior researchers (with less than four years of research experience), and 5.1 percent of respondents position themselves in the other category (see below Table 7-4).

Table 7-4: Professional Experience (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Junior researcher, i.e. less than 4 years of research experience	6	2.0	2.0	2.0
	Senior researcher, i.e. 4 years or more of research experience	276	92.9	92.9	94.9
	Other	15	5.1	5.1	100.0
	Total	297	100.0	100.0	

7.3.1.5 Respondents' Professional Background

The following variable is the professional background of the respondents who took part in the category 1 survey (Potential Participants). The frequencies procedure suggests the 67.7 percent of respondents in category 1 work in academia and 22.9 percent of subjects work in other research institutes or laboratories. Further 3.4 percent of respondents work for business or industry, 3.7 percent of respondents work for governments. The rest of the respondents (2.4 percent) do not associate themselves with either of the listed groups of organisations as they selected the group *other* (see below Table 7-5).

Table 7-5: Professional Background (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Academia	201	67.7	67.7	67.7
	Other research institute/laboratory	68	22.9	22.9	90.6
	Business or industry	10	3.4	3.4	93.9
	Government	11	3.7	3.7	97.6
	Other	7	2.4	2.4	100.0
	Total	297	100.0	100.0	

7.3.1.6 Participants' Formal Networking Experience

In the case of the *formal networking experience* variable, the frequencies procedure suggests a group (36.0 percent) out of 297 respondents reported that they had been involved in the research project (the same formal networking research scheme) prior to applying for new funding. The majority of respondents (64.0 percent) reported that they had no previous involvement in the formal networking scheme (see Table 7-6).

Table 7-6: Formal Networking Experience (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Yes	107	36.0	36.0	36.0
	No	190	64.0	64.0	100.0
	Total	297	100.0	100.0	

7.3.1.7 Respondents' Geographical Location (Country of Work)

Country Classification 1

The following variable is the *geographical distribution* of the respondents who took part in the category 1 survey (Potential Participants). Geographic location is often considered as a demographic variable while some researchers place in other categories (Sproull, 1995). Survey subjects were asked to report their country of work rather than just their country. This thesis is concerned with international (and primarily pan-European) networking research projects so to facilitate further analysis countries have been classified using several methods. Using the classification proposed by the United Nations Statistics Division, countries (as reported by the survey subjects as their work countries) have been split into four groups: Northern Europe, Southern Europe, Western Europe, Eastern Europe, Turkey plus Israel, and Other. The first frequencies procedure shows that the 10.8 percent of respondents in *category 1* work in Eastern European countries, 32.7 percent of respondents at the time of the survey worked in Western European countries, 22.9 percent of survey respondents are based for work in Northern European countries, and 30.3 percent of respondents work in countries in Southern Europe. A further 3.3 percent of survey subjects are based in Israel, Turkey or elsewhere (see Table 7-7).

Table 7-7: Geographical Distribution – Classification 1 (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Western Europe	97	32.7	32.7	32.7
	Southern Europe	90	30.3	30.3	63.0
	Northern Europe	68	22.9	22.9	85.9
	Eastern Europe	32	10.8	10.8	96.6
	Turkey and Israel	9	3.0	3.0	99.7
	Other Countries	1	0.3	0.3	100.0
	Total	297	100.0	100.0	

Country Classification 2

The second proposed classification[46] groups European Union (EU) Member States according to their accession to the EU. The frequencies procedure tests show that the respondents are distributed between countries in the following way: 76.8 percent work in the EU15 countries, 6.4 percent work in the NMS10 countries and 6.1 percent of respondents work in NMS2 countries. The rest (10.7 percent) of the survey

[46] EU15 The Member States of the EU until 2004, when 10 more countries joined the EU; NMS10 - New Member States which joined the EU in 2004; NMS2 - Bulgaria and Romania; Candidate EU – Turkey, Croatia, The Former Yugoslav Republic of Macedonia (source: http://ec.europa.eu);

respondents are based for work in other groups of countries (including Candidate EU countries, other European countries (Russia and Ukraine), and the rest of the world) (see below Table 7-8).

Table 7-8: Country Groups - Classification 2 (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	EU15	228	76.8	76.8	76.8
	Other Europe	22	7.4	7.4	84.2
	NMS10	19	6.4	6.4	90.6
	NMS 2	18	6.1	6.1	96.6
	Rest of the World	5	1.7	1.7	98.3
	Candidate EU	4	1.3	1.3	99.7
	Other	1	.3	.3	100.0
	Total	297	100.0	100.0	

7.3.1.8 Distribution by Scientific Domain

In case of the breakdown by *scientific domain* variable, (see section 6.5.2 for more information on the COST Domains) the frequencies procedure suggests the largest group of respondents (15.5 percent) are involved in the research projects in the MPNS Domain and 15.2 percent of subjects work in the field of ISCH Domain. Further, 13.8 percent of respondents work in FA Domain, 10.4 percent work in the field of BMBS, and 9.8 percent of subjects work in the field of ICT. A share of 6.4 percent of researchers work in FPS Domain, the same number of subjects (6.4 percent) work in the field of TUD while another 5.1 percent of Potential Participants came from the field of CMST, and the rest of the respondents (4.4 percent) applied for networking funding with interdisciplinary research proposals (IE) (see Table 7-9 below).

Table 7-9: Breakdown by Scientific Domain (Potential Participants)

		Frequency	*Percent*
Valid	MPNS (Materials, Physical and Nanosciences)	46	15.5
	ISCH (Individuals, Societies, Culture and Health)	45	15.2
	FA (Food and Agriculture)	41	13.8
	ESSEM (Earth System Science and Environmental Management)	39	13.1
	BMBS (Biomedicine and Molecular Biosciences)	31	10.4
	ICT (Information and Communication Technologies)	29	9.8
	FPS (Forests, their Products and Services)	19	6.4
	TUD (Transport and Urban Development)	19	6.4
	CMST (Chemistry and Molecular Sciences and Technologies)	15	5.1
	IE (Interdisciplinary Exploratoria)	13	4.4
	Total	297	100.0

7.3.1.9 Application Result Status

The following variable is the funding application status distribution of the respondents who took part in the category 1 survey (Potential Participants). Survey subjects (applicants who applied for networking funding) were grouped according to the status of their funding application. The application process included three stages: stage 1, stage 2 and selected finalists. The frequencies procedure suggests that out of 296 applicants only 5.7 percent have been approved for funding, while 89.2 percent of applicants did not make it through stage 1, and 5.1 percent of applicants failed at stage 2 (see Table 7-10).

Table 7-10: Funding Application Status (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Failed Stage 1	265	89.2	89.2	89.2
	Failed Stage 2	15	5.1	5.1	94.3
	Finalists	17	5.7	5.7	100.0
	Total	297	100.0	100.0	

7.3.2 Socio-Demographics of the Survey Sample 2 – Current Project Participants

7.3.2.1 Participants' Age

The first variable that was analysed with the frequency procedure is the age of the respondents who took part in the survey, category 2 (Current Participants). According to the observed frequencies, the youngest respondent in category 2 was aged 21 years old at the time of the survey and the oldest participant was aged 78 years old (see Table 7-11). The centre of the distribution can be approximated by the median (or second quartile) 49 (years of age), and half of the data values fall between 41 years and 57 years, the first and third quartiles.

Table 7-11: Respondents Age (Current Participants)

N	Valid	2,173
	Missing	0
Mean		48.73
Median		49.00
Mode		50
Std. Deviation		10.243
Variance		104.914
Skewness		0.026
Std. Error of Skewness		0.053
Range		57
Minimum		21
Maximum		78
Percentiles	25	41.00
	50	49.00
	75	57.00

7.3.2.2 Respondents' Gender

The next variable that was analysed with the frequency procedure is the *gender* of the respondents who took part in the survey, category 2. Observed frequencies suggest that 76 percent of respondents in the *category 2* are male, while the rest (24 percent) are female (see Table 7-12).

Table 7-12: Gender (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Male	1651	76.0	76.0	76.0
	Female	522	24.0	24.0	100.0
	Total	2173	100.0	100.0	

7.3.2.3 Respondents' Educational Level (Doctoral Level)

The following variable is the educational level (on the doctoral level) of the respondents who took part in the survey, category 2. The results of the frequencies procedure suggest that 87.2 percent of respondents in category 2 hold a doctoral degree or equivalent and 12.8 percent of subjects reported that they do not hold a PhD degree (or an equivalent) (see Table 7-13).

Table 7-13: Educational Level (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Yes	1895	87.2	87.2	87.2
	No	278	12.8	12.8	100.0
	Total	2173	100.0	100.0	

7.3.2.4 Respondents' Professional Experience

The following variable is the professional experience of the respondents who participated in the category 2 survey. The frequencies procedure results suggest the 90.3 percent of respondents in category 2 position themselves as senior researchers (with four or more years of research experience), 3.6 percent of subjects position themselves as junior researchers (with less than four years research experience). The rest of the respondents (6.1 percent) position themselves in the other category – non-research group (see Table 7-14).

Table 7-14: Professional Experience (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Junior researcher	79	3.6	3.6	3.6
	Senior researcher	1962	90.3	90.3	93.9
	Other	132	6.1	6.1	100.0
	Total	2173	100.0	100.0	

7.3.2.5 Respondents' Professional Background

The following variable is the *professional background* of the respondents who took part in the category 2 survey. In category 2, according to the frequencies procedure, 63.7 percent of respondents work in *academia*, 25.4 percent of subjects work in *other research institutes or laboratories*, 4.0 percent of respondents work for *business or industry* and 5.7 percent of respondents work for *governments*. The rest of the respondents (1.2 percent) do not associate themselves with any of the listed groups of organisations as they selected the group *other* (see Table 7-15).

Table 7-15: Professional Background (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Academia	1,384	63.7	63.7	63.7
	Other research institute/laboratory	551	25.4	25.4	89.0
	Business or industry	88	4.0	4.0	93.1
	Government	123	5.7	5.7	98.8
	Other	27	1.2	1.2	100.0
	Total	2,173	100.0	100.0	

7.3.2.6 Participants' Formal Networking Experience

In case of the *formal networking experience variable,* the frequencies procedure suggests that a group of respondents (9.8 percent) reported being involved in the research project (the same formal networking research scheme) for less than one year (see Table 7-16)..

Table 7-16: Formal Networking Experience (Current Participants)

		Frequency	*Percent*
Valid	Less than 1 year	213	9.8
	Between 1 and 2 years	365	16.8
	More than 2 years but less than 5 years	799	36.8
	Between 5 years and 10 years	540	24.9
	More than 10 years	256	11.8
	Total	2,173	100.0

Further, 16.8 percent of subjects participated in the same formal networking research programme for a period between one and two years, another 36.8 percent of respondents participated in this research project scheme for a period from two to five years. 24.9 percent of respondents participated in this research project scheme

for a period between 5 and 10 years while the rest of the respondents, 11.8 percent, have spent more than 10 years in research projects under the same formal networking scheme

7.3.2.7 Participants' Multi-Networking (Involvement in Several Research Projects)

The following variable is the participation in more than one networking project of a similar type by the respondents who took part in the category 2 survey. The frequencies procedure suggests that 22.8 percent of respondents in category 2 participate simultaneously in several research projects under the same formal networking research scheme at the time of the survey while the majority of respondents (77.2 percent) are involved in one formal networking research projects at the time of the survey (see Table 7-17).

Table 7-17: Involvement in several formal networking projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Yes	495	22.8	22.8	22.8
	No	1,678	77.2	77.2	100.0
	Total	2,173	100.0	100.0	

The following Figure 7-1 below offers a visual summary of the distribution of values of the variable (*involvement in several formal networking projects*).

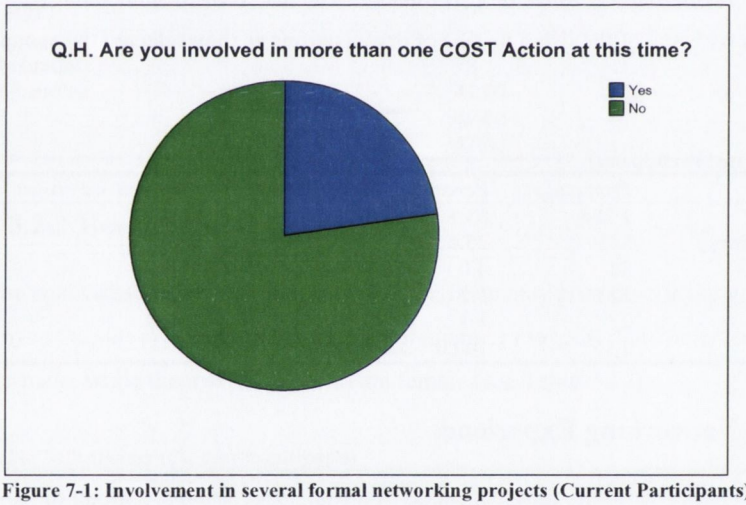


Figure 7-1: Involvement in several formal networking projects (Current Participants)

7.3.2.8 Multi-Networking (Involvement in more than one FNR project) versus FNR Experience (Years in FNR Programme)

This subsection will investigate whether there is a relationship between respondents' FNR experience and tendency to be involved in more than one FNR project at a time.

Table 7-18: Multi-Networking in FNR projects versus FNR Experience (Current Participants)

	N	*Mean*	*Std. Deviation*	*Std. Error*
Less than 1 year	213	1.13	0.333	0.023
Between 1 and 2 years	365	1.12	0.323	0.017
More than 2 years but less than 5 years	799	1.21	0.410	0.014
Between 5 years and 10 years	540	1.30	0.458	0.020
More than 10 years	256	1.37	0.483	0.030
Total	2,173	1.23	0.420	0.009

While the mean of the multi-networking variable does not make sense as such, it does allow for comparison between groups (here, 1 = 'involved only in one FNR project' and 2 = 'involved in more than one FNR project at the same time'). The cross-group comparison of means reveals a trend: in the first two years of researchers' involvement in an FNR project, they tend not to be involved in additional projects within the same FNR scheme. However, after the first two years there is a trend towards taking part in more than one FNR project.

7.3.2.9 Respondents' Geographical Location (Country of Work)

The following variable is the geographical distribution of the respondents who took part in the category 2 survey. Geographic location is often considered as a demographic variable while some researchers place in other categories (Sproull, 1995). Survey subjects were asked to report their country of work rather than just their country.

Table 7-19: Geographical Distribution – Classification 1 (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Eastern Europe	348	16.0	16.0	16.0
	Western Europe	609	28.0	28.0	44.0
	Northern Europe	557	25.6	25.6	69.7
	Southern Europe	588	27.1	27.1	96.7
	Turkey and Israel	61	2.8	2.8	99.5
	Other Countries	10	0.5	0.5	100.0
	Total	2,173	100.0	100.0	

As this thesis is concerned with international and primarily pan-European networking research projects, and in order to facilitate further analysis, countries have been classified using several methods. Using the classification proposed by the United Nations Statistics Division[47], countries (as reported by the survey subjects as their work countries) have been split into four groups: Northern Europe, Southern Europe, Western Europe, Eastern Europe, Turkey plus Israel, and Other. The first frequencies procedure shows that the 16 percent of respondents (in category 2) work in Eastern European countries, 28 percent of respondents at the time of the survey work in Western European countries, 25.6 percent of survey respondents are based for work in Northern European countries, and 27.1 percent of respondents work in countries in Southern Europe. Further 2.8 percent of survey subjects are based in either Israel or Turkey with another 0.5 percent of respondents based in other countries (see Table 7-19).

The second proposed classification[48] groups European Union (EU) Member States according to their accession to the EU (see below Table 7-20). The frequencies table shows that the respondents are distributed between countries in the following way: 62.8 percent work in the EU15 countries, 20.1 percent work in the NMS10 countries, 3.6 percent of respondents work in NMS2 countries. The rest (17.2 percent) of survey respondents are based for work in other groups of countries (including Candidate EU countries, other European countries (Russia and Ukraine), and the rest of the world).

[47] Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings suggested by the UN Statistics Division: http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe

[48] EU15 The Member States of the EU until 2004, when 10 more countries joined the EU; NMS10 - New Member States which joined the EU in 2004; NMS2 - Bulgaria and Romania; Candidate EU – Turkey, Croatia, The Former Yugoslav Republic of Macedonia (source: http://ec.europa.eu);

Table 7-20: Country Groups - Classification 2 (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	EU15	1,365	62.8	62.8	62.8
	NMS10	436	20.1	20.1	82.9
	NMS 2	78	3.6	3.6	86.5
	Candidate EU	43	2.0	2.0	88.4
	Other Europe	204	9.4	9.4	97.8
	Rest of the World	47	2.2	2.2	100.0
	Total	2,173	100.0	100.0	

7.3.2.10 Distribution by Scientific Domain

In case of the breakdown by scientific domain variable (see Section 6.5.2 for more information on the COST Domains), the frequencies procedure suggests the largest group of respondents (18.5 percent) are involved in the research projects in CMST Domain, 16.6 percent of subjects work in the field of FA Domain, 13.8 percent of respondents work in MPNS Domain. The rest of the respondents are split in the following way: 11.0 percent work in the field of FPS, 10.2 percent of subjects work in the field of TUD and 9.9 percent of researchers work in ESSEM Domain. The number of subjects participating in the survey from other scientific Domains (BMBS, ISCH, ICT and IE) accounted for less than 10 percent per Domain (see Table 7-21).

Table 7-21: Breakdown by Scientific Domain (Current Participants)

		Frequency	*Percent*
Valid	CMST (Chemistry and Molecular Sciences and Technologies)	401	18.5
	FA (Food and Agriculture)	360	16.6
	MPNS (Materials, Physical and Nanosciences)	300	13.8
	FPS (Forests, their Products and Services)	240	11.0
	TUD (Transport and Urban Development)	221	10.2
	ESSEM (Earth System Science and Environmental Management)	216	9.9
	BMBS (Biomedicine and Molecular Biosciences)	155	7.1
	ISCH (Individuals, Societies, Culture and Health)	141	6.5
	ICT (Information and Communication Technologies)	122	5.6
	IE (Interdisciplinary Exploratoria)	17	0.8
	Total	2,173	100.0

7.3.2.10.1 Researcher's Professional Background (Sector) versus Research Domain (Current Participants)

This subsection will look closer into how different professional sectors (background) are represented across different research domains. According to the results (Appendix 7) across all domains the most active involvement of business and industry representatives takes place in TUD (12.2 percent of all participants) and FPS (7.1 percent) domains while the smallest share of business/industry representatives has been recorded in ESSEM (1.4 percent of all respondents in this domain) and CMST (1.5 percent of all respondents). There is a *strong* representation of *government* participants in the following domains: ESSEM (13.9 percent of all respondents in the domain), FA (9.4 percent), TUD (9 percent), FPS (6.3 percent) and IE (5.9 percent). Government is *least* represented in MPNS (1 percent), ISCH (2.1 percent), BMBS (2.6 percent) and CMST (2.5 percent). The highest percentage of *academic participants* is in CMST (85.3 percent of all respondents in this domain), BMBS (79.4 percent), ISCH (78.0 percent) and ICT (71.3 percent).

The smallest share of academic participants is in FPS (43.8 percent of all respondents in this domain), ESSEM (46.8 percent) and TUD (48 percent). Researchers from *research institutes and laboratories* are best of all represented in FPS (42.1 percent of all respondents in the domain), ESSEM (36.6 percent) and FA

(32.8 percent). Research institutes and laboratories represent more than a quarter of all participants in the following domains: IE (29.4 percent), TUD (28.5 percent) and MPNS (26.3 percent). The lowest representation of these participants is in CMST (10.5 percent), ISCH (13.5 percent) and BMBS (12.9 percent). Overall, some domains have a greater diversity of participants. Based on the representation of different groups, the most diverse domains are TUD and FPS. The least diverse domains are CMST, ISCH, BMBS and MPNS.

7.3.2.11 Experience of Grant System

The next variable *experience of grant system* variable in the result of the frequencies procedure suggests that the largest group of respondents (*93.5* percent) are not familiar/experienced in the self-administered types of research projects while the rest of the respondents (6.5 percent) have some degree of familiarity with the instrument (see Table 7-22).

Table 7-22: Participants with the Knowledge/Experience of Grant System

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	On the grant	142	6.5	6.5	6.5
	Not on the grant	2.031	93.5	93.5	100.0
	Total	2.173	100.0	100.0	

7.3.2.12 Project Level Position

The following variable is the project level position of the respondents who took part in the category 2 survey (see Table 7-23).

Table 7-23: Project Position (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	MC Chairs	80	3.7	3.7	3.7
	MC Members	1,676	77.1	77.1	80.8
	MC Vice Chair	38	1.7	1.7	82.6
	Other Participants	379	17.4	17.4	100.0
	Total	2,173	100.0	100.0	

The frequencies procedure suggests the majority of respondents – 77.1 percent – participate as Management Committee (MC) Members while only small numbers of participants have specific positions such as Management Committee Chairs (3.7 percent), and Management Committee Vice-Chairs (1.7 percent). The rest of survey respondents (17.4 percent) are not involved as such in formal project managements and are involved in the projects as regular researchers.

7.3.3 Socio-Demographics of the Survey Sample 3 – Experts

7.3.3.1 Experts' Age

The first variable, which was analysed with the frequency procedure, is the age of the respondents who took part in the survey category 3 (Project Experts) (see Table 7-24). According to the observed frequencies the youngest respondent in category 3 was aged 29 years old at the time of the survey and the oldest participant was 72 years old.

Table 7-24: Respondents' Age (Experts)

N	Valid	114
	Missing	0
Mean		52.89
Median		54.00
Mode		58
Std. Deviation		8.412
Variance		70.757
Skewness		-.250
Std. Error of Skewness		.226
Range		43
Minimum		29
Maximum		72
Percentiles	25	47.00
	50	54.00
	75	59.00

7.3.3.2 Gender

The next variable that was analysed with the frequency procedure is the *gender* of the respondents who took part in the survey category 3 (see Table 7-25). Observed frequencies suggest the 82.5 percent of respondents in *category 3* are male, with the rest (17.5 percent) being female.

Table 7-25: Respondents' Gender (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Male	94	82.5	82.5	82.5
	Female	20	17.5	17.5	100.0
	Total	114	100.0	100.0	

7.3.3.3 Respondents' Educational Level (Doctoral Level)

The following variable is the *educational level* (on the PhD level) of the respondents who participated in the survey, category 3 (see Table 7-26). The results of the frequencies procedure suggest that 90.4 percent of respondents in *category 3* hold a doctoral degree or equivalent and 9.6 percent of subjects reported that they do not hold a PhD degree (or an equivalent).

Table 7-26: Educational Level (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Yes	103	90.4	90.4	90.4
	No	11	9.6	9.6	100.0
	Total	114	100.0	100.0	

7.3.3.4 Professional Background

The following variable is the professional background of the respondents who took part in the category 3 survey (see Table 7-27).

The frequencies procedure suggests that 65.8 percent of respondents (in the *category 3)* work in *academia*, 21.9 percent of subjects work in *other research institutes or laboratories*, 0.9 percent of respondents work for *governments* while the rest of the respondents – 11.4 percent do not associate themselves with any of the listed groups of organisations and selected the group *other*. None of the Experts works for industry or businesses.

Table 7-27: Professional Background (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Academia	75	65.8	65.8	65.8
	Other research[49]	25	21.9	21.9	87.7
	Other	13	11.4	11.4	99.1
	Government	1	.9	.9	100.0
	Total	114	100.0	100.0	

7.3.3.5 Participants' Formal Networking Experience

In case of the formal networking experience variable, the frequencies procedure suggests that 7.9 percent of respondents have been involved in activities associated with the work of formal networking research projects (the same formal networking research scheme) for less than one year. Further, 13.2 percent of subjects were involved in the operations of the collaborative scheme for a period between one to two years. About a quarter of respondents (27.2 percent) were involved to some extent in this project scheme for a period of two to five years, while 26.3 percent of respondents participated in this research project scheme for a period between 5 and 10 years. Over a quarter of all respondents (25.4 percent) have spent more than 10 years in research projects under the same formal networking scheme (see Table 7-28).

Table 7-28: Formal Networking Experience (Experts)

		Frequency	*Percent*
Valid	Less than 1 year	9	7.9
	Between 1 and 2 years	15	13.2
	More than 2 years but less than 5 years	31	27.2
	Between 5 years and 10 years	30	26.3
	More than 10 years	29	25.4
	Total	114	100.0

7.3.3.6 Respondents' Geographical Location (Country of Work)

Geographical location is considered to be an important demographic variable while some academics place in other categories (Sproull, 1995). The following variable is the geographical distribution of the respondents who took part in the category 3, survey subjects were asked to report their country of work rather than just their country (see Table 7-29). This thesis is concerned with international and primarily pan-European networking research projects and to facilitate further analysis countries were classified using several methods. Using the classification proposed by the United Nations Statistics Division[50] countries (as reported by the survey subjects as their work countries) have been split into four groups: Northern Europe, Southern Europe, Western Europe, Eastern Europe, Turkey plus Israel, and Other.

Table 7-29: Geographical Distribution of Respondents – Classification 1 (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Eastern Europe	20	17.5	17.5	17.5
	Western Europe	22	19.3	19.3	36.8
	Northern Europe	35	30.7	30.7	67.5
	Southern Europe	29	25.4	25.4	93.0
	Turkey and Israel	5	4.4	4.4	97.4
	Other Countries	3	2.6	2.6	100.0
	Total	114	100.0	100.0	

[49] Other research institutions and laboratories

[50] Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings suggested by the UN Statistics Division: http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe

The first frequencies procedure shows that 17.5 percent of experts (in *category 3)* work in Eastern European countries, 19.3 percent of respondents at the time of the survey work in Western European countries, 30.7 percent of survey respondents are based for work in Northern European countries, and 25.4 percent of respondents work in countries in Southern Europe. Further, 4.4 percent of survey subjects are based in either Israel or Turkey with another 2.6 percent of respondents based elsewhere. The second employed classification[51] reviews European Union (EU) Member States and groups these countries according to their accession to the EU (see Table 7-30). The frequencies procedure tests show that respondents are distributed between countries in the following way: 48.2 percent work in the EU15 countries, 28.9 percent work in the NMS10 countries and 5.3 percent of respondents work in NMS2 countries. The rest (17.5 percent) of survey respondents are based for work in other groups of countries (including Candidate EU countries, other European countries (Russia and Ukraine), and the rest of the world).

Table 7-30: Country Groups - Classification 2 (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	EU15	55	48.2	48.2	48.2
	NMS10	33	28.9	28.9	77.2
	NMS 2	6	5.3	5.3	82.5
	Candidate EU	5	4.4	4.4	86.8
	Other Europe	9	7.9	7.9	94.7
	Rest of the World	3	2.6	2.6	97.4
	Other	3	2.6	2.6	100.0
	Total	114	100.0	100.0	

7.3.3.7 Distribution by Scientific Domain

The next analysed variable is a breakdown by scientific domain (see Table 7-31). The frequencies procedure suggests 14.9 percent of respondents are nominated experts in BMBS Domain, 14.0 percent of subjects are nominated experts in the field of ISCH Domain, 13.2 percent of respondents are government nominated experts in TUD Domain, 12.3 percent work in the field of CMST and 11.4 percent of subjects are nominated experts in the field of FA. FPS and MPNS Domains accounted for 10.5 percent of the 114 respondents. ESSEM and ICT Domains accumulatively account just for 13.1 percent (7.0 and 6.1 percent respectively) of the overall number of experts who responded to the survey category 3.

Table 7-31: Breakdown by Scientific Domain (Experts)

		Frequency	*Percent*
Valid	BMBS (Biomedicine and Molecular Biosciences)	17	14.9
	ISCH (Individuals. Societies. Culture and Health)	16	14.0
	TUD (Transport and Urban Development)	15	13.2
	CMST (Chemistry and Molecular Sciences and Technologies)	14	12.3
	FA (Food and Agriculture)	13	11.4
	FPS (Forests. their Products and Services)	12	10.5
	MPNS (Materials. Physical and Nanosciences)	12	10.5
	ESSEM (Earth System Science and Environmental Management)	8	7.0
	ICT (Information and Communication Technologies)	7	6.1
	Total	114	100.0

[51] EU15 The Member States of the EU until 2004, when 10 more countries joined the EU; NMS10 - New Member States which joined the EU in 2004; NMS2 - Bulgaria and Romania; Candidate EU – Turkey, Croatia, The Former Yugoslav Republic of Macedonia (source: http://ec.europa.eu);

7.3.3.8 Expert Group Position

The following variable is the expert group position of the respondents who took part in the category 3 survey (see Table 7-32). The frequencies procedure suggests the majority of respondents (95.6 percent) participate as Expert[52] Committee Members while only small numbers of participants have committee specific positions such as Committee Chairs (2.6 percent) and Committee Vice-Chairs (1.8 percent).

Table 7-32: Project Position (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Member	109	95.6	95.6	95.6
	Chair	3	2.6	2.6	98.2
	Vice-Chair	2	1.8	1.8	100.0
	Total	114	100.0	100.0	

7.3.3.9 Participation in Project as Individual Researcher

The following analysed variable is participation in formal networking projects as individual researchers of those experts who took part in the survey category 3 (see Table 7-33). The results of the frequencies procedure suggest that 38.6 percent of 114 respondents in category 3, additional to their expert position, are also involved in formal networking projects as individual researchers while the majority of surveyed experts (61.4 percent) are not involved in any formal networking research projects as individual researchers.

Table 7-33: Participation in Networking Projects as Individual Researchers (Experts)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Yes	44	38.6	38.6	38.6
	No	70	61.4	61.4	100.0
	Total	114	100.0	100.0	

7.4 Analyses of FNR Motives, Outputs and Expectations

This section of the chapter is concerned with the data analysis within the scope of the first research question of this thesis in relation to research outputs attributable to participation in formal networking research projects (FNR projects). The analysis is focused around the findings from the data reported by the respondents in three categories of surveys: Category 1 (Potential Participants), Category 2 (Current Participants) and Category 3 (Experts). The category 1 survey respondents were asked to indicate the reasons they applied for formal networking funding. The respondents were offered three reasons. The statistical analysis is expected to demonstrate which of these reasons are deemed as the most important. The respondents were also asked to indicate which of the instruments were generally available under the funding. As some of the respondents in this category have indicated previous experience or involvement in formal networking projects this variable (previous experience) was controlled during the data analysis.

The second section will deal with the data collected from the survey of category 2 – Current Participants. The results are expected to assist further analysis to address the first research question – whether participation in formal networking projects can lead to certain categories of research outputs, as discussed in an earlier chapter of this thesis. The data analysis will look closer at the individual results reported by the surveyed respondents in each of the identified categories. It is possible to anticipate that certain additional variables

[52] An Expert Committee here is a Domain Committee (at COST)

such as professional experience, professional background and geographical location can have an impact on the networking productivity and as a result, these variables will be controlled. The third section of this data analysis will deal with the results reported by the surveyed experts – respondents in the category 3 survey. The experts were asked to report their perception of to what extent they believe participants in formal networking projects can achieve indicated research outputs as a result of their participation in the projects. Some experts have personal experience or involvement in formal networking projects and therefore this variable (*experts' involvement in networking projects as individual researchers*) was controlled.

7.4.1 Potential Participants' Motives for Applying for FNR Funding

To answer the research question 1A, the Category 1 survey respondents were asked to indicate the reasons they apply for formal networking funding. The respondents were asked to choose one of three reasons. The statistical analysis is expected to demonstrate which of these reasons are deemed the most important. The respondents were also asked to indicate what instruments are generally available under the funding. As some of the respondents in this category have indicated previous experience or involvement in formal networking projects, this variable (previous experience) was controlled during the data analysis. Three main reasons were offered to respondents: access to additional funding, meeting peers through cross-border networking and enhancing the chance of disseminating research results. The respondents were asked to indicate which of these reasons was the most important to them. Out of 297 respondents, the majority (58.6 percent) report meeting peers through cross-border networking as the most important reason for applying for networking funding. Gaining access to additional funding was quoted as the most important reason by 30.3 percent of respondents. The third reason (to enhance the chance of disseminating project results) was reported as the most important reason by 11.1 percent of the respondents (see Table 7-34).

Table 7-34: Most important reason for applying for formal networking funding (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	To meet peers through cross-border networking	174	58.6	58.6	58.6
	To gain access to additional funding	90	30.3	30.3	88.9
	To enhance the chance of disseminating project results	33	11.1	11.1	100.0
	Total	297	100.0	100.0	

The respondents were further asked to indicate the second and the third most important reasons for applying for formal networking funding. Equal numbers of respondents ranked gaining access to additional funding and enhancing the chance of disseminating research results as the second most important aspect to them (34.7 percent of respondents per each reason). A smaller number of respondents (30.6 percent) reported meeting peers through cross-border networking as the second most important reason for applying for formal networking funding (see Table 7-35).

Table 7-35: Second most important reason for applying for formal networking funding (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	To gain access to additional funding	103	34.7	34.7	34.7
	To enhance the chance of disseminating project results	103	34.7	34.7	69.4
	To meet peers through cross-border networking	91	30.6	30.6	100.0
	Total	297	100.0	100.0	

The largest number of respondents ranked *enhancing the chance of disseminating research* and results as the *third most important* to them (54.2 percent of respondents per each reason). *Gaining access to additional funding* was ranked as the third most important reason by 35 percent of respondents.

Meeting peers through cross-border networking was the third most important reason for applying for formal networking funding was reported by 10.8 percent of potential participants (see Table 7-36).

Table 7-36: Third most important reason for applying for formal networking funding (Potential Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	To enhance the chance of disseminating project results	161	54.2	54.2	54.2
	To gain access to additional funding	104	35.0	35.0	89.2
	To meet peers through cross-border networking	32	10.8	10.8	100.0
	Total	297	100.0	100.0	

7.4.1.1 Reasons for applying – controlling for previous experience of FNR funding scheme

As previous experience of a particular funding instrument can have a certain impact on the expectations individual researchers set when applying for funding, it was decided to control for this variable (*previous experience of the FNR funding scheme*). To control for the effect of this variable separate tests were run to establish if there are differences between how these two groups of potential participants (group 1 – applicants with previous experience of the funding scheme, and group 2 – applicants without previous experience of the funding scheme) ranked the most important reason for applying for networking funding.

A significant majority of those with previous experience of funding (65.4 percent) reported meeting peers through cross-border networking as their most important reason for applying for funding. Only smaller numbers of respondents reported *gaining access to additional funding* (17.8 percent) and enhancing *the chance of disseminating project results* (16.8 percent) as their most important reason to apply for funding (see Table 7-37).

Table 7-37: The most important reason to apply for networking funding (Potential Participants with prior experience of the funding scheme)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	To meet peers through cross-border networking	70	65.4	65.4	65.4
	To gain access to additional funding	19	17.8	17.8	83.2
	To enhance the chance of disseminating project results	18	16.8	16.8	100.0
	Total	107	100.0	100.0	

Out of respondents (Potential Participants) without any prior experience of the scheme, the votes have been mainly split between the following reasons: meeting peers (54.7 percent) and additional funding (37.4 percent). Only 7.9 percent of respondents without prior experience ranked disseminating research results as the most important factor for the application for new funding.

Table 7-38: The most important reason to apply for networking funding (Potential Participants without prior experience of the funding scheme)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	To meet peers through cross-border networking	104	54.7	54.7	54.7
	To gain access to additional funding	71	37.4	37.4	92.1
	To enhance the chance of disseminating project results	15	7.9	7.9	100.0
	Total	190	100.0	100.0	

7.4.1.2 Reasons for applying – controlling for Country of Work

The results of the survey were further controlled for the Country of Work of respondents using Country Classification 1[53] (in addition to the variable experience of FNR funding scheme prior to application). The analysis compared the reasons quoted by respondents across different groups of countries as their most important reason for applying for FNR funding. The results (see Appendix 11) suggest that there are some differences between the groups of countries. The analysis specifically examines respondents from the four categories of countries: Eastern Europe, Western Europe, Northern Europe and Southern Europe (respondents from outside of these four were excluded).

The majority of the Western Europeans surveyed (71.4 percent of all Western European respondents with prior experience of FNR funding scheme) reported *meeting peers* through cross-border networking as the main reason for applying for funding at the time of survey. Out of the Western Europeans who did not have any FNR funding experience prior to their application relatively close shares of respondents reported one of the two reasons: *meeting peers* (45.5 percent of all Western Europeans without FNR experience), and *access to additional funding* (47.3 percent of all Western Europeans without FNR experience). The Northern European respondents in both groups (respondents with and without FNR experience) reported *meeting peers* as their main reason for applying for FNR funding (68.4 percent of respondents with FNR experience and 65.3 percent of respondents without FNR experience). Only about a third of the Northern European respondents without prior FNR experience reported *access to additional funding* as the most important reason for applying for funding. Respondents from Southern Europe displayed results very similar to Northern Europeans. The largest share of respondents, irrespective of whether they had prior FNR experience at the time of the survey, reported *meeting peers* as their most important reason for applying for new funding (69.2 percent of respondents with prior experience and 60.9 percent of respondents without prior FNR experience). Only about a quarter of all respondents without prior FNR funding experience reported *access to additional funding* as the most important reason.

However, the results reported by researchers from Eastern European countries differed to some extent from those from the other three groups of countries. Out of the Eastern European respondents with prior FNR experience half of all respondents (50.0 percent) reported *meeting peers* as their most important reason for applying for new FNR funding. However, 50 percent of Eastern European respondents without any prior experience of FNR funding reported *access to additional funding* as the most important reason for applying for funding.

[53] Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings suggested by the UN Statistics Division: http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe

7.4.1.3 Reasons for applying – controlling for Research Domain

The results of the survey were also additionally controlled for the Research Domain of respondents using Domain Classification (in addition to the variable experience of FNR funding scheme prior to application). The analysis compared the reasons quoted by respondents across different Scientific Domains as their most important reason for applying for FNR funding. The results (see Appendix 12 and Appendix 13) suggest that there are some differences between the respondents across some Domains.

The majority of respondents with FNR experience across most Domains (BMBS (80 percent), CMST (71.4 percent), ESSEM (83.3 percent), FA (56.3 percent), FPS (57.1 percent), ICT (85.7 percent), ISCH (75 percent), MPNS (41.4 percent), TUD (40 percent) reported *meeting peers* as the most important reason for applying for funding. Respondents (with FNR experience) in TUD Domain reported higher (40 percent) interest in the third motive: *enhancing chance of disseminating research results*. At the same time, significantly large groups of respondents without FNR experience in some Domains (BMBS (47.6 percent), FPS (40 percent), ICT (40.9 percent), ISCH (51.5 percent), and MPNS (52.9 percent), reported gaining *access to additional funding* as the most important reason to apply for FNR funding.

7.4.1.4 Interest in Particular FNR Instruments (Potential Participants)

This section deals with the data collected from potential FNR participants (category 1 survey). The questions in this category of the survey are expected to provide insights into what specific types of support applicants are particularly interested in. As certain variables such as professional experience, professional background and country of work, and previous FNR experience can have an influence on the networking productivity these variables were controlled. The participants were asked to what extent they are interested in particular FNR instruments supported within FNR programme (on a scale from 1 (*not interested at all*) to 10 (*highly interested*). The respondents were further offered a list of ten items[54]:

1. FNI1: Support for the preparation of meetings, workshops, conferences
2. FNI2: Short-term scientific mission used to fund exchange visits to an institution or laboratory
3. FNI3: Training school (for dissemination)
4. FNI4: General Action Support grants (GASGs) for the support of the project's website, secretarial support, small-scale activities
5. FNI5: Annual Grants (an alternative to the Pay as You Go scheme)
6. FNI6: Contributions to Publications
7. FNI7: Subsidies for support activities, i.e. review, co-ordinate, evaluate or summarise the results of activities or prepare a document or a booklet
8. FNI8: Strategic workshops and/or large conferences
9. FNI9: Near Neighbour Scheme budget that allows involvement of researchers in the Europe's 'Near Neighbourhood'
10. FNI10: Travel Reimbursements.

[54] These ten items were the actual instruments employed in COST Actions

Responses to a single Likert item in this section of the thesis will be treated as ordinal data. When treated as such Likert responses can be analysed with bar charts, central tendency (displayed through the median/the mode), measures of dispersion (as summarised by the range across quartiles, or in some cases, by standard deviation), as well as some other tests. However, in some further sections of this thesis the Likert scale data will also be treated as interval through the application of summated scores.

7.4.1.4.1 Analysis of Reported Interest in Instruments

This section is concerned with the overall interest in FNR Instruments reported by respondents (Potential Participants). Overall, results suggest that respondents reported relatively high interest in most listed FNI instruments (see Appendix 14). Respondents reported equally high interest in the support of strategic workshops and large conferences (FNI8, mean = 8.37) and reimbursement of travel expenses (FNI10, mean = 8.37). Potential participants also reported strong interest in FNI5 (Annual grants, mean = 7.08), FNI7 (Subsidies for support i.e. review, co-ordinate, evaluate or summarise the results of activities or prepare a document or a booklet, mean = 7.06), and FNI9 (Near Neighbour Scheme, mean = 7.57). Slightly weaker interest has been reported in FNI3 (training schools, mean = 6.87), FNI4 (General Action Support Grants used for the support of an Action's website, secretarial support, small-scale activities, mean = 6.68), and FNI6 (contributions to publications, mean = 6.95).

7.4.1.4.2 Interest in Instruments versus professional experience

The next step is to analyse whether there is a difference in the interests of potential participants with different research experience (*senior* versus *junior*). This subsection therefore tests an assumption that there are statistically significant differences between the interests in FNI instruments reported by potential participants in two experience groups (*junior* researchers and *senior* researchers). Respondents who did not self-report as either junior (less than four years of research experience) or senior (more than four years of research experience) researchers were excluded from this particular analysis. The results can lack representativeness as the number of junior respondents is significantly lower (6) than the number of senior researchers (276). The initial results suggest that there are certainly differences in the way junior and senior applicants rate their interests in particular FNI instruments (see Appendix 15, p. 287). Senior researchers expressed stronger interest in the following instruments: FNI1 (support for the preparation of meetings, workshops, conferences, $mean^S = 8.63$ against $mean^J = 7.50$), FNI2 (STSMs, $mean^S = 8.28$ against $mean^J = 8.00$), FNI3 (STSMs, $mean^S = 6.89$ against $mean^J = 5.00$), FNI5 (Annual grants, $mean^S = 7.09$ against $mean^J = 6.83$), FNI8 (strategic workshops/large conferences, $mean^S = 8.38$ against $mean^J = 6.50$), FNI9 (Near Neighbour Scheme, $mean^S = 7.51$ against $mean^J = 7.00$), and FNI10 (Travel Reimbursements, $mean^S = 8.42$ against $mean^J = 7.00$). However, junior researchers expressed slightly stronger interest than senior researchers in two other instruments: FNI6 (contributions to publications, $mean^J = 7.17$ against $mean^S = 7.02$) and FNI7 (small-scale subsidies, $mean^J = 7.17$ against $mean^S = 7.03$). Further results of the Welch and Brown-Forsythe statistics suggested that while there are differences in the means of reported results these are however, not statistically significant except in the case of all FNI4 (GASGs, sig < 0.05 indicating group differences) (see Appendix 16, p. 287).

7.4.1.4.3 Interest in Instruments versus professional background

This subsection will analyse whether there is a difference in the interests of potential participants from different professional sectors (background) (*academia, research institutes/laboratories, government, and business/ industry*). This subsection tests an assumption that there are statistically significant differences between interest in FNI instruments reported by potential participants in four sectoral groups. Respondents who did not self-report as working in one of these fields were excluded from this particular analysis.

The initial results of comparing the means of reported scores suggest that there are certain differences in how respondents ranked different FNI Instruments (see Appendix 17, p. 288). Academic participants reported a higher than average interest in FNI3 (mean = 6.96) and FNI5 (mean = 7.15), however, they reported lower results than other groups in FNI7 (mean = 6.82) and FNI9 (mean = 7.48). Participants from research institutes and laboratories reported a higher than average interest in FNI1 (mean = 8.96) and FNI10 (mean = 8.56), they also reported lower than average interest in FNI4 (mean = 6.54). Business and Industry respondents reported higher interest than participants from other groups did in FNI3 (mean = 7.00), FNI4 (mean = 7.80), FNI7 (mean = 7.80) and FNI9 (mean = 8.10), they also reported lower interest than other groups in FNI2 (mean = 7.00), FNI6 (mean = 6.40), and FNI8 (mean = 8.20). Government participants reported higher interest in FNI2 (mean = 8.73), FNI6 (mean = 7.64) and FNI8 (mean = 8.73), however, they expressed a lower than average interest in FNI1 (mean = 8.18), FNI3 (mean = 6.09), FNI5 (mean = 6.36) and FNI10 (mean = 7.91). However, further results of the Welch and Brown-Forsythe statistics suggested that while there are differences in the means of reported results, these are not statistically significant (at < 0.05 level) (see Appendix 18, p. 288).

7.4.1.4.4 Interest in Instruments versus country of work

This subsection will analyse whether there is a difference in the interests of potential participants from different regions of Europe (*Eastern Europe, Western Europe, Southern Europe and Northern Europe*). This subsection tests an assumption that there are statistically significant differences between interest in FNI instruments reported by potential participants in four sectoral groups. Respondents who do not work in countries in one of the four European regions were excluded from this particular analysis.

The initial results of comparing the means of reported scores suggest that there are certain differences in how respondents from the four country groups ranked different FNI Instruments (see Appendix 21, p. 289). Eastern European participants reported a higher than average interest in FNI1, FNI2, FNI3, FNI4, FNI6, FNI7 and FNI8, but they reported relatively low (in comparison with other respondents) results in FNI5, FNI9, and FNI10. Southern Europeans reported a stronger than average interest in FNI2, FNI3 and FNI9, they also reported lower than average interest in FNI1, FNI6, FNI7, FNI8 and FNI10. Western Europeans reported a stronger than average interest in FN1 and FNI10, while they also expressed a weaker than average interest in FNI2, FNI5, FNI8 and FNI9. Northern Europeans expressed an interest lower than average in most instruments (FNI3, FNI4, FNI5, FNI6, FNI8, FNI9 and FNI10), however they expressed interest in one instrument stronger than any other group, FNI1.

Further results of the Welch and Brown-Forsythe statistics suggested while there are differences in the means of reported results, these are not statistically significant except in case of all FNI9 (Near Neighbour Scheme, sig < 0.05, indicating group differences) (see Appendix 22, p. 290). The results also show a trend towards significant differences in the way respondents from different country groups reported their interest in FNI2 (STSMs) and FNI3 (Training Schools) (while these differences however did not prove to be statistically significant, they show a trend toward significance (Bangalore & Messerli, 2006)).

7.4.1.4.5 Interest in Instruments versus prior FNR experience

This subsection will analyse the survey responses to identify whether there is a difference in interests of potential participants with and without prior FNR experience (*with FNR experience and without FNR experience)*. This subsection will test the assumption that there are statistically significant differences between the interest in FNI instruments reported by applicants depending on their earlier experiences.

The results of comparing the means of reported scores suggest that there are differences in how respondents from these two groups ranked different FNI Instruments (see Appendix 19, p. 289). In general, respondents with prior experience of FNR projects felt expressed stronger interest in all of the FNI instruments except for FNI5 (Annual Grants). The Welch and Brown-Forsythe statistics suggest that while there are differences in the means of reported results, these are statistically significant only in the case of FNI1 (Support for the preparation of meetings, workshops, conferences), FNI6 (Contributions to Publications) and FNI10 (Travel Reimbursements) (see Appendix 20, p. 289).

7.4.2 Research Outputs Attributable to Formal Networking Programmes

This section of data analysis deals with the data collected from the survey of participants who were involved in formal networking projects at the time of the survey (category 2). The questions in this category should shed further light on whether project participants attribute certain categories of research outputs to their participation in formal networking projects as discussed in an earlier chapter of this thesis. This part of the data analysis will look closer at the individual results reported by surveyed respondents in each of the identified categories. As it can be anticipated that certain additional variables such as professional experience, professional background and geographical location can have an impact on the networking productivity, this research will control for these variables.

The participants were asked to what extent they thought they had achieved the following outcomes from participation in formal networking research projects. For each of the listed outcomes the respondents were asked to indicate whether they had reached it fully, to a great extent, in part, to a small extent, had not reached it at all or if any of the outcomes were not applicable to them.

The respondents were offered a list of eleven items (research UPGS and UPSC outputs):

1. UPGS1: Joint publications in high-ranked scientific journals (peer review)
2. UPGS2: Publication of a book
3. UPGS3: Industrial applications
4. UPGS4: Patents

5. UPGS5: Submission of proposal(s) for a new EU-funded project
6. UPGS6: Influence on policy issues (at European level and/or country level)
7. UPSC1: International conference of high standard
8. UPSC2: Raised the international profile of participant's organisation
9. UPSC3: Raised the international profile of participant's own research
10. UPSC4: Raised the international profile of the funding sponsor
11. UPSC5: Utilisation of project results at national level

Responses to a single Likert item in this section of the thesis will be treated as ordinal data. When treated as ordinal data, such Likert responses can be analysed with bar charts, central tendency (displayed through the median/ the mode), measures of dispersion (as summarised by the range across quartiles, or in some cases, by standard deviation), as well as some other tests. However, in further sections of this thesis the Likert scale data will also be treated as interval through the application of summated scores.

7.4.2.1 UPGS Outputs (Upgrading, Upshifting and Upstreaming)

Within the scope of the conceptual framework developed earlier, first statistical tests were applied to the following range of anticipated research results: The tests were applied to the following range of research results:

- UPGS1: Joint publications in high-ranked scientific journals (peer review)
- UPGS2: Publication of a book
- UPGS3: Industrial applications
- UPGS4: Patents
- UPGS5: Submission of proposal(s) for a new EU-funded project
- UPGS6: Influence on policy issues (at European level and/or country level)

7.4.2.1.1 UPGS1: Joint Publications in peer-reviewed journals

Respondents were asked to what extent they had achieved joint publications as a result of their participation in formal networking research projects. The answers scored from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-39 below) include measures of central tendency such as the mean and median. The mean of the sample is 3.04 and its median is 3.0. The table also displays measures of dispersion (spread of the distribution) such as the standard deviation, as well as measures of distribution, such as skewness and kurtosis, which indicate how much a distribution varies from a normal distribution.

Skewness measures the asymmetry of a distribution. A negative skewness value (-0.186) indicates a negatively skewed distribution in response to the question. As this ratio is not significantly different from 0, it is possible to assume that the variable has a normal distribution. The summary table also shows that fifty percent of respondents have achieved joint publications to an extent ranging from 2 (*to a small extent*) to 4 (*to a great extent*).

Table 7-39: Joint publications as a result of formal networking research projects (Current Participants)

N	Valid	1951
	Missing	222
Mean		3.04
Median		3.00
Std. Deviation		1.201
Variance		1.442
Skewness		-.186
Std. Error of Skewness		.055
Minimum		1
Maximum		5
Percentiles	25	2.00
	50	3.00
	75	4.00

Further, the frequency procedure was applied to the response dataset. Frequency tables are useful for summarising variables with a limited number of distinct categories. For each value of a variable, a frequency table displays the number of times (count) that value occurs (see Table 7-40 below). The table below displays the number and percentage of cases for each value of the variable. Overall, 10.2 percent of initial 2,173 respondents believe that joint publications *do not apply* to their participation in FNR projects.

According to the frequencies table, 11.0 percent of the rest of respondents have *fully* achieved joint publications in high ranked peer-reviewed scientific journals as the result of their involvement in a formal networking research project. Further, 26.8 percent of respondents have achieved joint publications *to a great extent*, while another group of 31.5 percent of respondents have achieved joint publications at least *in part*. Another 16.5 percent of respondents report not achieving joint publications at all as a result of their involvement in the formal networking programme. A group of 14.3 percent of respondents have only achieved joint publications to a small extent.

Table 7-40: Joint publications as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	279	12.8	14.3	14.3
	To a small extent	321	14.8	16.5	30.8
	In part	615	28.3	31.5	62.3
	To a great extent	522	24.0	26.8	89.0
	Fully	214	9.8	11.0	100.0
	Total	1,951	89.8	100.0	
Missing	System	222	10.2		
Total		2,173	100.0		

In total, *33.8* percent of all 2,173 respondents have reported achieving joint publications *fully* or to a *great extent* as a result of networking within the scope of the programme. About one fifth of 2,173 original respondents (*23.0* percent) did not achieve ('not at all' and 'not applicable') any joint publications as a result of their participation in networking projects.

7.4.2.1.2 UPGS2: Publication of a book

Respondents were asked to what extent they had achieved the *publication of a book* due to their participation in formal networking research projects. The answers scored from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 (not applicable). Summary statistics (see Table 7-41 below) include measures of central tendency such as the mean and median. The mean of the sample is 2.71 and its median is 3.0. The table also displays skewness that indicates how much a distribution varies from a normal distribution. A

positive skewness value (0.194) indicates a positively skewed distribution in the responses to the question. As this ratio is close to zero it is possible to assume that the variable has a normal distribution. The summary table also shows that fifty percent of respondents have achieved publication of a book to the extent ranging from 1 ('not at all') to 4 ('to a great extent').

Table 7-41: Publication of a book as a result of formal networking research projects (Current Participants)

N	Valid	1,652
	Missing	521
Mean		2.71
Median		3.00
Std. Deviation		1.485
Variance		2.204
Skewness		.188
Std. Error of Skewness		.060
Minimum		1
Maximum		5
Percentiles	25	1.00
	50	3.00
	75	4.00

Table 7-42 below displays the number and percentage of cases for each value of the variable. Nearly a quarter of all respondents (24.0 percent) believe that the publication of a book does not apply to their participation in the networking research project. These respondents have been excluded from further analysis. According to the frequencies table below, 16.2 percent of the rest of respondents have *fully* achieved publication of a book as the result of their involvement in formal networking research project. Further, 18.1 percent of subjects have achieved publication of a book *to a great extent*, while another group of 19.7 percent of respondents have achieved publication of a book at least *in part*. A group of 12.8 percent of respondents have achieved publication of a book only *to a small extent*, and about a third of respondents (33.2 percent) reported not achieving publication of a book as a result of their involvement, however, they did not report it as a non applicable output. In total, *26.1* percent of all 2,173 participants reported achieving publication of a book fully or to a great extent as a result of their networking within the scope of the programme. Further *24.8* percent of all 2,173 FNR participants achieved publication of a book in part or to a small extent, while the rest of all respondents (*49.2* percent) did not achieve ('*not at all*' and 'not *applicable*') any publication of a book as a result of their participation in networking projects.

Table 7-42: Publication of a book as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	548	25.2	33.2	33.2
	To a small extent	212	9.8	12.8	46.0
	In part	325	15.0	19.7	65.7
	To a great extent	299	13.8	18.1	83.8
	Fully	268	12.3	16.2	100.0
	Total	1,652	76.0	100.0	
Missing	System	521	24.0		
Total		2,173	100.0		

7.4.2.1.3 UPGS3: Industrial applications

Respondents were asked to what extent they had achieved *industrial applications* as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-43 below) include measures of central tendency such as the mean (2.24) and median (2.0). A positive skewness value (0.459)

indicates a positively skewed distribution in response to the question. The summary table also shows that fifty percent of respondents have achieved industrial applications to the extent ranging from 1 (*not at all*) to 3 (*in part*).

Table 7-43: Industrial applications as a result of formal networking research projects (Current Participants)

N	Valid	1,486
	Missing	687
Mean		2.24
Median		2.00
Std. Deviation		1.092
Variance		1.192
Skewness		.459
Std. Error of Skewness		.063
Minimum		1
Maximum		5
Percentiles	25	1.00
	50	2.00
	75	3.00

Table 7-44 below shows that 31.6 percent of 2,173 respondents reported that industrial applications do not apply (*not applicable*) to their FNR participation. These respondents were excluded from further analysis. A further 2.6 percent of the remaining respondents reported achieving industrial applications *fully* as a result of their FNR projects. Another 10.2 percent of subjects have achieved industrial applications *to a great extent* while another group of 28.5 percent of respondents have achieved industrial applications at least *in part*. A group of 26.4 percent of respondents have achieved industrial applications only *to a small extent*. About a third of all respondents (32.3 percent) reported *not at all* achieving industrial applications as a result of their involvement in the formal networking programme.

Table 7-44: Industrial applications as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	480	22.1	32.3	32.3
	To a small extent	392	18.0	26.4	58.7
	In part	424	19.5	28.5	87.2
	To a great extent	151	6.9	10.2	97.4
	Fully	39	1.8	2.6	100.0
	Total	1,486	68.4	100.0	
Missing	System	687	31.6		
Total		2,173	100.0		

In total, *8.7* percent out of 2,173 participants have reported achieving industrial applications *fully* or *to a great extent* as a result of their networking within the scope of the programme. To some extent (in part or to a small extent), industrial applications have been achieved by 37.5 percent of all respondents. The rest of respondents (*53.7* percent) did not achieve (*not at all* and *not applicable*) any industrial applications as a result of their participation in networking projects.

7.4.2.1.4 UPGS4: Patents

Respondents were asked to what extent they had achieved *patents* as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-45 below) include measures of central tendency such as the mean (1.67) and median (1.0). A positive skewness value (1.324) indicates a positively skewed distribution in the responses to the question suggesting that the variable does not have a normal

distribution. The summary table also shows that fifty percent of respondents have achieved patents to the extent ranging from 1 (not at all) to 2 (to a small extent).

Table 7-45: Patents as a result of formal networking research projects (Current Participants)

N	Valid	1210
	Missing	963
Mean		1.67
Median		1.00
Std. Deviation		.980
Variance		.960
Skewness		1.324
Std. Error of Skewness		.070
Minimum		1
Maximum		5
Percentiles	25	1.00
	50	1.00
	75	2.00

Further, a frequency Table 7-46 below shows that 44.3 percent of 2,173 participants reported that patents do not apply (not applicable) to them as a FNR output. These respondents were excluded from further analysis. From the rest of respondents only 1.2 percent reported achieving patents fully while a further 5.0 percent of respondents achieved patents to a great extent. Additionally, a group of 14.8 percent of respondents reported achieving patents at least in part, and another group of 17.4 percent reported achieving patent only to a small extent. The majority of respondents (61.7 percent) reported that they did not at all achieve patents as a result of their FNR project activities.

Table 7-46: Patents as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	746	34.3	61.7	61.7
	To a small extent	210	9.7	17.4	79.0
	In part	179	8.2	14.8	93.8
	To a great extent	61	2.8	5.0	98.8
	Fully	14	.6	1.2	100.0
	Total	1,210	55.7	100.0	
Missing	System	963	44.3		
Total		2,173	100.0		

In total, *3.4* percent of 2,173 original participants have reported achieving patents *fully* or to a *great extent* as a result of their networking within the scope of the programme. Only 17.9 percent of all respondents managed to achieve patents in part or to a small extent. The large majority of 2,173 respondents (*78.6* percent) did not achieve (*not at all* and *not applicable*) any patents as a result of their participation in networking projects.

7.4.2.1.5 UPGS5: Submission of proposal(s) for a new funded project (EU-funded)

Respondents have been asked to what extent they had achieved a *submission of proposals for new funded projects (EU-funded)* as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-47 below) include measures of central tendency such as the mean (2.83) and its median (3.0).

Table 7-47: Submission of Proposal(s) for new funded projects (EU funded) as a result of formal networking research projects (Current Participants)

N	Valid	1,847
	Missing	326
Mean		2.83
Median		3.00
Std. Deviation		1.307
Variance		1.708
Skewness		-.068
Std. Error of Skewness		.057
Minimum		1
Maximum		5
Percentiles	25	2.00
	50	3.00
	75	4.00

The table also displays skewness to indicate how much a distribution varies from normal . A small positive skewness value (-0.068) indicates a slight negative skewed distribution in the response to the question. As this ratio is very close to zero it is possible to assume that the variable has a normal distribution. The summary table also shows that fifty percent of respondents have achieved a submission of proposals for new funded projects (EU funded) to the extent ranging from 2 (to a small extent) to 4 (to a great extent).

A frequency Table 7-48 below suggests that 15.0 percent of 2,173 participants do not view the submission of proposals for new funded projects as an applicable to their output. These respondents were excluded from further analysis. According to the frequencies table, 9.7 percent of the rest of the current participants (1,847 respondents) have *fully* achieved a submission of a proposal(s) for new funded projects as the result of their involvement in a formal networking research project. Further, 24.9 percent of subjects have achieved proposals for new funded projects (EU funded) *to a great extent*, while another group of 28.0 percent of respondents have achieved a submission of a proposal(s) for new funded projects (EU funded) at least i*n part*. A group of 13.2 percent of respondents have achieved proposals for new funded projects (EU funded) only *to a small extent*. Over one quarter of all respondents (24.1 percent) reported *not achieving at all* the submission of a proposal(s) for new funded projects (EU funded) as a result of their involvement in the formal networking programme.

Table 7-48: Submission of proposal(s) for new funded projects (EU funded) as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	446	20.5	24.1	24.1
	To a small extent	244	11.2	13.2	37.4
	In part	518	23.8	28.0	65.4
	To a great extent	459	21.1	24.9	90.3
	Fully	180	8.3	9.7	100.0
	Total	1,847	85.0	100.0	
Missing	System	326	15.0		
Total		2,173	100.0		

In total, *29.4* percent of 2,173 participants reported achieving a submission of a proposal(s) for new funded projects (EU funded) fully or to a great extent as a result of their networking within the scope of the programme. Over a third of respondents (*35.0* percent) achieved this output *in part* or *to a small extent*, while a further 35.5 percent reported that they could not or did *not* achieve it *at all* (*not applicable* or *not at all*) as an FNR output.

7.4.2.1.6 UPGS6: Influence on policy issues (at European level and/or country level)

Respondents were asked to what extent they had achieved *influence on policy issues (at European level and/or national level)* as a result of their participation in formal networking research projects. The answers ranged from 1 (not at all) to 5 (fully), with an additional answer point 0 (not applicable) (see Table 7-49 below). The summary table shows measures of central tendency: the mean of the sample is 2.60 and its median is 3.0. A positive skewness value (0.101) indicates a positively skewed distribution in the responses to the question. As this ratio is close to zero, it is possible to assume that the variable has a normal distribution. The summary table also shows that fifty percent of respondents have achieved industrial applications to the extent ranging from 2 (*to a small extent*) to 3 (*in part*).

Table 7-49: Influence on policy issues as a result of formal networking research projects (Current Participants)

N	Valid	1,848
	Missing	325
Mean		2.60
Median		3.00
Std. Deviation		1.089
Variance		1.186
Skewness		.101
Std. Error of Skewness		.057
Minimum		1
Maximum		5
Percentiles	25	2.00
	50	3.00
	75	3.00

Further, a frequency table has been built to the responses displaying the number and percentage of cases for each value of the variable (see Table 7-50 below). The table suggests that 15.0 percent of all 2,173 respondents do not view influence on policy issues as an applicable FNR output. These responses were excluded from further analysis in this section. According to the frequencies table below, only 3.7 percent of the rest of current participants have *fully* achieved influence on policy issues as the result of their involvement in formal networking research project. A further 16.4 percent of subjects have achieved influence on policy issues *to a great extent*, while a group of 35.6 percent of respondents have achieved it at least *in part*. A group of 24.5 percent of respondents have achieved influence on policy issues only *to a small extent*. Another group of respondents (19.8 percent) report *not achieving (not at all)* any influence. In total, *17.0* percent of all 2,173 participants have reported achieving influence on policy issues *fully* or *to a great extent* as a result of their networking within the scope of the FNR programme. More than half of all respondents (51.1 percent) reported achieving this output in part or at least to a small extent. About one third of respondents (*31.8* percent) reported not achieving (*not at all* and *not applicable*) any influence on policy issues as a result of their participation in networking projects.

Table 7-50: Influence on policy issues as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	366	16.8	19.8	19.8
	To a small extent	453	20.8	24.5	44.3
	In part	658	30.3	35.6	79.9
	To a great extent	303	13.9	16.4	96.3
	Fully	68	3.1	3.7	100.0
	Total	1,848	85.0	100.0	
Missing	System	325	15.0		
Total		2,173	100.0		

7.4.2.2 Upscaling Outputs (UPSC Outputs)

In line with the conceptual framework developed earlier, further statistical tests have been applied to the following range of anticipated UPSC research results:

- UPSC1: Participation at an International conference of high standard
- UPSC2: Raising international profile of researcher's organisation
- UPSC3: Raising international profile of researcher's own research
- UPSC4: Raising international profile of funding sponsor
- UPSC5: Utilisation of networking research project results at national level

7.4.2.2.1 UPSC1: Participation at an International conference of high standard

Respondents have been asked to what extent they achieved *participation at an international conference of high standard* as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-51 below) include measures of the central tendency such as the mean (3.75) and its median (4.00). The table also displays skewness that indicates how much a distribution varies from a normal distribution. A negative skewness value (-0.715) indicates a negatively skewed distribution in the responses to the question. The summary table also shows that fifty percent of respondents have achieved industrial applications to the extent ranging from 3 (*in part*) to 4 (*to a great extent*).

Table 7-51: UPSC1. International Conference as a result of formal networking research projects (Current Participants)

N	Valid	2,044
	Missing	129
Mean		3.75
Median		4.00
Std. Deviation		.962
Variance		.926
Skewness		-.715
Std. Error of Skewness		.054
Minimum		1
Maximum		5
Percentiles	25	3.00
	50	4.00
	75	4.00

Further, a frequency was created from the responses displaying the number and percentage of cases for each value of the variable (see Table 7-52 below).

Table 7-52: International Conference as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	60	2.8	2.9	2.9
	To a small extent	131	6.0	6.4	9.3
	In part	507	23.3	24.8	34.1
	To a great extent	901	41.5	44.1	78.2
	Fully	445	20.5	21.8	100.0
	Total	2,044	94.1	100.0	
Missing	System	129	5.9		
Total		2,173	100.0		

Out of the initial group of 2,173 respondents, only 20.5 percent of current participants have fully achieved participation at an international conference of high standard as the result of their involvement in formal

networking research project. Further, 41.5 percent of subjects have achieved it 'to a great extent', while another group of 23.3 percent of respondents have achieved participation at least in part. A group of 6.0 percent of respondents have achieved it only to a small extent. Only a small share all respondents (2.8 percent) report not achieving participation at an international conference of high standard as a result of their involvement in the formal networking programme. Finally, another small group of respondents (5.9) believe that it did not apply to their participation in the networking research project. In total, *91.3* percent of participants have reported achieving participation at international conferences fully or at least to some extent (sum of 'fully', 'to a great extent', 'in part' or 'to a small extent' responses) as a result of their networking within the scope of the programme. Less than one tenth of all respondents (*8.7* percent) did not achieve ('not at all' and 'not applicable') any participation at international conferences as a result of their participation in networking projects.

7.4.2.2.2 UPSC2: Raising international profile of researcher's organisation

Respondents have been asked to what extent they had achieved a *raised international profile of the researcher's own organisation* as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-53 below) include measures of central tendency such as the mean and median. The mean of the sample is 3.46 and its median is 4.00. The table also displays skewness that indicates how much a distribution varies from a normal distribution. A negative skewness value (-0.351) indicates a negatively skewed distribution in responses to the question. The summary table also shows that fifty percent of respondents have achieved industrial applications to the extent ranging from 3 ('in part') to 4 ('to a great extent').

Table 7-53: Increased international profile of researcher's organisation as a result of formal networking research projects (Current Participants)

N	Valid	2,110
	Missing	63
Mean		3.46
Median		4.00
Std. Deviation		.964
Variance		.930
Skewness		-.351
Std. Error of Skewness		.053
Minimum		1
Maximum		5
Percentiles	25	3.00
	50	4.00
	75	4.00

Further, a frequency table was designed around the responses displaying the number and percentage of cases for each value of the variable (see Table 7-54 below). Of the 2,173 respondents, 2.9 percent believe UPSC2 as a FNR output does not apply to their participation in projects. These respondents were excluded from further analysis. According to the frequencies table below, 13.3 percent of current participants have *fully* achieved a raised international profile of the researcher's own organisation as the result of their involvement in formal networking research project. Further 37.3 percent of subjects have achieved it *to a great extent*, while another group of 34.8 percent of respondents achieved it at least *in part*. A group of 11.5 percent of respondents achieved raised international profile of the researcher's own organisation only to *a small extent*.

Only a small number of respondents (3.1 percent) reported not achieving a raised international organisational profile. In total, *49.2* percent of 2,173 participants have reported achieving raised international profile of the researcher's own organisation *fully* or *to a great extent* as a result of their networking within the scope of the programme. Further 44.9 percent of all respondents achieved this output at least to some extent (*in part* or *to a small extent*). Only a relatively small portion of respondents (*5.9* percent) did not achieve (*not at all* and *not applicable*) it.

Table 7-54: Increased international profile of researcher's organisation as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	65	3.0	3.1	3.1
	To a small extent	242	11.1	11.5	14.5
	In part	734	33.8	34.8	49.3
	To a great extent	788	36.3	37.3	86.7
	Fully	281	12.9	13.3	100.0
	Total	2,110	97.1	100.0	
Missing	System	63	2.9		
Total		2,173	100.0		

7.4.2.2.3 UPSC3: Raising international profile of researcher's own research

Respondents were asked to what extent they had achieved a *raised international profile of the researcher's own research* as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-55 below) include measures of central tendency such as the mean and median. The mean of the sample is 3.60 and its median is 4.00. The table also displays skewness that indicates how much a distribution varies from a normal distribution. A negative skewness value (-0.429) indicates a negatively skewed distribution in responses to the question. The summary table also shows that fifty percent of respondents have achieved industrial applications to the extent ranging from 3 ('in part') to 4 ('to a great extent').

Table 7-55: Raised international profile of the researcher's own research as a result of formal networking research projects (Current Participants)

N	Valid	2,116
	Missing	57
Mean		3.60
Median		4.00
Std. Deviation		.944
Variance		.891
Skewness		-.429
Std. Error of Skewness		.053
Minimum		1
Maximum		5
Percentiles	25	3.00
	50	4.00
	75	4.00

Further, a frequency table was designed to illustrate the responses displaying the number and percentage of cases for each value of the variable (see Table 7-56 below). Of all survey respondents, 2.6 percent reported that UPSC3 as an output *does not apply* to their participation in FNR projects. These respondents were not included in the further research. According to the frequencies table below, 16.5 percent of the remaining participants have *fully* achieved a raised international profile of their own research as the result of their involvement in formal networking research project. Further, 40.9 percent of subjects have achieved a raised

international profile of their research *to a great extent*, while another group of 31.0 percent of respondents have achieved it at least *in part*. A small share (9.5 percent) of subjects reported achieving it *to a small extent*. Only 2.2 percent report not achieving raised international profile of the researcher's own research as a result of their involvement in the formal networking programme.

Table 7-56: Raised international profile of the researcher's own research as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	46	2.1	2.2	2.2
	To a small extent	201	9.2	9.5	11.7
	In part	655	30.1	31.0	42.6
	To a great extent	865	39.8	40.9	83.5
	Fully	349	16.1	16.5	100.0
	Total	2,116	97.4	100.0	
Missing	System	57	2.6		
Total		2,173	100.0		

In total *55.9* percent of 2,173 participants reported achieving raised international profile of the researcher's own research *fully* or *to a great extent* as a result of their networking within the scope of the programme. Over a third of all surveyed respondents (39.3 percent) reported achieving UPSC3 output *to a small extent* or *in part*. A small group of respondents (*4.7* percent) did not achieve (*not at all* and *not applicable*) raised international profile of the researcher's own research as a result of their participation in networking projects.

7.4.2.2.4 UPSC4: Raising international profile of funding sponsor

Respondents were asked to what extent they had achieved *raised international profile of the funding sponsor*[55] as a result of their participation in formal networking research projects. The answers ranged from 1 ('not at all') to 5 ('fully'), with an additional answer point 0 ('not applicable'). Summary statistics (see Table 7-57 below) include measures of central tendency such as the mean and median. The mean of the sample is 3.62 and its median is 4.00.

Table 7-57: Raised international profile of the funding sponsor as a result of formal networking research projects (Current Participants)

N	Valid	2,091
	Missing	82
Mean		3.62
Median		4.00
Std. Deviation		.940
Variance		.883
Skewness		-.514
Std. Error of Skewness		.054
Minimum		1
Maximum		5
Percentiles	25	3.00
	50	4.00
	75	4.00

A negative skewness value (-0.514) indicates a negatively skewed distribution in the responses to the question. The table also shows that fifty percent of respondents have achieved industrial applications to the extent ranging from 3 ('in part') to 4 ('to a great extent'). Further, a frequency table shows the responses displaying the number and percentage of cases for each value of the variable (see Table 7-58 below). A share

[55] In the context of the survey (Category 2), funding sponsor is COST (European Cooperation in the field of Science and Technology).

of 3.8 percent of 2,173 surveyed respondents reported that the output UPSC4 as an output measure does not apply to their participation in the FNR project. These respondents were excluded from further analysis in this subsection. According to the frequencies table below (see Table 7-58), 16.3 percent of current participants have *fully* achieved a raised international profile of the funding sponsor as the result of their involvement in formal networking research project.

Table 7-58: Raised international profile of the funding sponsor as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	51	2.3	2.4	2.4
	To a small extent	183	8.4	8.8	11.2
	In part	619	28.5	29.6	40.8
	To a great extent	898	41.3	42.9	83.7
	Fully	340	15.6	16.3	100.0
	Total	2,091	96.2	100.0	
Missing	System	82	3.8		
Total		2,173	100.0		

42.9 percent of those surveyed achieved raised international profile of the funding sponsor *to a great extent*, while another group of 29.6 percent of respondents have achieved it at least *in part*. A group of 8.8 percent of respondents stated achieving it only *to a small extent*. A small fraction of the respondents (2.4 percent) report not achieving raised international profile of the funding sponsor as a result of their involvement in the formal networking programme. In total, *56.9* percent of participants reported achieving a raised international profile of the funding sponsor *fully* or *to a great extent* as a result of their networking within the scope of the programme. Over a third of all respondents (36.9 percent) reported achieving this output *in part* or at least *to a small extent*. A small number of respondents (*6.1* percent) did not achieve (*not at all* and *not applicable*) raised international profile of the funding sponsor as a result of their participation in networking projects.

7.4.2.2.5 UPSC5: Utilisation of networking research project results at national level

Respondents were asked to what extent they had achieved *utilisation of networking research project results at national level* as a result of their participation in formal networking research projects (see Table 7-59 below). The mean of the sample is 3.22 and its median is 3.0. A negative skewness value (-0.249) indicates a negative skewed distribution in the responses to the question.

Table 7-59: Utilisation of networking research project results at national level as a result of formal networking research projects (Current Participants)

N	Valid	2,067
	Missing	106
Mean		3.22
Median		3.00
Std. Deviation		1.053
Variance		1.108
Skewness		-.249
Std. Error of Skewness		.054
Minimum		1
Maximum		5
Percentiles	25	3.00
	50	3.00
	75	4.00

Further, a frequency table shows the responses displaying the number and percentage of cases for each value of the variable (see Table 7-60 below). Out of 2,173 respondents to the survey, 4.9 percent of respondents

reported that the UPSC5 output does not apply to them. These respondents were excluded from further analysis. According to the frequencies table below, 10.8 percent of current participants have *fully* achieved utilisation of networking research project results at national level as the result of their involvement in formal networking research project. Further 29.9 percent of subjects have achieved utilisation of networking research project results at national level to a *great extent*, while nearly a third of all respondents (36.9 percent) have achieved it at least *in part*. A group of 15.6 percent of respondents achieved it only *to a small extent*. A relatively small part of all respondents (6.4 percent) report not achieving at all UPSC5 output as a result of their involvement in the formal networking programme.

Table 7-60: Utilisation of networking research project results at national level as a result of formal networking research projects (Current Participants)

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Not at all	140	6.4	6.8	6.8
	To a small extent	322	14.8	15.6	22.4
	In part	763	35.1	36.9	59.3
	To a great extent	619	28.5	29.9	89.2
	Fully	223	10.3	10.8	100.0
	Total	2,067	95.1	100.0	
Missing	System	106	4.9		
Total		2,173	100.0		

In total, *88.7* percent of participants have reported achieving utilisation of networking research project results at national level fully or at least to some extent (sum of 'fully', 'to a great extent', 'in part' or 'to a small extent' responses) as a result of their networking within the scope of the programme. The rest of the respondents (*11.3* percent) did not achieve ('not at all' and 'not applicable') any utilisation of networking research project results at national level because of their participation in networking projects.

7.4.2.3 Controlling for Education, Experience, Background, Country and Domain

An important question is in whether the observed output results are the same for the entire population or whether there are some other possible explanations. To extend our knowledge about the acquired results we will investigate if the results change under different situations (Rosenberg, 1968). Researchers using survey methods often control for other variables during the phase of data analysis (Nardi, 2005). As suggested in the reviewed literature, one can anticipate that certain additional variables such as educational level, professional experience, professional background and geographical location (country of work) can also have an impact on a researcher's networking research productivity, and therefore, these variables will be controlled (for) (as per research question 3B) (Bozeman & Corley, 2004; Gaughan & Bozeman, 2002).

To control for variables such as educational level, country of work, research experience, professional background, and science domain a series of statistical procedures such as t-tests were used. It is possible to compare the means across these two groups by employing the independent-samples t-test procedure compares. T-tests ask whether the difference between the means of several groups is statistically significant from zero. Therefore, when the data comes from a sample of respondents, they are technically being asked if the difference between the true means in the populations from which these samples have been derived is zero (Nardi, 2005). Following this logic, this study is setting a null hypothesis, 'There is no difference between the two sample means, they are the same and they are from the same population'.

7.4.2.3.1 Educational Level versus Research Outputs (Current FNR Participants)

7.4.2.3.1.1 Educational Level versus UPGS Outputs

In the case of educational level, variable respondents can be grouped into two groups: researchers with a PhD and researchers without a PhD. The Descriptives Table 7-61 below displays the sample size, mean, standard deviation, and standard error for both groups (group 1 – respondents educated at the PhD level, group 2 – respondents without a PhD degree). In five analysed research output variables (with an exception of industrial applications), on average respondents who had doctoral level degrees reported higher research outputs than the comparison group, and they vary a little more around their average.

Table 7-61: Group Statistics Descriptives (UPGS Outputs versus Educational Level, Current Participants)

	PhD degree	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
Joint publications	Yes	1895	2.77	1.448	.033
	No	278	2.43	1.534	.092
Publication of a book	Yes	1895	2.07	1.740	.040
	No	278	2.02	1.719	.103
Industrial applications	Yes	1895	1.52	1.370	.031
	No	278	1.65	1.446	.087
Patents	Yes	1895	.95	1.111	.026
	No	278	.79	1.050	.063
Influence on policy issues	Yes	1895	2.22	1.363	.031
	No	278	2.12	1.386	.083
Total	Yes	1895	2.44	1.567	.036
	No	278	2.19	1.593	.096

Researchers with a PhD degree achieved joint publications with a mean of 2.77 (mean of 2.43 for those without a PhD), publication of a book with a mean of 2.07 (2.02)[56], achieved patents with a mean standing at 0.95 (0.79), influenced policy issues with a reported mean at 2.22 (2.12) and submitted proposal(s) for new funded projects with a mean at 2.44 (2.19) (see Table 7-61). However, the results are the reverse for the variable industrial applications where respondents without a doctoral degree reported slightly higher achieved results with the mean at 1.65 when compared to respondents with a PhD with the mean at 1.52. The actual independent-samples t-test procedure compares means for two identified groups of cases (based on doctoral education level). The Table 7-62 below provides test results for UPGS variables both assuming equal variances and not assuming equal variances across groups.

Table 7-62: Independent Samples Test (UPGS Outputs versus Educational Level), Current Participants

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
									Lower	*Upper*
UPGS1. Joint publications	EVA[57]	6.157	.013	-3.648	2171	.000	-.342	.094	-.526	-.158
	EVNA[58]			-3.494	353.207	.001	-.342	.098	-.534	-.149
UPGS2. Publication of a book	EVA	.201	.654	-.463	2171	.643	-.052	.112	-.271	.167
	EVNA			-.467	365.319	.641	-.052	.111	-.269	.166
UPGS3. Industrial	EVA	6.302	.012	1.459	2171	.145	.129	.089	-.044	.303
	EVNA			1.401	353.784	.162	.129	.092	-.052	.311

[56] Here, results in brackets are for respondents without a doctoral level degree.
[57] EVA – equal variances assumed
[58] EVNA – equal variances not assumed

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-taile	Mean Differ ence	Std. Error Differ	95% Confidence Interval of the Difference	
applications										
UPGS4. Patents	EVA	.008	.927	-2.155	2171	.031	-.153	.071	-.292	-.014
	EVNA			-2.249	374.103	.025	-.153	.068	-.286	-.019
UPGS5. Submission of proposal(s) for a new project	EVA	.025	.875	-2.426	2171	.015	-.245	.101	-.443	-.047
	EVNA			-2.397	360.187	.017	-.245	.102	-.445	-.044
UPGS6. Influence on policy issues	EVA	.137	.712	-1.120	2171	.263	-.098	.088	-.270	.074
	EVNA			-1.107	360.188	.269	-.098	.089	-.273	.076

In cases when the significance values for the Levene test were high[59] (publication of a book, patents, submission of proposals for a new funded project, and influence on policy issues), the results used were those that assume equal variances for both groups, otherwise results that do not assume equal variances across the groups were used. A low significance value for the t-test (typically less than 0.05) indicates that there is a significant difference between the two group means. As a result, in the case of joint publications, patents and the submission of proposals for new funded projects, it is possible to suggest significant differences between the two defined groups (researchers with and without a PhD degree). Table 7-63 below displays similar results for UPGS variables achieved with the use of the Welch and Brown-Forsythe statistics. Significance value in the table below indicates the significance level of the F-test. Small significance values (< 0.05) indicate group differences. Such differences exist between the respondent groups based on their educational level in case of the following variables: joint publications, patents and submission of proposals for new funded projects. There are no significant differences between the means of groups based on the respondents' educational level in case of publication of a book, industrial applications and influence on policy issues.

Table 7-63: Robust Tests of Equality of Means (UPGS Outputs versus Educational Level), Current Participants

		Statistic(a)	df1	df2	Sig.
UPGS1. Joint publications	Welch	12.207	1	353.207	.001
	Brown-Forsythe	12.207	1	353.207	.001
UPGS2. Publication of a book	Welch	.218	1	365.319	.641
	Brown-Forsythe	.218	1	365.319	.641
UPGS3. Industrial applications	Welch	1.963	1	353.784	.162
	Brown-Forsythe	1.963	1	353.784	.162
UPGS4. Patents	Welch	5.057	1	374.103	.025
	Brown-Forsythe	5.057	1	374.103	.025
UPGS5. Submission of proposal(s) for a new EU funding	Welch	5.745	1	360.187	.017
	Brown-Forsythe	5.745	1	360.187	.017
UPGS6. Influence on policy issues	Welch	1.225	1	360.188	.269
	Brown-Forsythe	1.225	1	360.188	.269

a Asymptotically F distributed.

7.4.2.3.1.2 Educational Level versus UPGS Outputs

The *Descriptives* Table 7-64 below summarises the UPGS outputs and displays the sample size, mean, standard deviation, and standard error for two educational groups (group 1 – respondents educated at the PhD level, group 2 – respondents without a PhD degree). Across all five UPSC output variables, on average,

[59] Typically greater than 0.05

respondents with doctoral level degrees reported higher level of outputs than the comparison group. The results vary a little less around their average except for UPSC5 (utilisation of project results at national level).

Table 7-64: Group Statistics Descriptives (UPSC Outputs versus Educational Level), Current Participants

	PhD Degree	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
UPSC1. International conference of high standard	Yes	1,895	3.56	1.282	.029
	No	278	3.35	1.312	.079
UPSC2. Raised the international profile of participant's organisation	Yes	1,895	3.37	1.104	.025
	No	278	3.32	1.179	.071
UPSC3. Raised the international profile of participant's own research	Yes	1,895	3.54	1.060	.024
	No	278	3.26	1.283	.077
UPSC4. Raised the international profile of the funding sponsor	Yes	1,895	3.51	1.140	.026
	No	278	3.31	1.213	.073
UPSC5. Utilisation of project results at national level	Yes	1,895	3.07	1.253	.029
	No	278	3.05	1.147	.069

Table 7-65 below provides test results for five UPSC variables both assuming equal variances and not assuming equal variances across groups. In cases when the significance values for the Levene test were high[60] (UPSC1, UPSC2 and UPSC4), the results assume equal variances for both groups, otherwise results that do not assume equal variances across the groups were used (for variables UPSC3 and UPSC5).

Low[61] significance values for the t-test indicate that there is a significant difference between the two group means for variables UPSC1, UPSC3 and UPSC4 (see Table 7-65). There are, however, no statistically significant differences between the group means for UPSC2 and UPSC5.

Table 7-65: Independent Samples Test (UPSC Outputs versus Educational Level), Current Participants

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean Difference*	*Std. Error Difference*	*95% Confidence Interval of the Difference*	
UPSC1. Intern. conference of high standard	EVA[62]	.276	.599	2.522	2171	.012	.208	.083	.046	.370
	EVNA[63]			2.479	358.961	.014	.208	.084	.043	.374
UPSC2. Raised the international profile of participant's organisation	EVA	.382	.537	.631	2171	.528	.045	.072	-.095	.185
	EVNA			.601	352.054	.548	.045	.075	-.103	.193
UPSC3. Raised the international profile of participant's own research	EVA	8.542	.004	3.979	2171	.000	.279	.070	.141	.416
	EVNA			3.455	334.792	.001	.279	.081	.120	.438
UPSC4. Raised the intern. profile of funding sponsor	EVA	.720	.396	2.623	2171	.009	.194	.074	.049	.338
	EVNA			2.504	352.538	.013	.194	.077	.042	.346
UPSC5. Utilisation of project results	EVA	4.956	.026	.184	2171	.854	.015	.080	-.142	.171
	EVNA			.196	380.823	.844	.015	.075	-.132	.161

Table 7-66 displays similar results for UPSC variables achieved with the use of the Welch and Brown-Forsythe statistics. Significance value in the table below indicates the significance level of the F-test. Small significance values (< 0.05) indicate statistically significant group differences for variables UPSC1, UPSC3 and UPSC4. However, the Welch and Brown-Forsythe statistics suggest there are no significant differences between the means of groups based on the respondents' educational level in case of variables UPSC2 and UPSC5.

[60] Typically greater than 0.05
[61] Typically less than 0.05
[62] EVA – equal variances applied
[63] EVNA – equal variances not applied

Table 7-66: Robust Tests of Equality of Means (UPSC Outputs versus Educational Level), Current Participants

		Statistic(a)	*df1*	*df2*	***Sig.***
UPSC1. International conference of high standard	Welch	6.144	1	358.961	.014
	Brown-Forsythe	6.144	1	358.961	.014
UPSC2. Raised the international profile of participant's organisation	Welch	.361	1	352.054	.548
	Brown-Forsythe	.361	1	352.054	.548
UPSC3. Raised the international profile of participant's own research	Welch	11.938	1	334.792	.001
	Brown-Forsythe	11.938	1	334.792	.001
UPSC4. Raised the international profile of funding sponsor	Welch	6.269	1	352.538	.013
	Brown-Forsythe	6.269	1	352.538	.013
UPSC5. Utilisation of project results at national level	Welch	.039	1	380.823	.844
	Brown-Forsythe	.039	1	380.823	.844

a Asymptotically F distributed.

7.4.2.3.2 Research Experience versus Research Outputs (Current FNR Participants)

This subsection tests the assumption of whether there are statistically significant differences between the scores reported by respondents in two groups of researchers: senior researchers and junior researchers. Respondents who did not include themselves in one of these groups (by placing themselves in the '*other*' group) were excluded from this particular analysis. All respondents placed themselves into one of the three groups: senior researchers with more than four years of research experience, junior researchers with less than four years of research experience, and others (non-researchers). This research tested whether there are significant differences between the FNR outputs reported by the first two groups: senior researchers and junior researchers. The Welch and Brown and Brown-Forsythe statistics test showed that while there were some differences in the variances in these two groups, the differences in means, however, were not found to be statistically significant (see Appendix 7, Appendix 8, Appendix 9 and Appendix 10).

7.4.2.3.3 Professional Background (Sector) versus Research Outputs (Current FNR Participants)

One of the assumptions is that respondents' professional background (academia, other research institute/lab, business or industry, government or others) can have an effect on their research outputs.

7.4.2.3.3.1 Professional Background (Sector) versus UPGS Outputs

This subsection tests an assumption that there are statistically significant differences between the scores reported by respondents in four different professional sectors: academia, research institutes/laboratories, government, and business or industry. Respondents who did not include themselves in one of these four sectors (places themselves in the '*other*' group) were excluded from this particular analysis. Table 7-67 displays the result of the Welch and Brown-Forsythe statistics testing the null hypothesis that there is no difference in means between the results reported by respondents across four professional sectors.

Small significance values (< 0.05) indicate group differences. The differences exist between the professional background groups in case of the following variables: joint publications, publication of a book, industrial applications and submission of proposals for new funded projects. There are no significant differences between the means of groups based on the professional background in case of patents and influence on policy issues.

Table 7-67: Robust Tests of Equality of Means (UPGS Outputs versus Professional Background), Current Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
UPGS1. Joint publications	Welch	5.007	3	262.932	.002
	Brown-Forsythe	5.441	3	435.918	.001
UPGS2. Publication of a book	Welch	3.775	3	263.025	.011
	Brown-Forsythe	3.762	3	465.725	.011
UPGS3. Industrial applications	Welch	8.315	3	261.307	.000
	Brown-Forsythe	8.556	3	432.023	.000
UPGS4. Patents	Welch	.212	3	261.213	.888
	Brown-Forsythe	.204	3	450.101	.894
UPGS5. Submission of proposal(s)	Welch	6.223	3	263.333	.000
	Brown-Forsythe	6.070	3	436.098	.000
UPGS6. Influence on policy issues	Welch	1.241	3	263.845	.295
	Brown-Forsythe	1.201	3	462.300	.309

a Asymptotically F distributed.

Table 7-68 provides a closer look at the means recorded in each of the professional sectors by providing the cross-tabulation breakdown of the means recorded for UPGS results versus respondents' professional background (the UPGS4 variable is excluded from this table, see Appendix 29). First, respondents working in academia reported the highest results in achieving joint publications (mean of 2.79) along with respondents from research institutes and laboratories (mean at 2.68). The highest achievement in terms of publication of a book has been reported by those working in the government sector (mean = 2.28) and respondents from research institutes/labs. Surprisingly, the lowest results were reported by academia (mean = 1.98) and business/industry respondents (mean = 1.88).

Table 7-68: Group Statistics Descriptives (UPGS Outputs versus Professional Background), Current Participants

CV6. Professional Background		*UPGS1. Joint publications*	*UPGS2. Publication of a book*	*UPGS3. Industrial applications*	*UPGS5. Submission of proposal(s)*
Academia	Mean	2.79	1.98	1.44	2.39
	N	1384	1384	1384	1384
	Std. Deviation	1.457	1.722	1.361	1.585
Other Research	Mean	2.68	2.23	1.65	2.57
	N	551	551	551	551
	Std. Deviation	1.450	1.754	1.369	1.512
Business & Industry	Mean	2.18	1.88	2.13	2.06
	N	88	88	88	88
	Std. Deviation	1.580	1.780	1.492	1.670
Government	Mean	2.59	2.28	1.64	2.01
	N	123	123	123	123
	Std. Deviation	1.407	1.733	1.409	1.539
Total	Mean	2.73	2.06	1.53	2.40
	N	2146	2146	2146	2146
	Std. Deviation	1.463	1.737	1.379	1.573

Respondents working in business or industries reported the highest level of achieving industrial applications with the mean standing at 2.13 (and the cross-group mean equal to 1.53), while the lowest results were reported by academic respondents (1.44). Submission of proposals for new funded projects was achieved most by those based in research institutes/labs (mean = 2.57) and academia (mean = 2.39), while the lowest results have been achieved by respondents representing business/industry (mean = 2.06) and government (mean = 2.01). Overall, the null hypotheses (that there are no differences between the means across groups) can be rejected in the case of four UPGS outputs: UPGS1, UPGS2, UPGS3 and UPGS5 in support of the alternative hypotheses, which state that there are significant differences in means of scores reported by respondents from four professional sectors.

7.4.2.3.3.2 Professional Background versus UPSC Outputs (Current Participants)

Table 7-69 below displays the result of the Welch and Brown-Forsythe statistics for UPSC variables. Small significance values (< 0.05) indicate group differences. Therefore, it is possible to conclude that statistically significant differences exist between the professional background groups in the case of the following variables: UPSC1, UPSC2, UPSC3 and UPSC5. There are no significant differences between the means of groups based on the professional background in case of UPSC4.

Table 7-69: Robust Tests of Equality of Means (UPSC Outputs versus Professional Background), Current Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
UPSC1. International conference of high standard	Welch	2.652	3	264.717	.049
	Brown-Forsythe	2.863	3	452.692	.036
UPSC2. Raised the international profile of researcher's organisation	Welch	2.741	3	263.458	.044
	Brown-Forsythe	2.593	3	431.571	.052
UPSC3. Raised the international profile of researcher's own research	Welch	6.087	3	254.359	.001
	Brown-Forsythe	6.864	3	341.630	.000
UPSC4. Raised the international profile of funding sponsor	Welch	.078	3	265.586	.972
	Brown-Forsythe	.083	3	499.027	.969
UPSC5. Utilisation of project results at national level	Welch	3.802	3	266.569	.011
	Brown-Forsythe	3.903	3	504.740	.009

a Asymptotically F distributed.

The following table (see Table 7-70 below) provides a cross-tabulation breakdown of the means recorded for UPSC results versus respondents' professional background. Respondents working in government structures (mean = 3.64), as well as those working in other research institutes/labs (mean = 3.59) and academia (mean = 3.52) reported the highest levels of achieving UPSC1, while the lowest results have been reported by respondents representing business and industry. Those working in either academia (mean = 3.34) or other research institutes/labs (mean = 3.47) have achieved UPSC2 (raised the international profile of their organisations) to the largest extent across all groups. The highest levels of the UPSC3 outputs also have been reported by those respondents who work either in academia (mean = 3.54) or other research organisations (mean = 3.58). Scholars in research institutes and labs also reported the highest levels of UPSC5 (with means at 3.22). Finally, respondents working for the research institutes and labs reported the highest level of achieving UPSC5 as a project result with the mean at 3.22, while those from other sector reported similar lower results.

Table 7-70: Group Statistics Descriptives (UPSC Outputs versus Professional Background), Current Participants

CV6. Professional Background		*UPSC1. International conference of high standard*	*UPSC2. Raised the international profile of researcher's organisation*	*UPSC3. Raised the international profile of researcher's research*	*UPSC4. Raised the international profile of funding sponsor*	*UPSC5. Utilisation of project results at national level*
Academia	Mean	3.52	3.34	3.54	3.49	3.02
	N	1384	1384	1384	1384	1384
	Std. Deviation	1.293	1.128	1.045	1.154	1.258
Other Research	Mean	3.59	3.47	3.58	3.49	3.22
	N	551	551	551	551	551
	Std. Deviation	1.276	1.054	1.067	1.142	1.204
Business/ Industry	Mean	3.18	3.24	3.08	3.45	2.99
	N	88	88	88	88	88
	Std. Deviation	1.352	1.184	1.448	1.027	1.129
Government	Mean	3.64	3.25	3.17	3.44	2.99
	N	123	123	123	123	123
	Std. Deviation	1.188	1.091	1.341	1.222	1.245

CV6. Professional Background		*UPSC1. International conference of high standard*	*UPSC2. Raised the international profile of researcher's organisation*	*UPSC3. Raised the international profile of researcher's research*	*UPSC4. Raised the international profile of funding sponsor*	*UPSC5. Utilisation of project results at national level*
Total	Mean	3.53	3.37	3.51	3.48	3.07
	N	2146	2146	2146	2146	2146
	Std. Deviation	1.287	1.111	1.095	1.149	1.241

Overall, the null hypotheses (that there are no differences between the means across groups) can be rejected in the case of four UPGS outputs: UPGS1, UPGS2, UPGS3 and UPGS5 in support of the alternative hypotheses, which state that there are significant differences in means of scores reported by respondents from four professional sectors.

7.4.2.3.4 Country of Work versus Research Outputs

7.4.2.3.4.1 Country of Work versus UPGS Outputs

This subsection tests the assumption that there are statistically significant differences between the scores reported by respondents working in four European country groups[64]. Respondents who work outside of the four groups of countries were excluded from this particular analysis. Table 7-71 below displays the result of the Welch and Brown-Forsythe statistics. Sig indicates the significance level of the F-test. Small significance values (< 0.05) indicate group differences. The results of the test suggest that there are statistically significant differences between the respondents in groups (based on the country classification 1) in case of all UPGS research outputs except for industrial applications.

Table 7-71: Robust Tests of Equality of Means (UPGS Outputs versus Country of Work, Classification 1), Current Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
UPGS1. Joint publications	Welch	10.115	3	1066.339	.000
	Brown-Forsythe	10.481	3	1926.892	.000
UPGS2. Publication of a book	Welch	5.155	3	1069.959	.002
	Brown-Forsythe	5.166	3	1947.293	.001
UPGS3. Industrial applications	Welch	.889	3	1059.632	.446
	Brown-Forsythe	.907	3	1866.116	.437
UPGS4. Patents	Welch	13.538	3	1040.389	.000
	Brown-Forsythe	12.596	3	1666.216	.000
UPGS5. Submission of proposal(s)	Welch	6.695	3	1065.574	.000
	Brown-Forsythe	6.673	3	1916.543	.000
UPGS6. Influence on policy issues	Welch	9.197	3	1062.786	.000
	Brown-Forsythe	9.308	3	1890.506	.000

a Asymptotically F distributed.

One of the assumptions is that respondents' country of work can have an effect on their research outputs. The following Table 7-72 provides a cross-tabulation breakdown of the means recorded for UPGS results versus respondents' country of work. The highest results in achieving joint publications have been reported by Eastern European (mean = 2.95) and Western European researchers (mean = 2.84). In terms of publishing a book, the highest results have been reported by the Western European respondents (mean = 2.24), while the highest achievements in terms of industrial applications have been reported by respondents working in Eastern Europe (mean = 1.62) and Western Europe (1.53). The highest results in achieving submission of

[64] Classification 1: Eastern Europe, Western Europe, Northern Europe and Southern Europe. Countries outside these groups were excluded for the purpose of this analysis.

proposals for new funded projects have been reported by Eastern European researchers (mean = 2.58) and respondents working in Southern Europe (mean = 2.51). Respondents from Eastern Europe and Southern Europe also reported the highest influence on policy issues (EU and national levels) with respective means standing at 2.47 and 2.32. Overall, the results reported by Northern European respondents were the lowest across all country groups.

Table 7-72: Group Statistics Descriptives (UPGS Outputs versus Country of Work, classification 1), Current Participants

CV2. Country of Work (CL1:E/W/O)		*UPGS1. Joint publications*	*UPGS2. Publication of a book*	*UPGS3. Industrial applications*	*UPGS4. Patents*	*UPGS5. Submission of proposal(s)*	*UPGS6. Influence on policy issues*
Eastern Europe	Mean	2.95	2.09	1.62	*1.09*	2.58	2.47
	N	348	348	348	*348*	348	348
	Std. Deviation	1.432	1.698	1.428	*1.236*	1.564	1.382
Western Europe	Mean	2.84	2.24	1.53	*.85*	2.43	2.07
	N	609	609	609	*609*	609	609
	Std. Deviation	1.423	1.771	1.370	*1.044*	1.576	1.371
Northern Europe	Mean	2.46	1.85	1.47	*.73*	2.17	2.09
	N	557	557	557	*557*	557	557
	Std. Deviation	1.493	1.703	1.363	*.911*	1.558	1.315
Southern Europe	Mean	2.77	2.10	1.54	*1.07*	2.51	2.32
	N	588	588	588	*588*	588	588
	Std. Deviation	1.438	1.744	1.371	*1.183*	1.548	1.357
Total	Mean	2.74	2.07	1.53	*.92*	2.41	2.21
	N	2102	2102	2102	*2102*	2102	2102
	Std. Deviation	1.458	1.739	1.378	*1.096*	1.568	1.362

7.4.2.3.4.2 Country of Work versus UPSC Outputs

Table 7-73 below displays the result of the Welch and Brown-Forsythe statistics for UPSC output variables. Sig indicates the significance level of the F-test and small significance values (< 0.05) indicate group differences. Based on the results of the test it is possible to conclude that there are statistically significant differences between the respondents in groups (based on the country classification 1) in case of all UPSC outputs.

Table 7-73: Robust Tests of Equality of Means (UPSC Outputs versus Country of Work, Classification 1), Current Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
UPSC1. International conference of high standard	Welch	2.517	3	1060.114	.057
	Brown-Forsythe	2.682	3	1883.450	.045
UPSC2. Raised the international profile of researcher's organisation	Welch	2.898	3	1071.773	.034
	Brown-Forsythe	2.872	3	1956.614	.035
UPSC3. Raised the international profile of researcher's own research	Welch	9.873	3	1065.178	.000
	Brown-Forsythe	10.157	3	1919.664	.000
UPSC4. Raised the international profile of funding sponsor	Welch	7.391	3	1072.725	.000
	Brown-Forsythe	7.030	3	1963.219	.000
UPSC5. Utilisation of project results at national level	Welch	7.391	3	1075.920	.000
	Brown-Forsythe	6.994	3	1986.254	.000

a Asymptotically F distributed.

The following Table 7-74 provides a cross-tabulation breakdown of the means recorded for three identified UPSC output variables versus respondents' country of work. The table suggests that respondents from certain countries report generally higher results, for example, Eastern Europeans tend to report higher results which are generally matched only by respondents from Southern European countries. Respondents from Northern Europe tend to report the lowest results on all five UPSC outputs when compared to respondents from other countries, including Western European respondents.

Table 7-74: Group Statistics Descriptives (UPGS Outputs versus Country of Work, classification 1), Current Participants

CV2. Country of Work (CL1:E/W/O)		*UPGS1. International conference of high standard*	*UPGS2. Raised the international profile of researcher's organisation*	*UPGS3. Raised the international profile of researcher's research*	*UPGS4. Raised the international profile of funding sponsor*	*UPGS5. Utilisation of project results at national level*
Eastern Europe	Mean	3.57	3.50	3.63	3.68	3.30
	N	348	348	348	348	348
	Std. Deviation	1.305	1.075	1.072	1.107	1.158
Western Europe	Mean	3.58	3.30	3.52	3.43	3.05
	N	609	609	609	609	609
	Std. Deviation	1.230	1.180	1.139	1.201	1.246
Northern Europe	Mean	3.39	3.32	3.29	3.34	2.93
	N	557	557	557	557	557
	Std. Deviation	1.363	1.072	1.134	1.099	1.208
Southern Europe	Mean	3.56	3.38	3.60	3.53	3.11
	N	588	588	588	588	588
	Std. Deviation	1.262	1.087	.994	1.156	1.251
Total	Mean	3.53	3.36	3.50	3.48	3.08
	N	2102	2102	2102	2102	2102
	Std. Deviation	1.289	1.110	1.095	1.152	1.228

7.4.2.3.5 Scientific Domain versus FNR Outputs

7.4.2.3.5.1 Scientific Domain versus UPGS Outputs

ANOVA test results suggest small significance values (< 0.05) which indicate statistically significant differences between the results reported by respondents from different scientific domains, except for the patents (see Appendix 23 and Appendix 24). The following Table 7-75 provides a cross-tabulation breakdown of the means recorded for three identified UPGS output variables versus respondents' country of work. The table suggests that joint publications are to a greater extent achieved by participants from IE, CMST and FA, while researchers from other FPS and ISCH domains reported the lowest results in achieving joint publications. Respondents from IE, ISCH and ICT performed better compared to researchers in other domains in publishing a book.

On the other hand, CMST participants reported the lowest results. Not surprisingly the results in achieving patents and industrial applications were generally lower than results in achieving any other UPGS output. The highest results in achieving industrial applications have been reported by respondents from IE, and above average results have been reported by the respondents working in FPS and ICT, while as expected the lowest results in this category have been reported by the respondents from ISCH. In terms of submitting new proposals for EU-funded projects as a result of their FNR project, the highest results have been reported by participants from ICT, IE and TUD, while the lowest have been reported by CMST and ISCH respondents. The highest results in influencing policy issues have been reported by IE respondents, followed by respondents from FPS, FA and BMBS. The lowest results in this category have been reported by respondents from CMST, followed by ICT and ESSEM .

Table 7-75: Group Statistics Descriptives (UPGS Outputs versus Scientific Domain), Current Participants

Domain		*UPGS1(r). Joint publications*	*UPGS2(r). Publication of a book*	*UPGS3(r). Industrial applications*	*UPGS4(r). Patents*	*UPGS5(r). Submission of proposal(s)*	*UPGS6(r). Influence on policy issues*
BMBS	Mean	3.09	2.83	2.28	1.79	2.90	2.76
	N	147	121	113	98	134	139

Domain		*UPGS1(r). Joint publications*	*UPGS2(r). Publication of a book*	*UPGS3(r). Industrial applications*	*UPGS4(r). Patents*	*UPGS5(r). Submission of proposal(s)*	*UPGS6(r). Influence on policy issues*
	Std. Deviation	1.193	1.515	1.130	1.048	1.291	1.171
CMST	Mean	3.24	1.88	1.88	1.53	2.58	2.33
	N	371	263	262	242	349	336
	Std. Deviation	1.171	1.194	1.008	.860	1.374	1.112
ESSEM	Mean	3.04	2.85	1.94	1.60	2.71	2.52
	N	194	171	127	93	174	182
	Std. Deviation	1.210	1.446	1.045	.934	1.262	1.081
FA	Mean	3.18	2.91	2.32	1.76	2.98	2.65
	N	323	286	264	220	309	315
	Std. Deviation	1.152	1.460	1.063	1.012	1.288	.986
FPS	Mean	2.73	2.82	2.43	1.63	2.84	2.86
	N	219	211	184	141	219	215
	Std. Deviation	1.124	1.435	1.022	1.052	1.283	1.108
ICT	Mean	3.04	3.01	2.40	1.59	3.08	2.56
	N	109	94	102	75	110	106
	Std. Deviation	1.232	1.662	1.110	.960	1.286	1.087
IE	Mean	3.41	3.62	2.80	1.14	3.29	3.33
	N	17	13	10	7	14	12
	Std. Deviation	1.228	1.502	1.135	.378	1.204	.778
ISCH	Mean	2.74	3.39	1.81	1.75	2.69	2.48
	N	115	111	43	24	104	114
	Std. Deviation	1.351	1.550	1.029	.989	1.330	1.091
MPNS	Mean	3.10	2.44	2.46	1.67	2.79	2.50
	N	269	204	221	192	252	230
	Std. Deviation	1.217	1.401	1.114	.978	1.226	1.101
TUD	Mean	2.76	2.96	2.41	1.83	3.03	2.78
	N	187	178	160	118	182	199
	Std. Deviation	1.150	1.413	1.123	1.048	1.327	1.016
Total	Mean	3.04	2.71	2.24	1.67	2.83	2.60
	N	1951	1652	1486	1210	1847	1848
	Std. Deviation	1.201	1.485	1.092	.980	1.307	1.089

Overall, CMST domain participants reported lower results on all UPGS outputs (except in achieving patents, when they scored at the top of the range) when compared to other research domains. Similarly, ISCH respondents tend to report lower results in achieving industrial applications, submission of proposals, and influence on policy issues. Domains FA and FPS reported generally very high results on all outputs (with an exception of lower results in achieving joint publications by FPS participants). Surprisingly, respondents from the IE (Interdisciplinary Exploratoria[65]) domain reported better results in all categories when compared to respondents from any other domain.

7.4.2.3.5.2 Scientific Domain versus UPSC Outputs

ANOVA test results suggest small significance values (< 0.05) which indicate statistically significant differences between the results reported by respondents from different scientific domains, however, there are no statistically significant differences in terms of patents (see Appendix 24). Table 7-76 below provides a cross-tabulation breakdown of the means recorded for three identified UPSC output variables versus respondents' country of work. Overall, CMST reported the lowest results among all domain groups on all UPSC outputs while IE generally reported the highest results. However, outside of these two domains, two other domains, FA and FPS, reported higher than average results on all of the outputs. Respondents from the TUD domain reported generally consistently high results on all outputs except for joint publications. ISCH

[65] Interdisciplinary Exploratoria Domain was set to provide opportunities for potential high gain networking activities complementing other Domain Committees

respondents reported higher than average results on achieving UPSC1 (conferences), UPSC2 (raising the international profile of researcher's organisations) and UPSC3 (raising the international profile of the researcher's own research), however, they reported results in the lower range in terms of achieving UPSC4 (raising the international profile of the funding sponsor) and UPSC5 (utilisation of results at national level).

Table 7-76: Group Statistics Descriptives (UPGS Outputs versus Scientific Domain), Current Participants

Domain		*UPSC1(r). International conference of high standard*	*UPSC2(r). Raised the international profile of researcher's organisation*	*UPSC3(r). Raised the international profile of researcher's own research*	*UPSC4(r). Raised the international profile of funding sponsor*	*UPSC5(r). Utilisation of project results at national level*
BMBS	Mean	3.89	3.47	3.53	3.74	3.12
	N	148	152	152	150	146
	Std. Deviation	1.007	1.048	1.073	.930	1.086
CMST	Mean	3.70	3.23	3.44	3.40	2.96
	N	386	391	396	388	377
	Std. Deviation	.944	.993	.960	.976	1.070
ESSEM	Mean	3.70	3.38	3.58	3.55	3.29
	N	198	209	210	206	211
	Std. Deviation	.955	.896	.862	.924	.974
FA	Mean	3.92	3.52	3.67	3.77	3.41
	N	342	351	351	345	345
	Std. Deviation	.883	.968	.931	.867	1.016
FPS	Mean	3.76	3.76	3.69	3.77	3.41
	N	229	236	232	235	234
	Std. Deviation	.958	.833	.915	.886	1.025
ICT	Mean	3.71	3.49	3.69	3.60	3.16
	N	112	119	119	121	120
	Std. Deviation	.992	.964	.946	.900	1.012
IE	Mean	4.00	4.00	4.06	4.06	3.65
	N	17	17	17	17	17
	Std. Deviation	.791	.707	.748	.659	.786
ISCH	Mean	3.76	3.48	3.61	3.59	3.09
	N	132	130	132	134	126
	Std. Deviation	1.057	.982	.994	1.028	.996
MPNS	Mean	3.74	3.43	3.62	3.58	3.18
	N	279	290	294	284	279
	Std. Deviation	.999	.972	.955	1.004	1.133
TUD	Mean	3.53	3.53	3.63	3.64	3.34
	N	201	215	213	211	212
	Std. Deviation	.938	.931	.879	.875	1.015
Total	Mean	3.75	3.46	3.60	3.62	3.22
	N	2044	2110	2116	2091	2067
	Std. Deviation	.962	.964	.944	.940	1.053

7.4.3 Experts' Scores on Individual Researcher's Networking Outputs

The third section of this data analysis deals with the results reported by the surveyed experts – respondents in the survey, category 3. The experts were asked to report to what extent they believe participants in formal networking projects can achieve indicated research outputs as a result of their participation in the projects. Some of the experts have personal experience or involvement in formal networking projects and therefore this variable (*experts' involvement in networking projects as individual researchers*) was used as a control variable. Experts' research domain is the second variable that was controlled (for).

7.4.3.1 Overview of UPGS and UPSC Variables

The list of 11 research outputs was re-coded into UPGS and UPSC re-coded variables. The new set of data included only scores from 1 (*not at all*) to 5 (*fully*), answers with the score 6 (not applicable) have been re-encoded as system missing values. All recoded variables were re-coded as UPGS(r)[66] and UPSC(r) variables. The distribution of means across six UPGS(r) variables ranges from the 3.53 (the highest) for UPGS5(r) to 2.28 (the lowest out of six UPGS variables) for UPGS4(r) (see Table 7-77 below). The frequencies summary table displays the following means for the rest of the UPGS variables: 3.44 (UPGS1(r)), 3.52 (UPGS2(r)), 2.60 (UPGS3(r)), and 2.92 (UPGS6(r)).

Table 7-77: UPGS Variables (Recoded) Frequencies Summary

		UPGS1(r). Joint publications	*UPGS2(r). Publication of a book*	*UPGS3(r). Industrial applications*	*UPGS4(r). Patents*	*UPGS5(r). Submission of proposal(s)*	*UPGS6(r). Influence on policy issues*
N	Valid	113	112	104	94	113	112
	Missing	1	2	10	20	1	2
Mean		3.44	3.52	2.60	2.28	3.53	2.92
Median		3.00	3.50	3.00	2.00	4.00	3.00
Std. Deviation		.743	.816	.819	.709	.814	.784
Variance		.552	.666	.670	.503	.662	.615
Minimum		2	1	1	1	1	1
Maximum		5	5	5	4	5	5
Percentiles	25	3.00	3.00	2.00	2.00	3.00	2.00
	50	3.00	3.50	3.00	2.00	4.00	3.00
	75	4.00	4.00	3.00	3.00	4.00	3.00

The distribution of means across five UPSC(r) variables ranges from the 3.91 (the highest) for UPSC4(r) to 3.29 (the lowest out of the five UPSC variables) for UPSC5(r) (see Table 7-78 below). Means of all UPSC(r) variables are all around approximately 3.70, with the frequencies summary table displaying the following means for the rest of the UPSC variables: 3.83 (UPSC1(r)), 3.63 (UPSC2(r)) and 3.74 (UPSC3(r)).

Table 7-78: UPGS Variables (Recoded) Frequencies Summary

		UPSC1(r). International conference of high standard	*UPSC2(r). Raised the international profile of researchers' organisation*	*UPSC3(r). Raised the international profile of participants' own research*	*UPSC4(r). Raised the international profile of funding sponsor*	*UPSC5(r). Utilisation of FNR project results at national level*
N	Valid	112	112	113	113	113
	Missing	2	2	1	1	1
Mean		3.83	3.63	3.74	3.91	3.29
Median		4.00	4.00	4.00	4.00	3.00
Std. Deviation		.781	.827	.799	.797	.809
Variance		.611	.685	.639	.635	.655
Minimum		2	2	2	2	2
Maximum		5	5	5	5	5
Percentiles	25	3.00	3.00	3.00	3.00	3.00
	50	4.00	4.00	4.00	4.00	3.00
	75	4.00	4.00	4.00	4.00	4.00

7.4.3.2 UPGS1(r): Joint publications in high-ranked scientific journals

The first variable is UPGS1(r) (*joint publications*). According to the observed frequencies, surveyed experts (respondents in the survey, category 3) reported scores from 2 (to *a small extent*) to 5 (*fully*) (see Table 7-79).

[66] Here the (r) symbol is used to distinguish between the original variables and newly re-encoded variables (with 'not applicable' responses encoded as system missing values)

Table 7-79: UPGS1(r). Joint Publications as a Networking Output as reported by Experts

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	6	5.3	5.3	5.3
	To a great extent	49	43.0	43.4	48.7
	In part	47	41.2	41.6	90.3
	To a small extent	11	9.6	9.7	100.0
	Total	113	99.1	100.0	
Missing	System	1	0.9		
Total		114	100.0		

The centre of the distribution can be approximated by the median (or second quartile) 3 (in part), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles. A closer look at the data suggests that 0.9 percent of all experts believe joint publications are *not applicable* as an individual research output from participation in a FNR project. Further, 9.7 percent of respondents in this survey believe that joint publications as a research output can only be achieved *to a small extent*. A group of 41.2 percent of experts believe joint publications can only be achieved *in part*, while the remaining experts (48.7 percent) argue that joint publications can be achieved either *to a great extent* or *fully*.

7.4.3.3 UPGS2(r): Publication of a book

Observed frequencies suggest that surveyed experts (respondents in the survey *category 3*) scored this research output UPGS2(r) from 1 (*not at all*) to 5 (*fully*) from a five point Likert scale (see Table 7-80). The centre of the distribution can be approximated by the median (or second quartile) 2.50 (between 'to a great extent' and 'in part'), and half of the data values is between scores 3 (in part) and 4 (to a large extent), the first and third quartiles. A closer look at the data suggests that 1.8 percent of all experts believe *publication of a book* should not be considered (as it is *not applicable*) as an individual research output from participation in a formal networking project. Further, 8.0 percent of all other respondents in this survey believe that UPGS2(r) as a research output either cannot be achieved by participants at all or can only be achieved to a small extent. A group of 42.0 percent of experts believe publication of a book can only be achieved *in part*. Half of the experts (50.0 percent) believe that publication of a book can be achieved by individual researchers *to a great extent* or *fully*.

Table 7-80: UPGS2(r). Publication of a Book as a Networking Output as reported by Experts

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	12	10.5	10.7	10.7
	To a great extent	44	38.6	39.3	50.0
	In part	47	41.2	42.0	92.0
	To a small extent	8	7.0	7.1	99.1
	Not at all	1	.9	.9	100.0
	Total	112	98.2	100.0	
Missing	System	2	1.8		
Total		114	100.0		

7.4.3.4 UPGS3(r): Industrial Applications

According to the observed frequencies, surveyed experts (respondents in the survey category 3) scored this research output UPGS3(r) from 1 (not at all) to 5 (fully) (see Table 7-81). The centre of the distribution can be approximated by the median (or second quartile) equal to 3 (in part), and half of the data values is between scores 2 (to a small extent) and 3 (in part), the first and third quartiles.

Table 7-81: UPGS3(r). Industrial Applications as a Networking Output as reported by Experts

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	2	1.8	1.9	1.9
	To a great extent	10	8.8	9.6	11.5
	In part	42	36.8	40.4	51.9
	To a small extent	44	38.6	42.3	94.2
	Not at all	6	5.3	5.8	100.0
	Total	104	91.2	100.0	
Missing	System	10	8.8		
Total		114	100.0		

The data suggests that 8.8 percent of all experts believe *industrial applications* are not applicable as an individual research output from participation in a formal networking project. Further 48.1 percent of all other respondents in this survey believe that UPGS3(r) as a research output either cannot be achieved by participants *at all* or can only be achieved *to a small extent*. A group of 40.4 percent of experts believe industrial publications can only be achieved in part, while only a minority of experts (11.5 percent) consider that industrial applications can be achieved to a great extent or fully.

7.4.3.5 UPGS4(r): Patents

According to the observed frequencies, surveyed experts scored this research output UPGS4(r) from 1 (not at all) to 4 (to a great extent) (see Table 7-82). The centre of the distribution can be approximated by the median (or second quartile) equal to 2 (to a small extent), and at least half of the data values is between scores 2 (to a small extent) and 3 (in part), the first and third quartiles (see the visual summary in Table 7-82). A relatively large group (17.5 percent) of all surveyed experts believe patents are *not applicable* as an individual research output from participation in a formal networking project. Of the rest 55.3 percent believe that UPGS4(r) as a research output can only be achieved *to a small extent*. Over a quarter of experts (29.8 percent) believe patents can only be achieved *in part*. Only a minority of all respondents (4.3 percent) believe that patents can be achieved *to a great extent*.

Table 7-82: UPGS4(r). Patents as a Networking Output as reported by Experts

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	To a great extent	4	3.5	4.3	4.3
	In part	28	24.6	29.8	34.0
	To a small extent	52	45.6	55.3	89.4
	Not at all	10	8.8	10.6	100.0
	Total	94	82.5	100.0	
Missing	System	20	17.5		
Total		114	100.0		

7.4.3.6 UPGS5(r): Submission of Proposal(s) for a New Funded Project (EU-funded)

According to the observed frequencies, surveyed experts scored this research output UPGS4(r) from 1 (not at all) to 5 (fully) (see Table 7-83). The centre of the distribution can be approximated by the median (or second quartile) equal to 4 (to a great extent), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles. A closer look at the data suggests that only one percent of all surveyed experts (0.9 percent) believe *submission of proposals for new EU-funded projects* are *not applicable* as an individual research output from participation in a formal networking project (see Table 7-83). Over half of the remaining experts (54 percent) believe that UPGS4(r) as a research output can only be

achieved *to a great extent* or even *fully*. The rest of the respondents believe that the submission of proposals for new EU-funded projects can be achieved either *to a small extent* (6.2 percent) or *not at all* (1.8 percent).

Table 7-83: UPGS5(r). Submission of Proposal(s) for new EU-funded project(s) as a Networking Output as reported by Experts

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	10	8.8	8.8	8.8
	To a great extent	51	44.7	45.1	54.0
	In part	43	37.7	38.1	92.0
	To a small extent	7	6.1	6.2	98.2
	Not at all	2	1.8	1.8	100.0
	Total	113	99.1	100.0	
Missing	System	1	0.9		
Total		114	100.0		

7.4.3.7 UPGS6(r): Influence on policy issues (at European level and/or country level)

According to the observed frequencies, surveyed experts scored this research output UPGS6(r) from 1 (not at all) to 5 (fully) (see Table 7-84). The centre of the distribution can be approximated by the median (or second quartile) equal to 3, and half of the data values is between scores 2 (to a small extent) and 3 (in part), the first and third quartiles. Further, the data suggests that only a small group of surveyed experts (1.8 percent) believe *influence on policy issues* are not applicable as an individual research output from participation in a formal networking project (see Table 7-84). Over two thirds of the remaining experts (77.7 percent) believe that UPGS6(r) as a research output can only be achieved *to a small extent*, *in part* or *not at all*. The rest of the respondents believe that influence on policy issues can be achieved to a great extent (21.4 percent) or fully (0.9 percent).

Table 7-84: UPGS6(r). Influence on Policy Issues as a Networking Output as reported by Experts

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	1	0.9	0.9	0.9
	To a great extent	24	21.1	21.4	22.3
	In part	55	48.2	49.1	71.4
	To a small extent	29	25.4	25.9	97.3
	Not at all	3	2.6	2.7	100.0
	Total	112	98.2	100.0	
Missing	System	2	1.8		
Total		114	100.0		

7.4.3.8 UPSC1(r): International conference of high standard

According to the observed frequencies, surveyed experts scored this research output UPSC1(r) from 2 (to a small extent) to 5 (fully) (see Table 7-85). The centre of the distribution can be approximated by the median (or second quartile) equal to 4 (to a great extent), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles. A closer look at the data suggests that only a small group of surveyed experts (1.8 percent) believe *international conferences* are not applicable as an individual research output from participation in a formal networking project (see Table 7-85). About two thirds of the remaining experts (68.8 percent) believe that UPSC1(r) as a research output can only be achieved *to a great extent* or only *fully*. Only a small percentage of respondents believe that *international conferences* issues can be achieved *to a small extent* (4.5 percent). Approximately a quarter of the surveyed experts (26.8 percent) believe participants in FNR projects should achieve international conferences at least *in part*.

Table 7-85: UPSC1(r). International conference of high standard

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	21	18.4	18.8	18.8
	To a great extent	56	49.1	50.0	68.8
	In part	30	26.3	26.8	95.5
	To a small extent	5	4.4	4.5	100.0
	Total	112	98.2	100.0	
Missing	System	2	1.8		
Total		114	100.0		

7.4.3.9 UPSC2(r): Raised International Profile of Participant's Organisation

According to the observed frequencies, surveyed experts scored on this research output UPSC2(r) from 2 (to a small extent) to 5 (fully) (see Table 7-86). The centre of the distribution can be approximated by the median (or second quartile) equal to 4 (to a great extent), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles (see the visual summary in Table 7-86 below). A closer look at the data suggests that only a small group of surveyed experts (1.8 percent) believe *raised international profile of participant's organisation* is not applicable as an individual research output from participation in a formal networking project. The majority of the remaining experts (58.9 percent) believe that UPSC2(r) as a research output can be achieved *to a great extent* or *fully*. The rest of the respondents believe that raised international profile of a participant's organisation can only be achieved to a small extent or in part (41.0 percent).

Table 7-86: UPSC2(r). Raised the international profile of researchers' organisation

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	15	13.2	13.4	13.4
	To a great extent	51	44.7	45.5	58.9
	In part	36	31.6	32.1	91.1
	To a small extent	10	8.8	8.9	100.0
	Total	112	98.2	100.0	
Missing	System	2	1.8		
Total		114	100.0		

7.4.3.10 UPSC3(r): Raised International Profile of Participant's Own Research

According to the observed frequencies, surveyed experts scored this research output UPSC3(r) from 2 (to a small extent) to 5 (fully) (see Table 7-87). The centre of the distribution can be approximated by the median (or second quartile) equal to 4 (to a great extent), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles.

Table 7-87: UPSC3(r). Raised international profile of participant's own research

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	17	14.9	15.0	15.0
	To a great extent	58	50.9	51.3	66.4
	In part	30	26.3	26.5	92.9
	To a small extent	8	7.0	7.1	100.0
	Total	113	99.1	100.0	
Missing	System	1	.9		
Total		114	100.0		

Only about one percent of all surveyed experts (0.9 percent) believe *raising international profile of participant's own research* is not applicable as an individual research output from participation in a formal networking project. The majority of the experts (66.4 percent) responded that UPSC3 could be achieved *fully*

or *to a great extent* as a research output. Just over a third (33.6 percent) believe that UPSC3(r) as a research output can only be achieved only *to a small extent* or *in part*.

7.4.3.11 UPSC4(r): Raised International Profile of Funding Sponsor

According to the observed frequencies, surveyed experts scored this research output UPSC4(r) from 2 (to a small extent) to 5 (fully) (see Table 7-88). The centre of the distribution can be approximated by the median (or second quartile) equal to 4 (to a great extent), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles.

Table 7-88: UPSC4(r). Raised international profile of funding sponsor

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	26	22.8	23.0	23.0
	To a great extent	56	49.1	49.6	72.6
	In part	26	22.8	23.0	95.6
	To a small extent	5	4.4	4.4	100.0
	Total	113	99.1	100.0	
Missing	System	1	0.9		
Total		114	100.0		

Approximately one percent of surveyed experts (0.9 percent) believe *raising the international profile of funding sponsor* is not applicable as an individual research output from participation in a formal networking project. A large majority of the experts (72.6 percent) reported that participants should be able to achieve UPSC4 as a research output *fully* or at least *to a great extent*. The rest of the experts (27.4 percent) believe that UPSC4(r) as a research output can only be achieved *to a small extent* or only *in part*.

7.4.3.12 UPSC5(r): Utilisation of project results at national level

According to the observed frequencies, surveyed experts scored this research output UPSC5(r) from 2 (to a small extent) to 5 (fully) (see Table 7-89). The centre of the distribution can be approximated by the median (or second quartile) equal to 3 (in part), and half of the data values is between scores 3 (in part) and 4 (to a great extent), the first and third quartiles.

Table 7-89: UPSC5(r). Utilisation of project results at national level

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Fully	8	7.0	7.1	7.1
	To a great extent	34	29.8	30.1	37.2
	In part	54	47.4	47.8	85.0
	To a small extent	17	14.9	15.0	100.0
	Total	113	99.1	100.0	
Missing	System	1	0.9		
Total		114	100.0		

About one percent of surveyed experts (0.9 percent) reported that *utilisation of networking project results at national level* can be considered *not applicable* as an individual research output from participation in a formal networking project. Further 37.2 percent of the rest of respondents believe the project participants could achieve UPSC5 as a research output *fully* or at least *to a great extent*. A large share of respondents (62.8 percent) believe that UPSC5 as a research output can only be achieved *to a small extent* or only *in part*.

7.4.4 Controlling for Experts Involvement in FNR as Individual Researchers

As a large share of respondents (44 percent) in the Expert group reported being involved in FNR projects as individual researchers (see Table 7-33 in Section 7.3.3.9), it is proposed to review the scores Experts reported while controlling for their Involvement in FNR as Individual Researchers. First, a one-way analysis of variance (ANOVA) test is employed which produces a one-way analysis of variance for a quantitative dependent variable (*UPGS* and *UPSC outputs*) by a single independent factor (*Participation in formal networking projects as individual researchers*) variable. ANOVA is generally used to test the hypothesis that several means are equal. This technique is an extension of the two-sample t-test. The results of the ANOVA test suggest that there are statistically significant differences between the two groups: Experts^{N} (Experts who are not involved in FNR projects as individual researchers) and Experts^{Y} (Experts who are involved in FNR projects as individual researchers) (see Table 7-90). Statistical differences indicated by small significance values (sig < 0.05) have been indicated for the following variables: UPGS1, UPGS2, UPSC2, UPSC3, UPSC4 and UPSC5. The differences on the rest of the variables (UPGS3, UPGS4, UPGS5, UPGS6 and UPSC1) have been deemed statistically insignificant (sig > 0.05). It can be suggested that while experts who are not involved in projects themselves as individual researchers can be more objective, they can also be less informed of the reality of these FNR projects.

Table 7-90: ANOVA test results – Testing for differences in scores between Expert Groups based on Experts personal involvement in FNR projects as individual researchers

		Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
UPGS1. Joint publications in high ranked scientific journals (peer review)	Between Groups	2.709	1	2.709	5.082	*.026*
	Within Groups	59.167	111	.533		
	Total	61.876	112			
UPGS2. Publication of a book	Between Groups	4.348	1	4.348	6.870	*.010*
	Within Groups	69.616	110	.633		
	Total	73.964	111			
UPGS3. Industrial applications	Between Groups	1.244	1	1.244	1.871	.174
	Within Groups	67.795	102	.665		
	Total	69.038	103			
UPGS4. Patents	Between Groups	.629	1	.629	1.252	.266
	Within Groups	46.180	92	.502		
	Total	46.809	93			
UPGS5. Submission of proposal(s) for a new funded project	Between Groups	.100	1	.100	.150	.700
	Within Groups	74.042	111	.667		
	Total	74.142	112			
UPGS6. Influence on policy issues (at European level and/or country level)	Between Groups	1.564	1	1.564	2.579	.111
	Within Groups	66.713	110	.606		
	Total	68.277	111			
UPSC1. International conference of high standard	Between Groups	2.086	1	2.086	3.492	.064
	Within Groups	65.691	110	.597		
	Total	67.777	111			
UPSC2. Raised the international profile of researchers' organisation	Between Groups	3.105	1	3.105	4.686	*.033*
	Within Groups	72.886	110	.663		
	Total	75.991	111			
UPSC3. Raised the international profile of participants' own research	Between Groups	6.576	1	6.576	11.233	*.001*
	Within Groups	64.982	111	.585		
	Total	71.558	112			
UPSC4. Raised the international profile of funding sponsor	Between Groups	7.185	1	7.185	12.475	*.001*
	Within Groups	63.930	111	.576		
	Total	71.115	112			
UPSC5. Utilisation of project results at national level	Between Groups	7.453	1	7.453	12.551	*.001*
	Within Groups	65.910	111	.594		
	Total	73.363	112			

The next step is to examine the scores reported by Experts in each of the two groups to explore these differences (see Table 7-91 below). Experts^{N} have generally higher expectations only when it comes to variables UPGS4, and UPGS6. However, Experts^{Y} report higher results for the rest of the variables.

Table 7-91: Means Differences – Testing for differences in scores between Expert Groups based on Experts personal involvement in FNR projects as individual researchers

			UPGS1	UPGS2	UPGS3	UPGS4	UPGS5	UPGS6	UPSC1	UPSC2	UPSC3	UPSC4	UPSC5
Experts^{Y}	N	Valid	44	43	41	39	44	44	44	44	44	44	44
		Missing	0	1	3	5	0	0	0	0	0	0	0
	Mean		***3.64***	***3.77***	***2.73***	2.18	***3.57***	2.77	***4.00***	***3.84***	***4.05***	***4.23***	***3.61***
	Median		4.00	4.00	3.00	2.00	4.00	3.00	4.00	4.00	4.00	4.00	4.00
	Std. Deviation		.685	.841	.775	.601	.900	.859	.682	.805	.714	.642	.813
	Variance		.469	.707	.601	.362	.809	.738	.465	.649	.510	.412	.661
Experts^{N}	N	Valid	69	69	63	55	69	68	68	68	69	69	69
		Missing	1	1	7	15	1	2	2	2	1	1	1
	Mean		3.32	3.36	2.51	***2.35***	3.51	***3.01***	3.72	3.50	3.55	3.71	3.09
	Median		3.00	3.00	2.00	2.00	4.00	3.00	4.00	4.00	4.00	4.00	3.00
	Std. Deviation		.757	.766	.840	.775	.760	.723	.826	.820	.796	.824	.742
	Variance		.573	.587	.706	.601	.577	.522	.682	.672	.633	.679	.551

Experts^{Y} (experts personally involved in FNR projects as researchers)
Experts^{N} (experts not involved in FNR projects as researchers)

7.4.5 Difference in Perspectives – comparing Scores reported by Current Participants and Experts involved in FNR as Individual Researchers

In the previous section, the scores reported by two groups of Experts (based on their involvement in FNR projects as individual researchers) were compared. The results of the comparison suggest there are significant differences in how Experts from the two groups rank specific research outputs (for results see Section 7.4.4). However, it is now proposed to compare the mean scores reported by the Current Participants and those reported by the Experts with personal involvement in FNR projects (Experts^{Y}) (see Table 7-92).

Table 7-92: Difference in Perspectives – comparing Scores reported by Current Participants and Experts

		UPGS1	*UPGS2*	*UPGS3*	*UPGS4*	*UPGS5*	*UPGS6*	*UPSC1*	*UPSC2*	*UPSC3*	*UPSC4*	*UPSC5*
Experts^{Y}	Mean	3.64	3.77	2.73	2.18	3.57	2.77	4.00	3.84	4.05	4.23	3.61
	Median	4	4	3	2	4	3	4	4	4	4	4
	Std. Deviation	0.69	0.84	0.78	0.60	0.90	0.86	0.68	0.81	0.71	0.64	0.81
	Variance	0.47	0.71	0.60	0.36	0.81	0.74	0.47	0.65	0.51	0.41	0.66
Experts^{N}	Mean	3.32	3.36	2.51	2.35	3.51	3.01	3.72	3.50	3.55	3.71	3.09
	Median	3	3	2	2	4	3	4	4	4	4	3
	Std. Deviation	0.76	0.77	0.84	0.78	0.76	0.72	0.83	0.82	0.80	0.82	0.74
	Variance	0.57	0.59	0.71	0.60	0.58	0.52	0.68	0.67	0.63	0.68	0.55
Participants	Mean	2.73	2.06	1.53	0.93	2.40	2.21	3.53	3.36	3.51	3.48	3.07
	Median	3	2	1	1	3	2	4	3	4	4	3
	Std. Deviation	1.46	1.74	1.38	1.11	1.57	1.37	1.29	1.11	1.10	1.15	1.24
	Variance	2.14	3.02	1.91	1.22	2.47	1.87	1.66	1.24	1.20	1.33	1.54
Means Differences	Diff. between Experts(Y) and Experts(N)	0.32	0.41	0.22	-0.17	0.06	-0.24	0.28	0.34	0.50	0.52	0.52
	Diff. in Means between Experts(Y) and Actual Participants	0.91	1.71	1.20	1.25	1.17	0.56	0.47	0.48	0.54	0.75	0.54
	Diff. in Means between Experts(N) and Actual Participants	0.59	1.30	0.98	1.42	1.11	0.80	0.19	0.14	0.04	0.23	0.02

Both Groups of Experts (Experts^{Y} and Experts^{N}) reported higher scores (greater expectations) on all variables when compared with the score means reported by the Actual Participants in FNR projects. However, out of the two groups, Experts^{N} reported scores on UPSC variables relatively close to the ones reported by the Participants.

7.5 Exploring Relationships between Researcher Productivity and Other Variables

This section will address the second research question posed by this thesis and will investigate the relationship between researcher networking productivity and the length of time spent being involved in formal networking research projects. An 11-item scale was developed in an earlier chapter of this thesis to measure individual participants' networking research productivity. It consists of two sub-scales: UPGS outputs (upgrading, upshifting and upstreaming) and UPSC outputs (upscaling). All of the eleven items were scored on a five-point Likert scale with the response points ranging from 1 (*not at all*) to 5 (*fully*). After the questionnaire is completed, each item can be analysed separately or item responses may be summated to create a score for a group of items. Responses to such Likert scales may be summated under the condition that all items use the same Likert scale and that the scale is used as an interval scale, so that they can then be treated as interval data measuring a latent variable. If these summed up responses are normally distributed, parametric statistical tests such as the analysis of variance can be applied. Alternatively, the data acquired from Likert scales, can be turned (reduced) into nominal by combining all responses into two categories such as 'achieved' and 'not achieved'. In this case, the Chi-Square, Cochran Q and McNemar-test are common statistical procedures that can be used after this conversion.

7.5.1 Formal Networking Research Productivity Dimensionality, Structural Invariance and Factor Structure

Principal components analysis (PCA) is a statistical technique that linearly transforms the original set of variables in a smaller set of uncorrelated variables that represents most of the information in the original set of variables and can be effective in joint use with other multivariate analysis techniques (including multiple regression analysis) (Lewis-Beck, 1994). The goal of PCA is very close to that of factor analysis in that both techniques try to provide an explanation of the variation in a set of observed variables on the basis of several underlying dimensions (Lewis-Beck, 1994). This thesis tests a number of hypotheses based on the proposed dimensions of networking research productivity, yet such testing will only be valid and useful if the survey respondents distinguish these dimensions as different. This is where PCA will serve as a useful statistical technique to interpret the underlying structure of the most important principal components (Bartholomew, Steele, Moustaki & Galbraith, 2008). A PCA was therefore conducted with the 11 items of the research productivity measure for the data collected through survey category 2 (current participants).

The commonly recommended method of Varimax rotation with Kaiser normalisation was used to clarify the structure of factors which would fit the data set best (Loehlin, 1998). Table 7-93 below shows that there are two eigenvalues larger than 1: component 1 (eigenvalue of 5.26) and component 2 (eigenvalue of 1.107).

This finding suggests that two common factors (components) would adequately account for the inter-correlations among the eleven research outputs variables (Lewis-Beck, 1994).

Table 7-93: Principal Component Analysis and Total Variance Explained By Components

Component	*Initial Eigenvalues*			*Extraction Sums of Squared Loadings*			*Rotation Sums of Squared Loadings*		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	**5.260**	47.818	47.818	5.260	47.818	47.818	3.247	29.518	29.518
2	**1.107**	10.062	**57.880**	1.107	10.062	57.880	3.120	28.362	57.880
3	.832	7.560	65.440						
4	.621	5.646	71.086						
5	.613	5.575	76.661						
6	.537	4.884	81.545						
7	.514	4.677	86.221						
8	.469	4.265	90.487						
9	.402	3.655	94.141						
10	.384	3.492	97.634						
11	.260	2.366	100.000						

Extraction Method: Principal Component Analysis

In line with the reviewed literature, the identified items loaded together. In fact, the six UPGS items loaded on component 2, while the five UPSC items loaded on component 1 (see Table 7-94 below). These first two factors cumulatively explain a total variance of 57.88% (initial eigenvalues). The results of PCA suggest that the phenomenon of formal networking research productivity appears to display sufficient invariance in this particular context in order to proceed to test the earlier established hypotheses. Furthermore, the respondents in the survey 2 study appear to distinguish between two dimensions of research productivity, allowing for separate tests for these two dimensions. The scale appears to confirm to the expected factor structure.

Table 7-94: Rotated Component Matrix (Output Variables)

	Component	
	1	2
UPSC3. Raised the international profile of researcher's own research	**0.852**	0.208
UPSC2. Raised the international profile of researcher's organisation	**0.841**	0.196
UPSC4. Raised the international profile of funding sponsor	**0.761**	0.299
UPSC5. Utilisation of project results at national level	**0.664**	0.393
UPSC1. International conference of high standard	**0.568**	0.356
UPGS4. Patents	0.137	**0.759**
UPGS5. Submission of proposal(s) for a new EU-funded project	0.240	**0.688**
UPGS2. Publication of a book	0.195	**0.663**
UPGS3. Industrial applications	0.319	**0.661**
UPGS6. Influence on policy issues (at European level and/or country level)	0.374	**0.615**
UPGS1. Joint publications in high-ranked scientific journals (peer review)	0.339	**0.601**

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization (Rotation converged in 3 iterations)

7.5.2 Formal Networking Research Productivity Measure(s)

The internal consistency reliability for this scale is satisfactory. In the next stage of the instrument development process a Cronbach's alpha value was generated for each construct. As measured with Cronbach's alpha, the internal consistency reliability for the two subscales and the scale overall exceeded *0.80* in every case (see Table 7-95 below).

Table 7-95: Formal Networking Research Productivity Measure (FNRP)

	UPGS scale	*UPSC scale*	FNRP Measure scale
Survey Group	6 items	5 items	11 items
Category 2	0.805	0.828	0.884

Constructs are generally accepted if the Cronbach's alpha value is greater than 0.7 (Flynn, Schroeder & Sakakibara, 1994). The proposed measures therefore display good measuring properties. Based on these positive results of the preliminary analysis of the research productivity measure (in the context of formal networking) this study proceeds to analyse the productivity data.

7.6 FNR, UPGS and UPSC Measures of Productivity

The following section will deal with the research hypotheses that have been earlier developed in section 3.6. The hypotheses that certain variables (such as the length of involvement in formal networking research (FNR) programmes and simultaneous involvement in several[67] FNR projects at a time) may be used to predict the formal networking research productivity (FNR Productivity, UPGS Productivity and UPSC Productivity) are tested with the use of regression analyses models.

Dependent variables: FNRP (FNR Productivity), UPGS Productivity, UPSC Productivity
Independent variables: LIP_FNR (Length of time involved with projects), ISP_FNR (*multi-networking* - Involvement in more than one FNR project)
Control variables: CV1 (Research Field (Domain)), CV2 and CV3 (Country of Work (Classification 1[68] and 2[69])), CV4 (Educational Level (Doctoral Degree)), CV5 (Research Experience), and CV6 (Professional Background).

In earlier sections of the data analysis, the responses to Likert items were treated as ordinal data. However, in this section the Likert scale data is treated as interval following recommendations by Keller and Warrack (2000). As a result, it can be summated provided that the questions use the same Likert scale in order to build a scale measuring a latent variable. Once the data is treated as interval, certain specific statistical tests such as ANOVA (analysis of variance) can be employed.

7.6.1 Multiple Regression Analysis

Regression is a statistical technique that allows the investigation of relationships between dependent (predictor) variables and independent variables. Academics currently share a general understanding that multiple regression is one of the most widely used methods for conducting multivariate analysis, mostly when more than three variables are involved (Bryman & Cramer, 2008). Hypotheses I to III (section 3.6) are predicting linear relationships. Multiple regression technique is therefore employed to test these relationships. Each hypothesis is tested through hierarchical multiple regression procedures. The statistical package used for these analyses is SPSS (version 15 for Windows). For the testing of all hypotheses, summative scale

[67] Involvement in more than one FNR project at the same time
[68] Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings suggested by the UN Statistics Division: http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe
[69] EU15 The Member States of the EU until 2004, when 10 more countries joined the EU; NMS10 - New Member States which joined the EU in 2004; NMS2 - Bulgaria and Romania; Candidate EU – Turkey, Croatia, The Former Yugoslav Republic of Macedonia (source: http://ec.europa.eu);

scores were formed for the FNR Productivity, as well as for each of the Productivity dimensions: UPGS and UPSC Productivities. During the regression analyses, two methods for generating regression models were applied: enter method and stepwise method.

The enter method allows researchers to specify the entire list of variables to be entered into the model as well as the order of entering them into the model. Another method used for generating regression models is known as *stepwise* multiple regression which allows the computer to enter the variables either individually or in blocks (groups) of variables in the order of their correlation with the dependent variable (Nardi, 2005). As a result, the strongest predictor is selected first and so on, one at a time from the entire list of independent variables until one of these variables turns to be not statistically significant (usually set at the 0.05 level of significance) to enter the equation. During the regression procedures for this thesis the author also tested for multicollinearity which proved not to be a problem in the conducted regression analyses as for all analyses the variance inflation factors (VIF) were lower than 10 (as well as the condition index in collinearity diagnostics was smaller than 15) (Huizingh, 2007).

7.6.2 Hypotheses IA and IB: (FNR Productivity Regression Models)

In order to avoid an overestimation of the utility of the independent variables of interest it is generally recommended to account first for control variables (Stevens, 2002). Based on the theoretical considerations, six control variables (from CV1 to CV6) have been selected as relevant control variables.

Basic FNRP Regression Model with six Control Variables (from CV1 to CV6)

Following the recommendation from Stevens (2002), the author first entered (using *enter* method) six earlier identified variables (from CV1 to CV6) in the basic regression model (see Table 7-96) which accounted for less than one percent of explained variance ($R^2 = 0.008$). After entering all six control variables, these variables together accounted for 0.8 percent (0.5% adjusted R square) of the variance (at significance level 0.01). An analysis of variance (ANOVA) during the linear regression procedure was carried out in relation to the six control variables in the basic model. Because of the significance value of the $F < 0.05$ (0.01) the independent variables were considered to be doing a good job explaining the variation in the dependent variable. Further, the t-statistics can be used to determine the relative importance of each variable in the model (see Table 7-96).

Table 7-96: Regression Coefficients (a) – Basic Regression Model with control variables (from CV1 to CV6)

Model		*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
1	(Constant)	31.564	1.345		23.460	.000
	CV1. Research Domain	.043	.066	.014	*.651*	.515
	CV2. Country Of Work (CL1:E/W/O)	-.271	.161	-.036	*-1.687*	.092
	CV3. Country Of Work (CL2: EU/Non-EU)	.319	.140	.049	**2.283**	.023
	CV4. Doctoral Degree	-1.863	.639	-.069	**-2.913**	.004
	CV5. Research Experience	-.492	.415	-.027	*-1.185*	.236
	CV6. Professional Background	.132	.231	.013	*.570*	.568

a Dependent Variable: FNR Productivity Score; b *Enter* Method; c $R^2 = 0.008$ (adjusted $R^2 = 0.005$)

Out of the six entered control variables only two proved to be statistically significant at the 0.05 level in this regression model in spite of the relatively small absolute variance explained by them: CV3 (Country of

Work, Classification 2) and CV4 (Educational Level, Doctoral Degree). The other four variables (CV1, CV2, CV5 and CV6) turned out not to be significant predictors.

7.6.2.1 Hypothesis IA (FNR Productivity and Multi-Networking)

Null Hypothesis (H_0^{IA}): *There is no association between researcher's involvement in more than one FNR Project (multi-networking) and researcher's FNR Productivity (FNRP)*

Alternative Hypothesis (H_1^{IA}): *Researcher's involvement in more than one FNR Project (multi-networking) is associated with the researcher's FNR Productivity (FNRP)*

The *Involvement in more than one FNR Project* variable (ISP_FNR) in addition to six control variables was entered. Adding ISP_FNR variable resulted in an increase in the explained variance of 2.8% for a total of R^2 of 0.036 or 3.6% (statistically significant at $p < 0.0005$) (see Table 7-97). The newly added variable ISP_FNR in this regression model is a statistically significant predictor (beta = 3.673, $p < 0.0005$). Also, a positive b coefficient (beta = 3.673) for ISP_FNR means that those who are involved in more than one FNR project at the same time, tend to score higher on FNR Productivity. Variable CV4 (Doctoral Degree) remained statistically significant in this regression model: CV4 (beta = 1.577, $p < 0.007$). The rest of the variables (CV1, CV2, CV3, CV5 and CV6) were deemed not statistically significant (at 0.05 level).

Table 7-97: Regression Coefficients (a) – FNRP Regression Model with six CV variables and ISP_FNR variable

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	21.701	1.675		12.959	.000
CV1. Research Domain	.060	.066	.020	.916	.360
CV2. Country Of Work (CL1:E/W/O)	-.159	.159	-.021	-.998	.318
CV3. Country Of Work (CL2: EU/Non-EU)	.249	.138	.039	1.808	.071
CV4. Doctoral Degree	**1.577**	.631	.058	**2.497**	.013
CV5. Research Experience	-.513	.409	-.029	-1.254	.210
CV6. Professional Background	.176	.228	.018	.772	.440
ISP_FNR. Involvement in more than 1 FNR Project	**3.673**	.458	.171	**8.016**	.000

a Dependent Variable: FNR Productivity Score; b *Enter* Method; c $R^2 = 0.036$ (adjusted $R^2 = 0.033$)

The results of regression analysis substantiate the significance of the relationship between the researcher's involvement in more than one FNR project and FNR productivity, and leads to the null hypothesis H_0^{IA} being rejected in favour of support of the alternative hypothesis H_1^{IA}, which states that there is an association between ISP_FNR and FNR productivity. Overall, there is support for the hypothesis that involvement of researchers in more than one FNR project at the same time (multi-networking) would be *positively associated* with the individual researcher's FNR productivity.

7.6.2.2 Hypothesis IB: (FNR Productivity and Time in FNR Projects)

Null Hypothesis (H_0^{IB}): *There is no association between the length of time researcher is involved in formal networking research projects and researcher's FNR Productivity (FNRP)*

Alternative Hypothesis (H_1^{IB}): *The length of time researcher is involved in formal networking research projects is associated with the researcher's FNR Productivity (FNRP)*

Learning over Time

Entered next was the *Length of Time Involved with FNR Projects* variable (LIP_FNR) in the regression model in addition to the seven control variables (CV1 to CV6, plus ISP_FNR) for an increase in the explained variance of 6.1% for a total of R^2 of 0.097 or 9.7% (statistically significant at $p < 0.0005$) (see Table 7-98). Further, t-statistics can be used to determine the relative importance of each variable in the model. While LIP_FNR proves to be a significant predictor (beta = 2.067, $p < 0.0005$), some of the control variables became statistically significant: CV3 (beta = 0.399, $p \leq 0.003$) and CV5 (beta = -0.825, $p \leq 0.038$). Furthermore, a positive b coefficient (beta = 2.067) for LIP_FNR (Number of Years in FNR Projects) means that those who scored higher on this variable also score higher on FNR Productivity. Variable CV4 (beta = 1.322, $p \leq 0.031$) and ISP_FNR (beta = 2.672, $p < 0.0005$) remained statistically significant while others, CV2 (Country of Work, Classification 1) and CV6 (Professional Background), did not prove to be statistically significant.

The regression analysis and ANOVA findings substantiate the significance of the relationship between the time spent in FNR projects and FNR productivity and leads to the null hypothesis H_0^{IB} being rejected in favour of support of the alternative hypothesis H_1^{IB} which states that there is an association between the time spent in FNR projects and researcher FNR productivity. Therefore, it is possible to conclude that support has been found for the hypothesis that the length of time a researcher is involved in formal networking research projects would be *positively associated* with the researcher's individual FNR productivity.

Table 7-98: Regression Coefficients (a) - FNRP Regression Model with six CV variables and LIP_FNR variable

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	16.696	1.673		9.980	.000
CV1. Research Domain	.181	.064	.059	2.817	.005
CV2. Country Of Work (CL1:E/W/O)	-.100	.154	-.013	-.652	.514
CV3. Country Of Work (CL2: EU/Non-EU)	**.399**	.134	.062	2.976	.003
CV4. Doctoral Degree	**1.322**	.611	.049	2.161	.031
CV5. Research Experience	**-.825**	.397	-.046	-2.080	.038
CV6. Professional Background	.038	.221	.004	.171	.864
ISP_FNR. Involvement in more than 1 FNR	**2.672**	.451	.124	5.921	.000
LIP_FNR. Number of Years in FNR Projects	**2.067**	.171	.258	12.107	.000

a Dependent Variable: FNR Productivity Score; b *Enter* Method; c $R^2 = 0.097$ (adjusted $R^2 = 0.094$)

7.6.3 Hypotheses IIA and IIB (UPGS Productivity Regression Models)

Basic UPGS Regression Model with Control Variables (from CV1 to CV6)

As recommended by Stevens (2002), six earlier identified variables (from CV1 to CV6) were first entered which accounted for two percent of explained variance ($R^2 = 0.020$, adjusted $R^2 = 0.015$) (at significance level 0.005) (see Table 7-99).

Out of the six entered control variables, only two proved to be statistically significant at the 0.05 level in this regression model despite the relatively small absolute variance explained by them: CV1 (Research Domain, beta = 0.160, $p \leq 0.004$) and CV3 (Country of Work, Classification 2, beta = 0.273, $p \leq 0.027$). The other four variables (CV2, CV4, CV5 and CV6) did not turn out to be significant predictors.

Table 7-99: Regression Coefficients (a) – UPGS Basic Model with control variables (from CV1 to CV6)

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	13.348	1.388		9.615	.000
CV1. Research Domain	.160	.056	.092	2.859	.004
CV2. Country Of Work (CL1:E/W/O)	-.100	.134	-.024	-.746	.456
CV3. Country Of Work (CL2: EU/Non-EU)	.273	.123	.070	2.214	.027
CV4. Doctoral Degree	.841	.568	.051	1.480	.139
CV5. Research Experience	-.690	.355	-.066	-1.943	.052
CV6. Professional Background	.208	.200	.035	1.045	.296

a Dependent Variable: UPGS Productivity Score; b *Enter* Method; c $R^2 = 0.020$ (adjusted $R^2 = 0.015$)

7.6.3.1 Hypothesis IIA (UPGS Productivity Regression Model)

Null Hypothesis (H_0^{IIA}): *There is no association between researcher's involvement in more than one FNR Project (multi-networking) and researcher's UPGS Productivity*

Alternative Hypothesis (H_1^{IIA}): *Researcher's involvement in more than one FNR Project (multi-networking) is associated with the researcher's UPGS Productivity*

The *Involvement in more than one FNR Project* variable (ISP_FNR) was then entered in addition to the earlier entered six control variables. Adding ISP_FNR variable resulted in an added 1.8% increase in the explained variance of a total of R^2 of 0.038 or 3.8% (significant at $p < 0.0005$) (see Table 7-100).

Table 7-100: Regression Coefficients (a) - UPGS Model with six CV variables and ISP_FNR variable

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	11.476	1.446		7.937	.000
CV1. Research Domain	.167	.055	.096	3.010	.003
CV2. Country Of Work (CL1:E/W/O)	-.060	.133	-.014	-.454	.650
CV3. Country Of Work (CL2: EU/Non-EU)	.246	.123	.063	2.007	.045
CV4. Doctoral Degree	.684	.565	.042	1.211	.226
CV5. Research Experience	-.659	.352	-.063	-1.871	.062
CV6. Professional Background	.245	.198	.042	1.238	.216
ISP_FNR. Involvement in more than 1 FNR Project	1.544	.365	.133	4.234	.000

a Dependent Variable: UPGS Productivity Score; b *Enter* Method; c $R^2 = 0.038$ (adjusted $R^2 = 0.031$)

The added variable ISP_FNR in this regression model is a statistically significant predictor (beta = 1.544, $p < 0.0005$). In addition, a positive b coefficient (beta = 1.544) for ISP_FNR means that those who scored higher on this variable also score higher on UPGS Productivity. Some of the other variables are deemed statistically significant in this regression model: CV3 (Country of Work, Classification 2, with beta = 0.246, $p \leq 0.045$), CV1 (Research Domain, with beta = 0.167, $p \leq 0.003$). The rest of the variables (CV2, CV4, CV5 and CV6) were deemed statistically not significant (at 0.05 level).

The regression analysis substantiates the significance of the relationship between the researcher's involvement in several FNR projects and UPGS productivity and leads to the null hypothesis H_0^{IIA} being rejected in favour of support of the alternative hypothesis H_1^{IIA} which states that there is an association between involvement in more than one FNR project (multi-networking) and researcher UPGS productivity. Overall, support was found for the hypothesis that the involvement of researchers in more than one FNR project (at the same time) would be positively related to individual researcher's UPGS productivity.

7.6.3.2 Hypothesis IIB (UPGS Productivity Regression Model)

Null Hypothesis (H_0^{IIB}): *There is no association between the length of time researcher is involved in formal networking research projects and researcher's UPGS Productivity*

Alternative Hypothesis (H_1^{IIB}): *The length of time researcher is involved in formal networking research projects is associated with the researcher's UPGS Productivity*

The *Length of Time Involved with FNR Projects* variable (LIP_FNR) was entered after the seven control variables (CV variables and ISP_FNR variable) for an increase in the explained variance of 1.3% for a total of R^2 of 0.044 or 4.4% (statistically significant at $p < 0.0005$) (see Table 7-101). Variable LIP_FNR proves to be a significant predictor in this regression model (beta = 0.383, $p \leq 0.009$). A positive b coefficient (beta = 0.0383) for LIP_FNR means that those who scored higher on this variable also score higher on UPGS Productivity. Variables CV1 (Research Domain, beta = 0.182, $p \leq 0.001$) and CV3 (Country of Work, Classification 2, beta = 0.278, $p \leq 0.024$) remained statistically significant. The rest of the entered variables did not remain statistically significant.

The regression analysis validates the significance of the relationship between the time researchers are involved in FNR projects and their individual UPGS productivity. This leads to the null hypothesis H_0^{IIB} being rejected in favour of support of the alternative hypothesis H_1^{IIB} which states that there is an association between involvement in more than one FNR project (multi-networking) and researcher UPGS productivity.

Overall, there is support for the hypothesis that the length of time researchers are involved in formal networking research projects is *positively associated* with their UPGS productivity.

Table 7-101: Regression Coefficients (a) - UPGS Regression Model with six CV variables, ISP_FNR and LIP_FNR variables

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	10.472	1.492		7.018	.000
CV1. Research Domain	**.182**	.056	.104	3.272	.001
CV2. Country Of Work (CL1:E/W/O)	-.039	.133	-.009	-.291	.771
CV3. Country Of Work (CL2: EU/Non-EU)	**.278**	.123	.071	2.259	.024
CV4. Doctoral Degree	.601	.564	.037	1.065	.287
CV5. Research Experience	-.705	.352	-.067	-2.005	.045
CV6. Professional Background	.233	.198	.040	1.182	.238
ISP_FNR. Involvement in more than 1 FNR project	**1.421**	.367	.122	3.874	.000
LIP_FNR. Number of Years in FNR Projects	**.383**	.147	.083	2.609	.009

a Dependent Variable: UPGS Productivity Score; b *Enter* Method; c $R^2 = 0.044$ (adjusted $R^2 = 0.037$)

7.6.4 Hypotheses IIIA and IIIB (UPSC Productivity Regression Models)

Basic UPSC Regression Model with Control Variables (from CV1 to CV6)

Following the recommendation by Stevens (2002), the first six earlier identified variables (from CV1 to CV6) were entered which accounted for just 1.1 percent of explained variance ($R^2 = 0.011$) (alpha 0.003) (see Table 7-102). From the six entered control variables, only two proved to be statistically significant at the 0.05 level in this regression model despite the relatively small absolute variance explained by them: CV2 (Country of Work, Classification 1, beta = -.0172, $p \leq 0.015$) and CV3 (Country of Work, Classification 2, beta =

0.209, $p \leq 0.001$). The other four variables (CV1, CV4, CV5 and CV6) were not deemed statistically significant in this basis regression model.

Table 7-102: Regression Coefficients (a) – UPSC Basic Model with control variables (from CV1 to CV6)

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	16.913	.731		23.144	.000
CV1. Research Domain	.039	.030	.031	1.311	.190
CV2. Country Of Work (CL1:E/W/O)	-.172	.071	-.056	-2.428	.015
CV3. Country Of Work (CL2: EU/Non-EU)	.209	.062	.077	3.346	.001
CV4. Doctoral Degree	.416	.290	.036	1.434	.152
CV5. Research Experience	-.060	.191	-.008	-.314	.754
CV6. Professional Background	.068	.104	.016	.652	.514

a Dependent Variable: UPSC Productivity Score; b *Enter* Method; c $R^2 = 0.011$ (adjusted $R^2 = 0.007$)

7.6.4.1 Hypothesis IIIA (UPSC Productivity Regression Model)

Null Hypothesis (H_0^{IIIA}): *There is no association between researcher's involvement in more than one FNR Project (multi-networking) and researcher's UPSC Productivity*

Alternative Hypothesis (H_1^{IIIA}): *Researcher's involvement in more than one FNR Project (multi-networking) is associated with the researcher's UPSC Productivity*

Involvement in more than one FNR Project variable (ISP_FNR) was entered in addition to the earlier entered six control variables (see Table 7-103). Adding ISP_FNR variable resulted only in a 1.0% increase in the explained variance of a total of R^2 of 0.021 or 2.1%. Despite a small absolute value of increase, this regression model is significant at $p < 0.0005$. The added variable ISP_FNR in this regression model is a statistically significant predictor (beta = 0.914, $p < 0.0005$). A positive *b* coefficient (beta = 0.914) for ISP_FNR means that those who scored higher on this variable also scored higher on UPGS Productivity. Some of the other variables remained statistically significant in this regression model: CV2 (Country of Work, Classification 1, beta = -0.145, $p \leq 0.041$) and CV3 (Country of Work, Classification 2, with beta = 0.190, $p \leq 0.002$).

Table 7-103: Regression Coefficients (a) - UPSC Model with six CV variables and ISP_FNR variable

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	15.866	.763		20.804	.000
CV1. Research Domain	.041	.029	.032	1.397	.162
CV2. Country Of Work (CL1:E/W/O)	-.145	.071	-.047	-2.046	.041
CV3. Country Of Work (CL2: EU/Non-EU)	.190	.062	.070	3.054	.002
CV4. Doctoral Degree	.336	.289	.029	1.163	.245
CV5. Research Experience	-.064	.190	-.008	-.335	.738
CV6. Professional Background	.080	.103	.019	.771	.441
ISP_FNR. Involvement in more than 1 FNR	.914	.201	.104	4.543	.000

a Dependent Variable: UPSC Productivity Score; b *Enter* Method; c $R^2 = 0.021$ (adjusted $R^2 = 0.018$)

The rest of the variables (CV1, CV4, CV5 and CV6) were deemed not statistically significant (at 0.05 level). The regression analysis validates the significance of the relationship between the researcher's involvement in several FNR projects and their individual UPSC productivity, and leads to the null hypothesis H_0^{IIIA} being rejected in favour of supporting the alternative hypothesis H_1^{IIIA}. Overall, support was found for the hypothesis that the involvement of researchers in more than one FNR project at the same time would be *positively associated* with their UPSC productivity.

7.6.4.2 Hypothesis IIIB (UPSC Productivity Regression Model)

Null Hypothesis (H_0^{IIIB}): *There is no association between the length of time researcher is involved in formal networking research projects and researcher's UPSC Productivity*

Alternative Hypothesis (H_1^{IIIB}): *The length of time researcher is involved in formal networking research projects is associated with the researcher's UPSC Productivity*

Learning over Time

Length of Time Involved with FNR Projects variable (LIP_FNR) was entered in addition to the seven control variables (CV variables and ISP_FNR variable) for an increase in the explained variance of 1.9% for a total of R^2 of 0.040 (adjusted R square .036) (statistically significant at $p < 0.0005$) (see Table 7-104). Variable LIP_FNR proves to be a significant predictor in this regression model (beta = 0.486, $p \leq 0.0005$). A positive b coefficient (beta = 0.486) for LIP_FNR means that those who scored higher on this variable also scored higher on UPGS Productivity. Some of the control variables deemed statistically significant: CV1 (Research Domain, beta = 0.070, $p \leq 0.018$), CV3 (Country of Work, Classification 2, beta = 0.222, $p < 0.0005$) and ISP_FNR (beta = 0.708, $p < 0.0005$). The rest of the entered variables (CV2, CV4, CV5 and CV6) were not deemed statistically significant. The regression analysis substantiated the significance of the relationship between the time researchers are involved in FNR projects and their individual UPSC productivity. As a result, the null hypothesis H_0^{IIIB} is rejected in favour of support for the alternative hypothesis H_1^{IIIB} which states that there is an association between the length of time researchers are involved in FNR projects and researchers' individual UPSC productivity. The results provided support for the hypothesis that the length of time researchers are involved in formal networking research projects would be *positively associated* with individual researchers' UPSC productivity.

Table 7-104: Regression Coefficients (a) - UPSC Regression Model with six CV variables, ISP_FNR and LIP_FNR variables

Model	*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
	B	*Std Error.*	*Beta*		
(Constant)	14.660	.781		18.770	.000
CV1. Research Domain	***.070***	.029	.055	*2.361*	.018
CV2. Country Of Work (CL1:E/W/O)	-.133	.070	-.043	-1.902	.057
CV3. Country Of Work (CL2: EU/Non-EU)	***.222***	.062	.082	*3.600*	.000
CV4. Doctoral Degree	.275	.287	.024	.959	.338
CV5. Research Experience	-.149	.189	-.019	-.788	.431
CV6. Professional Background	.045	.102	.011	.441	.659
ISP_FNR. Involvement in more than 1 FNR project	***.708***	.202	.081	*3.506*	.000
LIP_FNR. Number of Years in FNR Projects	***.486***	.080	.143	*6.092*	.000

a Dependent Variable: UPSC Productivity Score; b *Enter* Method; c $R^2 = 0.040$ (adjusted $R^2 = 0.036$)

7.6.5 FNR Productivity Regression Model Results when Controlling for Scientific Domain

This subsection examines whether there are any cross-domain differences in application of the regression models. Five control variables (CV2 to CV6) were entered, *Involvement in more than one FNR Project* variable (ISP_FNR) and *Length of Time Involved with FNR Projects* variable (LIP_FNR) into the model. The variables were entered using *enter* multiple regression. This analysis has been separately for each domain to determine which of the seven variables correlated with the dependent variables (FNR productivity). The

results of the regression test show different outcomes when controlling for the scientific domain of the respondents (see Appendix 30, Appendix 31 and Appendix 32). For BMBS domain, these variables proved to be statistically significant predictors explaining for a total of R^2 of 0.133 or 13.3% (statistically significant at $p < 0.005$). For CMST domain these variables proved to be statistically significant predictors explaining for a total of R^2 of 0.058 or 5.8% (statistically significant at $p < 0.005$). For ESSEM domain, these variables proved to be statistically significant predictors explaining for a total of R^2 of 0.058 or 5.8% (statistically significant at $p < 0.05$). For FA domain these variables proved to be statistically significant predictors explaining a total of R^2 of 0.084 or 8.4% (statistically significant at $p < 0.005$).

For FPS domain, these variables proved to be statistically significant predictors explaining for a total of R^2 of 0.077 or 7.7% (statistically significant at $p < 0.005$). For ICT domain, the variables proved to be statistically significant predictors explaining for a total of R^2 of 0.221 or 22.1% (statistically significant at $p < 0.005$). For ISCH domain, they proved to be statistically significant predictors explaining for a total of R^2 of 0.273 or 27.3% (statistically significant at $p < 0.005$). For MPNS domain, the variables proved to be statistically significant predictors explaining for a total of R^2 of 0.139 or 13.9% (statistically significant at $p < 0.005$). For TUD domain, these variables proved to be statistically significant predictors explaining for a total of R^2 of 0.090 or 9.0% (statistically significant at $p < 0.005$). For IE domain, the variables did not prove to be statistically significant predictors (at $p < 0.05$).

This subsection is particularly interested in finding out whether both variables (*Involvement in more than one FNR Project* variable (ISP_FNR) and *Length of Time Involved with FNR Projects* variable (LIP_FNR)) remained statistically significant predictors for researcher productivity in each of the domains. Both variables proved to be statistically significant predictors in CMST, ESSEM, FA, ICT and TUD domains. In the rest of the domains (MPNS, ISCH, FPS, and BMBS) the *Length of Time Involved with FNR Projects* variable (LIP_FNR)) remained statistically a significant predictor (statistically significant at $p < 0.005$), while the *Involvement in more than one FNR Project* variable (ISP_FNR) variable did not deem statistically significant predictor (at $p < 0.005$).

7.6.6 FNR Productivity Regression Model Results when Controlling for Professional Background (Sector)

This subsection further explores the relationship in the results of the regression model when applied to respondents from different professional sectors (academia, research institute/laboratories, government and industry/business) that is controlling for variable CV6. Five control variables (CV1 to CV5) were entered, *Involvement in more than one FNR Project* (multi-networking) variable (ISP_FNR) and *Length of Time Involved with FNR Projects* variable (LIP_FNR) into the model. The variables were entered using *enter* multiple regression. This analysis has been separate for each professional sector to determine which of the seven variables correlated with the dependent variables (FNR productivity). The results of the regression test show different outcomes when controlling for scientific domain of the respondents (see Appendix 33, Appendix 34 and Appendix 35). In case of *academic* respondents these variables proved to be statistically significant predictors explaining for a total of R^2 of 0.111 or 11.1% (statistically significant at $p < 0.005$). For the group of *research institutes/laboratories* participants, a model with these variables also proved to explain

for a total of R^2 of 0.144 or 14.4% (statistically significant at $p < 0.005$). This model also explained a total of R^2 of 0.206 or 20.6% of variance in the group of business and industry respondents (statistically significant at $p < 0.005$). *In case of government sector, these variables did not prove to be statistically significant predictors (at $p < 0.05$).*

This subsection further explored two variables (*Involvement in more than one FNR Project* variable (ISP_FNR) and *Length of Time Involved with FNR Projects* variable (LIP_FNR)) deemed statistically significant predictors for FNR productivity in each of the four professional groups. Both variables proved to be statistically significant predictors in only two groups: academia and research institutes and laboratories. In the rest of groups (business/industry and government), the two variables did not deem statistically significant predictors (at $p < 0.005$).

7.7 Summary

Chapter 7 provided an overview of the results of the statistical tests conducted with the data collected in three surveys (categories 1, 2 and 3). This chapter further included a number of important sections that followed the logic of the research questions. The sections were:

- the socio-demographics of the participants, experts and potential participants to FNR projects,
- the motives for application for funding from a sponsor funding FNR projects,
- anticipated FNR outputs as perceived by experts responsible for the selection of the new FNR projects,
- reported FNR outputs as perceived by participants of actual FNR projects, and finally,
- tests of hypotheses to analyse the relationships between different aspects of participation in the FNR projects and different forms of research productivity.

Following several methodological recommendations in the literature this chapter presented both patterns of results and the analyses for their relevance to the research issues and hypotheses (Lindsay, 1995; Perry, 1998). An overall discussion of all the collated results of this study (drawing on all methods employed) is presented in Chapter 8, which deals with the data results and their analysis in the context of the study objectives. Chapter 8 also focuses on the interrelationships between the variables in relation to FNR projects in general through further integration of the information into a meaningful whole so that conclusions and recommendations can be developed.

Chapter 8. CONCLUSIONS AND IMPLICATIONS

8.1 Introduction

Chapter 1 of this thesis outlined the rationale, research problems, objectives and methodology for the study. The following chapter clarified the environment of scientific collaborative networks, research collaboration motives and factors, researcher productivity in terms of motives and outputs. Chapter 3 offered an overview of dominant theoretical perspectives and proposed an integrated theoretical and conceptual framework. It was followed by Chapter 4 which provided a detailed description of the collaborative research in the European Research Area with a particular focus on different forms of funding programmes. After explaining the research design, instruments and methods applied in the study (Chapter 5), Chapter 6 proposed to set this research in the context of formal networking research projects funded by COST and financed within the EC Framework Programmes. The survey data was analysed and interpreted (Chapter 7). In this final Chapter of the thesis, conclusions are drawn from the research results with regard to the objectives of the study (each research problem and proposition), and compared with research findings that were offered by the pertinent literature. The limitations of the study are identified. To conclude the study, research recommendations and implications for theory and future research are then outlined.

8.2 Addressing Research Objectives

One primary level objective of this study is to understand the advantages of funded formal networking research (FNR) projects in terms of research outputs and outcomes at the level of individual participants. Another primary level objective of this study is to explore whether researchers involved in FNR projects learn to network as measured by their research productivity. However, as earlier discussed, this requires the understanding of several related aspects (second level objectives): (1) *motives*, which drive researchers to apply for new FNR funding, (2) individual *outputs*, which are viewed as achievable by the experts who set the criteria for new projects, as well as (3) research outputs *(productivity)* which can actually be achieved in the process of FNR projects. These three major areas of inquiry translate into several secondary level objectives.

8.3 Other Research Objectives

Prior to tackling the primary level research objectives, this study focuses on reaching the secondary level objectives. Before any analyses of individual research outputs, this study will first provide an overview of the socio-demographic profile of respondents in each of three respondent groups central to this study.

8.3.1 Socio-Demographical Profiles of Respondents

What is a typical individual in each of these groups? What are their attributes? This section will attempt to plot the socio-demographical profiles of respondents in three categories: Potential Participants (Applicants), Current Participants, and Experts. A summary of the socio-demographical participants' profile follows and a synopsis below:

- **Age Distribution**. An average current participant (mean = 48.83) is about 2.5 years older than an average applicant (mean = 46.3), while an average scientific expert is even older (mean = 52.89) (see Table 7-1, Table 7-11 and Table 7-24). The involvement of younger participants (under 35 years old) is limited to 11.2 percent among current participants, while among applicants the share of younger participants increases to about 15.2 percent. This is possibly a result of the new ERA-wide policy aimed to involve more junior researchers promoted by funding schemes (COST, 2008b) as well as focused attempts to make the Framework Programmes 'more friendly for young researchers' (European Parliament, 2005, p.44).
- **Gender Distribution**. The distribution of gender was very close in all three categories of respondents: more than 75% of respondents in each category are male, and in all cases, less than 25% are female (see Table 7-2, Table 7-12 and Table 7-25). The highest share of females (24%) was recorded among respondents in category 2 (Current Participants), while the lowest share of females (17.5%) was registered among Experts.
- **Educational Level (Doctoral Degree or Equivalent)**. Across all categories, respondents shared similar profile in regards to having a doctoral level degree (see Table 7-3, Table 7-13, and Table 7-26). Approximately 90 percent of all respondents have a PhD or equivalent degree (the highest share of PhD holders is reported among Potential Participants with 90.6 percent and the lowest share is Current Participants at 87.2 percent). About 10 percent of respondents in each category do not have a doctoral level degree (respectively, the highest percentage was noted among Current Participants at 12.8 percent, and the lowest share was recorded among Potential Participants at 9.4 percent). The split on educational level is almost identical for respondents from Potential Participants and Current Participants groups. Educational Level is generally perceived as an important factor determining success of research initiatives such as FNR projects.
- **Professional Background**. The breakdown across different professional fields is similar across all three categories (see Table 7-5, Table 7-15, and Table 7-27). Approximately 90 percent of respondents work in academia or other research institutes or laboratories, another four percent of Potential Participants and Current Participants work in Businesses or Industry (there are no representatives of Business/Industry among Experts due to the nature of their position). Government workers are represented differently in the three categories: just less than one percent of Experts, less than four percent of Potential Participants and less than 6 percent of Current Participants. Generally, there is a tendency to involve a wide range of stakeholders to participate in actual FNR projects. Although on the other hand, they do not tend to lead active research career in parallel and, therefore, government workers are generally not expected to apply for research funding. Experts are generally nominated (often by home countries ministries) from among the most eminent researchers in each research domain.
- **Professional Experience**. The number of early stage researchers is somewhat low, ranging from two percent (among Potential Participants) to 3.6 percent (among Current Participants) (Table 7-4 and Table 7-14). The question about respondents' professional experience was not queried of Experts as by definition these are senior eminent researchers. Approximately five percent of all respondents in both groups (Potential and Current Participants) define themselves outside the scientific (research) environment.

- **Geographical Distribution (Country of Work). Classification 1**[70]. Based on Classification 1, respondents are split into groups similarly across all three categories of respondents with a few exceptions (see Table 7-7, Table 7-19, and Table 7-29). Generally, each category of respondents (Current Participants and Experts) has about 16 percent of respondents from Eastern Europe, however, their share among respondents in the category of Potential Participants is only 10.8 percent. Similarly, the share of Western Europeans among Potential Participants is 32.7 percent against only 19.3 percent of Western Europeans among Experts (and 28 percent of them among Current Participants).
- **Geographical Distribution (Country of Work). Classification 2**[71]. The use of Classification 2 offers a different perspective on Geographical distribution (of countries of work) (see Table 7-8, Table 7-20 and Table 7-30). The largest shares of respondents in all three categories are from the EU Countries and Candidate States (90.6% among Potential Participants, 88.5% among Current Participants and 86.8% of Experts). However, a further breakdown shows that different parts of the EU are represented differently across the three categories of respondents. The Experts group most closely resembles the ratio of COST Member States with 48.2 percent of Experts working in EU15 States and 28.9 percent of Experts working in NMS10 States. The breakdown in the other two categories of respondents is very different. Respondents from the EU15 Member States make up for 76.8 percent of all respondents among Potential Participants and 62.9 percent of all respondents among Current Participants.
- **Research Domain Distribution**. All individual research Domains (as grouped in 6.5.2) have been represented in all three surveys (see Table 7-9, Table 7-21 and Table 7-31). Among the Potential Participants the shares of respondents per each domain ranged from 5.1 percent from the CMST Domain (Chemistry and Molecular Sciences and Technologies) to 15.5 percent from the MPNS Domain (Materials, Physical and Nanosciences). In contrast, among the respondents in the Current Participants category, respondents from the CMST Domains were the largest share of respondents (18.5 percent), while the ICT Domain (Information and Communication Technologies) were the least represented with 5.6 percent share of all respondents. The Expert respondents have been represented more evenly with most Domains receiving approximately from 10.5 percent to 14.9 percent per Domain. Only two domains (ESSEM (Earth System Science and Environmental Management) and ICT) have accounted for less than 10 percent of all respondents (7% and 6.1% respectively).
- **Participants' experience of Formal Networking Programmes (Current Participants and Scientific Experts)**. The majority of respondents from Current Participants (63.4 percent) have been in their first COST Action (less than five years[72] overall) (see Table 7-16 and Table 7-28). Nearly a quarter of all respondents have been involved in FNR projects for between 5 and 10 years (it is possible therefore to assume that they are involved at least in their second consecutive COST Action). A small percentage of all Current Participants (11.8 percent) are involved in FNR for more

[70] Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings suggested by the UN Statistics Division: http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe

[71] EU15 The Member States of the EU until 2004, when 10 more countries joined the EU; NMS10 - New Member States which joined the EU in 2004; NMS2 - Bulgaria and Romania; Candidate EU – Turkey, Croatia, The Former Yugoslav Republic of Macedonia (source: http://ec.europa.eu);

[72] An average COST Action runs over a period of 4 to 5 years

than 10 years (or more than three consecutive FNR projects). The situation is slightly different among Scientific Experts where less than fifty percent of all Experts (48.3 percent) have been involved scientific expert activities at COST for less than five years. The rest of Experts (51.7 percent) have been involved in COST activities for longer than five years. More than a quarter of all Experts (25.4 percent) have been involved in COST activities for longer than 10 years. Experts are generally senior researchers and there seems to be a relationship between their general experience and their nomination as Scientific Experts[73] by their home countries.

- **Participants' Involvement in more than one FNR project (Current Participants)**. The majority of all Current Participants (77.2 percent) were only involved in research activities of one FNR project at the time of the survey (see Table 7-17). The rest (22.8 percent) reported being involved in more than one COST Action at the time of the survey.
- **Management Committee Level Position (Current Participants)**. The majority of respondents (77.1 percent of all Current Participants) are involved in the research activities of their FNR projects at the level of Management Committee Members which means they have a voting right in the decision making of their FNR projects (see Table 7-23). Further 17.4 percent of respondents are not formally involved in the work of the project Management Committees. 5.4 percent of all respondents are involved at the level of either MC Chairs or Vice-Chairs.
- **Domain Committee Level Position (Experts)**. The majority of respondents in this category are active Domain Committee Members (95.6 percent) representing their home countries. A small percentage of Experts (4.4 percent) are active Domain Chairs or Vice-Chairs.
- **Participation in FNR Project as Individual Researchers (Experts)**. Over a third of all Expert respondents (38.6 percent) reported their individual involvement in FNR Projects (COST Actions) as individual researchers. The rest of the respondents (61.4 percent) reported that they were not involved in research activities of FNR Projects.
- **Applicants' Previous Experience of FNR funding scheme (Potential Participants)**. About a third of all respondents (36 percent of Potential Participants) have participated (or were involved in COST Actions at the time of the survey) previously to FNR projects (COST Actions). The majority of Potential Participants (64 percent), however, did not have any such FNR experience at the time of the survey.
- **Application Status (Potential Participants)**. The data from the Potential Participants category has been additionally analysed in terms of how applicants' proposals scored during an Open Call held by the Funding Sponsor (see Table 7-10). Only 5.7 percent of all applicants have made it to the Final stage of the Open Call. The majority of respondents (94.3 percent of all applicants) failed to reach the Final stage of the Open Call. These results are in line with the official results of Open Calls reported by the COST/ESF Office (COST, 2007c). However, these results confirm both a great demand for this specific type of networking funding as well as low success rate for applicants.

To summarise, the *representative applicant* in the survey 1 (Potential Participant) is a male researcher in his 40s. He has a doctoral degree (PhD) and is a senior researcher with more than 4 years of research experience working in the academic environment (academia, research institute or laboratory) in an EU Member State or

[73] As discussed earlier, Scientific Experts represent Domain Committee Members in the current COST structure.

an EU Candidate State. He is unlikely to have any previous experience of formal networking research programmes such as COST prior to his application for networking funding from COST.

The *typical FNR participant* in the survey 2 (from Current Participant in the COST Actions) is a male in his late 40s. He is a senior researcher with a PhD degree and more than four years of research experience. He is involved in research activities of only one FNR Project (under the same funding scheme) and has voting rights in his research project. He is working at a university, research institute or laboratory (academia) in one of the EU Member State or an EU Candidate State.

The *typical Scientific Expert* in the survey 3 is a male in his 50s. He has a PhD qualification and is a senior researcher (by definition). The typical Expert has been involved in FNR Programme activities for more than five years. He works in academic research in one of the EU Member or Candidate States and is very likely to be involved in research activities of the FNR Projects as an individual researcher.

8.3.2 Summary of Findings

This section provides an overview of the findings from the research study and a comparison with the literature. This overview will follow this logic of addressing research objectives (see Figure 8-1) and is in line with the summary of research questions initially introduced in Chapter 3 (see Table 3-2, p. 32):

- Reasons that drive researchers to apply for new formal networking research projects funding;
- Research outputs from FNR projects as expected by field experts setting the evaluation and assessment criteria for new FNR projects;
- Attainable research results (FNR outputs) as reported by the actual participants in FNR projects;
- Factors that have an impact on researchers productivity in FNR projects;
- Improvement of researcher productivity in FNR projects over time.

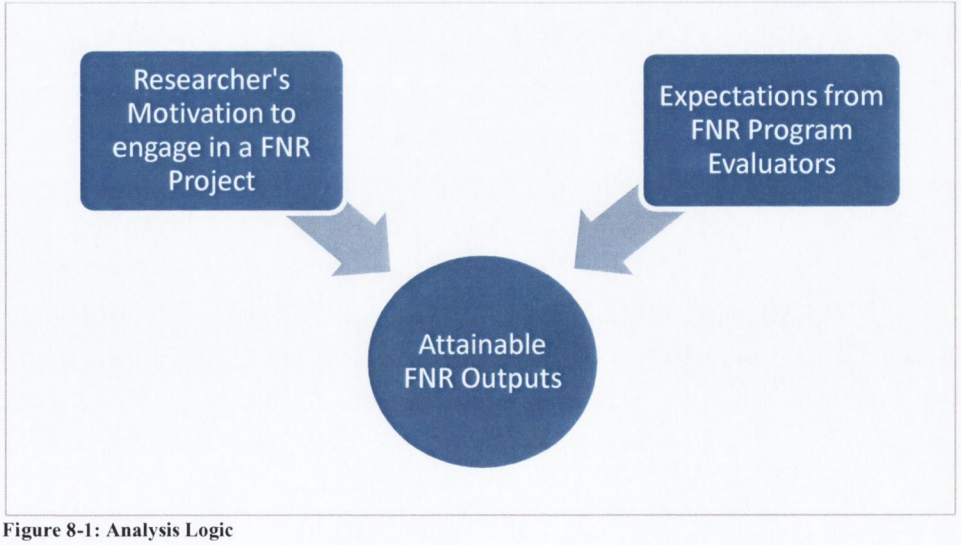


Figure 8-1: Analysis Logic

8.3.3 Understanding Motives for Participation in FNR Programmes

Research Question 1A: What are the motives behind an individual researcher's decision to get involved in FNR projects?

The survey comprised of 297 respondents from 32 countries (COST Member States) – researchers who submitted new proposals during an Open Call (preceding the survey) held by COST, a FNR funding sponsor. Main factors and motives for research collaboration have been identified in the reviewed literature. Surveying researchers applying for FNR funding (Survey Category 1 – Potential Participants) was undertaken in order to gain a perspective from potential users of FNR projects (both with prior FNR experience and without it). In agreement with the reviewed literature, this research paper proposed focusing on three sets of motives: *access to additional funding*, *meeting peers through cross-border networking* and *disseminating research results* (see section 2.4.6). Furthermore, this research suggested combining these motives into a research motivation hierarchy pyramid (see Figure 8-2).

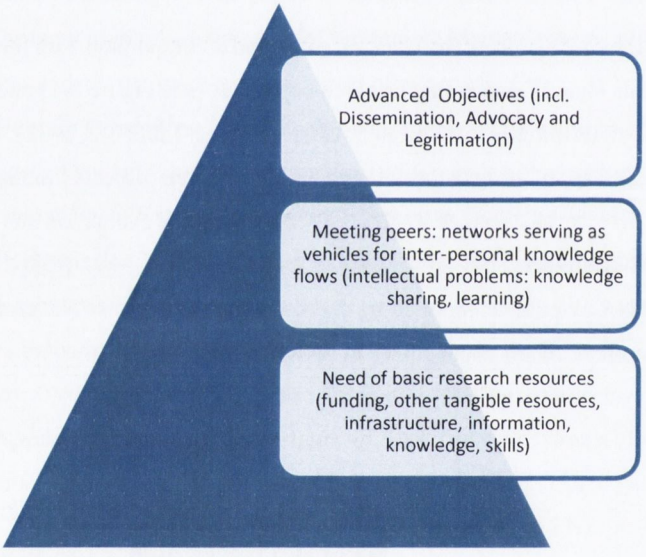


Figure 8-2: Pyramid of individual research motives

Survey findings suggest that the majority of all survey respondents reported *meeting peers through cross-border collaboration* as their *main reason* for applying for new collaborative research project funding. *Access to additional funding* was quoted as the second most important reason for applying for FNR funding, while improving chances of disseminating project results was the third most important reason for applying for FNR funding. This is in line with the fact that one of the main motives for participating in collaborative research projects is the interconnectedness of researchers (Wagner & Leydesdorff, 2005). Pertinent literature proposed that collaborative research networks and alliances are often seen as important sources of innovation mainly due to research collaboration becoming an important means of acquiring and organising S&T human capital (Bozeman & Corley, 2004). Researchers pro-actively seek to meet other researchers for collaboration as it allows them to achieve greater results than through independent (or sole in-house) research. Researchers experienced in FNR projects further confirm these results.

The large majority of them (65.4 percent of researchers with FNR scheme experience) viewed *meeting peers* as the most important reason for submitting their application. A possible explanation can be provided from the perspective of social learning theory. One of the identified aspects of research collaboration was linked to learning from collaborators with higher recognition in the field. Other researchers' experience is seen as an important resource in itself. In a collaborative environment the more experienced researchers serve as models of desired and successful performance and productivity. This phenomenon has been developed into *social learning theory* (Bandura, 1977). The behaviour of these experienced researchers can be perceived or accepted as models and as a result such behaviours can be learnt through modelling. This development within a network can be important as participants can learn by observing the behaviour of their peers and the results of such behaviours. A slightly different possible explanation as to why the respondents seek to collaborate with external researchers can come from the perspective of lagging resources. According to this perspective, developed within the centre-periphery theory, researchers from countries lagging in particular expertise or resources would be willing to engage in collaborative research with the counterparts from leading countries (Wallerstein, 1979). In the context of scientific and technical collaboration this theory suggests that through partnerships between countries with high technological development and other less developed countries this gap can be narrowed by a range of formal pan-European research programmes. It is possible to argue that participation in FNR programmes provides Eastern European researchers with access to academic researchers and infrastructure in the 'old' EU countries. In addition, applicants lacking former FNR experience scored relatively high on *accessing additional funding* (37.4 percent as opposed to 17.8 percent of applicants with previous experience of the funding scheme). A possible explanation is that researchers who are not yet experienced in a particular funding scheme are less aware of the internal culture and formal objectives of the funding scheme, and therefore, the motives they reported reflect the desired application of the funds rather than the actual application of it.

Another related finding was the difference in reasons for applying for FNR funding among respondents from different groups of countries. According to the survey results the majority of respondents from the Western, Northern and Southern countries (irrespective of their prior experience of FNR funding schemes) applied for new FNR funding primarily to improve their chances of *meeting peers* through cross-border collaboration. However, the findings for respondents from Eastern Europe are somewhat different. A smaller share of respondents with prior FNR experience applied for FNR funding primarily to *meet peers*, yet out of Eastern European applicants without prior experience of the FNR funding scheme a large majority to a large extent view this as an opportunity to gain *access to additional funding* rather than to meet new peers. First, a possible explanation of the difference in how Eastern European respondents reported their application motives depends on their prior experience of the FNR funding scheme. The Eastern European respondents that have previously participated in FNR projects are familiar with the procedures, requirements and objectives of the scheme while the respondents lacking this experience report their '*unadjusted*' expectations in relation to their FNR project application. Yet, another possible explanation to this observed pattern can be relatively low level funding levels across countries. In the case of Eastern European researchers, if the level of research funding in these countries is significantly lower (which is also suggested based on the figures for GERD (Gross Domestic Expenditure on R&D as percentage of GDP, see Appendix 36, p. 298) than in other European countries (Northern, Southern and Western countries) academic researchers tend to engage in FNR project activities as a way of increasing their research budget.

The reason ranked as the least important of the three reasons provided during the survey was *enhancing the chance of disseminating research results*. While this reason did not score as high as the other reason, a significant number of respondents reported their interest in it. This can be explained by the fact that international collaborative projects can produce outputs (for example, such as publications and industrial applications) which would allow participating researchers to improve their own research profile (as well as the research profile of their institution).

Another finding was further identified by controlling for the scientific field of applicants. The majority of respondents with prior FNR funding experience from all research fields (scientific domains) reported meeting peers as the main reason for applying for FNR funding, with a particularly strong support in most 'hard science' fields (see Appendix 12). This confirms an earlier expectation that researchers from institutions in these fields have an above average propensity to join such international collaborative programmes. Another explanation can be in the increased division of labour among scientists often leading to cross-field (or other heterogeneous forms) collaboration (Frenken et al., 2005). The survey results support the proposition that such cross-field creation and integration of research results have become one of the principal forms of solving research problems in many scientific fields.

During the data analysis another finding was identified. The large majority of researchers without FNR funding experience in ISCH primarily reported *gaining access to additional funding* as their main reason for applying. This is in contrast to both the ISCH respondents with FNR experience and the respondents without FNR experience in all other Domains[74], who reported *meeting peers* as their main reason for applying for FNR funding. In agreement with Melin (2000) the results show that many researchers collaborate for specific and pragmatic reasons which reflect their individual and domain circumstances. It is also in line with Gulbrandsen and Selby (1994b) who identified differences in patterns of research funding between different research fields. In the case of ISCH domain, while external funding (for example, industry funding) can be widely available in the fields of 'hard science', 'soft scientists' (Social Sciences and Humanities) to a large extent depend on governments for their funding. Therefore, these results suggest that while researchers in some fields (such as physics or mathematics) have been historically active in international collaboration (Arvanitis et al., 2008), social scientists have benefited less from the advantages of international collaborative research, but once exposed to international collaboration they seek to take part in such formal programmes again. Another explanation is that applicants with previous FNR experience were better informed about the FNR organisation's objectives and the type of funding provided by it.

8.3.3.1 Understanding Networking Programme Instruments that interest Potential Applicants

Research Question 1B: Which Instruments (associated with formal networking) most interest Applicants?

To understand better applicants' motivation to participate in FNR projects (research question 1A), the author of this thesis sought to learn (research question 1B) which specific formal networking instruments (FNI Instruments) were of a particular interest to new applicants (while also controlling for respondents' research

[74] TUD, MPNS, ICT, FPS, FA, ESSEM, CMST and BMBS

experience, work field/sector and country/region of work). The survey questioned researchers who submitted new proposals during the Open Call preceding the survey held by COST. These questions were included in the survey to gain an additional perspective from potential users of FNR projects (both with prior FNR experience and without it) as to understand which particular existing FNI (formal networking instruments) interest them most.

Junior researchers expressed a stronger interest in support for publications and subsidies for support activities (i.e. review, co-ordinate, evaluate or summarise the results of activities or prepare a document or a booklet). *Senior* researchers expressed a stronger interest in the rest of the instruments. As junior researchers are in the early stages of their career, they can be more eager in comparison with the senior researchers to kick-off the build-up of their professional reputation by producing the most basic research outputs: publications, as they probably perceive the expenses associated with these types of activities as significant expenses.

Academics are, more than any other professional group, interested in the dissemination of research results through training schools. In *research institutes and laboratories* researchers are, more than other groups, interested in support for the preparation of meetings (workshops and conferences) and reimbursements of travel expenses. *Business and Industry* respondents reported a higher interest in new training and dissemination opportunities, smaller subsidies (e.g. for websites and secretarial support), and the involvement of wider international participation. In comparison with other participants, *government* participants are more interested in short-term visits to other institutions and publications, as well as strategic events such as workshops and/or large conferences. It is possible to suggest that academics and industry/business researchers are more likely to be interested in the training of new younger researchers while applied institutes, laboratories and government do not normally deal with these issues within the scope of their research activities.

When controlling for the *Country of Work* (Region of Europe), this research found statistically significant differences in the way these four groups of respondents ranked their interest in the '*Near Neighbour*' budget, additional budget that allows involving researchers from outside of Europe (COST Member States) into the FNR projects (Near Neighbour Scheme). From the four groups, *Southern Europeans* reported the highest interest in this programme, while Northern, Western and Eastern Europeans expressed a lower than average interest in this additional funding budget. At the same time, Eastern and Southern Europeans expressed a stronger interest in STSMs and Training schools, while Northern and Western Europeans expressed a weaker interest in them. In COST, Near Neighbour budget is utilised by Actions that closely cooperate with institutions and individuals from outside[75] of the COST Member States. It is possible to suggest that Southern European participants are more open or interested in participation of external (participants from non-COST countries), possibly because of their closer ties with participants from Near Neighbour countries.

In general, respondents with prior experience of FNR projects expressed a stronger interest in most FNI instruments in comparison to respondents without prior experience of them. A possible explanation can be in that respondents who have once participated in a particular form of FNR programmes would be more familiar

[75] Under this strategy special support is to be provided for the integration of scientists from the Balkan Region, countries from Mediterranean Basin countries and from the countries of the Newly Independent States (NIS)

both with the particular instruments offered under the scheme (including terminology). Overall, the majority of potential FNR users expressed a particularly stronger interest in support of strategic workshops and conferences and reimbursement of travel expenses. A relatively strong interest was also reported in subsidies (for support in preparing summaries/evaluation) and the near neighbour scheme. At the same time, respondents reported a lower interest in training schools, small-scale activities support and contributions to publications. One of the possible explanations is that many researchers are traditionally more familiar with networking as work conducted at large events such as conferences. Overall, the results show that organised networking can take forms that most new potential participants are not too familiar in the context of formal networking research programmes.

8.3.4 Understanding which FNR Outputs and to What Extent are Expected from Participants

Research Question 2: What FNR outputs do funding sponsors (experts) expect from FNR participants?

The nature of research funding often means that researchers wishing to obtain new funding have to go through a competitive evaluation process. This often implies that during such an evaluation process, potential research proposals are evaluated and only the most capable will receive funding. The evaluation process often enquires into whether proposals are capable of delivering certain results. This research examined results reported by Domain Experts in one of the FNR schemes in the ERA. These Experts are generally nominated by their home countries' ministries and are generally experienced researchers in their fields. As shown earlier, the typical Expert in the survey has a PhD qualification, he is involved in FNR project activities for more than five years and is likely to be involved in one of FNR projects as an individual researcher. Among other responsibilities, these experts are expected to evaluate new research proposals, monitor running projects as well as conducting final assessments of the finished FNR projects. Research suggests that these experts generally have high expectations (programme expectations) when it comes to a particular range of research outputs. The majority of experts believe that FNR researchers should be able to achieve joint publications, publication of a book, submission of proposals for new funded research projects, international conference papers, and raised international profiles of the researchers' organisation, their own research and the funding sponsor. However, only a relatively small group of all experts believe that FNR participants should be able to achieve Patents or Industrial Applications as a result of their involvement in FNR projects. In fact, many experts believe that patents and industrial applications as a research output are not applicable to the context of FNR research projects. Nevertheless, a significant number of experts believe that researchers should be able to utilise their FNR project results at least in their home countries.

Another finding suggests that the expectations of experts depend on their personal experience of FNR projects (see Appendix 23, Appendix 24 and Appendix 25). Interestingly, those experts who were involved in FNR projects as individual researchers generally expressed higher expectations than the experts who lacked such experience in terms of most research outputs attainable from participation in FNR projects. Experts lacking such experience had higher expectations that researchers should be able to achieve patents and influence on policy issues (at European and/or country level) as a result of their participation in FNR projects.

8.3.5 Research Results Attainable in the Process of FNR Projects

Research Question 3A: Which FNR outputs can be achieved through participation in formal networking research (FNR) programmes?

The large majority of surveyed researchers (fully or to a great extent) achieved as a result of their involvement in FNR projects most of the following research outputs: attendance of an international conference, raised international profiles of researchers' own research work, their organisations, and the international profile of the funding organisation (see Appendix 26). Smaller groups of participants (around 30 percent of all surveyed respondents) achieved to the same extent joint publications, publications of books, submission of proposals for new EU-funded research projects, and utilisation of their FNR project results at the national level. Only a small share of all surveyed researchers achieved industrial applications or managed to influence policy-makers with the results of their FNR projects. Only one in approximately every thirty FNR participants achieved patents as a result of their FNR project activities. The majority of surveyed researchers did not achieve *either fully or to a great extent* any of the UPGS outputs. The majority of respondents did not manage to a full or great extent to achieve raising their institution's international profile or to achieve utilisation of their project results at the national level.

Overall, these results identified an interesting pattern. Researchers involved in FNR projects tend to achieve most of the UPSC outputs (upscaling), yet only a small number of respondents report achieving UPGS outputs (upgrading, upstreaming and upshifting). Furthermore, some of the UPGS outputs such as the publication of books, industrial applications, patents, submission of proposals for new EU research funding, and influence on policy issues are perceived as *inapplicable* by a significant share of FNR project participants. On the other hand, while most of the UPGS outputs and two of the upscaling results were not achieved *fully or to a great extent* by the majority of respondents, significantly larger shares of FNR participants report achieving these results at least *in part*.

8.3.5.1 Impact of Researcher's Education, Experience, Professional Background and Country of Work on FNR Outputs

Research Question 3B: What is the impact of Researcher's educational level, level of experience, scientific domain and professional background and country of work on their research outputs?

In addition to research question 3A, this research examined closer the relationships between the research outputs in interest and a number of additional variables which could potentially play a certain role in determining the research results achievable during the course of formal networking research projects: level of education, experience, professional sector and country of work (research question 3B).

Participant's Research Experience and FNR Outputs

Lee and Bozeman (2005) suggest that more senior researchers (with more years of experience) are more likely to have built and benefitted from networks on all levels. In partial disagreement with Lee and Bozeman

suggestion, this study observed no statistically significant differences in the research outputs (FNR outputs) reported by senior researchers (with more than four years of research experience) and junior researchers (with less than four years of research experience) (see Appendix 7, Appendix 8, Appendix 9 and Appendix 10). This is also in partial disagreement with the findings by Levin and Stephan (1991) who suggested that at least when it comes to publishing activity younger scientists are more productive than their older colleagues. The results of this study did not confirm any significant differences when controlling for the participants' research experience.

Researcher's Educational Level and FNR Outputs

Researchers qualified at the PhD level (or equivalent) in general tend to achieve FNR outputs (with the only exception of industrial applications) to a greater extent than those who lack a doctoral degree. Overall, those with a doctoral degree achieve greater results on the following outputs (statistically significant differences):

- joint publications,
- patents,
- submission of proposals for new EU-funded projects,
- attendance of an international conference,
- raising the international profile of the researcher's own research, and
- raising the international profile of the FNR funding sponsor organisation.

Participant's Professional Background (Sector) and FNR Outputs

This research further examined the differences between the results reported by respondents working in four professional sectors: academia, other research institutes/laboratories, business/industry or government (see Appendix 27 and Appendix 28).

Academic respondents generally tend to achieve greater results (in comparison with other professional sectors) in the following outputs: joint publications, submission of proposals, raising the international profile of their own research, and raising the international profile of their organisations. These academic participants, however, perform generally less notably than other researchers in achieving either industrial applications or patents. These findings generally agree with some other studies in that academic researchers get evaluated on the basis of a number of items such as the number of scientific publications, new grants, recognition with award for contribution to field (Cummings & Kiesler, 2004; EC, 2005b; Heimeriks et al., 2003). Academic researchers recognise that active publishing has an impact on both the ranking of individual researchers as well as their respective home institutions (Thijs & Glänzel, 2008). To a great extent, active publishing leads to recognition and to an even more accelerated build-up of additional social capital (van Rijnsoever et al., 2008). It is possible to suggest that academic researchers involved in FNR projects tend among other things to perform extremely well in achieving outputs which increase researchers' chances both in establishing their position in their scientific fields and in ensuring future research funding.

In comparison, individuals from research institutes and laboratories tend to achieve greater results in joint publications, publications of books, attendance of international conferences, raising profiles of their own

research as well as their organisations' profiles, and achieve greater degree of utilisation of project results at national level. Similarly to academic participants, researchers working in laboratories and other research institutes (applied research) also actively engage in profile increasing activities such as publishing, however, due to the more applied nature of their research, these participants work better in applying their research and ensuring utilisation of their project results at the national or European levels.

As a result of their involvement in FNR projects (such as COST Actions), industry and business representatives tend to achieve greater results in industrial applications and patents. However, to a much lesser extent than other participants, they do achieve joint publications, publication of books, attendance at conferences, and raise the international profiles of their own work and their organisation's profile or utilisation of the research results at national level. As anticipated, industry and business participants in FNR projects tend to outperform other participants in terms of achieving industrial applications and patents in agreement with authors who argue that participation in scientific networks can lead to effective innovations and such interaction with the scientific community can be crucial for a company's ability to incubate and commercialise new ideas (MIT, 2002). However, these industry/business participants still engage in other activities such as publishing, maybe if not to the same extent as academic participants. This is in agreement with the authors (Ponds et al., 2007) who suggest that firms taking part in a collaborative arrangement with universities or governmental research groups will have to engage in academic publishing as there is no other way around it.

When government representatives join an FNR project they tend to perform better compared with the participants from other professional sectors in achieving publications of books and attendance of international conferences. Generally they do not (greatly) raise the international profile of their organisations, nor do they greatly achieve submitting proposals for further funded research. A possible explanation is that government representatives see certain types of publications as important communication systems of dissemination crucial knowledge (Heimeriks et al., 2003). There is also a possibility that government participants are under the peer pressure to avoid inferior ranking within their network (Sgourev & Zuckerman, 2006). In fact, by engaging in publishing activities such as publication of books and presenting at major international conferences, non-academic organisations prevent being excluded from highly specialised knowledge networks (often in academic circles) (Rosenberg, 1990 in Charles and McNulty 1999).

Research Domain and FNR Outputs

This research looked closer into whether there were any differences in FNR outputs reported by respondents from different research fields (domains). First, certain patterns in the results were identified. The highest results on most outputs were reported by the respondents from the IE Domain (Interdisciplinary Exploratoria[76]). Domains FA (Food and Agriculture) and FPS (Forests, their Products and Services) also reported generally very high results on all FNR outputs (with an exception of lower results in achieving joint publications by FPS participants). Respondents from the Transport and Urban Development (TUD) domain generally reported consistently higher results on most outputs (except for joint publications).

[76] Interdisciplinary Exploratoria Domain was set to provide opportunities for potential high gain networking activities complementing other Domain Committees

The *lowest results* on most outputs were reported by researchers from the Chemistry and Molecular Sciences and Technologies (CMST) Domain. CMST domain in COST had a long-standing specific domain culture which probably to some extent explains these consistently lower results compared to other domains. The CMST domain for a long period of time operated on different rules and had a different structure (in terms of funding distribution, approval of new projects, etc.) and it is possible that this inter-network culture to a certain extent has an impact on the way researchers from this domain evaluate and report their output results. Interestingly, CMST domain is one of the least homogeneous domains in representing different professional sectors (such as business/industry, government or even research institutes/laboratories) as the majority of participants in this domain represent academia.

Social Sciences and Humanities (ISCH) respondents reported higher than average results on conference attendance, raising the international profile of the researcher's organisation and raising the international profile of the researcher's own research. However, these ISCH respondents reported results in the lower range in terms of achieving raising the international profile of the funding sponsor and utilisation of results at national level. Not surprisingly, ISCH respondents tend to achieve lower results in achieving industrial applications; however, they also achieve lower results in terms of achieving submission of proposals and influence on policy issues.

Overall, this research suggests that certain *applied research results* (such as patents, industrial applications and utilisation of results on national level) are domain-specific. The highest results are reported by respondents working in BMBS (Biomedicine and Molecular Biosciences), FPS, MPNS (Materials, Physical and Nanosciences) and TUD (approximately one in every 20 respondents in each Domain achieved patents); in BMBS, FA, FPS, ICT (Information and Communication Technologies), MPNS and TUD (about every tenth respondent reported achieving industrial applications); and ESSEM (Earth System Science and Environmental Management), FA, FPS and TUD (approximately, four in 10 respondents reported achieving utilisation of results at the national level).

In agreement with other studies (Barnes et al., 2002) all participants in collaborative projects involving non-academic participants must ensure an appropriate balance between academic objectives and non-academic (industrial or business) priorities in order to achieve mutual benefits. This study also confirms that respondents from the domains, which did well on achieving applied research outputs, also manage to achieve high results in terms of other outputs. These results can to some extent be related to the large share of non-academic participants in some of these domains in particular, TUD and FPS. This is in line with other authors' findings (Landry et al., 1996) who found that research collaboration (cross-sectional as well as intra-sectoral) can indeed increase researcher productivity. Their results suggest that the biggest impact on researcher performance is in case of collaborations with industry (rather than with other peers or other academic institutions). However, it is also in partial disagreement with other authors' findings that the high level of heterogeneity in a formal research network can impede the achievement of research results due to some inherent sources of unproductive conflicts that lie in the differences in ideas, research interests and cultural specifics (Bammer, 2008; Putnam, 2007).

Country of Work (European Region) versus FNR Outputs

Respondents from Southern and Eastern Europe tend to report higher results on most UPGS and UPSC outputs, while Northern Europeans tend to lower their reported results. A possible explanation is in the cultural divide that is generally observed in Europe along two gradients: a North-South gradient of economic growth and state development (with Northern and Western countries being at the top of the range and the Southern or Mediterranean countries being at the bottom), and a more recent, an East-West gradient (Siegrist & Wahrendorf, 2008). Possibly, due to the cultural differences along these two gradients Eastern Europeans and Southern Europeans in this survey tend to credit higher results to their participation in formal projects while respondents from Northern Europe and, to some extent, respondents from Western Europe tend to be more reserved in attributing their personal results to their participation in a formal project.

8.3.6 Learning to Network over Time

Research Question 4 (also, research questions 5 and 6): Do FNR participants learn to network over the time of their involvement in FNR projects?

Among other questions this research examines how a participant's research productivity, associated with their involvement in formal networking research activities, changes over time. In line with some other studies (Lee and Bozeman, 2005) this research suggests that the longer researchers are involved in collaborative research the more likely they are to build new collaborations and a career. Therefore, they tend to produce higher results associated with these new collaborations. Similarly to other funded research projects, in formal networking research (FNR) programmes where the funding sponsor only finances networking activities (and not the actual research) the participant's research productivity should change (improve) over time. Based on the pertinent studies of research collaboration and the participant's performance (Bonzi, 1992; Porac et al., 2004), this study suggests a number of hypotheses that individual research productivity associated with participation in FNR projects tends to change over time. This research expects to identify positive influences of the length of the participant's exposure to FNR project scheme on their research productivity.

Various authors have sought to propose different dimensions in the analysis of researcher motives associated with participation in collaborative arrangements, and they have recommended three dimensions: upgrading performance, upstreaming analysis and activities, and upshifting impact (Engel, 1993). During the data analysis stage this study found support that respondents distinguish between these two dimensions (UPGS (upgrading, upshifting and upstreaming) and UPSC (upscaling). Based on these two dimensions, this research further proposed three measures of researcher productivity associated with participation in FNR projects.

The measure of the UPGS Productivity (a summative construct including six research outputs) intends to measure researcher productivity in terms of achieving upgrading, upshifting and upstreaming objectives. The second measure, UPSC Productivity is a summative construct which includes five upscaling research outputs. However, the main index, FNR Productivity (a summative score which includes eleven of both UPGS and UPSC outputs), integrates both of UPGS and UPSC measures to produce an overall measure of formal networking research productivity associated with the individual researcher's involvement in FNR projects.

Two important findings have been identified in this research in relation to the relationship between researcher performance (measured by UPGS, UPSC and FNR Productivity measures) and their multi-networking (involvement in more than one FNR project at the same time) and the length of time the researcher is involved in collaborative scheme projects. *First*, data analysis revealed that those researchers who take part in FNR programmes for longer periods tend to be involved in more than one of these FNR projects at a time (multi-networking variable). An additional discovery offered strong support that the researcher's involvement in several projects under the same FNR scheme is positively associated with all three types of their research productivity. Researchers who are involved in several FNR projects in parallel tend to be those producing higher productivity results when measured in terms of their UPGS, UPSC and FNR Productivities. This is in agreement with other studies (Lee and Bozeman, 2005) which suggest that researchers exposed to collaborative environment are more likely to build more networks and produce greater results.

Second, support has been found to suggest that researchers who are involved in FNR projects for longer tend to produce overall greater results when measured with the UPGS, UPSC, and FNR Productivity measures. This is in agreement with other researchers' findings (Bonzi, 1992; Porac et al., 2004) that individual productivity in collaborative projects tends to relate positively to the *duration* of these projects. Researcher productivity tends to increase in collaborative networks but the increase is generally higher for the more heterogeneous research networks.

8.3.7 Summary of Findings

At the end of Chapter 3, the author introduced an overview of research questions and related hypotheses pursued by this thesis (see Table 3-2, p. 80). While previous subsections of this chapter describe the research findings in relation to this study, these are further summarised in Table 8-1 below:

Table 8-1: Summary of Findings

Focus Areas	*Research Questions*	*Brief Summary of Findings*
Motivation	**Research Question 1A**: What are the motives behind an individual researcher's decision to get involved in FNR projects?	This research showed that formal networking research projects (such as COST Actions) are perceived not only as an additional source of funding but are seen *primarily* as an important *resource* in itself. Researchers who generally experience funding to be scarce in their research field (Social Sciences and Humanities) or in their country of work (for example, Eastern European countries) tend to view FNR projects as an additional funding source rather than a venue for meeting peers. However, it is important to note that even these researchers tend to change the way they perceive FNR projects, seeing it as an opportunity to meet potential collaborators and to disseminate results of their research activities.
	Research Question 1B: Which individual Instruments associated with Formal Networking most	Research also further suggested that scholars make a decision to collaborate based on specific pragmatic reasons. Therefore, for example, junior researchers are generally interested in instruments that are especially important at the entry level - publications.

Focus Areas	*Research Questions*	*Brief Summary of Findings*
Motivation	interest Applicants? **Research Question 1B** (cont.)	On the other hand, those who have been exposed to the FNR projects tend to be more appreciative of all available instruments. Research also showed that there is a very high demand and interest in most FNR related instruments primarily in those that provide some sort of assistance with planning, managing and attending events (especially large-scale strategic conferences and workshops). While they can relate to, and see the benefits of event related instruments, many potential FNR project participants do not perceive with the same level of excitement some of the other instruments such as training schools or contributions to publications. However, there are also some differences in how different professional sectors value particular available instruments. So, academic and business/industry participants are more highly interested in training new researchers than any other instruments, while government participants increase their visibility/exposure to research environment by attaching higher value to their visits to other institutions, large international events, such as conferences and producing publications, such as books. Another finding is related to how researchers from different parts of Europe value involvement of external (mainly non-EU) researchers in their projects with a particularly high interest in this coming from the *Southern* European participants.
Programme Expectations	**Research Question 2**: What FNR outputs do funding sponsors expect from FNR participants?	This research also shows that evaluators generally expect two groups of outputs: (1) *universal*: joint publications of some sort, a further progress in securing new external funding, and raised international visibility of researcher's own work, as well as of activities by their home institution and the activities of the funding sponsor; (2) *secondary*: influence on policy issues, utilisation of project results at the national level, industrial applications and patents. While experts are generally very positive that most outputs can be achieved by FNR project participants at least to some extent, another finding suggests that the expectations of experts greatly depend on their personal experience of FNR projects. Experts with FNR experience generally expressed higher expectations than the experts who lacked such experience in terms of most research outputs attainable from participation in FNR projects. Experts lacking such an experience tend to set higher expectations that researchers should be able to achieve patents and influence on policy issues (at European and/or country level) as a result of their work within FNR projects. However, the results also suggest that experts (irrespective of their personal experience of FNR projects) tend to set expectations significantly higher than what participants tend to achieve.

Focus Areas	*Research Questions*	*Brief Summary of Findings*
Productivity	**Research Question 3A**: Which FNR outputs can be achieved through participation in formal networking research (FNR) programmes?	This study further suggests that FNR participants tend to achieve two groups of outputs: (1) *commonly reported* outcomes: upgrading, upstreaming and upshifting outputs, (2) *advanced* outcomes: UPSC (upscaling) outputs (except for patents and industrial applications which are deemed as field-specific). Overall, these results identified another interesting pattern. Researchers involved in FNR projects tend to achieve most of the UPSC (upscaling) outputs, yet only a small number of them achieve UPGS (upgrading, upstreaming and upshifting) outputs. In fact, some of the UPGS outputs such as book publications, industrial applications, patents, submission of proposals for new research funding, and influence on policy issues are perceived as *inapplicable* by a significant share of FNR project participants. On the other hand, while most of the UPGS outputs and two of the UPSC (upscaling) results were not fully (or to a great extent) achieved by the majority of respondents, significantly larger percentages of FNR participants report to have achieved these results at least *in part*.
	Research Question 3B: What is the impact of additional variables (researcher's educational level, level of experience, scientific domain and professional background and country of work) on their research outputs?	This study observed no statistically significant differences in the research outputs (FNR outputs) reported by senior researchers (with more than four years of research experience) and junior researchers (with less than four years of research experience). In general, researchers qualified at PhD level (or an equivalent) tend to achieve FNR outputs (with the only exception of industrial applications) *to a greater extent* when compared with researchers without a doctoral degree. Participants from different professional background tend to achieve research outputs to a different extent and these differences can be linked to differences in objectives and motives for participation in formal collaborative projects. However, participation for any participants from any one professional sector (especially, industry/business and government) does not stop at the achievement of results which are inherent or of interest to this group. The evidence suggests that these participants in formal networking projects tend to achieve other results at least to some extent. Some of the most homogeneous domains (in terms of participation from industry, governments and applied research organisations in addition to the academic majority) such as Chemistry in general also tend to achieve lower results in comparison to the more heterogeneous domains (such as Transport or Forestry) which in general achieve the highest results on most outputs.

Focus Areas	*Research Questions*		*Brief Summary of Findings*
Productivity (cont.)	**Research Question 4**: Do FNR participants learn to network over the time of their involvement in FNR projects?	**Hypothesis IA**: Individual researcher's FNR Productivity is associated with the researcher's concurrent involvement in multiple (more than one) FNR projects (multi-networking)	Overall, this research found support for the hypothesis that involvement of researchers in more than one FNR project at the same time (multi-networking) is positively associated with the individual researcher's FNR productivity.
		Hypothesis IB: Individual researcher's FNR Productivity is associated with the overall time researcher is involved in FNR projects	Researchers who are involved in more than one FNR project in parallel tend to achieve greater results and higher productivity scores. As a result, this research suggests that the research productivity (associated with FNR projects) of researchers involved in FNR projects tends to improve over years spent in the programme.
	Research Question 5: What is the relationship between the researcher's *UPGS* productivity and the researcher's multi-networking and the overall time of involvement in FNR projects?	**Hypothesis IIA**: Individual researcher's UPGS Productivity is associated with their concurrent involvement in multiple (more than one) FNR projects (multi-networking)	The data analysis offered strong support that the researcher's involvement in several projects (under the same FNR scheme) is positively associated with all individual researcher's UPGS productivity. Researchers who are involved in several FNR projects in parallel tend to be those producing higher productivity results when measured in terms of their UPGS productivity.
		Hypothesis IIB: Individual researcher's UPGS Productivity is associated with the overall time the researcher is involved in FNR projects	This study has found support that researchers who are involved in FNR projects for longer tend to produce overall greater results when measured with the UPGS productivity measure. Overall, this research suggests that individual researcher's UPGS productivity tends to improve over years spent in the programme.
	Research Question 6: What is the relationship between the researcher's *UPSC* productivity and their multi-networking and the overall time of involvement in FNR projects?	**Hypothesis IIIA**: Individual researcher's UPSC Productivity is associated with their concurrent involvement in multiple (more than one) FNR projects (multi-networking)	Support was found for the hypothesis that the involvement of researchers in more than one FNR project at the same time would be positively associated with their UPSC productivity.
		Hypothesis IIIB: Individual researcher's UPSC Productivity is associated with the overall time the researcher is involved in FNR projects	The results provided support for the hypothesis that the length of time researchers are involved in formal networking research projects is positively associated with individual researchers' UPSC productivity. As a result, this study suggests that individual researcher's UPSC productivity tends to improve over years spent in the programme.

8.3.8 Note on Revised Conceptual Framework

Integration of the resource-based view and the social capital theory allowed this thesis to benefit from combining these theoretical perspectives. Having completed the data analyses, the empirical findings largely support the conceptual framework's main grounds for assessing individual researchers' motivation and productivity in formal networking research (FNR) projects. The revised framework incorporates a number of important issues (see Figure 8-3):

(1). This research has based its analyses on data acquired from three main sources: potential FNR participants (applicants), existing FNR participants and scientific experts (experts involved in routine evaluation/assessment of different aspects during the lifecycle of most FNR projects). To reflect these sources, the revised framework incorporates an additional outer layer illustrating three viewpoints.

(2). The framework was further revised to include additional variables which were found to be linked with the researcher's Networking Readiness (individual researcher's ability to take advantage of available infrastructure to achieve greater FNR outputs):

   a. Empirical results suggest that certain variables such as FNR experience (years of involvement in FNR Projects) and multi-networking (Researcher's Involvement in more than 1 FNR Project at the same time) are positively associated with individual researcher's productivity.

   b. Additional factors such as Education (Doctoral Degree) and Country of Work were found to be statistically significant, yet remain weak predictors of researcher's FNR Productivity variance.

(3). Furthermore, the revised framework views FNR productivity as a set of research networking outputs across two dimensions of research outcomes: UPGS (upgrading, upshifting and upstreaming) and UPSC (upscaling). The newly added category (UPSC category) implies that social actors involved in formal collaborative projects can upscale their productivity in terms of peer-recognition and legitimacy.

(4). Empirical findings further suggest the incremental nature of the improvement in FNR productivity. This change in the levels of associated research productivity is represented by the two arrows and is linked to the cyclical nature of learning to network (Networking Readiness).

   a. Researchers who are new to the FNR projects initially take some time to figure out how the projects work and how to use the opportunities provided by the programmes. In line with the Matthew effect (Merton, 1968), researchers involved in FNR projects experience an accelerated build-up of additional social capital once they have accumulated some initial social capital. As predicted by the social capital theorists (reviewed in section 3.3), this incremental build-up of social capital allows participants to gain increasingly greater benefits from being a part of a research network.

   b. An improved level of social capital can further lead to changes in collaborative motivation. As the empirical findings from this research suggest, researchers without initial FNR experience have motives different to researchers with such experience.

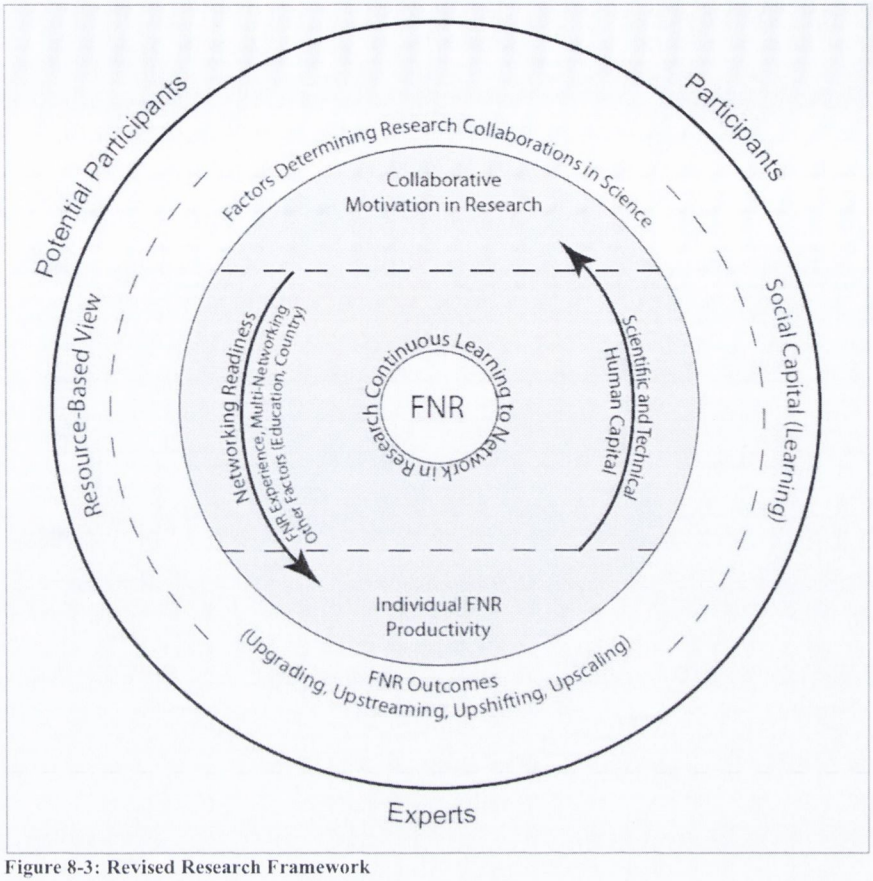


Figure 8-3: Revised Research Framework

Overall, the combined theoretical framework enables an explanation of participant motivation in formal networking research projects and justifies the examination of researcher productivity as a set of research outputs across the systems of research outcomes. What appears from the revised framework is the interconnection between different components examined in this study: factors determining collaborative behaviour in science, researchers' motives to participate in funded FNR projects, their research productivity, outcomes, etc. Furthermore, the revised framework emphasises the relationship between researchers' experience of the FNR projects and their associated FNR productivity. This is in agreement with other research findings (Bonzi, 1992; Porac et al., 2004) that productivity in collaborative projects relates positively to the duration of these projects.

8.4 Conclusions about the Research Problem

Overall, this research developed a number of conclusions contributing to both practice and science management theory.

1. Participation in formal networking research projects is generally motivated by a researcher's need to meet peers.

This research study attempted to improve our understanding of the motives that drive researchers to participate in formal collaborative research programmes. The pertinent literature generally agrees that the

decision to collaborate is a conscious and intentional decision for very specific reasons (Oliver, 1990). However, while collaboration is in many cases an informed and conscious choice, the motives and factors that guide individuals and organisations to such a decision may in fact be unrelated to their particular circumstances (Creech & Willard, 2001). These motives are broad statements of why collaboration is interesting and valuable to potential collaborators and as such these statements can be rather unclear.

This research study, in line with discussed motives and factors, confirmed the significance of external environmental constraints and institutions. The results of the study suggest that the majority of researchers generally engage in FNR projects in order to meet their peers. Meeting peers helps them to address a number of objectives. By networking with their peers, researchers build new networks which eventually allow them to gain access to new resources as suggested by the resource-based perspective (see 3.3). Researchers are driven by the conscious need to build relationships with the objective of social learning, communication and sense-making. Researchers are driven from the perspective of gaining access to new information, knowledge and skills, plus equipment and facilities. Participants of FNR projects acquire added-value through their participation in these networking activities which often results, as predicted by the social capital theory, in access to information, skills and in some cases to increased power (Uzzi & Dunlap, 2005). Initially, such relationships based on socially embedded ties between researchers also allow them to secure formal networking research funding (the *necessity* or *reciprocity* predictors).

2. *Motives driving researchers to join FNR projects depend on researchers' experience of FNR projects and tend to change over time.*

This research has identified an important pattern in how researchers' motivation to participate in FNR projects tends to change over time. At first, researchers are driven to join FNR projects by an initial set of several motives, over the time of their involvement in FNR projects the balance between the motives in this mix shifts significantly. Initially, researchers perceive FNR projects generally as an opportunity to meet peers and to gain additional funding. However, researchers who have experienced FNR projects perceive FNR projects differently: with a stronger emphasis on meeting peers, a significantly weaker emphasis on funding and a stronger emphasis on dissemination opportunities. This study suggests that initially most participants are interested mainly in meeting peers and additional funding while having participated in the projects they tend to diversify the way they perceive it to a more balanced mix of all three motives: meeting new peers, acquiring a new source of funding and, to a larger extent, as a knowledge dissemination channel.

Researchers change their attitude and expectations towards such programmes over the time they are involved in these collaborative projects. However, the identified pattern is not without some exceptions. The conducted research shows that priorities can differ depending on the researcher circumstances. Other reasons can also contribute to the researcher's decision to participate in a FNR project. In certain environments, research communities (for example, research communities that are historically short of research funding such as social sciences and humanities or researchers in some Eastern European countries) are driven initially and primarily by their need for research funding. However, with the experience of formal programmes, researchers even from these communities begin to see FNRs as an opportunity to meet peers and to disseminate their research results rather than a funding source.

3. Experts who generally evaluate FNR projects tend to set higher expectations when compared with the average results reported by the actual FNR project participants. Experts personally involved in FNR projects tend to have even higher expectations in terms of researchers' outputs.

Experts tend to set high expectations in terms of research outputs on all research outputs in question. Their expectations are generally significantly higher than what is generally achieved by the average participant. Experts who are personally involved in FNR projects tend to set even higher standards. This can be a level determining both standards and expectations; however, evaluations on the other hand should be more realistic.

4. *In FNR projects, researchers generally tend to achieve (to a great extent) upscaling outputs and (to a lesser extent) upgrading, upstreaming and upshifting outputs (as a result of their involvement in FNR projects).*

The study shows that participants who engage in formal networking research projects (which provide funding to cover only networking related expenses and do not support any direct research related costs) tend to achieve most of the studied research outputs, but to a different extent. They mostly achieve upscaling outcomes. To a lesser extent, they achieve upgrading, upstreaming and upshifting outputs, and only very few respondents achieve applied results (such as industrial applications and patents). So, what is the main function of involvement in FNR projects? Researcher participation in FNR projects can be seen as a tool to upscale their performance rather than as a tool to achieving upgrading, upstreaming or upshifting results. Furthermore, research productivity in FNR projects does not depend on one's research experience, while the level of education plays an important determining role, as more educated researchers tend to achieve greater results.

5. *Researchers tend to learn (how) to network as indicated by their productivity which gradually improves over the time of their involvement in FNR projects.*

Achieving results through *networking research* activities should be viewed as a specific skill which can be learnt or improved. While no statistically significant differences have been found between junior and senior researchers in their research outputs, this study found support in that researchers involved in FNR projects gradually increase their FNR productivity. This finding suggests that FNR participants learn to network over time as indicated by their productivity improving over time. By viewing networking as a resource, this research argues that productivity can be improved to an extent by teaching them to network. While researchers tend to learn, they learn from their environment surrounding them. FNR projects can be seen as *research community's virtual* colleges for researchers involved in projects.

On the other hand, researchers who engage in more than one FNR project seem to be more likely to have higher research productivity overall. This is also in line with an earlier finding that researchers with FNR project experience tend to adjust their motivation regarding participation in FNR projects. While researchers without such experience tend to consider to a significant extent FNR projects as an additional source of research funding, those with FNR experience tend to view their participation in FNR projects largely as an opportunity to meet their peers and to disseminate their research results. There is a possibility that these are

linked. Researchers who are new to the FNR projects initially take some time to figure out how the projects work and how make use of the opportunities provided by the programmes. With time, researchers identify new opportunities and build their personal networks.

In line with the Matthew effect (Merton, 1968), researchers involved in FNR projects experience an accelerated build-up of additional social capital once they have accumulated some initial social capital. Interaction helps people to build networks, to engage in collaborative research, and to build their research communities. As predicted by social capital theorists (reviewed in section 3.3), this build-up of social capital implies the existence of mutual norms, trust and a sense of mutual obligation. Once these are in place, participants are able to gain added-value from being a part of such research networks. In many cases, social capital is in fact about gaining value from being a member of such a network. Members of collaborative networks get access either to limited resources owned by other participants, or resources that can only be achieved through collaborative activities. As a result, collaborator membership in a network can provide them with improved *career prospects* or *new funding* opportunities. Many of the EU FP7 research funding programmes accept applications only from groups of collaborating researchers. In fact, some funding organisations set a minimum number of countries before a proposal is even reviewed. Collaborators, by putting such a proposal together, not only commit themselves to their group's research objectives but also facilitate and increase their own funding prospects.

Overall, while in some cases, research funding can also decrease a team's research performance, such collaborations can be impossible without funding (Arora et al., 1998). Nevertheless, these findings by Arora et al. (1998) point out that a funding opportunity does represent a strong motive for collaboration even if does not ensure an increased impact (Defazio et al., 2009). A recent report by the European Court of Auditors (2009) suggests that many collaborative research networks slowly die away without external funding. An overall conclusion is that as predicted by the RBV perspective applied at the level of an individual researcher, the very participation in FNR projects can be seen *as a resource* that allows individual researchers to gain competitive advantage in terms of research productivity and career development.

8.5 Implications for Theory and Methodology

This research provided contributions of methodological and theoretical natures. Firstly, the reviewed literature suggested that to this date researchers are still in a process of consolidating a general theory of collaboration (Wood & Gray, 1991). This research, however, contributed to the body of knowledge in the field of collaborative innovative structures (networks) by helping to further defragment and consolidate related literature. Secondly, this study found the existing literature to be limited and fragmented in its attempts to understand and to measure research outputs (and productivity) of formal networking research programmes. This thesis however proposed a measure (FNR Researcher Productivity) which incorporates both tangible and intangible outputs associated with participation in networking research programmes. The multi-angle approach of this study has provided further empirical and methodological contributions. The study's data collection process took the form of three complementing surveys addressed at three categories of respondents in order to gain complementing perspectives, developed a step-by-step framework of such data collection as well as its analysis.

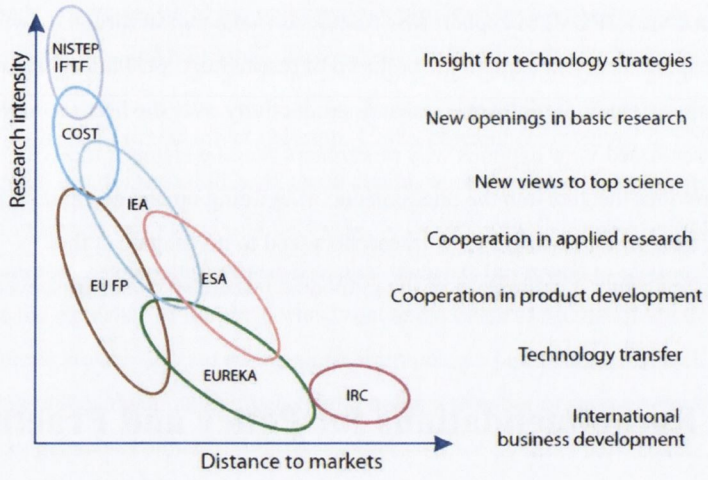
This study also proposed a new combined use of the resource-based view and social capital theory. This research employed the resource-based view (RBV) to explain why researchers take part in formal networking research projects. It applied social capital theory to explain the build-up of researchers' networking skill set (capability to network) and the improvement in participants' research productivity over the lifetime of the projects. Therefore, while the resource-based view explains why researchers become engaged in FNR projects, the social capital theory provides insights into the phenomenon of building up and accumulating social capital by participants. Also, most resource-based view researchers tend to investigate at the organisational level and only a very few apply it at the level of the individual researcher (van Rijnsoever et al., 2008).

8.6 Implications and Recommendations for Policy and Practice

The Marimon (2004) report[77] suggests that many EU funded collaborative research projects (such as Networks of Excellence or Integrated Projects) are supported by the European Commission without any clear goals. As a result, in some programmes, as suggested by the conducted research, researchers who are not familiar with these programmes perceive them differently to those who have experienced the programmes. With a number of international networking arrangements in operation in Europe some experts question the strategic position of some collaborative programmes such as COST. In fact, in their Final Review of COST in the Sixth Framework Programme, the EC-appointed high-level expert panel (Monfrey Panel) has raised its concerns (European Commission, 2007b). The Monfrey report suggests that COST must (a) rethink its place in the ERA, (b) decide on its target groups and the wider communities it wants to involve, and (c) decide on the geographical scope and the 'core-business' of COST (ibid, p.V).

In 2006, Tekes (the Finnish Funding Agency for Technology and Innovation) conducted a study that among other tasks examined the changing place of COST and EUREKA programmes among other international networks from research to business. In particular, the Tekes report (2006, p. 69) suggests that COST's position in the ERA is dependent on the ability of COST to renew its networks and to focus new and existing Actions on original and interdisciplinary research areas as to capitalise on its networking impact and provide a productive basis for the emergence of new research ideas. The authors of the Tekes report agree that COST fills a gap in the European R&D landscape that was not tackled by other collaborative research instruments (see Figure 8-4). In its current position COST seems to be especially well-positioned to enable and facilitate both new openings in basic research and new views to top science (TEKES, 2006). However, with the existing variety of formal collaborative research programmes in the ERA, research society may be unclear about the objectives of COST instruments. With good support from the Member States the COST budget in FP7 has been further increased by 50% to a budget of 30 million euros per year (from 80 million euros under the FP6 to 210 million euros in FP7). The future perspectives of COST have changed with the renewed political support but this must be translated into a clear added-value of COST in the bigger ERA picture (European Commission, 2007b). This perceived lack of strategic positioning combined with confusing COST governance structures can further contribute to this problem (European Commission, 2007b).

[77] This is a report prepared in 2004 by a high-level expert group, which was appointed to carry out the mid-term review of the effectiveness of new instruments, chaired by Dr Ramon Marimon, former Spanish Secretary of State for Science and Technology.



Adapted from Tekes (2006)
Figure 8-4: Map of some International Networks

In line with the findings documented by the Tekes and Monfrey reports, the results of this study support the view that COST Actions certainly play an important role in providing cost-effective, complementary alternatives for conducting international research networking (European Commission, 2007b; TEKES, 2006). However, to take a greater advantage of the available COST instruments, researchers (potential and actual project participants) should have a better understanding of the COST objectives as early in the process as possible. This research proposes a number of recommendations for policy and practice which could increase the added-value of FNR projects by improving individual links of the grant chain.

Presenting and promoting FNR Projects as a knowledge dissemination channel

While most participants generally join FNR projects as they are motivated by the opportunity to meet peers, they are also strongly interested in the funding that comes with such projects. Only a limited number of potential participants see the benefits of disseminating results through FNR programmes. This generally changes once participants have been exposed to FNR programme as they increasingly perceive it as a way of collaborating with new peers and as a channel for dissemination, while to a lesser extent viewing these networks as sources of additional funding. To some extent, this can be addressed by increasing applicants' awareness of FNR programme's benefits in terms of dissemination of the researcher's work results and collaborative work with peers. This can be achieved by circulating papers/publications written specifically to highlight the role of FNR programmes.

Raising greater awareness of the objectives of FNR projects and objectives in certain communities

This research also highlighted that in general Social Sciences and Humanities researchers and, in particular, researchers based in Eastern Europe to a greater extent experience shortages of research funding. Even though the reviewed FNR programmes do not provide research funding as such (only providing cover for networking related expenses), they are generally perceived by new applicants (from Eastern Europe as well as from the Social Sciences and Humanities area) primarily as an additional source of funding. The underfunding they experience generally results in a different motivation to participate in EU-funded FNR programmes. Therefore, it is crucial for science administration and policy-makers to consider these differences when developing new policies or designing evaluation methodologies.

Stronger promotion and encouragement of FNR projects among Early Stage Researchers

While generally funding sponsors realise the importance of involving early stage researchers, the average participant in the studies population is a senior researcher in his late 40s and less than one in twenty five participants is an early stage researcher. Current study shows that it is not the researcher's experience but their experience of FNR projects (length of involvement in FNR projects) that has an influence on productivity, so it may be possible to facilitate (or even catalyse) this learning process. Furthermore, COST could do more to encourage and facilitate participation of early stage researchers (including involvement of graduate research students) from institutions that might not be otherwise formally associated with COST Actions.

Sponsors' proactive approach to teaching researchers how to network: changing procedure-centred to outcome-centred approach

The obtained results support the conclusion that FNR projects researchers tend to improve their productivity over the time of their FNR projects. They also suggest that there are no statistically significant differences in productivity trends between senior and junior researchers. It can be further suggested that participants exposed to the stimulating environment created by FNR projects do indeed *learn to network*. However, organisations funding FNR projects could facilitate faster this learning process. For example, currently researchers joining COST Actions are continuingly given (by the COST/ESF Office) extensive information on the administrative procedures and budget planning associated with the participation in the projects yet the COST/ESF Office falls somewhat short of teaching '*FNR novices*' how to take full advantage of the FNR project environment.

A closer inspection of programme sponsors' websites shows:

- Funding sponsor organisations could improve the overall learning process by providing potential participants with easy to understand, intuitive information on the programme objectives and individual instruments.
- Science administrators and managers should further consider putting together information (in a form of easy to understand publications) on the practical aspects related to networking efforts. These could include guidance on how to identify individual potential research collaborators, how to work together on research projects and outputs such as publications or organising training schools, or how to deal in projects that result in industrial applications or patents, etc.
- Equip research managers (science officers) with this information and appropriate training in networking skills so that they can pass it on to the scientific and research community during meetings especially in the first year of each FNR project.
- Consider the introduction of a system of '*FNR gurus*' selected from the number of researchers (within individual research projects if possible) with the best FNR productivity and experience so they can share their networking skills with 'FNR novices' at informal sessions during workshops and conferences within the scope of each research project, or even Domain.
- Specific publications/manuals should be prepared for training (providing information) early stage researchers that could help them to understand the opportunities existing within the FNR projects that are open to them.

The value of this study for policy makers and science managers is in that:

- It contributes to the overall body of knowledge on collaborative research projects, and in particular on FNR projects, by offering guidelines for academia with regard to the added-value created and gained by individual researchers through participation in FNR projects, as well as by identifying training needs of participants involved in formal research networks.
- It determined the networking needs of individual researchers involved in research;
- It provided practical insights for science managers and administrators responsible for FNR projects management and assessment.

The resource-based view and the social capital theory strongly suggest that it is in the best interests of researchers to collaborate/network on a wide range of scientific and technological problems. The results of the study highlighted wide support of the research community for research tools facilitating such collaboration in the ERA (for example, COST Actions). In addition, even though this study shows that researchers tend to gain significant results due to their involvement in FNR projects, and their individual productivity tends to improve over the lifetime of such projects, yet scientific policy makers, administrators and managers could further facilitate these processes. Overall, the practical implications of the study are in contributing to efforts to understand the reasons behind the individual researcher's decision to participate in formal research networks, to gain insights in understanding expectations set by project evaluators, and to understand actually attainable project outputs. These insights can help funding organisations, government departments and other professionals to understand the benefits and limitations of formal networking research projects.

8.7 Limitations

Section 1.5 of this thesis outlined major delimitations of the research that were a deliberate part of the research (such as the ERA boundaries to the research problem). This section further discusses other limitations that became more apparent in the progress of conducting this study. Overall, this study based its findings on survey results from very large samples (the main survey included responses from over 2000 participants). Most research studies have their limitations; this survey study is no exception. The most apparent limitation of the survey is relatively low response rates. However, in survey research there is no single standard response rate (Fink, 1995a). Some forms of survey tend to have lower response rates than others and because non-response may introduce error, researchers should consider these when designing surveys to improve responses. Some of these steps include sending a letter from the head of the organisation to potential respondents asking them to participate and assuring respondents of confidentiality. Other steps would include sending a reminder to non-respondents and in addition ensuring the survey is short and easy to complete. For this study all these measures were adopted, however, as the surveys were carried out as a part of a larger strategic study the actual questionnaires were perceived to be on the longer side. Another limitation could be linked to differences in sizes of the three surveyed groups. While the results for each individual group of respondents can be considered representative, the results of the overall comparison of results between some of these groups are not always conclusive. Another possible limitation of this study is in the use of perceptions in data collection (self-reported research outputs) rather than easily quantifiable results. In terms of outcomes, this study focused primarily on short-term research outputs rather than on

achievement of long-term goals by individual researchers. In the surveys, respondents were asked to what extent they manage to achieve these outputs, yet they were not asked to quantify their self-reported results in terms of exact number of industrial applications or publications. In the survey of participants, they were asked the motives driving them to participate in FNR projects but they were not asked the reasons. Overall, while these the limitations must be acknowledged they do not detract from the significance of the findings of this study yet they provide platforms for future research.

8.8 Further Research

Based on the results of this particular research project and the overall infancy of the studied phenomenon, it is possible to suggest several directions for future research. First, a longitudinal study (over four years – typical duration of reviewed formal networking research projects), exploring and investigating the productivity of researchers involved in formal networking research projects, can be conducted. The undertaken study collected data from three major groups of respondents: potential participants, current participants and experts (project evaluators). In a future study, the same indicators (FNR outputs) can be offered not only to experts and current participants but also to the potential participants to find out the extent to which they anticipate achieving some of these outputs in their future FNR project. This would allow the comparison of potential participants' expectations to their actually attained results a few years later. This research also found some support that participants in formal research projects tend to learn to network over time and recommends science and research managers and administrators introduce a user-friendly way of teaching FNR participants how to take an advantage of their networking environment and project potential to the fullest. It would be interesting to conduct a longitudinal study of how results improve over time once such training is provided to participants. Another direction for future research is to investigate further the impact of relationships among project participants that exist prior to the commencement of an FNR project. The relationship between the researcher's existing networks and his/her research productivity could provide additional insights into whether outputs are the result of being exposed to new peers through participation in formal networking research projects, or if the work is a result of received funding to support activities that were already in place (Defazio et al., 2009). This research has examined the relationship between individual FNR productivity and this researcher's concurrent involvement (multi-networking) in more than one FNR project. The findings of this study suggest that the individual researcher's productivity is positively associated with such multi-networking. However, this study did not distinguish between the exact numbers of projects in which FNR participants are involved concurrently. However, a future study could further differentiate between the numbers of such concurrent projects (1, 2, 3, etc.), in order to establish whether individual FNR productivity continues to increase (or starts to decrease) once a researcher is involved in an increasing number of FNR research projects.

The undertaken study employed survey results mostly from European participants in formal networking research projects. Another possible direction is to look at more research networks and collaborative structures other than the projects funded by COST. Among other findings, this study suggests that researchers in specific communities (which generally are short of research funding, i.e. social sciences and humanities) often initially view formal networking research projects (i.e. COST Actions) as a way of getting access to additional funding (rather than as a venue for meeting peers or disseminating research results). The field

would also benefit from studying and comparing formal networking projects in other regions of the world. Similarly, while the original focus of this study was primarily on the academics involved in formal networking research projects, it is important to examine non-academic (in particular businesses or industry participants) participants in such projects.

The undertaken research primarily examines the motives driving researchers to participate in formal networking projects. It further examines attainable research outputs as reported by actual FNR participants as well as the expectations set by the experts involved in assessments, monitoring and evaluation activities in relation to the FNR projects. While this research does suggest a number of indicators of productivity and confirms that researcher productivity improves over time, it is still not clear if researchers continue to collaborate with their peers (who they meet during their involvement in FNR projects) once the project is over. A recent report from the European Court of Auditors (2009) strongly criticised many of the EU funded research networks (in particular Networks of Excellence) that tend to fall apart once their EU funding is over. While billions of euros are pumped by EU governments into collaborative project across the ERA only a very few of them tend to be sustainable once their main source of funding dries up. A similar research question can be asked in relation to the EU funded formal networking research projects (such as COST Actions). How sustainable are these networks and researchers' productivity after the projects have ended?

8.9 Concluding Remark

This thesis has focused on a number of research issues related to the phenomenon of formal networking research (FNR) projects. In particular, it examined them from the perspectives related to participant motivation, sponsors expectations, participant research productivity and participant learning within the context of formal research networks. This empirical study suggests that researchers do attribute certain research outputs to their participation in formal networking research projects and, that in fact, their research productivity tends to improve over the time they are involved in this form of collaborative research project.

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APPENDICES

Appendix 1: List of research outputs

Output	*Description*
UPGS1	Joint publications in high-ranked scientific journals (peer review)
UPGS2	Publication of a book
UPGS3	Industrial applications
UPGS4	Patents
UPGS5	Submission of proposal(s) for a new EU-funded project
UPGS6	Influence on policy issues (at European level and/or country level)
UPSC1	International conference of high standard
UPSC2	Raised the international profile of participant's organisation
UPSC3	Raised the international profile of participant's own research
UPSC4	Raised the international profile of the funding sponsor
UPSC5	Utilisation of project results at national level

Appendix 2: COST Scientific Domains

Domain	***Full Domain Name***
BMBS	Biomedicine and Molecular Biosciences
CMST	Chemistry and Molecular Sciences and Technologies
ESSEM	Earth System Science and Environmental Management
FA	Food and Agriculture
FPS	Forests, their Products and Services
ICT	Information and Communication Technologies
IE	Interdisciplinary Exploratoria
ISCH	Individuals, Societies, Culture and Health
MPNS	Materials, Physical and Nanosciences
TUD	Transport and Urban Development

Appendix 3: Formal Networking Research Programme Instruments (COST Instruments)

Instrument	*Description*
FNI1	Support for the preparation of meetings, workshops, conferences
FNI2	Short-term scientific mission (STSMs) used to fund exchange visits to an institution or laboratory
FNI3	Training school (for dissemination)
FNI4	General Action Support grants (GASGs) for the support of the project's website, secretarial support, small-scale activities
FNI5	Annual Grants (an alternative to the Pay as You Go scheme)
FNI6	Contributions to Publications
FNI7	Subsidies for support activities, i.e. review, co-ordinate, evaluate or summarise the results of activities or prepare a document or a booklet
FNI8	Strategic workshops and/or large conferences
FNI9	Near Neighbour Scheme budget that allows involvement of researchers in the Europe's 'Near Neighbourhood'
FNI10	Travel Reimbursements

Q.1. Among the following reasons to apply for COST network funding, what was the most important for you?	
To gain access to additional funding	1
To meet peers through cross-border networking	2
To enhance the chance of disseminating project results	3

Q.2. Did you consider alternatives to COST to get network funding?	
Yes	1
No	2

Q.3. For each of the following COST instruments, please indicate, on a scale from 1 to 10, the extent to which you are interested in it.	• *1 means that you are not interested at all* • *10 means that you are highly interested*	*Not Informed*
Support for the preparation of meetings, workshops, conferences	1 2 3 4 5 6 7 8 9 10	11
Short-term scientific missions used to fund exchange visits to an institution or laboratory	1 2 3 4 5 6 7 8 9 10	11
Training schools (for dissemination)	1 2 3 4 5 6 7 8 9 10	11
General Action Support Grants	1 2 3 4 5 6 7 8 9 10	11
(GASGs) used for the support of an Action website, secretarial support, small-scale activities	1 2 3 4 5 6 7 8 9 10	11
Annual Grants (an alternative to the "Pay as you go" scheme)	1 2 3 4 5 6 7 8 9 10	11
Contributions to publications	1 2 3 4 5 6 7 8 9 10	11
Subsidies for support activities, i.e. review, co-ordinate, evaluate or summarise the results of activities or prepare a document or a booklet	1 2 3 4 5 6 7 8 9 10	11
Strategic workshops and/or large conferences	1 2 3 4 5 6 7 8 9 10	11
Near Neighbours Scheme, i.e. budget that allows involvement of researchers in the Europe's 'Near Neighbours'	1 2 3 4 5 6 7 8 9 10	11
Travel reimbursements	1 2 3 4 5 6 7 8 9 10	11

Q.4. Would you consider applying again for COST network funding at the next opportunity?	
Yes	1
No	2

Q.5. What is your age?

Q.6. What is your gender?	
Male	1
Female	2

Q.7. In what country do you work?	
Austria	1
Belgium	2
Bulgaria	3
Croatia	4
Cyprus	5
Czech Republic	6
Denmark	7
Estonia	8
Finland	9
Former Yugoslav Republic of Macedonia (FYROM)	10
France	11
Germany	12

Q.7. In what country do you work?	
Greece	13
Hungary	14
Iceland	15
Ireland	16
Israel	17
Italy	18
Latvia	19
Lithuania	20
Luxembourg	21
Malta	22
Netherlands	23
Norway	24
Poland	25
Portugal	26
Republic of Serbia	27
Romania	28
Russia	29
Slovakia	30
Slovenia	31
Spain	32
Sweden	33
Switzerland	34
Turkey	35
Ukraine	36
United Kingdom	37
USA	38
Other	39

Q.8. Do you have a doctoral degree, i.e. a PhD or equivalent?	
Yes	1
No	2

Q.9. Where would you place yourself in respect to your research experience?	
Junior researcher, i.e. less than four years of research experience	1
Senior researcher, i.e. four years or more of research experience	2
Other	3

Q.10. Where would you place yourself according to your professional background?	
Academia	1
Other research institute/laboratory	2
Business or industry	3
Government	4
Other	5

Q.11. Were you involved in any of the COST Actions prior to the Current Open Call?	
Yes	1
No	2

Q.1. Overall, to what extent do you agree with the following statement about the role played by COST? Please indicate on a scale from 1 to 10 the extent to which you agree with it or not.										
1 = strongly disagree 10 = strongly agree										
COST plays an essential role in supporting cooperation among scientists and researchers across Europe	1	2	3	4	5	6	7	8	9	10

Q.2. To what extent do you think you achieved the following outcomes from COST participation? For each of the following outcomes, please indicate whether you have reached it *fully, to a great extent, in part, to a small extent* or you have *not reached it at all.*						
	Fully	To a great extent	In part	To a small extent	Not at all	Not applicable
International conference of high standard	1	2	3	4	5	6
Joint publications in high-ranked scientific journals (peer review)	1	2	3	4	5	6
Publication of a book	1	2	3	4	5	6
Industrial applications	1	2	3	4	5	6
Raised the international profile of participant's organisation	1	2	3	4	5	6
Raised the international profile of participant's own research	1	2	3	4	5	6
Raised the international profile of the funding sponsor	1	2	3	4	5	6
Utilisation of project results at national level	1	2	3	4	5	6
Patents	1	2	3	4	5	6
Influence on policy issues (at European level and/ or country level)	1	2	3	4	5	6
Submission of proposal(s) for a new Action in EU FP6, in particular networks of excellence (NOE)	1	2	3	4	5	6

Q.3. What is your age?

Q.4. What is your gender?	
Male	1
Female	2

Q.5. In what country do you work?	
Austria	1
Belgium	2
Bulgaria	3
Croatia	4
Cyprus	5
Czech Republic	6
Denmark	7
Estonia	8
Finland	9
Former Yugoslav Republic of Macedonia (FYROM)	10
France	11
Germany	12
Greece	13
Hungary	14
Iceland	15
Ireland	16
Israel	17
Italy	18
Latvia	19

Q.5. In what country do you work?	
Lithuania	20
Luxembourg	21
Malta	22
Netherlands	23
Norway	24
Poland	25
Portugal	26
Republic of Serbia	27
Romania	28
Russia	29
Slovakia	30
Slovenia	31
Spain	32
Sweden	33
Switzerland	34
Turkey	35
Ukraine	36
United Kingdom	37
USA	38
Other	39

Q.6. Do you have a doctoral degree, i.e. a PhD or equivalent?	
Yes	1
No	2

Q.7. Where would you place yourself in respect to your research experience?	
Junior researcher, i.e. less than four years of research experience	1
Senior researcher, i.e. four years or more of research experience	2
Other	3

Q.8. Where would you place yourself according to your professional background?	
Academia	1
Other research institute/laboratory	2
Business or industry	3
Government	4
Other	5

Q.9. For how many years have you been involved in the COST Actions?	
Less than 1 year	1
Between 1 and 2 years	2
More than 2 years but less than 5 years	3
Between 5 years and 10 years	4
More than 10 years	5

Q.10. Are you involved in more than one COST Action at this time?	
Yes	1
No	2

Q.1. To what extent do you think *researchers* achieved the following outcomes from COST participation?
For each of the following outcomes, please indicate whether they have reached it *fully, to a great extent, in part, to a small extent* or they have *not reached it at all.*

	Fully	To a great extent	In part	To a small extent	Not at all	Not applicable
International conference of high standard	1	2	3	4	5	6
Joint publications in high-ranked scientific journals (peer review)	1	2	3	4	5	6
Publication of a book	1	2	3	4	5	6
Industrial applications	1	2	3	4	5	6
Raised the international profile of participant's organisation	1	2	3	4	5	6
Raised the international profile of participant's own research	1	2	3	4	5	6
Raised the international profile of the funding sponsor	1	2	3	4	5	6
Utilisation of project results at national level	1	2	3	4	5	6
Patents	1	2	3	4	5	6
Influence on policy issues (at European level and/ or country level)	1	2	3	4	5	6
Submission of proposal(s) for a new Action in EU FP6, in particular networks of excellence (NOE)	1	2	3	4	5	6

Q.2. What is your age?

Q.3. What is your gender?	
Male	1
Female	2

Q.4. In what country do you work?	
Austria	1
Belgium	2
Bulgaria	3
Croatia	4
Cyprus	5
Czech Republic	6
Denmark	7
Estonia	8
Finland	9
Former Yugoslav Republic of Macedonia (FYROM)	10
France	11
Germany	12
Greece	13
Hungary	14
Iceland	15
Ireland	16
Israel	17
Italy	18
Latvia	19
Lithuania	20
Luxembourg	21
Malta	22
Netherlands	23
Norway	24

Q.4. In what country do you work?	
Poland	25
Portugal	26
Republic of Serbia	27
Romania	28
Russia	29
Slovakia	30
Slovenia	31
Spain	32
Sweden	33
Switzerland	34
Turkey	35
Ukraine	36
United Kingdom	37
USA	38
Other	39

Q.5. Do you have a doctoral degree, i.e. a PhD or equivalent?	
Yes	1
No	2

Q.6. Where would you place yourself according to your professional background?	
Academia	1
Other research institute/laboratory	2
Business or industry	3
Government	4
Other	5

Q.7. For how many years have you been involved in the COST Actions?	
Less than 1 year	1
Between 1 and 2 years	2
More than 2 years but less than 5 years	3
Between 5 years and 10 years	4
More than 10 years	5

Q.8. Are you involved as an individual researcher in any of the COST Action at this time?	
Yes	1
No	2

Appendix 7: Researcher Professional Sector and Research Domains (Current Participants)

Domain			*Frequency*	*Percent*	*Valid Percent*	*Cumulative Percent*
BMBS	Valid	Academia	123	79.4	79.4	79.4
		Other Research	20	12.9	12.9	92.3
		Business&Industry	6	3.9	3.9	96.1
		Government	4	2.6	2.6	98.7
		Other	2	1.3	1.3	100.0
		Total	155	100.0	100.0	
CMST	Valid	Academia	342	85.3	85.3	85.3
		Other Research	42	10.5	10.5	95.8
		Business&Industry	6	1.5	1.5	97.3
		Government	10	2.5	2.5	99.8
		Other	1	.2	.2	100.0
		Total	401	100.0	100.0	
ESSEM	Valid	Academia	101	46.8	46.8	46.8
		Other Research	79	36.6	36.6	83.3
		Business&Industry	3	1.4	1.4	84.7
		Government	30	13.9	13.9	98.6
		Other	3	1.4	1.4	100.0
		Total	216	100.0	100.0	
FA	Valid	Academia	197	54.7	54.7	54.7
		Other Research	118	32.8	32.8	87.5
		Business&Industry	9	2.5	2.5	90.0
		Government	34	9.4	9.4	99.4
		Other	2	.6	.6	100.0
		Total	360	100.0	100.0	
FPS	Valid	Academia	105	43.8	43.8	43.8
		Other Research	101	42.1	42.1	85.8
		Business&Industry	17	7.1	7.1	92.9
		Government	15	6.3	6.3	99.2
		Other	2	.8	.8	100.0
		Total	240	100.0	100.0	
ICT	Valid	Academia	87	71.3	71.3	71.3
		Other Research	25	20.5	20.5	91.8
		Business&Industry	5	4.1	4.1	95.9
		Government	3	2.5	2.5	98.4
		Other	2	1.6	1.6	100.0
		Total	122	100.0	100.0	
IE	Valid	Academia	10	58.8	58.8	58.8
		Other Research	5	29.4	29.4	88.2
		Government	1	5.9	5.9	94.1
		Other	1	5.9	5.9	100.0
		Total	17	100.0	100.0	
ISCH	Valid	Academia	110	78.0	78.0	78.0
		Other Research	19	13.5	13.5	91.5
		Business&Industry	4	2.8	2.8	94.3
		Government	3	2.1	2.1	96.5
		Other	5	3.5	3.5	100.0
		Total	141	100.0	100.0	
MPNS	Valid	Academia	203	67.7	67.7	67.7
		Other Research	79	26.3	26.3	94.0
		Business&Industry	11	3.7	3.7	97.7
		Government	3	1.0	1.0	98.7
		Other	4	1.3	1.3	100.0
		Total	300	100.0	100.0	
TUD	Valid	Academia	106	48.0	48.0	48.0
		Other Research	63	28.5	28.5	76.5
		Business&Industry	27	12.2	12.2	88.7
		Government	20	9.0	9.0	97.7
		Other	5	2.3	2.3	100.0
		Total	221	100.0	100.0	

Appendix 8: Differences in Means (Participants' Research Experience vs. Research Outputs)

	CV5. Research Experience	*N*	*Mean*	*Std. Deviation*	*Std. Error Mean*
UPGS1(r). Joint publications in high-ranked scientific journals (peer review)	Junior	72	2.83	1.311	.154
	Senior	1769	3.04	1.196	.028
UPGS2(r). Publication of a book	Junior	63	2.78	1.408	.177
	Senior	1491	2.70	1.490	.039
UPGS3(r). Industrial applications	Junior	59	2.47	1.006	.131
	Senior	1328	2.21	1.090	.030
UPGS4(r). Patents	Junior	46	1.83	1.141	.168
	Senior	1094	1.65	.967	.029
UPGS5(r). Submission of proposal(s) for a new EU-funded project	Junior	64	2.97	1.247	.156
	Senior	1677	2.81	1.310	.032
UPGS6(r). Influence on policy issues (at European level and/or country level)	Junior	60	2.73	1.163	.150
	Senior	1668	2.58	1.084	.027
UPSC1(r). International conference of high standard	Junior	73	3.68	1.039	.122
	Senior	1852	3.76	.954	.022
UPSC2(r). Raised the international profile of researcher's organisation	Junior	75	3.59	.773	.089
	Senior	1908	3.45	.971	.022
UPSC3(r). Raised the international profile of researcher's own research	Junior	77	3.71	.758	.086
	Senior	1928	3.60	.951	.022
UPSC4(r). Raised the international profile of funding sponsor	Junior	75	3.60	.959	.111
	Senior	1888	3.62	.935	.022
UPSC5(r). Utilisation of project results at national level	Junior	75	3.24	.942	.109
	Senior	1865	3.22	1.056	.024

Appendix 9: Robust Tests of Equality of Means (Participants' Research Experience vs. Research Outputs)

		Statistic(a)	*df1*	*df2*	*Sig.*
UPGS1(r). Joint publications in high-ranked scientific journals (peer review)	Welch	1.752	1	75.887	.190
	Brown-Forsythe	1.752	1	75.887	.190
UPGS2(r). Publication of a book	Welch	.205	1	68.005	.652
	Brown-Forsythe	.205	1	68.005	.652
UPGS3(r). Industrial applications	Welch	3.964	1	64.205	.051
	Brown-Forsythe	3.964	1	64.205	.051
UPGS4(r). Patents	Welch	1.075	1	47.754	.305
	Brown-Forsythe	1.075	1	47.754	.305
UPGS5(r). Submission of proposal(s) for a new EU-funded project	Welch	.947	1	68.415	.334
	Brown-Forsythe	.947	1	68.415	.334
UPGS6(r). Influence on policy issues (at European level and/or country level)	Welch	1.048	1	62.743	.310
	Brown-Forsythe	1.048	1	62.743	.310
UPSC1(r). International conference of high standard	Welch	.377	1	76.855	.541
	Brown-Forsythe	.377	1	76.855	.541
UPSC2(r). Raised the international profile of researcher's organisation	Welch	2.135	1	83.462	.148
	Brown-Forsythe	2.135	1	83.462	.148
UPSC3(r). Raised the international profile of researcher's own research	Welch	1.733	1	85.826	.192
	Brown-Forsythe	1.733	1	85.826	.192
UPSC4(r). Raised the international profile of funding sponsor	Welch	.020	1	79.691	.888
	Brown-Forsythe	.020	1	79.691	.888
UPSC5(r). Utilisation of project results at national level	Welch	.034	1	81.653	.853
	Brown-Forsythe	.034	1	81.653	.853

a Asymptotically F distributed.

Appendix 10: Independent Samples Test (Participants' Research Experience vs. Research Outputs)

		Levene's Test for Equality of Variances		*t-test for Equality of Means*						
		F	*Sig.*	*t*	*df*	*Sig. (2-tail.)*	*Mean Differ.*	*Std. Error Differ.*	*95% Confidence Interval of the Difference*	
									Lower	*Upper*
UPGS1(r). Joint publications	EVA	3.076	.080	-1.441	1839	.150	-.208	.144	-.491	.075
	EVNA			-1.324	75.887	.190	-.208	.157	-.521	.105
UPGS2(r). Publication of a book	EVA	1.063	.303	.430	1552	.667	.082	.191	-.293	.457
	EVNA			.453	68.005	.652	.082	.182	-.280	.444
UPGS3(r). Industrial applications	EVA	.667	.414	1.849	1385	.065	.267	.145	-.016	.551
	EVNA			1.991	64.205	.051	.267	.134	-.001	.536
UPGS4(r). Patents	EVA	4.045	.045	1.208	1138	.227	.177	.147	-.111	.465
	EVNA			1.037	47.754	.305	.177	.171	-.166	.521
UPGS5(r). Submission of proposal(s) for a project	EVA	3.128	.077	.929	1739	.353	.155	.167	-.172	.481
	EVNA			.973	68.415	.334	.155	.159	-.163	.472
UPGS6(r). Influence on policy issues	EVA	.042	.838	1.093	1726	.275	.156	.143	-.124	.436
	EVNA			1.024	62.743	.310	.156	.152	-.149	.461
UPSC1(r). International conference of high standard	EVA	.572	.449	-.664	1923	.506	-.076	.114	-.300	.148
	EVNA			-.614	76.855	.541	-.076	.124	-.322	.170
UPSC2(r). Raised the international profile of researcher's organisation	EVA	6.861	.009	1.183	1981	.237	.134	.114	-.088	.357
	EVNA			1.461	83.462	.148	.134	.092	-.049	.317
UPSC3(r). Raised the international profile of researcher's own research	EVA	7.014	.008	1.069	2003	.285	.117	.110	-.098	.332
	EVNA			1.316	85.826	.192	.117	.089	-.060	.294
UPSC4(r). Raised the international profile of funding sponsor	EVA	.011	.918	-.145	1961	.885	-.016	.110	-.232	.200
	EVNA			-.142	79.691	.888	-.016	.113	-.240	.208
UPSC5(r). Utilisation of project results at national level	EVA	1.231	.267	.167	1938	.867	.021	.124	-.222	.264
	EVNA			.186	81.653	.853	.021	.111	-.201	.243

EVA - Equal variances assumed, EVNA - Equal variances not assumed

Appendix 11: Applicant's most important reason for applying for FNR funding*Previous Experience of FNR Funding*Country Region (Classification 1)

Country of Work				*Previous FNR Experience*		*Total*
				Yes	*No*	
Eastern Europe	The most important reason to apply for network funding	To gain access to additional funding	Count	3	9	12
			% within Previous FNR Experience	21.4%	50.0%	37.5%
			% of Total	9.4%	28.1%	37.5%
		To meet peers through cross-border networking	Count	7	6	13
			% within Previous FNR Experience	50.0%	33.3%	40.6%
			% of Total	21.9%	18.8%	40.6%
		To enhance the chance of dissem. results	Count	4	3	7
			% within Previous FNR Experience	28.6%	16.7%	21.9%
			% of Total	12.5%	9.4%	21.9%
	Total		Count	14	18	32
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	43.8%	56.3%	100.0%
Western Europe	The most important reason to apply for network funding	To gain access to additional funding	Count	6	26	32
			% within Previous FNR Experience	14.3%	47.3%	33.0%
			% of Total	6.2%	26.8%	33.0%
		To meet peers through cross-border networking	Count	30	25	55
			% within Previous FNR Experience	71.4%	45.5%	56.7%
			% of Total	30.9%	25.8%	56.7%
		To enhance the chance of dissem. results	Count	6	4	10
			% within Previous FNR Experience	14.3%	7.3%	10.3%
			% of Total	6.2%	4.1%	10.3%
	Total		Count	42	55	97
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	43.3%	56.7%	100.0%
Northern	The most important	To gain access to additional funding	Count	3	17	20
			% within Previous FNR Experience	15.8%	34.7%	29.4%

Country of Work				*Previous FNR Experience*		*Total*
				Yes	*No*	
Europe	reason to		% of Total	4.4%	25.0%	29.4%
	apply for network funding	To meet peers through cross-border networking	Count	13	32	45
			% within Previous FNR Experience	68.4%	65.3%	66.2%
			% of Total	19.1%	47.1%	66.2%
		To enhance the chance of dissem. results	Count	3	0	3
			% within Previous FNR Experience	15.8%	.0%	4.4%
			% of Total	4.4%	.0%	4.4%
	Total		Count	19	49	68
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	27.9%	72.1%	100.0%
Southern Europe	The most important reason to apply for network funding	To gain access to additional funding	Count	4	17	21
			% within Previous FNR Experience	15.4%	26.6%	23.3%
			% of Total	4.4%	18.9%	23.3%
		To meet peers through cross-border networking	Count	18	39	57
			% within Previous FNR Experience	69.2%	60.9%	63.3%
			% of Total	20.0%	43.3%	63.3%
		To enhance the chance of dissem. results	Count	4	8	12
			% within Previous FNR Experience	15.4%	12.5%	13.3%
			% of Total	4.4%	8.9%	13.3%
	Total		Count	26	64	90
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	28.9%	71.1%	100.0%

Appendix 12: Applicant's most important reason for applying for FNR funding*Previous Experience of FNR Funding*Country Region * Previous FNR Experience * Applicant's Domain. Cross tabulation

Domain Applicants				*Previous FNR Experience*		*Total*
				Yes	*No*	
BMBS	The most important reason to apply for network funding	To gain access to additional funding	Count	0	10	10
			% within Previous FNR Experience	.0%	47.6%	32.3%
			% of Total	.0%	32.3%	32.3%
		To meet peers through cross-border networking	Count	8	11	19
			% within Previous FNR Experience	80.0%	52.4%	61.3%
			% of Total	25.8%	35.5%	61.3%
		To enhance the chance of dissem. results	Count	2	0	2
			% within Previous FNR Experience	20.0%	.0%	6.5%
			% of Total	6.5%	.0%	6.5%
	Total		Count	10	21	31
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	32.3%	67.7%	100.0%
CMST	The most important reason to apply for network funding	To gain access to additional funding	Count	1	2	3
			% within Previous FNR Experience	14.3%	25.0%	20.0%
			% of Total	6.7%	13.3%	20.0%
		To meet peers through cross-border networking	Count	5	6	11
			% within Previous FNR Experience	71.4%	75.0%	73.3%
			% of Total	33.3%	40.0%	73.3%
		To enhance the chance of dissem. results	Count	1	0	1
			% within Previous FNR Experience	14.3%	.0%	6.7%
			% of Total	6.7%	.0%	6.7%
	Total		Count	7	8	15
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	46.7%	53.3%	100.0%
ESSEM	The most important reason to apply for network funding	To gain access to additional funding	Count	2	9	11
			% within Previous FNR Experience	16.7%	33.3%	28.2%
			% of Total	5.1%	23.1%	28.2%
		To meet peers through cross-border networking	Count	10	16	26
			% within Previous FNR Experience	83.3%	59.3%	66.7%
			% of Total	25.6%	41.0%	66.7%
		To enhance the chance of dissem. results	Count	0	2	2
			% within Previous FNR Experience	.0%	7.4%	5.1%
			% of Total	.0%	5.1%	5.1%
	Total		Count	12	27	39
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	30.8%	69.2%	100.0%
FA	The most important	To gain access to additional funding	Count	3	7	10
			% within Previous FNR Experience	18.8%	28.0%	24.4%

Domain Applicants				*Previous FNR Experience*		*Total*
				Yes	*No*	
	reason to apply for network funding		% of Total	7.3%	17.1%	24.4%
		To meet peers through cross-border networking	Count	9	16	25
			% within Previous FNR Experience	56.3%	64.0%	61.0%
			% of Total	22.0%	39.0%	61.0%
		To enhance the chance of dissem. results	Count	4	2	6
			% within Previous FNR Experience	25.0%	8.0%	14.6%
			% of Total	9.8%	4.9%	14.6%
	Total		Count	16	25	41
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	39.0%	61.0%	100.0%
FPS	The most important reason to apply for network funding	To gain access to additional funding	Count	2	2	4
			% within Previous FNR Experience	14.3%	40.0%	21.1%
			% of Total	10.5%	10.5%	21.1%
		To meet peers through cross-border networking	Count	8	3	11
			% within Previous FNR Experience	57.1%	60.0%	57.9%
			% of Total	42.1%	15.8%	57.9%
		To enhance the chance of dissem. results	Count	4	0	4
			% within Previous FNR Experience	28.6%	.0%	21.1%
			% of Total	21.1%	.0%	21.1%
	Total		Count	14	5	19
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	73.7%	26.3%	100.0%
ICT	The most important reason to apply for network funding	To gain access to additional funding	Count	1	9	10
			% within Previous FNR Experience	14.3%	40.9%	34.5%
			% of Total	3.4%	31.0%	34.5%
		To meet peers through cross-border networking	Count	6	12	18
			% within Previous FNR Experience	85.7%	54.5%	62.1%
			% of Total	20.7%	41.4%	62.1%
		To enhance the chance of dissem. results	Count	0	1	1
			% within Previous FNR Experience	.0%	4.5%	3.4%
			% of Total	.0%	3.4%	3.4%
	Total		Count	7	22	29
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	24.1%	75.9%	100.0%
IE	The most important reason to apply for network funding	To gain access to additional funding	Count	2	1	3
			% within Previous FNR Experience	28.6%	16.7%	23.1%
			% of Total	15.4%	7.7%	23.1%
		To meet peers through cross-border networking	Count	4	4	8
			% within Previous FNR Experience	57.1%	66.7%	61.5%
			% of Total	30.8%	30.8%	61.5%
		To enhance the chance of dissem. results	Count	1	1	2
			% within Previous FNR Experience	14.3%	16.7%	15.4%
			% of Total	7.7%	7.7%	15.4%
	Total		Count	7	6	13
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	53.8%	46.2%	100.0%
ISCH	The most important reason to apply for network funding	To gain access to additional funding	Count	2	17	19
			% within Previous FNR Experience	16.7%	51.5%	42.2%
			% of Total	4.4%	37.8%	42.2%
		To meet peers through cross-border networking	Count	9	9	18
			% within Previous FNR Experience	75.0%	27.3%	40.0%
			% of Total	20.0%	20.0%	40.0%
		To enhance the chance of dissem. results	Count	1	7	8
			% within Previous FNR Experience	8.3%	21.2%	17.8%
			% of Total	2.2%	15.6%	17.8%
	Total		Count	12	33	45
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	26.7%	73.3%	100.0%
MPNS	The most important reason to apply for network funding	To gain access to additional funding	Count	5	12	17
			% within Previous FNR Experience	29.4%	41.4%	37.0%
			% of Total	10.9%	26.1%	37.0%
		To meet peers through cross-border networking	Count	9	16	25
			% within Previous FNR Experience	52.9%	55.2%	54.3%
			% of Total	19.6%	34.8%	54.3%
		To enhance the chance of dissem. results	Count	3	1	4
			% within Previous FNR Experience	17.6%	3.4%	8.7%
			% of Total	6.5%	2.2%	8.7%

Domain	*Applicants*			*Previous FNR Experience*		*Total*
				Yes	*No*	
	Total		Count	17	29	46
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	37.0%	63.0%	100.0%
TUD	The most important reason to apply for network funding	To gain access to additional funding	Count	1	2	3
			% within Previous FNR Experience	20.0%	14.3%	15.8%
			% of Total	5.3%	10.5%	15.8%
		To meet peers through cross-border networking	Count	2	11	13
			% within Previous FNR Experience	40.0%	78.6%	68.4%
			% of Total	10.5%	57.9%	68.4%
		To enhance the chance of dissem. results	Count	2	1	3
			% within Previous FNR Experience	40.0%	7.1%	15.8%
			% of Total	10.5%	5.3%	15.8%
	Total		Count	5	14	19
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	26.3%	73.7%	100.0%

Appendix 13: The most important reason to apply for network funding * Previous FNR Experience

Domain				*Previous FNR Experience*		*Total*
				Yes	*No*	
BMBS	The most important reason to apply for network funding	To gain access to additional funding	Count	0	10	10
			% within Previous FNR Experience	.0%	47.6%	32.3%
			% of Total	.0%	32.3%	32.3%
		To meet peers through cross-border networking	Count	8	11	19
			% within Previous FNR Experience	80.0%	52.4%	61.3%
			% of Total	25.8%	35.5%	61.3%
		To enhance the chance of dissem. results	Count	2	0	2
			% within Previous FNR Experience	20.0%	.0%	6.5%
			% of Total	6.5%	.0%	6.5%
	Total		Count	10	21	31
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	32.3%	67.7%	100.0%
CMST	The most important reason to apply for network funding	To gain access to additional funding	Count	1	2	3
			% within Previous FNR Experience	14.3%	25.0%	20.0%
			% of Total	6.7%	13.3%	20.0%
		To meet peers through cross-border networking	Count	5	6	11
			% within Previous FNR Experience	71.4%	75.0%	73.3%
			% of Total	33.3%	40.0%	73.3%
		To enhance the chance of dissem. results	Count	1	0	1
			% within Previous FNR Experience	14.3%	.0%	6.7%
			% of Total	6.7%	.0%	6.7%
	Total		Count	7	8	15
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	46.7%	53.3%	100.0%
ESSEM	The most important reason to apply for network funding	To gain access to additional funding	Count	2	9	11
			% within Previous FNR Experience	16.7%	33.3%	28.2%
			% of Total	5.1%	23.1%	28.2%
		To meet peers through cross-border networking	Count	10	16	26
			% within Previous FNR Experience	83.3%	59.3%	66.7%
			% of Total	25.6%	41.0%	66.7%
		To enhance the chance of dissem. results	Count	0	2	2
			% within Previous FNR Experience	.0%	7.4%	5.1%
			% of Total	.0%	5.1%	5.1%
	Total		Count	12	27	39
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	30.8%	69.2%	100.0%
FA	The most important reason to apply for network funding	To gain access to additional funding	Count	3	7	10
			% within Previous FNR Experience	18.8%	28.0%	24.4%
			% of Total	7.3%	17.1%	24.4%
		To meet peers through cross-border networking	Count	9	16	25
			% within Previous FNR Experience	56.3%	64.0%	61.0%
			% of Total	22.0%	39.0%	61.0%
		To enhance the chance of dissem. results	Count	4	2	6
			% within Previous FNR Experience	25.0%	8.0%	14.6%
			% of Total	9.8%	4.9%	14.6%
	Total		Count	16	25	41
			% within Previous FNR Experience	100.0%	100.0%	100.0%

Domain				*Previous FNR Experience*		*Total*
				Yes	*No*	
			% of Total	39.0%	61.0%	100.0%
FPS	The most important reason to apply for network funding	To gain access to additional funding	Count	2	2	4
			% within Previous FNR Experience	14.3%	40.0%	21.1%
			% of Total	10.5%	10.5%	21.1%
		To meet peers through cross-border networking	Count	8	3	11
			% within Previous FNR Experience	57.1%	60.0%	57.9%
			% of Total	42.1%	15.8%	57.9%
		To enhance the chance of dissem. results	Count	4	0	4
			% within Previous FNR Experience	28.6%	.0%	21.1%
			% of Total	21.1%	.0%	21.1%
	Total		Count	14	5	19
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	73.7%	26.3%	100.0%
ICT	The most important reason to apply for network funding	To gain access to additional funding	Count	1	9	10
			% within Previous FNR Experience	14.3%	40.9%	34.5%
			% of Total	3.4%	31.0%	34.5%
		To meet peers through cross-border networking	Count	6	12	18
			% within Previous FNR Experience	85.7%	54.5%	62.1%
			% of Total	20.7%	41.4%	62.1%
		To enhance the chance of dissem. results	Count	0	1	1
			% within Previous FNR Experience	.0%	4.5%	3.4%
			% of Total	.0%	3.4%	3.4%
	Total		Count	7	22	29
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	24.1%	75.9%	100.0%
IE	The most important reason to apply for network funding	To gain access to additional funding	Count	2	1	3
			% within Previous FNR Experience	28.6%	16.7%	23.1%
			% of Total	15.4%	7.7%	23.1%
		To meet peers through cross-border networking	Count	4	4	8
			% within Previous FNR Experience	57.1%	66.7%	61.5%
			% of Total	30.8%	30.8%	61.5%
		To enhance the chance of dissem. results	Count	1	1	2
			% within Previous FNR Experience	14.3%	16.7%	15.4%
			% of Total	7.7%	7.7%	15.4%
	Total		Count	7	6	13
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	53.8%	46.2%	100.0%
ISCH	The most important reason to apply for network funding	To gain access to additional funding	Count	2	17	19
			% within Previous FNR Experience	16.7%	51.5%	42.2%
			% of Total	4.4%	37.8%	42.2%
		To meet peers through cross-border networking	Count	9	9	18
			% within Previous FNR Experience	75.0%	27.3%	40.0%
			% of Total	20.0%	20.0%	40.0%
		To enhance the chance of dissem. results	Count	1	7	8
			% within Previous FNR Experience	8.3%	21.2%	17.8%
			% of Total	2.2%	15.6%	17.8%
	Total		Count	12	33	45
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	26.7%	73.3%	100.0%
MPNS	The most important reason to apply for network funding	To gain access to additional funding	Count	5	12	17
			% within Previous FNR Experience	29.4%	41.4%	37.0%
			% of Total	10.9%	26.1%	37.0%
		To meet peers through cross-border networking	Count	9	16	25
			% within Previous FNR Experience	52.9%	55.2%	54.3%
			% of Total	19.6%	34.8%	54.3%
		To enhance the chance of dissem. results	Count	3	1	4
			% within Previous FNR Experience	17.6%	3.4%	8.7%
			% of Total	6.5%	2.2%	8.7%
	Total		Count	17	29	46
			% within Previous FNR Experience	100.0%	100.0%	100.0%
			% of Total	37.0%	63.0%	100.0%
TUD	The most important reason to apply for network funding	To gain access to additional funding	Count	1	2	3
			% within Previous FNR Experience	20.0%	14.3%	15.8%
			% of Total	5.3%	10.5%	15.8%
		To meet peers through cross-border networking	Count	2	11	13
			% within Previous FNR Experience	40.0%	78.6%	68.4%
			% of Total	10.5%	57.9%	68.4%
		To enhance the	Count	2	1	3

Domain			Previous FNR Experience		Total
			Yes	No	
	chance of dissem. results	% within Previous FNR Experience	40.0%	7.1%	15.8%
		% of Total	10.5%	5.3%	15.8%
Total		Count	5	14	19
		% within Previous FNR Experience	100.0%	100.0%	100.0%
		% of Total	26.3%	73.7%	100.0%

Appendix 14: Descriptive Statistics, Interest in FNI Instruments (means) reported by Potential Participants

	N	Mean	Std. Deviation	Skewness	Std. Error
FNI1. Support for the preparation of meetings, etc.	297	8.63	1.814	-1.622	.141
FNI2. Short-term scientific missions (STSMs)	297	8.26	2.109	-1.459	.141
FNI3. Training schools (for dissemination)	297	6.87	2.446	-.572	.141
FNI4. General Action Support Grants (GASGs)	297	6.68	2.453	-.432	.141
FNI5. Annual Grants	297	7.08	2.440	-.711	.141
FNI6. Contributions to publications	297	6.95	2.601	-.630	.141
FNI7. Subsidies for support activities	297	7.06	2.313	-.700	.141
FNI8. Strategic workshops and/or large conferences	297	8.36	1.744	-1.473	.141
FNI9. Near Neighbours Scheme	297	7.57	2.270	-.894	.141
FNI10. Travel Reimbursements	297	8.37	1.941	-1.402	.141
Valid N (listwise)	297				

Appendix 15: Group Statistics, Interest in FNI Instruments vs. Research Experience, Potential Participants

	How would you describe yourself in regard to your research experience?	N	Mean	Std. Deviation	Std. Error Mean
FNI1. Support for the preparation of meetings, etc.	Senior researcher	276	8.63	1.783	.107
	Junior researcher	6	7.50	3.209	1.310
FNI2. Short-term scientific missions (STSMs)	Senior researcher	276	8.28	2.102	.127
	Junior researcher	6	8.00	2.608	1.065
FNI3. Training schools (for dissemination)	Senior researcher	276	6.89	2.449	.147
	Junior researcher	6	5.00	2.366	.966
FNI4. General Action Support Grants (GASGs)	Senior researcher	276	6.71	2.474	.149
	Junior researcher	6	5.17	1.169	.477
FNI5. Annual Grants	Senior researcher	276	7.09	2.457	.148
	Junior researcher	6	6.83	2.317	.946
FNI6. Contributions to publications	Senior researcher	276	6.92	2.606	.157
	Junior researcher	6	7.17	2.787	1.138
FNI7. Subsidies for support activities, etc.	Senior researcher	276	7.02	2.348	.141
	Junior researcher	6	7.17	1.169	.477
FNI8. Strategic workshops and/or large conferences	Senior researcher	276	8.38	1.719	.103
	Junior researcher	6	6.50	2.665	1.088
FNI9. Near Neighbours Scheme	Senior researcher	276	7.51	2.295	.138
	Junior researcher	6	7.00	2.098	.856
FNI10. Travel Reimbursements	Senior researcher	276	8.42	1.919	.116
	Junior researcher	6	7.00	3.225	1.317

Appendix 16: Robust Tests of Equality of Means (Interest in FNI Instruments vs. Research Experience), Potential Participants

		Statistic (a)	df1	df2	Sig.
FNI1. Support for the preparation of meetings, etc.	Welch	.735	1	5.067	.430
	Brown-Forsythe	.735	1	5.067	.430
FNI2. Short-term scientific missions (STSMs)	Welch	.068	1	5.142	.805
	Brown-Forsythe	.068	1	5.142	.805
FNI3. Training schools (for dissemination)	Welch	3.745	1	5.235	.108
	Brown-Forsythe	3.745	1	5.235	.108
FNI4. General Action Support Grants (GASGs)	Welch	9.531	1	6.020	.021
	Brown-Forsythe	9.531	1	6.020	.021
FNI5. Annual Grants	Welch	.072	1	5.248	.798
	Brown-Forsythe	.072	1	5.248	.798
FNI6. Contributions to publications	Welch	.047	1	5.192	.836
	Brown-Forsythe	.047	1	5.192	.836
FNI7. Subsidies for support activities, etc.	Welch	.085	1	5.914	.781
	Brown-Forsythe	.085	1	5.914	.781

		Statistic (a)	*df1*	*df2*	*Sig.*
FNI8. Strategic workshops and/or large conferences	Welch	2.950	1	5.091	.145
	Brown-Forsythe	2.950	1	5.091	.145
FNI9. Near Neighbours Scheme	Welch	.342	1	5.264	.583
	Brown-Forsythe	.342	1	5.264	.583
FNI10. Travel Reimbursements	Welch	1.149	1	5.077	.332
	Brown-Forsythe	1.149	1	5.077	.332

a Asymptotically F distributed.

Appendix 17: Interest in FNI Instruments vs. Professional Sector/Background, Potential Participants

Where would you place yourself according to your professional background?		*FNI1*	*FNI2*	*FNI3*	*FNI4.*	*FNI5*	*FNI6*	*FNI7*	*FNI8*	*FNI9*	*FNI10*
Academia	Mean	8.54	8.36	6.96	6.62	7.15	6.95	6.82	8.36	7.48	8.38
	N	201	201	201	201	201	201	201	201	201	201
	Std. Deviation	1.942	1.937	2.454	2.495	2.330	2.569	2.276	1.575	2.245	1.961
Research institute/ laboratory	Mean	8.96	8.18	6.66	6.54	7.07	6.85	7.50	8.34	7.59	8.56
	N	68	68	68	68	68	68	68	68	68	68
	Std. Deviation	1.239	2.473	2.398	2.482	2.678	2.856	2.428	2.113	2.481	1.832
Business or industry	Mean	8.40	7.00	7.00	7.80	6.80	6.40	7.80	8.20	8.10	8.20
	N	10	10	10	10	10	10	10	10	10	10
	Std. Deviation	2.221	2.539	2.539	2.098	2.440	2.011	2.616	2.098	1.912	1.549
Government	Mean	8.18	8.73	6.09	6.82	6.36	7.64	7.73	8.73	7.91	7.91
	N	11	11	11	11	11	11	11	11	11	11
	Std. Deviation	1.991	1.421	2.508	1.940	2.580	1.748	1.618	1.104	1.973	1.814
Total	Mean	8.62	8.29	6.86	6.65	7.09	6.93	7.04	8.36	7.54	8.40
	N	290	290	290	290	290	290	290	290	290	290
	Std. Deviation	1.815	2.087	2.441	2.461	2.421	2.592	2.319	1.714	2.277	1.909

Appendix 18: Robust Tests of Equality of Means (Interest in FNI Instruments vs. Professional Sector/Background), Potential Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
FNI1. Support for the preparation of meetings, etc.	Welch	1.654	3	24.112	.203
	Brown-Forsythe	1.067	3	29.733	.378
FNI2. Short-term scientific missions (STSMs)	Welch	1.241	3	24.667	.316
	Brown-Forsythe	1.478	3	39.093	.235
FNI3. Training schools (for dissemination)	Welch	.578	3	24.265	.635
	Brown-Forsythe	.604	3	41.488	.616
FNI4. General Action Support Grants (GASGs)	Welch	1.018	3	25.160	.401
	Brown-Forsythe	.997	3	57.318	.401
FNI5. Annual Grants	Welch	.367	3	24.115	.777
	Brown-Forsythe	.388	3	45.274	.762
FNI6. Contributions to publications	Welch	.799	3	25.745	.506
	Brown-Forsythe	.581	3	72.269	.629
FNI7. Subsidies for support activities	Welch	2.281	3	24.897	.104
	Brown-Forsythe	2.327	3	39.970	.089
FNI8. Strategic workshops and/or large conferences	Welch	.388	3	24.792	.763
	Brown-Forsythe	.185	3	39.728	.906
FNI9. Near Neighbours Scheme	Welch	.439	3	24.883	.727
	Brown-Forsythe	.403	3	58.530	.752
FNI10. Travel Reimbursements	Welch	.477	3	24.926	.701
	Brown-Forsythe	.526	3	50.003	.666

a Asymptotically F distributed.

Appendix 19: Interest in FNI Instruments vs. Previous FNR Experience, Potential Participants

Previous FNR Experience		*FNI1*	*FNI2*	*FNI3*	*FNI4*	*FNI5*	*FNI6*	*FNI7*	*FNI8*	*FNI9*	*FNI10*
Yes	Mean	8.88	8.41	7.17	7.00	6.75	7.46	7.30	8.61	7.70	8.71
	N	107	107	107	107	107	107	107	107	107	107
	Std. Deviation	1.426	2.004	2.405	2.311	2.664	2.526	2.348	1.583	2.348	1.833
No	Mean	8.48	8.17	6.71	6.50	7.27	6.66	6.92	8.23	7.49	8.18
	N	190	190	190	190	190	190	190	190	190	190
	Std. Deviation	1.989	2.166	2.460	2.517	2.290	2.605	2.288	1.819	2.227	1.979
Total	Mean	8.63	8.26	6.87	6.68	7.08	6.95	7.06	8.36	7.57	8.37
	N	297	297	297	297	297	297	297	297	297	297
	Std. Deviation	1.814	2.109	2.446	2.453	2.440	2.601	2.313	1.744	2.270	1.941

Appendix 20: Robust Tests of Equality of Means (Interest in FNI Instruments vs. Previous FNR Experience), Potential Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
FNI1. Support for the preparation of meetings, etc.	Welch	3.905	1	278.229	.049
	Brown-Forsythe	3.905	1	278.229	.049
FNI2. Short-term scientific missions (STSMs)	Welch	.947	1	234.385	.331
	Brown-Forsythe	.947	1	234.385	.331
FNI3. Training schools (for dissemination)	Welch	2.496	1	224.081	.116
	Brown-Forsythe	2.496	1	224.081	.116
FNI4. General Action Support Grants (GASGs)	Welch	3.003	1	235.917	.084
	Brown-Forsythe	3.003	1	235.917	.084
FNI5. Annual Grants	Welch	2.887	1	193.781	.091
	Brown-Forsythe	2.887	1	193.781	.091
FNI6. Contributions to publications	Welch	6.624	1	225.571	.011
	Brown-Forsythe	6.624	1	225.571	.011
FNI7. Subsidies for support activities	Welch	1.807	1	215.200	.180
	Brown-Forsythe	1.807	1	215.200	.180
FNI8. Strategic workshops and/or large conferences	Welch	3.559	1	245.999	.060
	Brown-Forsythe	3.559	1	245.999	.060
FNI9. Near Neighbours Scheme,	Welch	.576	1	210.337	.449
	Brown-Forsythe	.576	1	210.337	.449
FNI10. Travel Reimbursements	Welch	5.321	1	234.312	.022
	Brown-Forsythe	5.321	1	234.312	.022

a Asymptotically F distributed.

Appendix 21: Comparison of Means (Interest in FNI Instruments and European regions), Potential Participants

Country of Work		*FNI1*	*FNI2*	*FNI3*	*FNI4*	*FNI5*	*FNI6*	*FNI7*	*FNI8*	*FNI9*	*FNI10*
Eastern Europe	Mean	8.78	8.53	7.09	7.13	7.03	7.69	7.25	8.81	7.69	8.41
	N	32	32	32	32	32	32	32	32	32	32
	Std. Deviation	1.680	2.170	2.644	2.433	2.753	2.520	2.476	1.469	2.416	1.998
Western Europe	Mean	8.80	7.87	6.82	6.71	6.75	6.97	7.18	8.30	7.30	8.65
	N	97	97	97	97	97	97	97	97	97	97
	Std. Deviation	1.783	2.344	2.450	2.504	2.450	2.616	2.381	1.996	2.429	1.633
Northern Europe	Mean	8.76	8.13	6.35	6.35	6.93	6.79	7.13	8.25	7.22	8.25
	N	68	68	68	68	68	68	68	68	68	68
	Std. Deviation	1.658	2.205	2.619	2.460	2.628	2.837	2.362	1.799	2.317	2.003
Southern Europe	Mean	8.31	8.64	7.36	6.76	7.53	6.64	6.88	8.40	8.17	8.20
	N	90	90	90	90	90	90	90	90	90	90
	Std. Deviation	2.026	1.711	2.205	2.437	2.147	2.451	2.124	1.512	1.886	2.121
Total	Mean	8.64	8.25	6.91	6.69	7.07	6.91	7.08	8.38	7.60	8.39
	N	287	287	287	287	287	287	287	287	287	287
	Std. Deviation	1.829	2.125	2.456	2.462	2.448	2.614	2.302	1.751	2.268	1.925

Appendix 22: Robust Tests of Equality of Means (Interest in FNI Instruments and European regions), Potential Participants

		Statistic(a)	*df1*	*df2*	*Sig.*
FNI1. Support for the preparation of meetings, etc.	Welch	1.231	3	116.005	.302
	Brown-Forsythe	1.474	3	224.810	.222
FNI2. Short-term scientific missions (STSMs)	Welch	2.524	3	111.164	.061
	Brown-Forsythe	2.347	3	192.337	.074
FNI3. Training schools (for dissemination)	Welch	2.281	3	110.849	.083
	Brown-Forsythe	2.173	3	181.027	.093
FNI4. General Action Support Grants (GASGs)	Welch	.781	3	113.963	.507
	Brown-Forsythe	.785	3	207.889	.504
FNI5. Annual Grants	Welch	1.949	3	109.856	.126
	Brown-Forsythe	1.596	3	170.069	.192
FNI6. Contributions to publications	Welch	1.405	3	113.499	.245
	Brown-Forsythe	1.318	3	209.384	.269
FNI7. Subsidies for support activities	Welch	.376	3	111.666	.771
	Brown-Forsythe	.343	3	184.926	.795
FNI8. Strategic workshops and/or large conferences	Welch	1.069	3	117.090	.365
	Brown-Forsythe	.908	3	238.467	.438
FNI9. Near Neighbours Scheme	Welch	3.641	3	110.785	.015
	Brown-Forsythe	3.054	3	181.804	.030
FNI10. Travel Reimbursements	Welch	1.108	3	110.773	.349
	Brown-Forsythe	.970	3	191.733	.408

Appendix 23: ANOVA test results (Research Domain vs. UPGS outputs), Current Participants

			Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
UPGS1(r). Joint publications in high ranked scientific journals (peer review) * Domain	Between Groups	(Combined)	71.621	9	7.958	5.636	.000
	Within Groups		2740.796	1941	1.412		
	Total		2812.416	1950			
UPGS2(r). Publication of a book * Domain	Between Groups	(Combined)	295.033	9	32.781	16.094	.000
	Within Groups		3344.538	1642	2.037		
	Total		3639.571	1651			
UPGS3(r). Industrial applications * Domain	Between Groups	(Combined)	82.139	9	9.127	7.979	.000
	Within Groups		1688.187	1476	1.144		
	Total		1770.326	1485			
UPGS4(r). Patents * Domain	Between Groups	(Combined)	13.887	9	1.543	1.615	.106
	Within Groups		1146.890	1200	.956		
	Total		1160.778	1209			
UPGS5(r). Submission of proposal(s) for a new EU-funded project * Domain	Between Groups	(Combined)	51.169	9	5.685	3.368	.000
	Within Groups		3101.424	1837	1.688		
	Total		3152.593	1846			
UPGS6(r). Influence on policy issues (at European level and/or country level) * Domain	Between Groups	(Combined)	61.418	9	6.824	5.890	.000
	Within Groups		2129.437	1838	1.159		
	Total		2190.855	1847			

Appendix 24: ANOVA test results (Research Domain vs. UPSC outputs), Current Participants

			Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
UPSC1(r). International conference of high standard * Domain	Between Groups	(Combined)	25.794	9	2.866	3.124	.001
	Within Groups		1865.932	2034	.917		
	Total		1891.726	2043			
UPSC2(r). Raised the international profile of researcher's organisation * Domain	Between Groups	(Combined)	50.987	9	5.665	6.230	.000
	Within Groups		1909.703	2100	.909		
	Total		1960.690	2109			
UPSC3(r). Raised the international profile of researcher's own research * Domain	Between Groups	(Combined)	19.401	9	2.156	2.435	.009
	Within Groups		1864.359	2106	.885		
	Total		1883.760	2115			
UPSC4(r). Raised the international profile of funding sponsor * Domain	Between Groups	(Combined)	40.027	9	4.447	5.126	.000
	Within Groups		1805.427	2081	.868		
	Total		1845.455	2090			
UPSC5(r). Utilisation of project results at national level * Domain	Between Groups	(Combined)	58.012	9	6.446	5.942	.000
	Within Groups		2231.278	2057	1.085		
	Total		2289.290	2066			

a The grouping variable Domain is a string, so the test for linearity cannot be computed

Appendix 25: Means and Means differences between the scores reported by Experts (two groups) and Actual FNR Projects Participants

		UPGS1	UPGS2	UPGS3	UPGS4	UPGS5	UPGS6	UPSC1	UPSC2	UPSC3	UPSC4	UPSC5
Experts Y	Mean	3.64	3.77	2.73	2.18	3.57	2.77	4.00	3.84	4.05	4.23	3.61
	Median	4	4	3	2	4	3	4	4	4	4	4
	Std. Deviation	0.69	0.84	0.78	0.60	0.90	0.86	0.68	0.81	0.71	0.64	0.81
	Variance	0.47	0.71	0.60	0.36	0.81	0.74	0.47	0.65	0.51	0.41	0.66
Experts N	Mean	3.32	3.36	2.51	2.35	3.51	3.01	3.72	3.50	3.55	3.71	3.09
	Median	3	3	2	2	4	3	4	4	4	4	3
	Std. Deviation	0.76	0.77	0.84	0.78	0.76	0.72	0.83	0.82	0.80	0.82	0.74
	Variance	0.57	0.59	0.71	0.60	0.58	0.52	0.68	0.67	0.63	0.68	0.55
Participants	Mean	2.73	2.06	1.53	0.93	2.40	2.21	3.53	3.36	3.51	3.48	3.07
	Median	3	2	1	1	3	2	4	3	4	4	3
	Std. Deviation	1.46	1.74	1.38	1.11	1.57	1.37	1.29	1.11	1.10	1.15	1.24
	Variance	2.14	3.02	1.91	1.22	2.47	1.87	1.66	1.24	1.20	1.33	1.54
Means Differences	Diff between Experts(Y) and Experts(N)	0.32	0.41	0.22	-0.17	0.06	-0.24	0.28	0.34	0.50	0.52	0.52
	Difference in Means between Experts(Y) and Actual Participants	0.91	1.71	1.20	1.25	1.17	0.56	0.47	0.48	0.54	0.75	0.54
	Differences in Means between Experts(N) and Actual Participants	0.59	1.30	0.98	1.42	1.11	0.80	0.19	0.14	0.04	0.23	0.02

Appendix 26: Percentages of Current Participants who achieved UPGS and UPSC results greatly (fully or to a great extent), in part or reported these results as not applicable

Abbr.	*FNR outputs*	*Achieved Greatly*	*Achieved at least in part*	*Only in Part*	*Result does not apply*
		Fully + To a great extent	*In part + to a great extent + fully*	*In part*	*Not applicable*
UPGS1	Joint publications	33.9	62.2	28.3	10.2
UPGS2	Publication of a book	26.1	41.1	15	24
UPGS3	Industrial applications	8.7	28.2	19.5	31.6
UPGS4	Patents	3.4	11.6	8.2	44.3
UPGS5	Submission of proposal(s) for a new EU-funded project	29.4	53.2	23.8	15
UPGS6	Influence on policy issues	17	47.3	30.3	15
UPSC1	International conference of high standard	62	85.3	23.3	5.9
UPSC2	Raised the international profile of researcher's organisation	49.2	83	33.8	2.9
UPSC3	Raised the international profile of participant's own research	55.9	86	30.1	2.6
UPSC4	Raised the international profile of the funding sponsor	56.9	85.4	28.5	3.8
UPSC5	Utilisation of project results at national level	38.8	73.9	35.1	4.9

Appendix 27: Domains with highest reported results on patents, industrial applications, and utilisation of results on national level (Cumulative percent of *fully* and *to a great extent* responses)

Domain	*Patents*	*Industrial Applications*	*Utilisation of results*
	Fully + To a great extent (Cumulative Percent)	*Fully + To a great extent (Cumulative Percent)*	*Fully + To a great extent (Cumulative Percent)*
BMBS	4.5	10.3	36.1
CMST	1.7	4.7	29.9
ESSEM	2.8	4.6	41.7
FA	3.9	8.9	46.9
FPS	5.0	10.4	47.1
ICT	2.5	12.3	33.6
ISCH	1.4	1.4	27.0
MPNS	4.7	14.0	37.3
TUD	4.5	12.2	42.1

Appendix 28: FNR outputs (the highest and the lowest results) as achieved by different professional sectors as a result of their involvement in FNR projects

	FNR Outputs	*The highest results*	*The lowest results*
UPGS1	Joint publications in high-ranked scientific journals (peer review)	Academia, Research Institutes/Labs,	Business/Industry,
UPGS2	Publication of a book	Government, Research Institutes/Labs,	Business/Industry,
UPGS3	Industrial applications	Business/Industry,	Academia
UPGS4	*Patents*	*Business/Industry, Research Institutes/Labs,*	*Academia, Government*
UPGS5	Submission of proposal(s) for a new EU-funded project	Academia, Research Institutes/Labs,	Government, Business/Industry
UPGS6	*Influence on policy issues (at European level and/or country level)*	*Research Institutes/Labs,*	*All the rest*
UPSC1	International conference of high standard	Government, Research Institutes/Labs, Academia	Business/Industry
UPSC2	Raised the international profile of participant's organisation	Academia, Research Institutes/Labs,	Business/Industry, Government
UPSC3	Raised the international profile of participant's own research	Academia, Research Institutes/Labs,	Business/Industry,
UPSC4	*Raised the international profile of the funding sponsor*	*Academia, Research Institutes/Labs, Business/Industry, Government*	
UPSC5	Utilisation of project results at national level	Research Institutes/Labs,	All the rest

No statistically significant differences between professional sectors have been found for variables UPGS4, UPGS6 and UPSC4 (*text in italicised font)*

Appendix 29: UPGS Outputs (Current Participants). Controlling for Professional Sector/Background

CV6. Professional Background		*UPGS1. Joint publications*	*UPGS2. Publication of a book*	*UPGS3. Industrial applications*	*UPGS4. Patents*	*UPGS5. Submission of proposal(s) for a new project*	*UPGS6. Influence on policy issues*
Academia	Mean	2.79	1.98	1.44	.92	2.39	2.18
	N	1384	1384	1384	1384	1384	1384
	Std. Deviation	1.457	1.722	1.361	1.087	1.585	1.380
Other Research	Mean	2.68	2.23	1.65	.96	2.57	2.30
	N	551	551	551	551	551	551
	Std. Deviation	1.450	1.754	1.369	1.122	1.512	1.327
Business Industry	Mean	2.18	1.88	2.13	.97	2.06	2.17
	N	88	88	88	88	88	88
	Std. Deviation	1.580	1.780	1.492	1.159	1.670	1.375
Government	Mean	2.59	2.28	1.64	.92	2.01	2.17
	N	123	123	123	123	123	123
	Std. Deviation	1.407	1.733	1.409	1.164	1.539	1.383
Total	Mean	2.73	2.06	1.53	.93	2.40	2.21
	N	2146	2146	2146	2146	2146	2146
	Std. Deviation	1.463	1.737	1.379	1.103	1.573	1.367

Appendix 30: FNR Productivity Regression Model Summary, Controlling for Domain (Current Participants)

Domain	*Model*	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
BMBS	1	.364(a)	.133	.091	8.935
CMST	1	.241(b)	.058	.041	8.028
ESSEM	1	.290(c)	.084	.053	8.493
FA	1	.379(d)	.143	.126	8.624
FPS	1	.278(e)	.077	.050	8.433
ICT	1	.470(f)	.221	.173	6.927
IE	*1*	*.568(g)*	*.322*	*-.205*	*9.190*
ISCH	1	.523(h)	.273	.235	7.774
MPNS	1	.372(i)	.139	.118	9.016
TUD	1	.299(j)	.090	.060	9.050

a Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV4. Doctoral Degree, CV6. Professional Background, LIP_FNR. Number of Years in FNR Projects, CV2. Country of Work (CL1:E/W/O), CV5. Research Experience

b Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV5. Research Experience, CV4. Doctoral Degree, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, CV2. Country of Work (CL1:E/W/O), LIP_FNR. Number of Years in FNR Projects

c Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV6. Professional Background, CV3. Country of Work (CL2: EU/Non-EU), CV2. Country of Work (CL1:E/W/O), CV5. Research Experience, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree

d Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, CV5. Research Experience, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV2. Country of Work (CL1:E/W/O)

e Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV3. Country of Work (CL2: EU/Non-EU), LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV6. Professional Background

f Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV2. Country of Work (CL1:E/W/O), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, CV4. Doctoral Degree, LIP_FNR. Number of Years in FNR Projects

g Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV6. Professional Background, CV3. Country of Work (CL2: EU/Non-EU), LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree

h Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV2. Country of Work (CL1:E/W/O), CV5. Research Experience

i Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV6. Professional Background

j Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, LIP_FNR. Number of Years in FNR Projects, CV3. Country of Work (CL2: EU/Non-EU), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, CV6. Professional Background

Appendix 31: ANOVA (k), FNR Productivity Regression Model, Controlling for Domain (Current Participants)

Domain		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
BMBS	Regression	1792.998	7	256.143	3.208	.003(a)
	Residual	11736.589	147	79.841		
	Total	13529.587	154			
CMST	Regression	1557.519	7	222.503	3.452	.001(b)
	Residual	25329.498	393	64.452		
	Total	26887.017	400			
ESSEM	Regression	1375.970	7	196.567	2.725	.010(c)
	Residual	15004.581	208	72.137		
	Total	16380.551	215			
FA	Regression	4378.741	7	625.534	8.411	.000(d)
	Residual	26179.914	352	74.375		
	Total	30558.656	359			
FPS	Regression	1384.281	7	197.754	2.781	.009(e)
	Residual	16497.015	232	71.108		
	Total	17881.296	239			
ICT	Regression	1551.880	7	221.697	4.620	.000(f)
	Residual	5470.128	114	47.984		
	Total	7022.008	121			
IE	Regression	361.699	7	51.671	.612	.735(g)
	Residual	760.066	9	84.452		
	Total	1121.765	16			
ISCH	Regression	3023.941	7	431.992	7.149	.000(h)
	Residual	8036.995	133	60.429		
	Total	11060.936	140			
MPNS	Regression	3823.636	7	546.234	6.720	.000(i)
	Residual	23734.400	292	81.282		
	Total	27558.037	299			
TUD	Regression	1717.659	7	245.380	2.996	.005(j)
	Residual	17444.630	213	81.900		
	Total	19162.290	220			

a Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV4. Doctoral Degree, CV6. Professional Background, LIP_FNR. Number of Years in FNR Projects, CV2. Country of Work (CL1:E/W/O), CV5. Research Experience

b Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV5. Research Experience, CV4. Doctoral Degree, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, CV2. Country of Work (CL1:E/W/O), LIP_FNR. Number of Years in FNR Projects

c Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV6. Professional Background, CV3. Country of Work (CL2: EU/Non-EU), CV2. Country of Work (CL1:E/W/O), CV5. Research Experience, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree

d Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, CV5. Research Experience, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV2. Country of Work (CL1:E/W/O)

e Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV3. Country of Work (CL2: EU/Non-EU), LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV6. Professional Background

f Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV2. Country of Work (CL1:E/W/O), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, CV4. Doctoral Degree, LIP_FNR. Number of Years in FNR Projects

g Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV6. Professional Background, CV3. Country of Work (CL2: EU/Non-EU), LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree

h Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV6. Professional Background, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV2. Country of Work (CL1:E/W/O), CV5. Research Experience

i Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, CV3. Country of Work (CL2: EU/Non-EU), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree, CV6. Professional Background

j Predictors: (Constant), ISP_FNR. Involvement in More than 1 FNR Project, LIP_FNR. Number of Years in FNR Projects, CV3. Country of Work (CL2: EU/Non-EU), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, CV6. Professional Background

k Dependent Variable: FNR Productivity Score

Appendix 32: FNR Productivity Regression Model Coefficients (a). Controlling for Domain (Current Participants)

Domain		*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
BMBS	(Constant)	32.526	10.813		3.008	.003
	CV2. Country of Work (CL1:E/W/O)	-.072	.579	-.010	-.125	.901
	CV3. Country of Work (CL2: EU/Non-EU)	.145	.555	.021	.262	.794
	CV4. Doctoral Degree	-6.779	5.478	-.100	-1.238	.218
	CV5. Research Experience	-1.238	1.728	-.060	-.716	.475
	CV6. Professional Background	.131	.969	.011	.135	.893
	LIP_FNR. Number of Years in FNR Projects	2.553	.749	.275	3.407	.001
	ISP_FNR. Involvement in More than 1 FNR Project	4.127	2.096	.160	1.969	.051
CMST	(Constant)	25.565	5.147		4.967	.000
	CV2. Country of Work (CL1:E/W/O)	-.344	.366	-.047	-.940	.348
	CV3. Country of Work (CL2: EU/Non-EU)	.105	.332	.016	.316	.752
	CV4. Doctoral Degree	-2.627	2.157	-.061	-1.218	.224
	CV5. Research Experience	-.228	.983	-.012	-.232	.817
	CV6. Professional Background	.063	.664	.005	.095	.924
	LIP_FNR. Number of Years in FNR Projects	1.299	.394	.166	3.297	.001
	ISP_FNR. Involvement in More than 1 FNR Project	2.498	.977	.130	2.557	.011
ESSEM	(Constant)	20.007	4.191		4.774	.000
	CV2. Country of Work (CL1:E/W/O)	-.097	.472	-.014	-.205	.838
	CV3. Country of Work (CL2: EU/Non-EU)	.623	.398	.106	1.568	.118
	CV4. Doctoral Degree	.738	1.691	.033	.437	.663
	CV5. Research Experience	-1.140	1.342	-.065	-.849	.397
	CV6. Professional Background	-.186	.590	-.023	-.314	.753
	LIP_FNR. Number of Years in FNR Projects	1.840	.609	.222	3.020	.003
	ISP_FNR. Involvement in More than 1 FNR Project	2.077	1.515	.098	1.370	.172
FA	(Constant)	16.610	4.590		3.619	.000
	CV2. Country of Work (CL1:E/W/O)	.056	.377	.008	.149	.882
	CV3. Country of Work (CL2: EU/Non-EU)	.482	.311	.081	1.550	.122
	CV4. Doctoral Degree	1.095	1.890	.030	.580	.563
	CV5. Research Experience	.308	1.123	.014	.274	.784
	CV6. Professional Background	-.977	.489	-.101	-1.999	.046
	LIP_FNR. Number of Years in FNR Projects	2.539	.394	.327	6.446	.000
	ISP_FNR. Involvement in More than 1 FNR Project	2.760	1.095	.127	2.520	.012
FPS	(Constant)	23.823	4.431		5.377	.000
	CV2. Country of Work (CL1:E/W/O)	.221	.533	.026	.414	.679
	CV3. Country of Work (CL2: EU/Non-EU)	.707	.453	.102	1.560	.120
	CV4. Doctoral Degree	2.439	1.457	.116	1.674	.095
	CV5. Research Experience	-2.491	1.070	-.157	-2.328	.021
	CV6. Professional Background	-.542	.679	-.056	-.798	.426
	LIP_FNR. Number of Years in FNR Projects	1.369	.530	.171	2.582	.010
	ISP_FNR. Involvement in More than 1 FNR Project	1.242	1.145	.071	1.084	.279
ICT	(Constant)	14.292	5.306		2.694	.008
	CV2. Country of Work (CL1:E/W/O)	-.088	.609	-.012	-.145	.885
	CV3. Country of Work (CL2: EU/Non-EU)	-.555	.511	-.092	-1.086	.280
	CV4. Doctoral Degree	1.050	2.068	.044	.507	.613
	CV5. Research Experience	2.240	1.429	.136	1.567	.120
	CV6. Professional Background	-.571	.810	-.062	-.706	.482
	LIP_FNR. Number of Years in FNR Projects	2.082	.574	.318	3.628	.000
	ISP_FNR. Involvement in More than 1 FNR Project	3.677	1.504	.211	2.445	.016
IE	(Constant)	7.805	21.853		.357	.729
	CV2. Country of Work (CL1:E/W/O)	.292	1.794	.047	.163	.874
	CV3. Country of Work (CL2: EU/Non-EU)	1.099	1.874	.194	.586	.572
	CV4. Doctoral Degree	1.670	9.065	.087	.184	.858
	CV5. Research Experience	6.318	13.217	.183	.478	.644
	CV6. Professional Background	-1.303	3.020	-.181	-.432	.676
	LIP_FNR. Number of Years in FNR Projects	1.148	4.965	.094	.231	.822
	ISP_FNR. Involvement in More than 1 FNR Project	4.543	8.410	.180	.540	.602

Domain		*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
ISCH	(Constant)	13.432	5.790		2.320	.022
	CV2. Country of Work (CL1:E/W/O)	-.677	.537	-.104	-1.260	.210
	CV3. Country of Work (CL2: EU/Non-EU)	.311	.445	.057	.700	.485
	CV4. Doctoral Degree	.348	2.231	.013	.156	.876
	CV5. Research Experience	.191	1.419	.012	.135	.893
	CV6. Professional Background	-.971	.820	-.101	-1.184	.239
	LIP_FNR. Number of Years in FNR Projects	4.901	.736	.506	6.660	.000
	ISP_FNR. Involvement in More than 1 FNR Project	1.312	2.213	.046	.593	.554
MPNS	(Constant)	10.726	5.346		2.006	.046
	CV2. Country of Work (CL1:E/W/O)	-.595	.419	-.078	-1.419	.157
	CV3. Country of Work (CL2: EU/Non-EU)	.831	.393	.116	2.116	.035
	CV4. Doctoral Degree	4.650	2.013	.137	2.310	.022
	CV5. Research Experience	-1.078	1.227	-.052	-.879	.380
	CV6. Professional Background	1.469	.803	.112	1.828	.069
	LIP_FNR. Number of Years in FNR Projects	2.364	.476	.276	4.961	.000
	ISP_FNR. Involvement in More than 1 FNR Project	1.567	1.399	.063	1.120	.263
TUD	(Constant)	15.039	4.355		3.454	.001
	CV2. Country of Work (CL1:E/W/O)	.624	.540	.078	1.155	.249
	CV3. Country of Work (CL2: EU/Non-EU)	.073	.442	.011	.166	.868
	CV4. Doctoral Degree	2.355	1.451	.122	1.623	.106
	CV5. Research Experience	-1.011	1.041	-.079	-.972	.332
	CV6. Professional Background	.428	.691	.049	.620	.536
	LIP_FNR. Number of Years in FNR Projects	1.558	.537	.200	2.902	.004
	ISP_FNR. Involvement in More than 1 FNR Project	4.122	1.620	.174	2.544	.012

a Dependent Variable: FNR Productivity Score

Appendix 33: FNR Productivity Regression Model Summary, Controlling for Professional Sector/Background (Current Participants)

CV6. Professional Background	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
Academia	.334(a)	.111	.107	8.503
Other Research	.379(b)	.144	.133	8.428
Business&Industry	.454(c)	.206	.137	8.774
Government	.312(d)	.097	.042	8.352
Other	.711(e)	.505	.323	8.076

a Predictors: (Constant), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), ISP_FNR. Involvement in More than 1 FNR Project, CV1. Research Domain, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, LIP_FNR. Number of Years in FNR Projects

b Predictors: (Constant), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV3. Country of Work (CL2: EU/Non-EU), CV1. Research Domain, ISP_FNR. Involvement in More than 1 FNR Project, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree

c Predictors: (Constant), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), LIP_FNR. Number of Years in FNR Projects, CV2. Country of Work (CL1:E/W/O), CV1. Research Domain, ISP_FNR. Involvement in More than 1 FNR Project, CV4. Doctoral Degree

d Predictors: (Constant), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), ISP_FNR. Involvement in More than 1 FNR Project, LIP_FNR. Number of Years in FNR Projects, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, CV1. Research Domain

e Predictors: (Constant), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, LIP_FNR. Number of Years in FNR Projects, CV1. Research Domain, CV3. Country of Work (CL2: EU/Non-EU), ISP_FNR. Involvement in More than 1 FNR Projects

Appendix 34: ANOVA (f), FNR Productivity Regression Model, Controlling for Professional Sector/Background (Current Participants)

CV6. Professional Background		*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Academia	Regression	12480.357	7	1782.908	24.658	.000(a)
	Residual	99494.241	1376	72.307		
	Total	111974.598	1383			
Other research	Regression	6476.710	7	925.244	13.027	.000(b)
	Residual	38566.909	543	71.026		
	Total	45043.619	550			
Business Industry	Regression	1598.409	7	228.344	2.966	.008(c)
	Residual	6158.682	80	76.984		
	Total	7757.091	87			
Government	Regression	865.879	7	123.697	1.773	.099(d)
	Residual	8021.747	115	69.754		
	Total	8887.626	122			
Other	Regression	1266.313	7	180.902	2.774	.036(e)
	Residual	1239.094	19	65.215		
	Total	2505.407	26			

a Predictors: (Constant), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), ISP_FNR. Involvement in More than 1 FNR Project, CV1. Research Domain, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, LIP_FNR. Number of Years in FNR Projects

b Predictors: (Constant), CV5. Research Experience, CV2. Country of Work (CL1:E/W/O), CV3. Country of Work (CL2: EU/Non-EU), CV1. Research Domain, ISP_FNR. Involvement in More than 1 FNR Project, LIP_FNR. Number of Years in FNR Projects, CV4. Doctoral Degree

c Predictors: (Constant), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), LIP_FNR. Number of Years in FNR Projects, CV2. Country of Work (CL1:E/W/O), CV1. Research Domain, ISP_FNR. Involvement in More than 1 FNR Project, CV4. Doctoral Degree

d Predictors: (Constant), CV5. Research Experience, CV3. Country of Work (CL2: EU/Non-EU), ISP_FNR. Involvement in More than 1 FNR Project, LIP_FNR. Number of Years in FNR Projects, CV2. Country of Work (CL1:E/W/O), CV4. Doctoral Degree, CV1. Research Domain

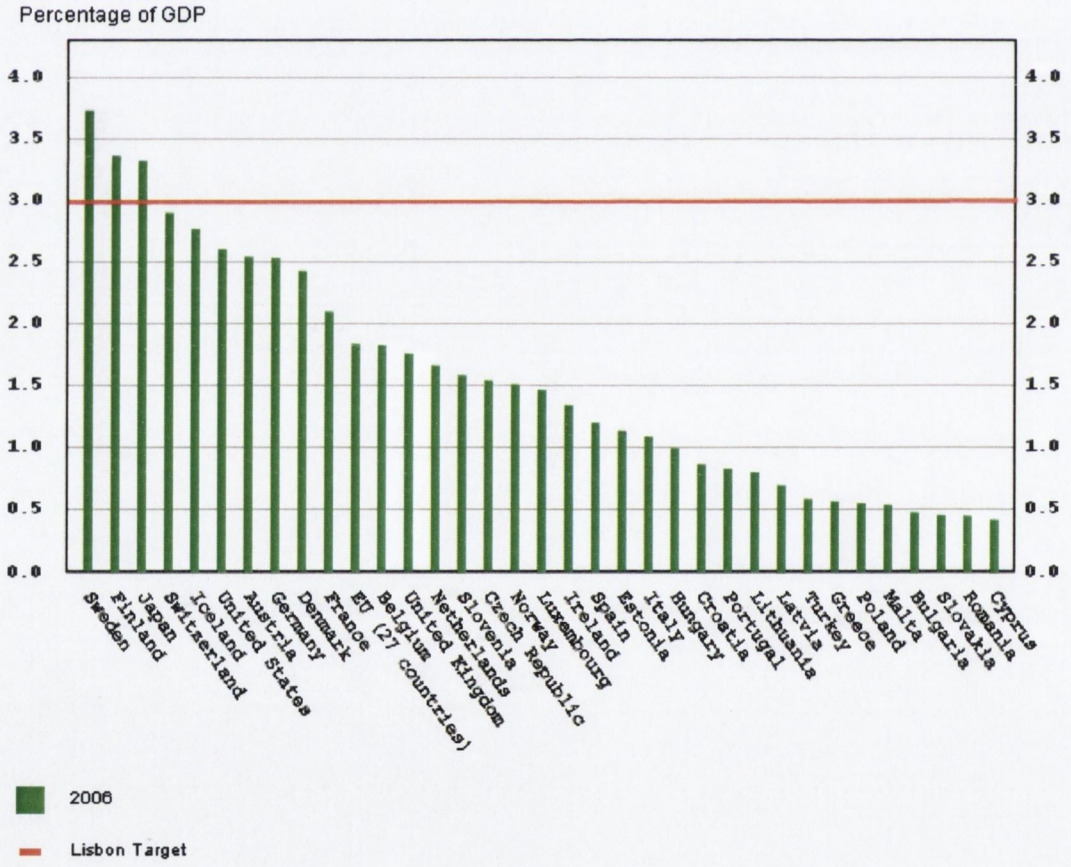
Appendix 35: FNR Productivity Regression Model Coefficients (a), Controlling for Professional Sector/Background (Current Participants)

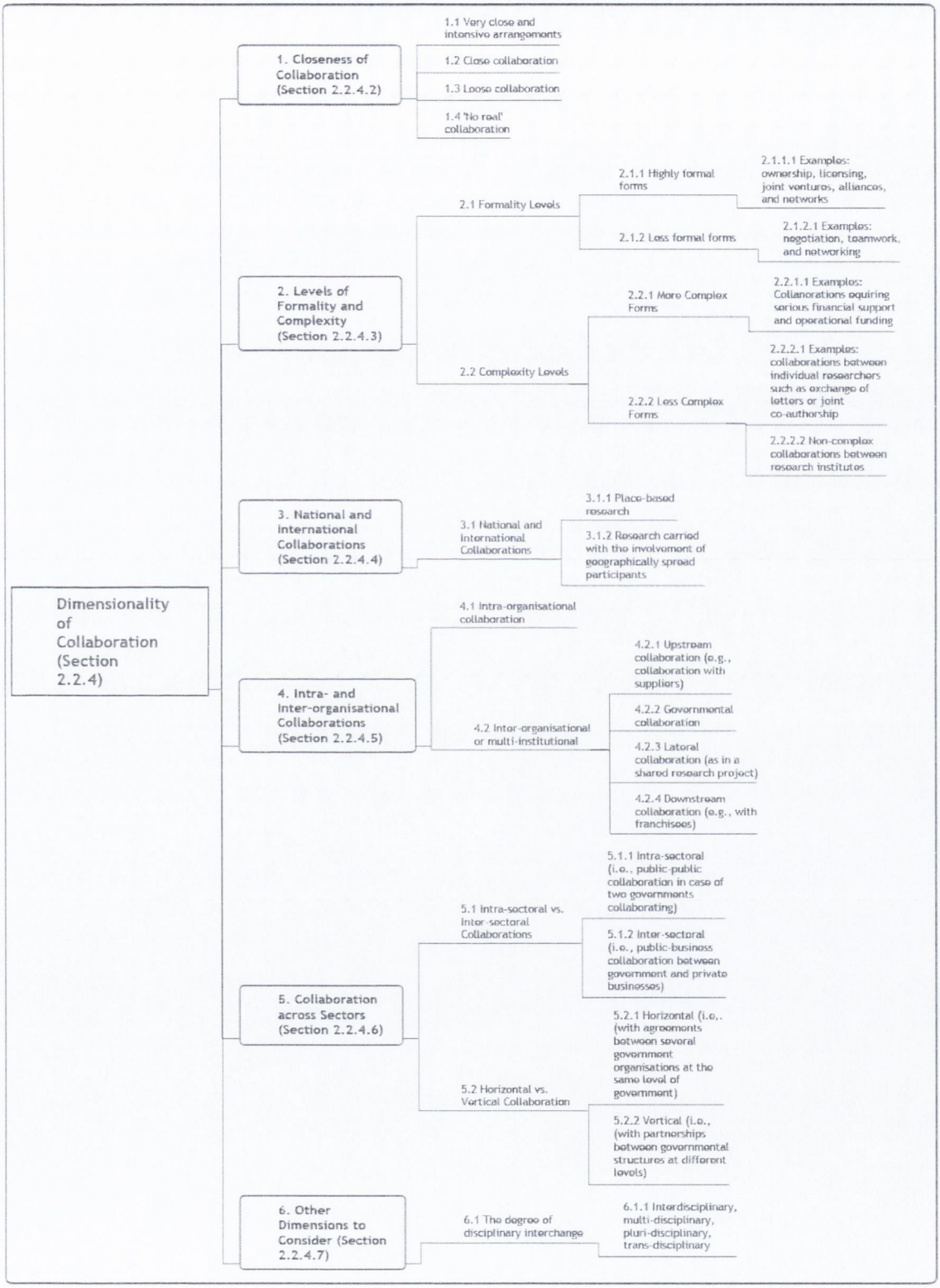
CV6. Professional Background		*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
Academia	(Constant)	21.986	2.361		9.310	.000
	ISP_FNR. Involvement in More than 1 FNR Project	3.536	.560	.166	6.317	.000
	CV1. Research Domain	.177	.078	.060	2.280	.023
	CV2. Country of Work (CL1:E/W/O)	-.303	.185	-.042	-1.639	.101
	CV3. Country of Work (CL2: EU/Non-EU)	.409	.166	.064	2.463	.014
	CV4. Doctoral Degree	-1.571	1.053	-.040	-1.492	.136
	LIP_FNR. Number of Years in FNR Projects	2.008	.214	.253	9.361	.000
	CV5. Research Experience	-.874	.649	-.036	-1.347	.178
Other research	(Constant)	17.116	2.832		6.044	.000
	ISP_FNR. Involvement in More than 1 FNR Project	.726	.829	.035	.877	.381
	CV1. Research Domain	.043	.135	.013	.315	.753
	CV2. Country of Work (CL1:E/W/O)	.279	.321	.035	.869	.385
	CV3. Country of Work (CL2: EU/Non-EU)	.625	.261	.096	2.393	.017
	CV4. Doctoral Degree	3.149	.939	.137	3.354	.001
	LIP_FNR. Number of Years in FNR Projects	2.670	.332	.327	8.047	.000
	CV5. Research Experience	-2.504	.756	-.133	-3.312	.001
Business Industry	(Constant)	2.209	7.190		.307	.759
	ISP_FNR. Involvement in More than 1 FNR Project	2.806	3.105	.095	.904	.369
	CV1. Research Domain	.889	.323	.293	2.749	.007
	CV2. Country of Work (CL1:E/W/O)	.384	1.085	.037	.354	.725
	CV3. Country of Work (CL2: EU/Non-EU)	-.347	.699	-.050	-.496	.621
	CV4. Doctoral Degree	7.927	2.352	.418	3.371	.001
	LIP_FNR. Number of Years in FNR Projects	1.100	.795	.142	1.383	.170
	CV5. Research Experience	-.037	1.256	-.004	-.030	.976

CV6. Professional Background		*Unstandardised Coefficients*		*Standardised Coefficients*	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
Government	(Constant)	20.795	5.550		3.747	.000
	ISP_FNR. Involvement in More than 1 FNR Project	.679	2.345	.027	.289	.773
	CV1. Research Domain	.220	.338	.070	.651	.516
	CV2. Country of Work (CL1:E/W/O)	1.644	.757	.205	2.171	.032
	CV3. Country of Work (CL2: EU/Non-EU)	-.965	.590	-.154	-1.636	.105
	CV4. Doctoral Degree	-1.952	1.765	-.113	-1.106	.271
	LIP_FNR. Number of Years in FNR Projects	1.300	.807	.152	1.611	.110
	CV5. Research Experience	.496	1.016	.050	.488	.626
Other	(Constant)	-20.557	14.609		-1.407	.176
	ISP_FNR. Involvement in More than 1 FNR Project	14.593	5.827	.588	2.504	.022
	CV1. Research Domain	1.431	.650	.436	2.203	.040
	CV2. Country of Work (CL1:E/W/O)	2.958	1.468	.429	2.015	.058
	CV3. Country of Work (CL2: EU/Non-EU)	2.541	1.394	.356	1.824	.084
	CV4. Doctoral Degree	.907	3.746	.043	.242	.811
	LIP_FNR. Number of Years in FNR Projects	2.773	1.525	.339	1.819	.085
	CV5. Research Experience	1.407	2.166	.135	.649	.524

a Dependent Variable: FNR Productivity Score

Appendix 36: Gross Domestic Expenditure on R&D (GERD) as Percentage of GDP (source: EuroStat[78])



[78] The figure is adapted (27th June 2009) from:
http://epp.eurostat.ec.europa.eu/portal/pls/portal/!PORTAL.wwpob_page.show?_docname=36126.PNG

Appendix 37: Dimensionality of Collaborative Forms (Extended Version)