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Gaps, Actors and the Process of Commercialising Applied Research from Irish Universities

A dissertation submitted to the University of Dublin for the Degree of Doctor of Philosophy
Mark Whelan
15th March 2010
School of Business
Trinity College Dublin
Declaration

I hereby declare that this thesis has not been submitted as an exercise for a degree at this or any other University, and that it is entirely my own work. I agree that the Library may lend or copy this thesis upon request.
Summary
The recent global economic crisis has increased the levels and frequency of calls by national and region governments for universities to contribute to economic growth (Etzkowitz and Chunyan, 2008). These calls emerge from reports such as The Lisbon Strategy (European Commission, 2000) which set out to ‘make Europe the most competitive and dynamic knowledge-base economy ... by 2010.’ In tandem with this call, the commercialisation of research offers universities a potential income source in the light of reduced state funding. However, many universities do not see the commercialisation of research as part of their mission (Benner and Sandstrom, 2000 and Etzkowitz, Webster et al., 2000), and those that do often lack the structures and policies necessary to commercialise their research (Siegel, Waldman et al., 2003a and EUA, 2005).

There are many holes in our knowledge on how to commercialise applied research. Using projects funded under the Enterprise Ireland Commercialisation Fund, this study examined projects to investigate the factors that influence the commercialisation of applied research from Irish universities. In particular, the research investigated the following questions:

- What gaps need to be overcome by Irish universities in the process of commercialisation to generate spinoffs and licences?
- Who are the actors that influence the closing of these gaps?
- Are there patterns in the way in which these actors intervene in the process, and is there a link to the commercialisation outcome (spinoff or licence)?
- What policy implications are there for the further development of the Triple Helix of university-industry-government relations?

Using a pilot survey followed by six cases, this study found that there are four gaps in the process of commercialisation: 1) an idea uniqueness gap, 2) a funding gap, 3) a knowledge gap and 4) an entrepreneurship gap. The study also found that five actors have a role to play in the closing of the gaps, they are: 1) the university, 2) government, 3) the principal investigator, 4) financial institutions and 5) industry (other firms).

In identifying these gaps this study also found that the gaps are different in four scenarios 1) pre-spinoff, 2) pre-licence, 3) post-spinoff and 4) post-licence. In this respect the findings extend a previous study by Verganti and Landoni (2005) by identifying the evolution of the gaps through the process of commercialisation.
The study concludes with a discussion of the implications of the research and recommendations (including policy recommendations) for the actors in the process. It also highlights opportunities for future research.
**Acknowledgments**

There are many people without whose help, encouragement and support this thesis would not have been completed. To my wife Susan, who has put up with never ending nights and weekends of 'I'm working on my PhD', I shall be eternally grateful, especially since the birth of our daughter Aimee. No more, I promise.

To my supervisor, Professor Paul Coughlan, who has read more than the required fourteen versions or every chapter and who has provided inspiration, advice and support over the past six years. It would have been a much more challenging journey without his guidance, his network of contacts and his eternally positive outlook.

To my employers, Enterprise Ireland, who funded most of my research and who gave me the time and opportunity necessary to complete it. In particular, to Jim Lawler, to whom I said I was nearly finished on several occasions.

To the academics, industrialists and members of the various Technology Transfer Offices who gave me unhindered access to their projects and who were honest and forthright in their answers and opinions. This research would not have been possible without their assistance.

To the friends and colleagues who helped me through the hard times and who read the various drafts. In particular, Dr. Gerard McHugh for his honest critiques, Dr. Mark Southern, Dr. Ann Ledwith and Prof. Eamonn Murphy for the endless questions and answers, Adrienne Horan for the professional finish to all the diagrams, and Valerie Vaughan who went beyond the call of duty in proof reading the final version (welcome to the world Anna).

And finally, to my family who have always supported me in everything I have done.
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<tr>
<td>4LV</td>
<td>4th Level Ventures</td>
</tr>
<tr>
<td>AMT</td>
<td>Advanced Manufacturing Technologies</td>
</tr>
<tr>
<td>ATRP</td>
<td>Advanced Technology Research Programme</td>
</tr>
<tr>
<td>AUTM</td>
<td>Association of University Technology Managers</td>
</tr>
<tr>
<td>BERD</td>
<td>Business Expenditure on Research and Development</td>
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<tr>
<td>BES</td>
<td>Business Expansion Scheme</td>
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<tr>
<td>C+</td>
<td>Commercialisation Plus</td>
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<tr>
<td>CAE</td>
<td>Computer Aided Engineering</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CF</td>
<td>Commercialisation Fund</td>
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<tr>
<td>CFTD</td>
<td>Commercialisation Fund: Technology Development</td>
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<tr>
<td>CHIU</td>
<td>Conference of the Heads of Irish Universities</td>
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<tr>
<td>CID</td>
<td>Contract of Indefinite Duration</td>
</tr>
<tr>
<td>CNT</td>
<td>Carbon Nanotubes</td>
</tr>
<tr>
<td>COO</td>
<td>Chief Operations Office</td>
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<tr>
<td>CTO</td>
<td>Chief Technology Officer</td>
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<tr>
<td>DA</td>
<td>Development Advisor</td>
</tr>
<tr>
<td>DCU</td>
<td>Dublin City University</td>
</tr>
<tr>
<td>DIT</td>
<td>Dublin Institute of Technology</td>
</tr>
<tr>
<td>ECC</td>
<td>Exploitation Consent Committee</td>
</tr>
<tr>
<td>EI</td>
<td>Enterprise Ireland</td>
</tr>
<tr>
<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<tr>
<td>ESRI</td>
<td>Economic and Social Research Institute</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>EUA</td>
<td>European University Association</td>
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<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
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<td>FMCG</td>
<td>Fast Moving Consumer Goods</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>HE</td>
<td>Higher Education</td>
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<td>HEA</td>
<td>Higher Education Authority</td>
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<td>HEIF</td>
<td>Higher Education Innovation Fund</td>
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<tr>
<td>HERD</td>
<td>Higher Education Expenditure on Research and Development</td>
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<tr>
<td>HPSU</td>
<td>High Potential Start Up</td>
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<td>HSE</td>
<td>Health Service Executive</td>
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<td>High Technology Based Firm</td>
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<td>ICT</td>
<td>Information and Communications Technology</td>
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<td>IDA</td>
<td>Industrial Development Authority (Ireland)</td>
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<td>ILO</td>
<td>Industrial Liaison Officer</td>
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ILRP  Industry Led Research Programme
IP    Intellectual Property
IPR   Intellectual Property Rights
MBA   Master of Business Administration
MIT   Massachusetts Institute of Technology
MRP   Materials Requirement Planning
NCO   No Commercial Outcome
NDA   Non Disclosure Agreement
NIS   National Innovation System
NPD   New Product Development
NUIG  National University of Ireland, Galway
NUIM  National University of Ireland, Maynooth
OECD  Organisation for Economic Cooperation and Development
OEM   Original Equipment Manufacturer
PAT   Programme in Advanced Technology
PAYE  Pay As You Earn
PI    Principal Investigator
PM    Project Manager
R&D   Research and Development
RAE   Research Assessment Exercise
RFQ   Request for Quotation
RPO   Research Performing Organisation
SCM   Supply Chain Management
SCS   Seed Capital Scheme
SE    Surrogate Entrepreneur
SFI   Science Foundation Ireland
SLA   Service Level Agreement
SME   Small and Medium Enterprise
SPSS  Statistical Package for the Social Sciences
TCD   Trinity College, Dublin
TD    Teachta Dála (Member of Parliament)
TTD   Technology Transfer Office Director
TTO   Technology Transfer Office
TTSI  Technology Transfer Strengthening Initiative
UCC   University College Cork
UCD   University College Dublin
UK    United Kingdom
UL    University of Limerick
US    United States
USP  Unique Superior Product
VC   Venture Capital
1.1 Introduction
Trends in globalisation, the current global economic crisis, and the rise of the knowledge economy have contributed to increased calls by national and regional governments for universities to contribute to the development of their economies (Etzkowitz and Chunyan, 2008). These calls emerge from reports such as The Lisbon Strategy (European Commission, 2000) which set out to 'make Europe the most competitive and dynamic knowledge-base economy ... by 2010', and more recently as a consequence of the recent global economic downturn (Etzkowitz, Ranga et al., 2008).

Universities have become the focus of intense scrutiny by policy makers who see them as a source of new firms and economic growth (Etzkowitz and Chunyan, 2008). Consequently, channelling knowledge into new sources of technological innovation has become an academic task according to Etzkowitz and Leydesdorff (2001)

Realisation of this third pillar of the universities' mission (the others being teaching and research) occurs through organizational innovations such as Technology Transfer Offices (TTO), incubator facilities and research centres with industrial participation (Etzkowitz and Leydesdorff, 2001). As a result, the National Innovation System model (Lundvall, 1992) which sees the firm as the leader in innovation is redundant according to Etzkowitz and Leydesdorff (2000), as is the linear model where basic research is applied via a market pull or technology push. Both are superseded by the Triple Helix model in which the university has a leading role to play in the development of new firms. This Triple Helix is based on the concept of separate university, industry and government spheres, and the knowledge that flows between them. It postulates that interaction between the universities, industry and government are the key to improving conditions for innovation in a knowledge based society (Etzkowitz, 2003).

1.2 The global economic crisis
Since the collapse of the credit markets in the US and the associated global financial crisis, the world has plunged into the deepest recession seen since the 1920s (National Competitiveness Council, 2009). As governments publish plans for economic survival, university-industry collaborations offer a source of economic growth. Here, the creation of new spinoff companies from university research can have the greatest
impact on the economy, through the creation of new firms (Etzkowitz and Chunyan, 2008).

The role of government in this type of crisis is to facilitate and encourage higher levels of interaction between industry and academia according to Etzkowitz and Leydesdorff (2000). In the Triple Helix, government acts as the source of funding for university-industry collaboration, as well as legislator and regulator in terms of how the collaboration occurs. As legislator, government puts the necessary public supports and policies in place, while as regulator it shapes the context in which the collaboration happens (Etzkowitz and Leydesdorff, 2000 and Etzkowitz, Webster et al., 2000).

1.2.1 The Irish economic crisis
The Irish economy is currently facing enormous challenges. The recession in Ireland has been among the most severe of developed economies to date, and the Economic and Social Research Institute (ESRI) forecasts an 8.3 percent decline in Irish GDP and a 9.2 percent decline in GNP in 2009 (National Competitiveness Council, 2009). As a consequence, the National Competitiveness Council recommends that the Irish government should fund programmes which have strong industry participation, leverage private sector investment, and drive consolidation in existing research infrastructures and centres (National Competitiveness Council, 2009).

At a recent Enterprise Ireland event (the Irish agency with responsibility for facilitating the commercialisation of state funded research) the creation of new spinoff companies from public funded research was highlighted as a government priority by the Tánaiste and Minister for Trade and Enterprise, Mary Coughlan, TD. However, Ireland is in a weaker position than countries such as the US and UK, as the current level of interaction between universities and industry is low, as is the current level of R&D by Irish owned firms (see Figure 1.1).

Despite the increases in R&D funding made in Ireland, only limited progress has been made towards the target set by the Government's Science Strategy (2.5 percent of GNP by 2013). Total R&D spending in Ireland increased from 1.26 percent of GNP in 2000 to 1.53 percent of GNP in 2006. This compares with an OECD average of 2.36 percent in 2006 (National Competitiveness Council, 2009).

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1 Enterprise Ireland Applied Research Forum, Guinness Hops Store, Dublin, 18th June 2009
Similarly, despite strong growth rates in expenditure, business R&D as a percentage of economic activity has remained relatively static over the past decade, (see Figure 1.2). Most business expenditure on R&D in Ireland is undertaken by foreign-owned companies (National Competitiveness Council, 2009). The majority of Irish companies do not engage in R&D, and those that do concentrate mainly on development rather than research (Enterprise Ireland, 2005).

Irish expenditure on R&D, as a proportion of GDP, has historically been well below the EU and OECD averages, and there has been little university-industry interaction. Although the actual spend on R&D increased significantly over the last decade, as a percentage of GDP it has remained static. In 2006, at 0.9% of GDP, Ireland’s Business Expenditure on R&D (BERD) was only 80% of the EU average and 58% of the OECD average (Forfás, 2007).

To encourage and help companies invest in R&D, the Irish government offers many grants and tax incentives. However, these have not delivered increased R&D spending as a percentage of GDP, as evident from Figure 1.2. It is well recognized that higher levels of interaction with universities can help to overcome this deficit.
To encourage companies to invest in R&D, government can provide assistance other than just funding. Promoting interaction with research institutions can help provide not only the necessary technology, but also the skills to conduct R&D internally.

Here, the needs of the university and industry can be matched together, and a role for the commercialisation of research becomes clearer. To grow, companies need to develop new products or processes. Access to technology is a fundamental gap that must be overcome by the company. Universities are one potential source of new technology. However, where the absorptive capacity (the ability of the company to integrate new knowledge) of industry is low, and the orientation of the university is not towards third pillar activities, there are issues that have to be overcome.

The 2004 Forfás Innovation Networks Report identified several barriers to effective knowledge transfer between academia and enterprise in Ireland, including lack of widespread knowledge of third level research projects, difficulties in drawing up Intellectual Property Rights (IPR) contracts, gaps in technology time horizons, and differences between industrial and academic cultures. Understanding how to overcome
these barriers to realise the potential from knowledge transfer is the driving force behind this research.

1.3 Triple Helix of university-industry-government relations

Leydesdorff and Etzkowitz (1996) developed the Triple Helix model to describe how governments, universities and industry interact in the knowledge economy. A key element of the Triple Helix is that the university supersedes industry as the primary source of (discontinuous) innovation and economic growth (Etzkowitz and Zhou, 2006).

Universities and industry assume tasks that were formerly largely the province of the other, as governments offer universities incentives to become involved in wealth creation activities (Etzkowitz and Leydesdorff, 2001). Within the Triple Helix the individual actors must better understand the needs of each other, and at times must play different roles in the relationship (Etzkowitz, Ranga et al., 2008).

The concept of the Entrepreneurial University also emerges from the Triple Helix to describe universities that have embraced technology as their third pillar (Etzkowitz, Ranga et al., 2008). The entrepreneurial university is defined as one that has control over its own strategic direction, is in close interaction with the other spheres (of the Triple Helix), and university research projects come from both internal and external sources (Etzkowitz, 2003). However, to be entrepreneurial Meyer, Siniläinen et al. (2003) argue that a high patent count is a prerequisite, as it demonstrates the required level of inventiveness. As a consequence, not all universities have the potential to be entrepreneurial.

1.4 Tensions arising from third pillar activities

Not all universities have embraced the concept of the third pillar. The increased emphasis on third pillar activities has caused fear amongst academics who believe that their academic freedom to conduct research is being impinged upon (Van Looy, Ranga et al., 2004). A debate has been ongoing for a decade as to whether the university should engage in third pillar activities, or if this is a corruption of their fundamental mission. This debate is the focus of what is described as the Second Academic Revolution (Etzkowitz, 2001; Etzkowitz, 2003).

1.4.1 The Second Academic Revolution

The First Academic Revolution occurred in the late nineteenth century when the debate revolved around whether universities should engage in research, or if their
sole purpose was to teach (Etzkowitz and Leydesdorff, 1998; Etzkowitz, 2003). For centuries, the mission of the university was solely to provide an education to those wealthy enough to afford it. With the onset of the industrial revolution in the mid nineteenth century, and the associated changes in work practices that ensued, the question was asked whether academics should involve themselves in investigating these phenomena. The result was the inclusion of research as the second fundamental pillar of the university (Etzkowitz, 2001).

Since then, universities have been seen as organizations devoted to the creation and diffusion of knowledge serving as a public good, mainly through research and education (Baldini, Grimaldi et al., 2004). Until recently, universities were not interested in, or tasked by government with, a role in economic development. The recent shift in government policy, and the corresponding desire by some universities to contribute on economic development has led to the debate on whether the role of the university should include commercialisation as its third pillar or not (Etzkowitz and Leydesdorff, 1998 and Etzkowitz, 2003).

There are many advantages to be gained by universities engaging with industry (EUA, 2005). Alongside the financial benefits derived from collaboration, the universities can also update their teaching and research and gain through the additional papers they publish (Neuvo, 2008). In the UK this can be particularly beneficial as the UK government commissions a Research Assessment Exercise (RAE) approximately every five years, the purpose of which is to enable the higher education funding bodies to distribute public funds for research selectively on the basis of quality. The RAE distributed around £5 billion as a result of the last assessment exercise in 2001 (the next exercise was underway at the time of writing).

While these potential advantages are evident, there has been considerable opposition to the proposed changes in the role of the university from some quarters (Etzkowitz, Webster et al., 2000). Academics argue that these changes will contaminate the university system by making it too applied, and by moving the university's focus from fundamental research to problem solving (Van Looy, Callaert et al., 2004 and Van Looy, Ranga et al., 2004).

For those academics that have moved their focus towards the third pillar, there are also concerns that the delays in publication inherent in a patent application can impact negatively on their career development (Van Looy, Ranga et al., 2004). There is empirical evidence in the literature, however, to refute this. Buenstorf (2009) found
that involvement in commercialisation activities did not adversely affect research output in terms of papers or citations. Other research has also shown that academics who patent are published in higher impact journals (Calderini and Franzoni, 2004, Van Looy, Callaert et al., 2004 and Van Looy, Ranga et al., 2004).

1.4.2 Third Pillar contributions to economic growth

The United States provides many examples of how universities can benefit by commercialising their research (O'Shea, Allen et al., 2005). Although billions of dollars have been made available to universities in the US by the federal government, there are no federally funded universities. This is due to a constitutional ban on the federal government setting policy or managing education at any level (OECD, 1999). In light of this, US universities have been much more interested in the commercial potential of their research, particularly since the Bayh Dole Act (1980) gave them the right to keep the royalties from government funded research (Baldini, Grimaldi et al., 2006).

The level of patenting by American universities and the number of licence agreements signed with industry has increased substantially since the Bayh Dole Act. According to Colyvas, Crow et al. (2002) 'the number of patents issued to universities and colleges more than doubled between 1979 and 1984, did so again between 1984 and 1989, and nearly doubled once more during the 1990s'. Similarly, Owen-Smith, Riccaboni et al. (2002) found patenting by US universities increased nearly sevenfold over the period 1976-1998. As a result universities are now often ranked according to the efficiency of their patent offices, their relations with companies, or revenues from sales of proprietary rights according to Chiesa and Piccaluga (2000).

1.4.3 Third Pillar activities are not a silver bullet

As a result of the high profile successes of some universities (e.g. MIT and Stanford), there is a perception that income from third pillar activities will provide a benefit to all; this is not the case. While the total value from licence royalties in the US was over $1billion by 2000, there are only a small number who benefited disproportionately from a few high performing licence deals. Most universities do not make substantial revenues, and run their TTO at a loss (Hughes, 2003, O'Shea, 2005 and Swamidass and Vulasa, 2009). MIT and Stanford have been successful as they have a long history of commercialisation and have developed a culture that encourages both academics and students to consider commercialising their research (Benner and Sandstrom, 2000).
Outside of the US, most countries witness the creation of no more than a couple of dozen spinoff firms each year (DeGroof and Roberts, 2004). Most European universities have not been anywhere near as successful as their American counterparts. However, there are some exceptions, as both Oxford and Cambridge Universities perform on a par with the most successful American Universities (Druilhe and Garnsey, 2004).

Capron and Cincera (2004) tell us that there are historical and philosophical roots to such divergences: European universities depend to a large extent on public financing, while the American ones are mainly privately financed. As the model for their funding changes, European universities can look to commercialisation as an alternative source of income from a more knowledgeable viewpoint.

### 1.4.4 Actors and third pillar activities in the Triple Helix

Considering the Triple Helix, Sazali, Haslinda et al. (2009) groups third pillar activities into four categories; the appropriability model, the dissemination model, the knowledge utilization model and the communications model. As will be developed in chapter 2, the communications model is of particular relevance to this study because it suggests that technology transfer is 'an on-going process which involves a two-way interactive process (non-linear) by continuously and simultaneously exchanging ideas among the individuals involved' (Sazali, Haslinda et al., 2009). Related to the communications model is the role of the actors in the various helices as articulated by Meyer, Siniläinen et al. (2003), something that will also be developed further in chapter 2.

### 1.5 Status of the commercialisation of applied research in Ireland

Given that the majority of Irish companies do not engage in R&D, and those that do concentrate mainly on development rather than research (Enterprise Ireland, 2005), it is interesting to note that more Irish firms engage in innovation (the creation of new products, services, or processes) than the EU-15 average (Figure 1.3 is the most recent data). This seeming contradiction may imply that while companies involve themselves in innovation, they are not necessarily developing new knowledge via R&D.
It may be that the companies see the creation of knowledge as solely the role of the universities. If so, it should be expected that the levels of university-industry interaction in Ireland are high, as industry attempts to access this knowledge. However, Figure 1.4 shows that rate of knowledge transfer in Ireland is at best, average (National Competitiveness Council, 2009).

The number of start up companies from Irish universities is also low in comparison with other European countries. Since the inception of specific support programmes to fund the commercialisation of applied research in 2001, there have been approximately 60 spinoffs from Irish universities. A study by Politecnico di Milano found that the rates of spinoffs from Irish universities lag other EU countries in terms of the number of start-ups per annum per thousand researchers (Verganti and Landoni, 2005).

One potential cause of this is that Irish universities do not consider commercialisation a strategic goal. The cohort of Irish university presidents wrote that the 'contribution from commercialisation will always be marginal in relative terms' as it only represents 0.2% of recurrent funding at present (CHIU, 2003). Part of the motivation for this thesis is a contention that the contribution should not always be marginal, and that the commercialisation of applied research offers an opportunity that Irish universities cannot afford to ignore.
1.5.1 State funding of research in Ireland

The Irish government invested €635 million in funding university research through Science Foundation Ireland (SFI) when it was set up in 2001. The same year also saw the introduction of funding specifically aimed at the commercialisation of applied research via Enterprise Ireland's Applied Technology Research Programme (ATRP) [renamed the Commercialisation Fund in 2003]. However, while the levels of investment by the Irish government have increased significantly, the rates as a percentage of GDP are still low (see Figure 1.5).

Ireland is in a particularly weak situation as the data on university funding shows that state funding is the main contributor to teaching and research activities (HEA, 2003). The state contributes 85% of the funding to the university sector and 90% to the Institutes of Technology (OECD, 2004) (Figure 1.6). However, this level is now dropping, and in 2009 a report to the Irish government recommended the reintroduction of student fees, as well as significant job and cost cuts in the third level sector in reaction to the current economic crisis (Special Group on Public Service Numbers and Expenditure Programmes, 2009).

If the Irish third level sector is to play the role expected by government in developing the economy, then it must have a stable financial base from which to work (HEA,
2003). Failure to adapt to the changing environment means that Ireland’s economic growth, development, and competitiveness will be the issue, rather than the needs of its educational institutions per se (CHIU, 2003). If the universities are to contribute to the growth of the economy, then they need to consider where they can source alternative research funding.

Figure 1.5 HERD as a % of GDP (National Competitiveness Council, 2009)

![Graph showing HERD as a % of GDP]

Figure 1.6 Sources of funding for Irish universities (Forfás, 2007)

![Bar chart showing sources of funding for R&D in higher education sector]

There has been insufficient engagement between the third level sector and industry to fund research that will 'stimulate sustained economic growth or meet current and potential demand' according to InterTrade Ireland (2006). This interaction between
universities and industry can provide a benefit to both parties. The universities can benefit from generating funds via the commercialisation of research, while industry benefits from the technologies they acquire. Government also benefits from this interaction through a growing economy, and the associated increases in public wealth.

Figure 1.7 (the most recently published data) shows that income from commercial sources accounts for only a small fraction of Irish HE sector income, approximately 0.2% (CHIU, 2003). This identifies an opportunity for growth, but also highlights that considerable effort will be required to grow this revenue stream. The experience of US universities suggests that these efforts can take more than a decade to bear fruit (Miyata, 2000).

Figure 1.7 University Financial Statements (CHIU, 2003)

1.6 Aim of this research study
This thesis research started in 2004 when the commercialisation of applied research was not a topic for popular debate. With the current economic situation, the commercialisation of applied research is accepted to be important to the universities in a number of ways. First, there are potential financial gains from licence agreements with third parties. Second, the projects funded under the commercialisation schemes offer researchers the opportunity to gain masters and doctoral level qualifications that help the universities meet the government’s target of doubling (over 2006 base) the number of science and engineering PhDs by 2013 (Irish Government, 2006). Third, the projects undertaken also provide the opportunity to publish research outcomes, increasing the profile of individual academics and the university. Finally, the funding available from government to carry out the research is an important income stream.
The associated overheads (30% of cost excluding capital) provide a means to support the administrative offices of the universities (such as Human Resources and Finance) not just those involved in the process of Technology Transfer.

This thesis now offers a timely contribution to the debate on whether, and how the commercialisation of applied research should form part of the universities mission. It also offers an opportunity to discuss what implications improved levels of knowledge transfer may have on the universities, industry and government.

To help the universities, industry and government better understand the role they have to play in the knowledge transfer process, both in an international and Irish context this research study proposes to address a number of outstanding concerns that arise from this chapter. These concerns are as follows:

- Does a set of best practices exist that can be followed by Irish universities to overcome the gaps that exist in the process of commercialisation?
- Who are the actors at whom these best practices are aimed?
- Are there patterns in the way in which these actors intervene in the process, and is there a link to the commercialisation outcome?
- What implications are there for the further development of theory, practice and policy in the area of university-industry interaction or university-industry-government relations?

It is hoped that the study will help universities, industry and government to better understand the process of commercialisation. Further, the research findings will offer both theoretical and policy contributions with respect to the development of existing models that describe the relationships between universities, industry and government with respect to the commercialisation of applied research.

In summary, there is a need to understand the process of commercialisation in Ireland, as Irish universities have been tasked with adding to the knowledge economy without an extensive history of doing so. This study will provide an insight into the process of commercialisation, while highlighting the actors that have a role to play in the process. It will also investigate if patterns exist in the way actors intervene, and make recommendations to the universities, industry and government on the role they have to play in the process.
1.7 Structure and flow of this thesis

This chapter highlighted the important role the commercialisation of applied research has to play in today’s economy. The remainder of this thesis is presented in nine chapters structured as follows:

Chapter 2 presents a review of the current literature on the subject of commercialisation. This is used to help understand what we already know about the phenomenon, and to identify the holes in our knowledge that can be addressed by this study. Chapter 3 builds on Chapters 1 and 2 to develop a conceptual model that may explain how the process of commercialisation works.

Chapter 4 outlines the research design used in this study to investigate the conceptual model. It discusses the tools and techniques used to collect and analyse the data on the conceptual model. This includes the use of a pilot survey and six cases.

Chapter 5 presents the data and analysis of the pilot survey. It uses the findings of the survey analysis to revise the conceptual model, and to choose six projects for inclusion in the case research. Chapters 6 and 7 present the data on these cases by institution. They also include the initial within case analysis of each case.

Chapter 8 then conducts the cross case analysis of the cases to draw conclusions. It also presents an emergent model for the commercialisation of applied research based on this study. Using this model, Chapter 9 presents the theoretical contribution made by this study, and highlights opportunities for future research.

Finally, Chapter 10 summaries the findings of this study with respect to the research questions. It also provides policy recommendations for the actors in the process of commercialisation.
CHAPTER 2: STATUS OF OUR KNOWLEDGE ON THE COMMERCIALISATION OF RESEARCH

2.1 Introduction
The commercialisation of university research has become a popular topic over the last decade with a number of journals specifically concentrating on the phenomenon. These include the Journal of Technology Transfer, Technovation, R&D Management, Research Policy, Journal of Business Venturing, Management Science and the Journal of Technology Transfer and Commercialisation. There have also been a number of books on the subject by authors such as (Tang, Vohora et al., 2004 and Bok, 2003 and Cunningham and Harney, 2006).

In this study, my interest is specifically in the literature that focuses on technology transfer, although there are other foci of the literature, such as research policy and the role of the university. I concentrate on the technology transfer literature as it can be applied to the issues that surround the transfer of knowledge from the universities to external actors. As Figure 2.1 shows, there is an overlap between the three fields that indicate that the policies and the role of the university are involved in technology transfer.

Figure 2.1 Spheres of the literature on commercialisation

Although many of the articles published in these books and journals discuss the importance of commercialising the outputs of university research, few if any have been able to provide definitive guidance on the factors that increase the levels of commercialisation. As a result, there are many gaps in our knowledge about how to commercialise applied research. This chapter reviews the current literature to identify what our current knowledge is, and to identify gaps in the literature to which this research can contribute.
This chapter is set out in three interlinked sections to help develop a clearer picture of what we know about the phenomenon and what gaps exist with respect to the issues articulated in Chapter 1. The first section discusses the literature on the Triple Helix (which is represented by the overlap between the three sets in Figure 2.1), while the second reviews the literature with respect to the gaps that must be overcome in the process, and the actors who help overcome these gaps. The third section summarises the findings of the literature and draws conclusions with respect to the research questions developed in Chapter 1.

2.2 Language used to describe commercialisation activities

The language used to describe the interaction between universities and industry (the collective term used in this study for the companies involved in the process) is diverse; terms include knowledge transfer, technology transfer and knowledge exchange. The purpose of this section is to clarify the terms used for the remainder of this thesis.

Technology transfer is defined as any ‘process by which basic understanding, information, and innovations move from a university, institute, or a government laboratory to individuals or firms in the private and quasi private sectors’ (Grandi and Grimaldi, 2003 and Lofsten and Lindelow, 2005). Knowledge transfer and knowledge exchange are seen as being broader, and include the transfer of personnel from universities to industry, consultancy work done by universities for industry, and the publication of academic papers (Hughes, 2003). In more general terms, technology transfer refers to the generation of licences and spinoff companies from university research (Grandi and Grimaldi, 2003).

For the purpose of this study I use the term commercialisation of applied research to refer specifically to the commercialisation of university research via a license, or the creation of a spinoff company. Both are done in an attempt to gain financial reward from technology transfer.

2.3 The Triple Helix Innovation Systems

The Triple Helix has been the subject of many papers over the last decade (Leydesdorff and Etzkowitz, 1996; Etzkowitz and Leydesdorff, 1998; Klofsten, Jones-Evans et al., 1999; Danell and Persson, 2003; Leydesdorff and Meyer, 2003; Meyer, Siniläinen et al., 2003; Goeghegan and Ryan, 2006 and Leydesdorff and Meyer, 2006), and a number of journal special issues, e.g. Research Policy 2006 35(10). Recently, Triple Helix theory has evolved to account for a set of twin helices
representing *Sustainability* (university-government-society) and *Innovation* (university-government-industry) (Etzkowitz and Zhou, 2006).

The Triple Helix of Sustainability accounts for the role society plays in acting as a brake on innovation to ensure it is compatible with society’s needs (Etzkowitz and Zhou, 2006). While sustainability has a place in the broader debate on innovation, my interest is in the relationship between the actors of the Triple Helix of Innovation, because I am interested in the relationships between the three actors involved in the commercialisation of applied research, i.e. university, industry and government.

**2.3.1 Description of the Triple Helix**

In a knowledge-based economy, the university becomes a key element of the innovation system as a seed-bed of new firms (Etzkowitz, Webster et al., 2000). The spheres of interaction between the three actors that were separate in the laissez faire systems of innovation are interwoven in the Triple Helix with a spiral pattern (Etzkowitz, Webster et al., 2000).

Etzkowitz and Leydesdorff (1998), Leydesdorff and Etzkowitz (1998) and Etzkowitz and Leydesdorff, 2000) argue that the linear process that describes the flow of scientific knowledge as a one-way flow from ‘fundamental to applied research and to product development’ is no longer valid, and that a new model is required to describe the interactions between industry and academia. This linear model which includes National Innovation Systems (NIS) (Lundvall, 1992), is being supplanted by new ideas and alternative models based upon interdisciplinary and spiral feedback links between technology and science (Etzkowitz and Leydesdorff, 1998).

Leydesdorff and Etzkowitz (1996) developed the Triple Helix model to describe how the different communication and interfaces between governments, universities and industry exist, and to ‘take account of the expanding role of the knowledge sector in relation to the political and economic infrastructure of the larger society’. Universities and firms are assuming tasks that were formerly the province of the other, so the boundaries between public and private, science and technology, university and industry are in flux (Etzkowitz and Leydesdorff, 1998).

There are four processes related to the exchange and use of knowledge which the Triple Helix model has identified: the *first* is internal transformation in each of the helices (representing university, industry and government), such as the development of lateral ties among companies through strategic alliances, or an assumption of an
economic development mission by universities. The second is the influence of one institutional sphere upon another in bringing about transformation. The third is the creation of a new overlay of trilateral linkages, networks, and organizations among the three helices, serving to institutionalize and reproduce interfaces as well as stimulate organizational creativity and regional cohesiveness. The fourth process is the recursive effect of these inter-institutional networks representing academia, industry and government, both on their originating spheres and the larger society (Etzkowitz, Webster et al., 2000).

In the Triple Helix, Leydesdorff and Etzkowitz (1996) recommend that the individual actors must better understand the needs of each other, and at times play different roles to ensure the interaction is successful. To understand what roles the actors play, the next section presents what the relevant literature says about the roles played by each of the three actors in the Triple Helix.

2.3.2 The role of the university in the Triple Helix
Since the late 1980's the interface between academia and industry has been increasingly identified as a factor of economic growth; a source of new products and companies, on the one hand, and of flows of knowledge to existing firms on the other (Etzkowitz and Leydesdorff, 1998). In effect, universities have become regional sources of economic development (Etzkowitz, Webster et al., 2000 and Etzkowitz, 2003). The university undertakes these activities not only to help improve the regional or national economy, but also to improve its own financial position.

2.3.2.1 Cultural issues
Etzkowitz, Webster et al. (2000) explain the emergence of the entrepreneurial university as a response to the increasing importance of knowledge in national and regional innovation systems, and the recognition that the university is a cost effective, creative inventor, and transfer agent of both knowledge and technology.

Benner and Sandstrom (2000) found that 'universities that have cultures that support commercialisation activities have higher levels of commercialisation and higher rates of spinoff activity'. By example they showed that 'at MIT commercialisation was considered an automatic and natural consequence of research activity' (O'Shea, Allen et al., 2007).
As discussed in Section 1.4, there are tensions associated with the changing role of the university. To overcome the challenges faced in adopting commercialisation as their third pillar, it is important to recognize that a change is necessary in the culture of the university (Perez Perez and Mantinez Sanchez, 2003). As the role of the university has not changed since the First Academic Revolution (Etzkowitz, 2001), the culture of academic institutions are well established and deep rooted. Expecting universities to change overnight is impractical.

Many academics consider that the only driver behind their research should be the desire to ‘increase and enhance human knowledge, regardless of any practical application’ (Etzkowitz, Webster et al., 2000). Others openly hold in contempt those who pursue anything other than basic research. Recent research suggests that the fears many academics hold about the impact that patenting (in particular) will have on their careers are ill founded. Studies by Udell (1990) and Van Looy, Callaert et al. (2004) concluded that universities who increase the amount of applied research they engaged in do not see a trade off with the quantity of basic research.

While some universities have successfully implemented policies on commercialisation, it is not practical to simply ignore the issues and concerns that exist within the third level institutions with respect to the commercialisation. A university is not typically a homogenous organisation, so expecting all the academics will share the same views is impractical. Matt and Schaeffer (2005) showed in their review of the Louis Pasteur University that some departments were interested in industry interaction, while others clearly had no interest.

### 2.3.2.2 Support on offer

The objective for the university is to ensure that it facilitates those who are, and are not, interested in commercialisation and where the university is strategically interested in commercialisation, that there is a connection between the basic and applied researchers in the institution to ensure the flow of ideas to industry.

One the biggest issues facing the university is in trying to understand what companies want and what they are prepared to pay for (Logar, Ponzurick et al., 2001 and Laird and Sjoblom, 2004). So when constructing their policies on commercialisation, universities must ensure that they are not only able to
identify what industry's technology needs are, but that they can deliver them (Buratti and Penco, 2001).

The university must interact with many actors in the technology transfer process, e.g. science parks, business innovation centres and government agencies. So it is essential that the university knows how to analyze, plan and implement their own technology transfer and commercialisation processes. Many have Technology Transfer Offices (TTO) whose role according to Calderini and Franzoni (2004) is to:

- Make firms aware of their technology needs and of the existence and potential benefits of new technologies.
- Monitor the local, national and international technology markets.
- Guide the communication process between donor (university) and recipient (company).
- Coach firms to minimize difficulties when implementing the adopted technologies.

2.3.2.3 Multiple personae in the university

A question that arises in the discussion on the role of the university is 'who is the university?'. Before considering that question, we first need to consider the role of the university and how it has changed over time. In the preface to his lectures (Newman, 1852), Cardinal Newman defined the university as 'a place of teaching universal knowledge... its object is, on the one hand, intellectual, not moral; and, on the other, it is the diffusion and extension of knowledge rather than the advancement'. So, Newman saw the role of the university as the advancement of (Catholic) students, not the advancement of knowledge.

This role is in contrast to the role the universities are being asked to play in the knowledge economy. Etzkowitz and Leydesdorff (2000) believe that the university, not industry, now play a key role in the development of new firms. Similarly, as mentioned in section 1.3, within the context of the Triple Helix, the university supersedes industry as the primary source of (discontinuous) innovation and economic growth (Etzkowitz and Zhou, 2006). Here we see that the role of the university has moved towards the advancement and dissemination of knowledge for public good. Hence there is the need for a model that describes how the university interact with external actors.
It is easy to recommend that an institution gets more involved with industry, but it is the academics who must engage, not a legal entity called the university. In that sense, the call for collaboration should be focused on the academics and not institutions. As a consequence, the academic may need to be recognised as a player in the Triple Helix.

The TTO is another internal entity that acts on behalf of the university in the process. A university may have written policies and missions that state its support for commercialisation activities; however, if the academic inventors are not interested in commercialisation, then it may be difficult for the TTO to create a commercial outcome, and vice versa.

The definition of 'who is the university' becomes an issue when we attempt to develop a model for commercialisation. If, at different times in the process the university is represented by different internal players, then we need to know who they are, when they are active in the process, and what role they play. The technology transfer literature has been silent on this issue, so there is an opportunity for this study to contribute to the literature on this subject.

2.3.3 The role of government in the Triple Helix

There are many policy tools and actions open to government to effect economic growth, including tax incentives, direct funding of university research, or funding for industry to become involved in R&D. The most appropriate tools and interventions depend on the current state of the economy (Dooley and Kirk, 2007). According to Etzkowitz (2003) government plays two roles in the Triple Helix, that of Venture Capitalist and Public Entrepreneur.

2.3.3.1 Government as venture capitalist and public entrepreneur

A lack of financial support at key times is a barrier to the creation of spinoff companies (Verganti and Landoni, 2005). Government can help address this issue by providing direct and indirect supports to universities (Di Gergorio and Shane, 2003), a trend that is becoming more popular globally. However, this policy may not bear fruit in the short-term (Ndonzuau, Pirnay et al., 2002).

In its role as Venture Capitalist, government provides financial contributions to VC seed funds aimed at university spinoffs (Etzkowitz, 2003). This funding-of-funds helps overcome the initial financial gap that most spinoffs face in raising seed funding (Spencer, Murtha et al., 2005). Depending on the industrial sector
the company is targeting, the size of this initial investment and how long it lasts can vary widely. For example, when developing a new drug, the time to market is much longer than for a computer based technology, so the time to first sale is also much longer, and the company are more reliant on the seed investment.

2.3.3.2 Conflicting roles of government

Table 2.1 identifies the 'disconnect' between the two roles played by government in the Triple Helix. In its role as public entrepreneur, government provides funding to academics to help commercialise their research. Then as VC, it attempts to pick winners, which inevitably means only funding a number of projects. At this point, government rejects projects it may have already funded in its role as public entrepreneur. The question that has to be asked is whether those (rejected) projects should have been funded by the state, or whether the criteria for funding used by government as a VC should not have been applied earlier.

Alternatively, would projects not funded have provided better opportunities to the VC? By necessity, the criteria used in the two situations are different. However, as government is the common actor, a tension may arise in how it attempts to separate the two situations. As the literature is silent on this subject, a better understanding of what gaps and barriers to commercialisation exist is required, so that the best decision can be made as early as possible in the process.

Table 2.1 Government roles in Triple Helix

<table>
<thead>
<tr>
<th>Triple Helix Role</th>
<th>Venture Capitalist</th>
<th>Public Entrepreneur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding criteria</td>
<td>Government funds VCs who attempt to pick winners</td>
<td>Government funds public research institutions to generate ideas with commercial potential</td>
</tr>
</tbody>
</table>

2.3.3.3 Government as regulator and legislator

Etzkowitz and Leydesdorff (2000), Etzkowitz, Webster et al. (2000) and Etzkowitz (2003) agree that 'government plays an important part in commercialising knowledge through setting the rules of the game'. As legislator, government puts the necessary public supports and policies in place, while as regulator it shapes the context in which the processes of commercialisation
happen. Governments also encourage the development of entrepreneurial universities through policies designed to promote and sustain university-industry interaction (Etzkowitz, 2003).

2.3.3.4 Government policies on intellectual property

In addition to policies on tax and funding mentioned earlier, Van Looy, Debackere et al. (2003) warn that governments and universities must take steps to 'improve intellectual property protection'. When the output of research is typically in the form of knowledge rather than a product, it is increasingly important that the university is able to protect this knowledge, so it can be sold or licensed to industry (Van Looy, Debackere et al., 2003).

It has been recognised by the American Council on Competitiveness (Chiesa and Piccaluga, 2000) that the identification and protection of IP is a key element in the commercialisation process, and that government policies must support this. The most often cited legislation in this respect is the 'Patent and Trademark Amendments Act' of 1980 passed by the American Congress. Better known as the Bayh-Dole Act (after its sponsors) the act allowed US universities to benefit financially from the licensing of IP developed from state funded research. Previously, the proceeds went to the federal government. The Bayh-Dole Act also specified that the individual inventor had to receive some share of the proceeds, although it did not place a target on the amount.

The Bayh-Dole model has been adopted throughout Europe as a method for encouraging commercialisation of university research. Sweden is a notable exception because, there, the inventor maintains the IP rights (Goldfarb and Henrekson, 2003). In studying the difference between the Swedish and US university models, Goldfarb and Henrekson (2003) found 'suggestive evidence that the American university system was more effective in facilitating commercialisation than the Swedish system'. This may suggest that to commercialise research, the university has to have a financial interest in the IP, otherwise it is not motivated to help the academics commercialise their research.

Proponents of Bayh-Dole give it credit for the increased level of patenting and licensing by American universities since the early 1980s (Miyata, 2000; Goldfarb and Henrekson, 2003). However, it is not without its critics. In their presentation to the Association of University Technology Managers (AUTM), Jensen and Thursby (2001) reviewed and updated the findings of Mowery, Nelson et al.
(2001) and argued that at least part of the increase in patenting and licensing was due to the new focus on biotechnology, and the opportunities it provided for commercialisation. Mowery, Nelson et al. (2001) also noted that the financial returns gained by many universities were modest, and that the IP regulations of some American universities stifled rather than encouraged university-industry collaboration.

Bayh Dole should not be seen as a one-size fits all solution. As Mowery, Nelson et al. (2001) highlighted, it may not be responsible for the increase in levels of patents and licensing from US institutions. However, as a framework it has allowed this growth to happen. If these increases would have happened without it will not be discussed here.

Most OECD governments have copied the structures of Bayh-Dole in an attempt to improve the levels of commercialisation from their HE sector. However, an updated Mowery and Sampat (2005) argues that 'emulation of the Bayh-Dole policy elsewhere in the OECD is likely to have modest success at best without greater attention to the underlying structural differences amongst the higher education systems in these nations'. Here the contextual issues are relevant. As van der Steen and Enders (2008) suggested, there is no one-size-fits-all solution, so governments need to consider what local factors may influence their policies.

2.3.3.5 Summary of government’s role

The factors included above relate to the roles that government plays in supporting the commercialisation of applied research. In the first instance, government acts as an entrepreneur and VC by providing direct and indirect financial supports to help academics. In the second it acts as regulator and legislator, developing policies such as those relating to ownership, and protection of IP and the exploitation of government-funded research. Whether the twin roles played by government are appropriate is dependent on the context in which the policies are implemented, and the expectations government has of them.

While the Bayh-Dole Act has been given credit for the increased levels of commercialisation in the US, it may not be an appropriate solution for other countries. van der Steen and Enders (2008) warn that National Innovation
Systems are contextual, and that copying a successful model is not a solution for all.

2.3.4 The role of industry in the Triple Helix

At different times, industry (the collective name for firms) has a different role to play in the commercialisation of research, and as a result has different relationships with the other actors. Industry acts both as the source of ideas for the academic researchers, and the sink for the technology they develop.

In the past, industry's interaction with universities has been hampered by the different cultures and goals that drive each; however, in the recent past both actors have seen the mutual benefits that can be achieved through the commercialisation of applied research, and have started to work together.

Industry's interaction is concerned with finding suitable technologies, processes or products in the academic institutions that they can integrate into new products or processes, and sell in the market place. This process does not always work or run smoothly, as the research conducted by the universities may not be market focused or market ready (Liu and Jiang, 2001), so interaction is not to the benefit of the company.

Some companies are also concerned about competition from academic spinoffs in their traditional markets, and argue that the universities should continue to offer support to existing companies only through the established channels of consultancy and training. The companies argue that the universities should not engage in the creation of new High Technology Based Firms (HTBF), as that would be in competition with existing industry (Etzkowitz, Webster et al., 2000).

2.3.4.1 Geographic location

Link and Scott (2005), Lawton Smith and Ho (2006) and O'Shea, Allen et al. (2007) all mentioned the influence of the geographic location in which the institution is based on the interaction between industry and academia. They contend that Boston, Oxford and Silicon Valley developed successfully in an economic sense in part due to the presence of eminent universities that attracted industry to their geographic location.

Start-ups also tend to locate geographically close to the institutions that spawn them (Di Gergorio and Shane, 2003 and Audretsch, Lehmann et al., 2005), as it
allows them to continue to interact with the department from which the spinoff originated. For example, Clayman and Holbrook (2003) found that in Canada, 80% of successful spinoffs remained geographically close to the institution that spawned them.

There is, however, a time when it may be important to give an impression that a spinoff is global, so that its focus is perceived immediately to be international, rather than local. In the case of Havok (Kennedy, 2007) the presence of a US sales office was a key factor in the success of the company. This gave US customers, who made up the global market, the impression that they were dealing with a local company, which in turn gave them confidence that the company would be there to support them.

### 2.3.4.2 Companies licensing technology

In general, companies take technology from external sources because it is quicker or cheaper to do so, or because they do not have the necessary skills or resources in house to develop the technology (Christensen, 1997). More specifically, Twiss (1992) noted that where firms found it particularly hard to be self-sufficient in technological innovation, external sources of knowledge and technology, such as universities, became important.

In the case of a potential spinoff company from the university environment, it is not uncommon that the individual involved does not have the necessary skills or resources to conduct the required level of market analysis (Mowery and Sampat, 2005). Frequently, the academic does not want to leave and start up a company, but still want a reward for their invention (Etzkowitz, Webster et al., 2000). In these cases, the only commercial option may be to license the technology to industry. Although it may appear to be the most straightforward avenue for commercialisation, it is still fraught with difficulties.

Even when a company identifies a university based technology that it requires, gaining access to it is often difficult (given the universities’ rules and regulations that stand in the way of commercialisation) (Siegel, Waldman et al., 2003a; Siegel, Waldman et al., 2003b and Markman, Gianiodis et al., 2005). Some of these barriers and difficulties stem from the contrasting goals of the university and industry, while others are due to the lack of process and / or experience of the partners negotiating a deal (Duke, 1995).
The company has to decide how much additional development work it is prepared to invest in the technology, and hence how mature the technology has to be before it licenses it (Russo and Herrenkohl, 1990). Duke (1995) found that where an innovation involved research by an academic that it took 6.2 years to commercialise the result.

2.3.5 Criticisms of the Triple Helix

Discussions on the Triple Helix in the literature can be grouped into three types. First, those that argue that the public or society should be included as the fourth actor, second, that the interactions between the actors cannot be measured; and third, those that argue that the Triple Helix is not actually a model as it has no predictive capability.

2.3.5.1 Society as a fourth actor

The Triple Helix model is based on the interactions that occur between universities, governments, and industry. However, Etzkowitz and Zhou (2006) report on a debate arising out of the 5th conference on the Triple Helix where society was proposed as a potential fourth actor. The debate centers on the role played by society in rejecting new technology and whether a Quadruple Helix is required to articulate this new role.

Rather than include society as a fourth actor, Etzkowitz and Zhou (2006) propose a set of twin helices of Sustainability and Innovation. Etzkowitz and Zhou argue that 'adding a fourth helix might cause the triadic model to lose its creative dynamic. Nevertheless, the expanded concept is required to incorporate a crucial missing dimension'. To resolve this paradox, Etzkowitz and Zhou 'propose an alternative university–public–government (yin) Triple Helix as a complement to the university–industry–government (yang) Triple Helix' (Etzkowitz and Zhou, 2006).

The idea of yin and yang is an important element of the twin helices as it suggests that balance is required between the two. So, in the case where society takes a negative view of a technology, the sustainability helix acts to balance out the innovation helix. In defining the twin helix approach, Etzkowitz and Zhou have not ignored the role society has to play, but suggest that their involvement should not be a primary focus of the Triple Helix.

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2 5th Triple Helix Conference, Turin, May 18-21, 2005
2.3.5.2 Measuring interactions in the Triple Helix

Meyer, Siniläinen et al. (2003) ask 'to what extent the different roles of actors in the helices can be appropriately measured'. They ask the question as they believe a purely informetric approach does not provide a clear picture of what is happening at the global level. This implies that to understand what is happening at a higher level, it is necessary to be able to measure what is happening in the individual bipartite relationships described by Leydesdorff and Etzkowitz (1996).

Leydesdorff and Etzkowitz (1996) developed the Triple Helix to describe how the different communication and interfaces between government, universities and industry exist. Their focus was on the presence of an interaction rather than some measure of it. The question Meyer, Siniläinen et al. (2003) raise suggests that the nature of the interaction is as important as the presence of an interaction.

2.3.5.3 Perceived failings of the Triple Helix as a model

O'Malley, McOuat et al. (2002) discuss whether university-industry-government relations are modelled effectively by the Triple Helix. O'Malley, McOuat et al. (2002) argue that the Triple Helix is not a model, as it has no predictive ability and does not provide a link between cause and effect. Instead, they view the Triple Helix as 'one of those accounts philosophers of science would call high level theory' (O'Malley, McOuat et al., 2002).

The critique offered by O'Malley, McOuat et al. (2002) puts limitations on researchers wishing to use the Triple Helix. In particular, it limits the use of the model to the description and understanding of the actors and their relationships. Predictive characteristics and cause and effect cannot be assigned to the model.

While the Triple Helix model may not predict exact outcomes, it is still useful as a model in which to consider university, industry, government interactions. A tool (or model) has usefulness according to Chiesa, Coughlan et al. (1996) if it provides value to the user. So, for this research, the question is whether to be of value, the model needs to have predictive capability, and if so, how much?

2.3.5.4 Summary of criticisms

On review of these alternative views of the Triple Helix it is evident that the arguments they put forward have strengths and weaknesses. It would appear that the call for the inclusion of the public in the overall system is rationale,
however, its inclusion as a fourth helix is rejected in favour of twin helices that act in balance.

The question raised by Meyer, Siniläinen et al. (2003) on the ability of the Triple Helix to measure interactions between actors points to a weakness in the Triple Helix that helps to direct this study. Finally, the Triple Helix may not be a model in the predictive sense, but it can be used in this research as a framework in which to consider the interrelationships between three actors. It is not used to predict the outcomes of the commercialisation process. It may provide also a frame in which to discuss the commercialisation of applied research, and also to compare and contrast my research with the findings of others who have used the Triple Helix as a framework. So, accepting the limitations set forth by (O'Malley, McOuat et al., 2002), the Triple Helix model is a useful framework for the purpose of this research.

2.3.6 Summary of the Triple Helix

The emergence of the Triple Helix and the debate on the role of the university in society has shown the importance of the roles played by the university, industry and government in today's society.

Those universities that have adopted the commercialisation of research as a strategic goal have become known as entrepreneurial universities (Etzkowitz, Webster et al., 2000). However, these universities are still in their infancy and there is little data of value to show if the practices they are using are effective or not. More research is required to determine how best to approach the commercialisation of research, and to understand 'who is the university?' at different points in the process.

Governments have a role to play in the Triple Helix. They do this most effectively by providing the funding for the universities to finance projects that have commercial potential, and the support mechanisms necessary to help spinoffs. They can also provide a regulatory environment that favours and encourages the commercialisation of applied research.

Industry acts both as the source of ideas for the academic researchers, and the sink for the technologies they develop. Industry's interaction with the universities has been hampered by the different cultures and goals that drive each; however, in the recent past, both actors have seen the mutual benefits that can be achieved through the commercialisation of applied research, and have started to work together.
The Triple Helix has not been without its critics. O'Malley, McOuat et al. (2002) do not believe the Triple Helix is a model in the scientific sense as it cannot predict process outcomes, and does not provide evidence of causality. While this may be the case, predictive ability is not the key characteristic required by a Technology Transfer model, and following this review I consider the Triple Helix as the most appropriate frame in which to consider the phenomenon under investigation by this research.

Finally, having spoken of commercialisation of applied research as a process of interactions between actors (that can be managed), I now look to the technology transfer literature to help identify what gaps and barriers exist in this process.

2.4 Technology Transfer Literature

As mentioned in section 2.1, the literature on the commercialisation of research has a number of different foci, one of which is technology transfer. Similarly, the technology transfer domain has many foci. Going back to the issues raised at the end of Chapter 1, my interest is in the domain that views the transfer process in terms of gaps that need to be overcome by actors, as I seek to understand if best practices exist to help Irish universities overcome the gaps in the commercialisation process.

The communications model of technology transfer described in section 1.4.4 demonstrates that the process can be viewed as a set of interactions between actors. Similarly, Meyer, Siniläinen et al. (2003) locate technology transfer in the Triple Helix, and specifically refer to the different roles actors play in the helices. As such, a model that presents the process of commercialisation in terms of actors and their interactions is a useful point from which to review the literature. A study of spinoffs from Italian universities by Verganti and Landoni (2005), presented their model in such a manner. As such, it acts as the starting point for my literature review.

2.4.1 Verganti and Landoni model

Based upon their review of Italian spinoffs, Verganti and Landoni (2005) contend that the process of generating spinoffs depends on how effectively different actors close three gaps. These gaps are described as funding, entrepreneurship and knowledge. Verganti and Landoni (2005) also suggest that to close these gaps a minimum of four actors are involved in the process of commercialisation: the parent institution (university), government, industry (other firms) and the financial institutions, (see Figure 2.2).
The three green boxes inside the *actual spinoff* box represent the gaps that must be overcome for the spinoff to be realised. The outer blue boxes present the actors who have a role to play in closing these gaps. The arrows from these actors to the large central box represent the ability of the actors to close the gaps. The larger arrows from *governmental policies* show how Verganti and Landoni contend that government policies influence each of the other actors, and their ability to close the gaps, which places their model within the framework of the Triple Helix. In terms of the literature domains mentioned above, they are also clearly within the technology transfer domain.

Figure 2.2 Gaps in the setting up of academic spinoffs

While the arrows from *government policies* to the other actors show its influence on their behaviour, arrows between the other actors to show how they might interact are missing. This may be a result of the focus of the Verganti and Landoni study which studied the influence government funding schemes had on academic spinoffs.

Verganti and Landoni also contend that there is a pool of academics who wish to start spinoffs represented by the inner of the two nested boxes. These *potential spinoffs* become *actual spinoffs* when the academics take a decision (represented by the...
individual choices box) to pursue a spinoff. This infers that the gap between potential and actual spinoffs is the personal decision of the academic to pursue a spinoff.

2.4.2 Gaps

This section reviews each of the gaps articulated in the Verganti and Landoni model. In particular, two recent literature reviews carried out by O'Shea, Chugh et al. (2008) and Djokovic and Souitaris (2008) are used.

2.4.2.1 Funding gap

Verganti and Landoni found that funding was a problem shared between all new companies, but it was more acute for academic spinoffs as they tend to 'lack links with potential investors, have an incomplete business model, and technology that still needs research efforts or patenting and prototyping activities'. As a result, potential spinoffs require more resources and often present higher levels of risk to potential investors. Verganti and Landoni found that funding was the biggest gap in the creation of spinoffs.

In their review of the literature on technology transfer, O'Shea, Chugh et al. (2008) grouped the extant literature into six groups. The first of which was resource endowments that included the availability of VC funding. O'Shea, Chugh et al. (2008) argued that without this funding, a spinoff was unlikely.

Clayman and Holbrook (2003) agree that the likelihood of generating a successful spinoff increases if the academic has access to more financial resources. However, universities cite access to VC as the major impediment faced by spinoff companies (Verganti and Landoni, 2005). The main issue is that the VCs prefer to invest after the seed phase, which means the promoters have to find alternative sources of seed capital (Calantone and Cooper, 1981 and Landry, Amara et al., 2006).

In the life sciences, the funding gap can be much greater than in other sectors due to the need for clinical trials and legislative approval for the product to be sold in each individual market. As a consequence, Wright, Lockett et al. (2006) conclude that life sciences are less likely to create spinoffs than engineering. While on the surface this would appear to be a plausible argument, it is inconsistent with an assertion by Mowery, Nelson et al. (2001) that the growth in the life-sciences was largely responsible for the growth in licensing and spinoffs from US universities since 1980.
While most local government agencies financially support the different costs related to legal protection (as part of their IP policy), very few finance the technological and commercial development (prototypes and business plans) required by a spinoff (Shane, 2002a). Where schemes for the financing of spinoffs exist, research at Politecnico di Milano found that they are generally loan based rather than grants (Verganti and Landoni, 2005) to ensure a flow of monies are available to continue the use of the funds.

When academics look for spinoff funding, Wright, Lockett et al. (2006) argue that a hierarchy of funding exists based on a hypothesis put forward by Roberts (1991): internal funding is preferred to external funding, and where these are insufficient, then debt is preferred to equity. This is consistent with the findings of Chiesa and Piccaluga (2000), who in Table 2.2 demonstrate that a 'prevalence of personal resources over other potential funding sources' clearly exists. This suggests that academics prefer not to involve external actors, maybe because they fear a potential loss of control.

Table 2.2 Favoured sources of income (Chiesa and Piccaluga, 2000)

<table>
<thead>
<tr>
<th>Source of Funds</th>
<th>Average</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal sources</td>
<td>4.57</td>
<td>1.37</td>
</tr>
<tr>
<td>Loans from friends and relatives</td>
<td>1.11</td>
<td>.22</td>
</tr>
<tr>
<td>Bank loans</td>
<td>1.86</td>
<td>1.48</td>
</tr>
<tr>
<td>Other loans</td>
<td>1.14</td>
<td>.48</td>
</tr>
<tr>
<td>Venture Capital</td>
<td>1.03</td>
<td>.03</td>
</tr>
<tr>
<td>Regional contribution</td>
<td>1.29</td>
<td>.97</td>
</tr>
<tr>
<td>Central government contribution</td>
<td>1.06</td>
<td>.11</td>
</tr>
<tr>
<td>EU contributions</td>
<td>1.31</td>
<td>.81</td>
</tr>
<tr>
<td>International contributions (non EU)</td>
<td>1.03</td>
<td>.03</td>
</tr>
</tbody>
</table>

Note: 1 = irrelevant, 5 = critical

However, where internal funding is not available, the only option is to look for external funding. When they approach VCs, most academics lack credibility as they have no entrepreneurial history (Di Gergorio and Shane, 2003). This means accessing VC funding is difficult given the prejudices listed earlier.
Relying on business angels is also problematic as most business angels lack "the requisite experience in high level science and engineering research and development to make a confident assessment of commercial potential" (Graff, Heiman et al., 2002). The only option then is to rely on the university to provide funding.

Lockett, Murray et al. (2002) found that universities are more likely to generate successful spinoffs if they are willing to make equity investments in spinoffs in lieu of royalty agreements. Similarly, Murray and Lott (1995) argue that universities taking equity for licensing technology is beneficial for the spinoff. However, the issue for many universities is access to a budget from which to support spinoffs. While VCs advise young scientists to stay in the university to continue to develop a technology and to avail of the infrastructures provided by the university (such as incubators and internal venture funds) (Etzkowitz and Leydesdorff, 1998), not all universities have incubators and fewer have internal venture funds. As a consequence, the availability of government funding is an important substitute to ensure commercialisation activities can continue.

2.4.2.2 Knowledge gap

Verganti and Landoni also found that potential spinoffs had to overcome a knowledge gap, consisting of managerial and technical elements. Wright, Lockett et al. (2006) and Lockett, Siegel et al. (2005) agree that researchers have knowledge gaps that they should focus on to improve commercialisation. Druilhe and Garnsey (2004) show that by improving the academic's knowledge of resources and opportunities, their choice of route to commercialisation can be shifted from licensing to spinoff creation.

Djokovic and Souitaris (2008) agree that a knowledge gap exists, but they argue that it is a TTO knowledge gap. Similarly, Gordon (2004) argues the TTO need training in marketing and distribution channels. So while the focus of Verganti and Landoni (2005) is on the academic, the gap can be evident in the other actors who represent the university at different stages of the process. This is further evidence of the multiple personae who act as the university in the process of commercialisation.

2.4.2.2.1 Managerial knowledge

Wright, Vohora et al. (2004) found that spinoffs typically lack the managerial expertise to acquire the resources necessary to exploit the potential of the IP
they are based on. They also found that academics typically lack business experience and commercial skills. (Chiesa and Piccaluga, 2000) concur with this finding and believe that this is why the use of Surrogate Entrepreneurs (SE) is common. The SE is brought in to manage the day to day activities of the business according to Lockett, Siegel et al. (2005), which allows the academic to focus on the technology.

Cesaroni, Conti et al. (2005) also suggests the use of an external consultant to overcome the managerial gap, as 'the lack of managerial capabilities represents one of the main barriers to technology transfer, and is a key area towards which external policy support ought to be directed' (Wright, Vohora et al., 2004). By the nature of their jobs, most academics lack commercial development experience, which means their projects suffer from a lack understanding of user needs (Lockett, Murray et al., 2002)

2.4.2.2.2 Technological knowledge

In spite of their areas of expertise, academics can have a technological gap. The gap as defined by Verganti and Landoni refers to 'the lack of industry-specific, commercial and entrepreneur-specific knowledge that could be linked to the research and technical background of the entrepreneurs, and to their underestimation of the importance of these competences'. While this is referred to as technological knowledge, the gap may be better described as market related.

O'Gorman, Byrne et al. (2008) and Vohora, Wright et al. (2004) both argue that market related knowledge is important to help match the technology and the market, as most commercialisation attempts fail in large part because of superficial knowledge of user needs (Wright, Vohora et al., 2004). Bessant and Rush (1995) recommend that the academic inventors get their technology out to customers as soon as possible to get feedback that they incorporate into the product to ensure it meets a market need. Fontes (2005) agrees that projects developed after feedback is received from the market, result in higher quality products.

Song, Song et al. (2009) found that new venture success was directly linked to first product success, so the importance of ensuring the first product meets the markets needs is critical.
The technological gap may be better defined as a *technology-market disconnect* where the gap is between what is being offered, and what is required. While this may be correct for market pull opportunities, it fails to consider the situation where a superior technology may emerge from a university without an obvious market need. The successful commercialisation of Gatorade is an example of where tens of millions of dollars have been received in royalties by the University of Florida from a technology push (Siegel, Waldman et al., 2003b).

Talk of market pull in favour of technology push also ignores the potential for disruptive innovations coming from the university, which is a core element of the Triple Helix according to (Etzkowitz and Zhou, 2006). Christensen (1997) believes that innovation takes two distinct and different forms; sustaining or disruptive. He says sustaining innovations improve the performance of an existing product, while disruptive innovations differ in that the performance of the product can be actually degraded (Christensen, 1997).

By their nature, disruptive innovations can be more difficult to manage due to the higher levels of uncertainty that exist, both in terms of the technology used, and the needs of the market place (MacKechnie, 2001). As such, it can be more difficult to transfer knowledge within a disruptive innovation project as the communication paths can be blurred.

2.4.2.3 Entrepreneurial gap

The absence of an entrepreneur is another gap that hinders the successful commercialisation of research according to Verganti and Landoni. O'Shea, Chugh et al. (2008) also found a stream of literature that focuses on the attributes and characteristics of the academic that make them entrepreneurial. In most cases the entrepreneur in question is the academic carrying out the research, or a member of the research team. However, in some cases an SE is added to the team later in the commercialisation process as the idea gets nearer the business development phase (Miyata, 2000).

Verganti and Landoni (2005) break the gap into two parts. First they believe that 'the academic entrepreneur often lacks the necessary commitment to the business venture due to their background and preferences and/or the position they have in their parent institution'. Second, the academics also lack social links or social resources, represented by contacts in industry and financial institutions.
O’Gorman, Byrne et al. (2008) believe that the gap materialises when the academics lack market knowledge, and they fail to recognise a commercial opportunity when it exists. Similarly, due to their career choices, commercialisation is not important to them, so they are not motivated to look for these opportunities (O’Gorman, Byrne et al., 2008).

2.4.2.3.1 Commitment

Spinoffs are more often generated by teams than by single individuals according to MacCormack, Verganti et al. (2001). Zucker, Darby et al. (2002) found their foundation was the result of the joint effort of a group. While the spinoff is often formed by a team, a single entrepreneur is still required to mobilize the resources necessary to deliver value and capture returns (Landry, Amara et al., 2006).

Where a team does not have the required skills at the start of a project they can, by deploying other resources, acquire the necessary skills in a relatively short period (Landry, Amara et al., 2006). There are also some who believe that entrepreneurship can be taught, and that universities and public agencies should offer programmes and courses in entrepreneurial skills (Clarysse and Moray, 2004).

Zucker, Darby et al. (2002) asks if it is appropriate to expect the individual academic to start a spinoff. Most academics made a lifestyle choice to be academics and in doing so they specifically rejected a career in industry. Expecting them to change their mind after many years is impractical. It may be more appropriate for the university / TTO to take the lead in commercialisation activities, as is the case in MIT. Benner and Sandstrom (2000) argue that funding is a key mechanism of change in the system, since its reward structure influences the performance and evaluation of research. However, there is no evidence that academics are motivated to commercialise their research for financial gain.

The literature does not discuss how academics see the creation of spinoffs in terms of career choices. Regardless, it is hard to imagine that mature academics will leave tenured positions to join a spinoff. As a result, funding single academics (as governments tend to do) and expecting them to commercialise their research on their own may be less than optimal.
2.4.2.3.2 Social links

Verganti and Landoni suggest that having social links helps the academics overcome the entrepreneurial gap. Steffensen, Rogers et al. (2000), Nicolaou and Birley (2003a), Nicolaou and Birley (2003b), Lindelöf and Löfsten (2004) and Johansson, Jacob et al. (2005) highlight the importance of networking and social links in successful technology transfer. In this context, social links refer to contacts (formal and informal) that the academics have with other professionals and non-professionals. These links are more usually referred to as social capital in the literature. Portes (1998) presents social capital as 'the aggregate of the actual or potential resources, which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance or recognition'.

Social capital is far from homogeneous according to Putnam (2000), and some forms of social capital are more useful than others. In the context of commercialisation, links that provide access to potential resources may be useful in helping to overcome gaps. As suggested by the definition above, these social links are not institutionalised, and are usually informal. Nor are they homogeneous, and the external players from whom the academics attempt to gather resources may differ according to the gap being addressed.

Arrow (2000) suggests that much of the reward from social interactions is intrinsic: that is, the interaction is the reward, or at least the motives for interaction are not economic. Arrow (2000) admits that people may get jobs through who they know, but the contention is that they do not seek out people or join social networks for that specific purpose.

In that sense it is impossible to suggest to academics who they should have links with to help them commercialise their research. Instead Druilhe and Garnsey (2004) state that the academics need to develop strong external ties to ensure they can mobilize the resources they require when necessary. Clarysse and Moray (2004) found that in the case where links between the academic community and industry were weakest, there was no commercialisation, while Luthje and Franke (2003) and Druilhe and Garnsey (2004) found that academics who had direct and indirect relationships with VCs were most likely to receive venture funding and were less likely to fail.
It is not surprising that commercialisation levels are low due to a lack of social links between academics and industry, as sources in the literature continually describe communication difficulties between academics and industry, e.g. Hughes (2003). If these barriers exist then it is unrealistic to assume that academics have strong social links with industry.

Lockett, Siegel et al. (2005) argue that a critical factor that may affect technology implementation involves the existence of a strong proponent within the company who was willing to actively sell the research to upper management, i.e. an entrepreneur to do what Gordon (2004) called missionary work.

2.4.3 Role of actors

While Verganti and Landoni provide a model describing the gaps in the process, they do not discuss the actual interventions made by the actors that influence the closing of these gaps. To understand the role of the actors it is necessary to return to the technology transfer literature to investigate how the actors are thought to help close the gaps. The Triple Helix also makes suggestions how the three actors should interact.

2.4.3.1 Government

The review by Djokovic and Souitaris (2008) grouped the literature on spinoff development into three categories; macro, messo and micro. The macro category papers examine the economic environment in which the spinoff exists, and focus on the roles played by industry and government in the spinoff process. Issues included the policies and support mechanisms provided by government and industry, as well as the impact of the market on the realisation of the spinoff.

The papers which examine the policies and incentives used by government (Bozeman, 2000; Shane, 2002a and Lockett, Siegel et al., 2005) found that government policy and industry-university interaction can stimulate the spinoff phenomenon. However, those that focus on explaining why a market driven approach is successful (Shane, 2001) lack empirical evidence according to Djokovic and Souitaris (2008), who suggest more research is necessary in this area.
As discussed earlier in section 2.3.3, government has a number of conflicting roles to play as it acts as both venture capitalist and public entrepreneur. The issue that arises is whether government should be picking winners by funding only certain projects in its role as VC, or funding as many as possible as a public entrepreneur.

As legislator and regulator government sets the rules of the game, and most have copied the US system in an attempt to mimic the success of some US universities (O'Shea, Allen et al., 2005). However, this one size fits all approach does not work, and governments need to take account of local context when setting policy (van der Steen and Enders, 2008).

### 2.4.3.2 Industry

The papers that focused on how industry (and the market) influenced the creation of spinoffs attempt to show how the type of technology, characteristics of the market, and the effectiveness of patents determine the type of spinoff created (Shane, 2001). There is an obvious link between the issues discussed in Section 2.4.2.2.2 on technological and market gaps, and the pull from industry in the development of new spinoffs. Where a need in the market is obvious, then realising a spinoff may be easier than if the spinoff is based on a technology push, or discontinuous innovation.

From the company's perspective, it has to decide how much the technology is worth to them. To do this the company has to consider how many additional development resources it is prepared to invest in the technology, and hence how mature the technology has to be before the company licenses it (Moray and Clarysse, 2005). Within large companies, where an innovation requires research by an academic institution to successfully develop it, it takes over six years to commercialise the university research (Siegel, Waldman et al., 2003a; Siegel, Waldman et al., 2003b and Markman, Gianiodis et al., 2005). This time lag can have a significant impact on the value the company places on the technology, and may also determine which technologies they are prepared to licence (e.g. it is unlikely a company could afford to wait six years to commercialise a technology in the Fast Moving Consumer Goods (FMCG) sector). They may however, wait that long in the life-sciences.
2.4.3.3 University

The meso-level studies identified by Djokovic and Souitaris (2008) examined the roles played by the university and the TTO. Studies grouped in this category try to identify the support mechanisms that are employed by the academic institution to incentivise spinoff creation, as well as to explore the effectiveness of spinoffs as a university technology transfer mechanism (Di Gergorio and Shane, 2003; Siegel, Waldman et al., 2003b; Lockett, Siegel et al., 2005 and Powers and McDougall, 2005).

A question that arises when reviewing the literature is who is being referred to when we discuss the university. In many cases it is the TTO, in some it is the legal entity responsible for setting policies and regulations, while in others it refers to the academic or academic team. In general, the TTO is referred to when discussing policies and supports, the legal entity when rewards or resource deficiencies, and the academic when discussing entrepreneurship.

Di Gergorio and Shane (2003), Siegel, Waldman et al. (2003b), Lockett, Siegel et al. (2005) and Powers and McDougall (2005) found that the size and experience of the TTO has a positive influence on spinoff activity. Similarly, the royalty regimes of the university were positively associated with spinoff creation according to Lockett and Wright (2005).

In those cases where the university has an incubator Vohora, Wright et al. (2004) found that this helps improve the levels of successful commercialisation. These incubators not only provide office and lab spaces at favourable rents, but they also provide a bridge or link between the university and industry, a factor Di Gergorio and Shane (2003) argue is linked to successful commercialisation. Incubation of the spinoff is not however a short term task and typically takes 12-18 months (Lockett, Siegel et al., 2005). When examining the literature on science and technology parks, the papers are inconclusive on their effectiveness. However, Siegel, Waldman et al. (2004) found that only one third of TTO staff they interviewed consider creating a spinoff as a route to commercialisation. Instead they focus on licensing because it is easier to achieve from their perspective (Colyvas, Crow et al., 2002).

Gordon (2004) argues that the university’s mission must be aligned with their actions. In this respect, DeGroof and Roberts (2004) suggest two different policy approaches taken by universities, shown in Figure 2.3. The first of these
The second approach is the \textit{high-selectivity-high-support} model where the university chooses a small number of spinoffs it believes have the highest probability of success. It then provides them with support to increase their chances of success. This is of greater risk to the TTO as they have to ensure they can pick the winners; otherwise the total number of spinoffs will drop. The \textit{high-selective} model is more appropriate for regions with an entrepreneurial culture gap, where VC funding is not readily available (DeGroof and Roberts, 2004).

A \textit{low-selective} approach may be appropriate if government is acting as \textit{public entrepreneur}, but not if it's acting as VC. In that case a more high-selective approach is required. In this context a balance needs to be found between the roles of government as public entrepreneur and venture capitalist. However, the universities need to be involved in this decision, and it is unlikely that universities would prefer a high-selective approach if it meant less funding in total from the state agencies who support commercialisation (as the universities also receive overhead payments on the funding they receive from these agencies). The tension between carrying out research for its own sake, and the...
commercial conditions set by government will always give rise to differences in opinion, as academics will always want funding to carry out research.

2.4.3.4 Academic

The inclusion of the university in the messo level and the academic in the micro level by Djokovic and Souitaris (2008) is a clear attempt to differentiate between the two, and show that they may have separate roles to play in closing the gaps. This is important as it shows that the internal players in the university are not homogeneous, and that they may have different goals at different times that need to be accounted for.

One of the issues that needs to be addressed is whether academics are the best cohort to fund in attempting to commercialise research (Zucker, Darby et al., 2002). Results of an empirical study by Thursby and Thursby (2002) suggest that where licensing is concerned, they are an appropriate cohort as they found that increased licensing was due ‘primarily to an increased willingness of faculty and administrators to license… rather than a shift in faculty research’. This suggests that given the necessary supports the academics can licence their technologies, while at the same time maintaining the integrity of their research.

However, in terms of spinoff creation, Shane (2002a) found that where technology is not licensed (and patents are effective), that the creation of a spinoff (via a licence to a non-inventor) increases the likelihood of commercialisation. This is primarily because the non-inventor is an economic actor who possesses commercial skills the academic does not. This suggests that academics may not be the most appropriate group to develop spinoffs.

A number of papers examining the effectiveness of spinoffs as a mechanism of technology transfer (Jensen and Thursby, 2001 and Shane, 2002a) found that inventor entrepreneurship is a second-best solution to the commercialisation of new technology.

Druilhe and Garnsey (2004) also argued that by improving the academic's knowledge of resources and opportunities, the academic's choice of route to commercialisation can be shifted from licensing to spinoff creation. This is more rewarding to the university, as Bray and Lee (2000) found ‘that spinning-out is a far more effective technology transfer mechanism compared to licensing, as it creates a ten times higher income’.
When considering the role of the founders in the spinout process, the literature considered the influence of both the academic, and/or an SE, on the performance of spinouts (Chiesa and Piccaluga, 2000; Cesaroni, Conti et al., 2005 and Lockett, Siegel et al., 2005). The academic has many choices (to join the spinoff full-time, part-time or not at all), but keeping the academic involved improves the effectiveness of the technology transfer (Roberts and Hauptman, 1986). Clarysse and Moray (2004) suggest that the academics can learn the required business skills, and 'instead of hiring a CEO at the start-up of the company, it might be a more efficient choice to coach the start-up team and give them the time and freedom to learn'.

2.4.4 Summary

The Verganti and Landoni model is based on the proposition that the successful spinoff of a research project is based on the closing of a number of gaps. These gaps include the absence of an entrepreneur to drive forward the business, the managerial and commercial skills to run the business, and the funding to pay for resources. There are at least four actors involved in providing the resources necessary to close those gaps: the university, industry, government (consistent with the Triple Helix) and the financial institutions.

The literature on technology transfer confirms the presence of these three gaps and helps to characterise them. The literature also confirms that a number of actors play a role in closing these gaps, and again characterises their actions.

However, a number of issues arise out the literature. Given the different roles apportioned to the university by the literature, it appears that we need to have a clearer definition of who the university is at different times in the process. At different times, the role of the university is played by the academic, the TTO, or the institution. Tensions can arise if the goals of these different internal players conflict with each other, e.g. if the TTO prefers a licence deal as it requires less work, when the academic wants to pursue a spinoff.

Similarly, we have to ask if the academics are the best cohort for government to target with its investment. The literature has shown that academics can commercialise their research via licensing. However, they are not as good at realising spinoffs, as this generally requires the commercial experience and the combined skills of a team.
There must also be a balance between the different roles played by government, i.e. VC versus public entrepreneur, and legislator versus regulator. The policies that government uses as VC may conflict with its role as public entrepreneur, so one must not outweigh the other. Similarly, the need for legislation to encourage commercialisation should not mean that over regulation restricts what the universities can do to commercialise their research.

While Bayh Dole is seen by many as the driver behind the increased levels of commercialisation in the US, it is not accepted as such by all. Those governments who have copied the Bayh Dole template should be aware of this, and must also remember that a one size fits all solution does not exist, as context needs to be accounted for.

2.5 Conclusions
This chapter reviewed the available literature on the commercialisation of research. Using the framework of the Triple Helix we see that the university, industry and government play different roles according to the context in which they operate.

The literature also shows that the creation of a spinoff is based on the closing of a number of gaps: funding, knowledge and entrepreneurship. These gaps can be closed by at least four actors: university, industry, government and the financial institutions. As the creation of spinoffs is about closing gaps, Lockett, Siegel et al. (2005) also believe the process is a managerial one.

Assuming this managerial focus, how the actors intervene to help close gaps, and the measures used to gauge these interventions are important. As Pfeffer and Sutton (2000) argue, there is a danger that 'what gets measured, gets done'. So the targets set to measure the performance of the various actors in the commercialisation process need to focus on adding value, rather than being focused on short-term, easy to measure outcomes that may actually be detrimental to the creation of a spinoff or licence.

While Verganti and Landoni (2005) and Lockett, Siegel et al. (2005) speak of various gaps, neither provide details on the factors that make up these gaps. In reviewing the literature it was clear that there were few papers that focus on the Irish context. Those studies that do focus on Ireland are either focused on the institution rather than the project or were published before the introduction of government funding aimed specifically at commercialising university research. This suggests a gap exists in the literature on the commercialisation of research in Ireland.
2.5.1 Revisiting the aim of this research study

In section 1.6 a number of issues relating to the process of commercialisation of applied research from Irish universities were highlighted. Using the findings of this chapter, Table 2.3 presents a summary of what we know about the topic.

Table 2.3 Opportunities arising from a review of the available literature

<table>
<thead>
<tr>
<th>We know</th>
<th>We do not know</th>
<th>Research opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>University, government and industry provide resources to academics wishing to commercialise their research</td>
<td>If there are patterns in when (chronologically) these resources are required</td>
<td>What is happening in the Irish third level sector</td>
</tr>
<tr>
<td>Overcoming gaps, e.g resources deficiencies, is necessary to commercialise research</td>
<td>What deficiencies exist and need to be overcome in an Irish setting</td>
<td>Investigate gaps in Ireland</td>
</tr>
<tr>
<td>Evidence from US and UK shows that academics are successfully commercializing their research</td>
<td>How interactions between the actors in the Triple Helix influence commercialisation?</td>
<td>How the actors and gaps relate to the Triple Helix</td>
</tr>
<tr>
<td>The provision of resources helps close gaps</td>
<td>Who is best placed to provide the resources to ensure success?</td>
<td>Patterns in the provision of resources by the actors</td>
</tr>
</tbody>
</table>

Taking these findings, and comparing them to the issues raised in section 1.6, we see a level of overlap between the two. By refining the issues raised in Section 1.6 to take account of the research opportunities listed above, the following research questions were developed. If addressed, the answers to these research questions will provide a theoretical contribution to the literature on technology transfer and the Triple Helix, and offer policy recommendations for the actors in the process.

- What gaps need to be overcome by Irish universities in the process of commercialisation to generate spinoffs and licences?
- Who are the actors that influence the closing of these gaps?
- Are there patterns in the way in which these actors intervene in the process, and is there a link to the commercialisation outcome (spinoff or licence)?
- What policy implications are there for the further development of the Triple Helix of university-industry-government relations?

To help answer these questions the next chapter presents a model for the commercialisation of research developed from the literature. How the model is investigated, and what tools and techniques are used to answer the research questions posed above are all discussed in Chapter 4.
CHAPTER 3 : DEVELOPMENT OF A CONCEPTUAL MODEL

3.1 Introduction

The means by which applied research from Irish universities can be commercialised is the phenomenon to be investigated by this research. I am particularly interested in answering the research questions developed in Chapter 2 and arising from the issues raised in Chapter 1 of this thesis. They are:

- What gaps need to be overcome by Irish universities in the process of commercialisation to generate spinoffs and licences?
- Who are the actors that influence the closing of these gaps?
- Are there patterns in the way in which these actors intervene in the process, and is there a link to the commercialisation outcome (spinoff or licence)?
- What implications are there for the further development of the Triple Helix of university-industry-government relations?

From Chapter 2 it is evident that the process of commercialisation is based on the interactions between the universities and industry, and that government plays a strong role in encouraging these interactions. As the Triple Helix model was developed to describe the interactions between universities, industry and government, it offers a theoretical framework in which to consider the phenomenon of interest to this research. It is used in this study to describe and understand the interactions between actors, and cognisant of the criticism by O'Malley, McOuat et al. (2002), it is not used for predictive purposes.

Chapter 2 also presented a model for the creation of spinoffs developed by Verganti and Landoni (2005). This model identified a number of potential gaps that had to be closed to realise a spinoff from academic research. It also identified the actors who can play a role in closing these gaps.

Therefore building on the findings from Chapter 2, I base my conceptual model in the framework of the Triple Helix, and use Verganti and Landoni (2005) as the starting point for the development of the conceptual model. The following section outlines how I develop my conceptual model.
3.2 Establishing the conceptual model

Forza (2009) provides a list of four items that a researcher should follow in developing a conceptual model. This section outlines how I deal with these four items in the development of my conceptual model.

- **Construct names and definitions**: the factors must be clearly labelled.
- **Propositions**: present and discuss the role of each factor and the proposed relationships between them.
- **Boundary conditions**: define the conditions under which the propositions are expected to hold.
- **Explanation**: provide an explanation of why we expect to observe these relationships based on existing theory.

The aim of this research is not just to extend the Verganti and Landoni model, but to add to it by addressing the research questions listed above. The use of the Verganti and Landoni model also allows for the grounding of the conceptual model in the established literature. In that way, the findings of this study can be compared with the literature, so that the contribution I hope to make can be seen with reference to Verganti and Landoni.

3.2.1 Construct names and definitions

I base the definition of my constructs on the technology transfer literature reviewed in Chapter 2. As I base my model on the same gaps and actors identified by Verganti and Landoni (2005), I use the same definitions they do.

The first actor is the parent institution (which I will label as the university as there are no other type of Research Performing Organisation (RPO) included in this research), which is the institution where the research is carried out. As highlighted in Chapter 2, the university can be represented by different internal actors at different times. It is the entity that sets the strategy and defines policies (Di Gergorio and Shane, 2003), while it is also represented by the TTO, or academic at other times (Siegel, Waldman et al., 2003a).

The second actor is the financial institutions, and represents external sources of funding (other than government), such as VCs or banks. The third actor is government (national and regional), while the final actor is the set of firms which is the collective term used to describe the companies that interact with the universities. I will label these other firms as industry for short.
The three gaps are defined as in Section 2.4.2: funding, knowledge and entrepreneurial. To demonstrate where each of these actors and gaps arise in the literature, I use Table 3.1 to present the list of constructs, alongside the list of papers where each is presented. The table also includes the variables that make up the constructs based on the corresponding papers.

Table 3.1 Development of the constructs

<table>
<thead>
<tr>
<th>Construct</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge gap</td>
<td>Di Gergorio and Shane (2003), Vohora, Wright et al. (2004)</td>
</tr>
<tr>
<td>Funding</td>
<td>Siegel, Waldman et al. (2003), Di Gergorio and Shane (2003)</td>
</tr>
<tr>
<td>Role of University</td>
<td>Di Gergorio and Shane (2003), Siegel, Waldman et al. (2003a)</td>
</tr>
<tr>
<td>Role of industry</td>
<td>Chiesa and Piccaluga (2000), Cesaroni, Conti et al. (2005), Lockett</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial skills of academic</td>
<td>Technical knowledge of academic</td>
</tr>
<tr>
<td>Management skills of academic</td>
<td></td>
</tr>
<tr>
<td>Lack of funds</td>
<td></td>
</tr>
<tr>
<td>Commercial skills of academics</td>
<td>Social Links</td>
</tr>
<tr>
<td>Ownership of previous spinoff</td>
<td>Patenting history</td>
</tr>
<tr>
<td>Frequency of links to industry</td>
<td></td>
</tr>
<tr>
<td>Policies that provide incentives for entrepreneurial activity</td>
<td>TTO structures and licensing strategies</td>
</tr>
<tr>
<td>University incubation strategy</td>
<td>Reward and recognition</td>
</tr>
<tr>
<td>Motivation of TTO staff</td>
<td>Structure of the TTO</td>
</tr>
<tr>
<td>Strength of marketing skills</td>
<td></td>
</tr>
<tr>
<td>Support programmes</td>
<td>Source of funding</td>
</tr>
<tr>
<td>Policies and regulations on commercialisation</td>
<td></td>
</tr>
<tr>
<td>Receptive industry</td>
<td></td>
</tr>
<tr>
<td>Source funding</td>
<td></td>
</tr>
<tr>
<td>Technical knowledge</td>
<td></td>
</tr>
<tr>
<td>Commercial knowledge</td>
<td></td>
</tr>
<tr>
<td>Social links</td>
<td></td>
</tr>
<tr>
<td>Business advice</td>
<td></td>
</tr>
</tbody>
</table>
The **funding gap** construct refers to a lack of finance that exists at any point in the project, and is defined by a variable called funding. The **knowledge gap** construct is made up of two variables, the commercial skills of the academic and his/her technical knowledge. The **entrepreneurial** construct is made up of two variables, commitment of the academic and his/her social links.

The **role of the university** construct is made up of a number of variables; these include its policies and strategies for commercialisation, the TTO structures, the motivation of the TTO staff, as well as the skills of the TTO staff. The **role of government** construct is made up of the variable referring to the support programmes offered by government as well as the policies and regulations it sets. The **role of industry** construct is to be receptive to the technology. The **role of the financial institutions** has two elements, the funding and business advice they offer. Finally, the **role of the Principal Investigator (PI)** is made up of his/her previous commercial experience and whether he/she acts as an entrepreneur.

How all these variables are operationalised is discussed in the research protocol included as appendix 1 to this thesis.

### 3.2.2 Propositions for inclusion in my conceptual model

As I use Verganti and Landoni (2005) as the basis for my model I accept for the moment their basic propositions that there are three gaps in the process that can be overcome by the intervention of the four actors they identify (see Figure 3.1).

Verganti and Landoni refer to two types of spinoff, **actual** and **potential**. Actual spinoffs occur where an academic attempts to commercialise his/her research via a spinoff. Potential spinoffs refer to the pool of projects with commercial potential.

Verganti and Landoni’s simple description implies that the only step between a project with potential to spinoff, and an actual spinoff is the decision of the academic to pursue a spinoff. I propose that the process is more complicated than this; the decision of the academic is not a simple go no-go decision. I propose that it is more useful to view this decision as the first step in an ongoing demonstration of commitment by the academic that is necessary to ensure the research is commercialised. As such, the academic has an ongoing role in the process that is not immediately obvious from Verganti and Landoni’s model. I propose that the **individual choice** of the academic in the Verganti and Landoni model is part of the ongoing commitment element of the entrepreneurial gap.
Figure 3.1 The process of commercialisation (Verganti and Landoni, 2005)

Given its base in the Technology Transfer literature, the Verganti and Landoni model does not consider the process by which a product or process is developed from the technology. For the purpose of this study, I propose that the development process used within the project is equally important, and by extension, that factors that influence success and failure in New Product Development (NPD) will be relevant here.

In project NewProd, run over a decade, Cooper (1979), Cooper and Kleinschmidt (1987) and Cooper (1994) found that three key factors distinguished between success and failure in NPD projects, they were:

- Presence of a unique superior product
- Market knowledge and market proficiency
- Technical and production synergy and proficiency

I propose that each of these findings has a relevance to commercialisation of research and that if any one is missing, then a spinoff or licence is unlikely to occur. The technical proficiency exists as part of the technological gap identified by Verganti and
Landoni. However, the market knowledge and proficiency gap is not included by Verganti and Landoni in their model, nor, is the unique superior product. I include this in the conceptual model as an idea uniqueness gap as it is unlikely that a product will be far enough developed during the project.

I propose the PI has a key role to play in closing the gaps via the skills and knowledge they bring to the process, and for these reasons I propose further that the PI is a fifth actor in the process.

The Verganti and Landoni model was developed as part of a study of financial supports for spinoffs from academic institutions. As such, it did not consider licensing as an alternative commercial outcome. As the literature has shown, licensing is the more common route to commercialisation, so any model that describes how the process of commercialisation works must accommodate both spinoffs and licences. I therefore propose three outcomes from the process; a spinoff, a licence, or no commercial outcome.

Building on Verganti and Landoni I propose three additional scenarios exist, bringing the total to four (see Figure 3.2). I add these scenarios to demonstrate that the gaps may change according to the route to commercialisation taken (spinoff or licence), and the point in the process where the interaction occurs (before or after spinoff or licence). I propose that the gaps in the spinoff scenario (e.g. funding) are different from those in the licensing scenario, requiring a different degree of closure (e.g. more funding). This also implies that there is a threshold below which the degree of closure leads to no commercial outcome.

Figure 3.2 Four Scenarios
Based on the literature on knowledge gaps, I also propose that interventions by the actors, coupled with a willingness of industry to engage with the universities and a supportive government, and the skill with which they intervene both influence the closing of the gaps.

Also, the maturity of their skills (ability to use lessons learned in projects to continuously improve the process, as defined by the Capability Maturity Model\(^3\) (CMM)) is relevant. The CMM was developed for the software industry, and characterises the maturity of processes; at the lowest level are ad hoc, unrepeatable processes, while at the highest level are well managed processes (Paulk, Weber et al., 1993). The Verganti and Landoni model, while identifying gaps and actors, does not identify explicitly differences in experience or maturity. Yet, this notion of using experience to improve a process may also be applied to technology transfer. I propose that the more experience (maturity) an actor displays, the greater their ability to close gaps. I further propose, that without a level of experience, the actors may fail to identify gaps that need to be closed, resulting in a failure to commercialise a project. Evidence of these two kinds of experience will be sought in measuring the level of knowledge possessed by the various actors.

The Verganti and Landoni model is limited to Scenario A. As I also proposed three other scenarios, where the size of the gaps may differ, it is logical to propose that an actor needs to display the capability to recognise what interactions are required in the four different scenarios, and that a different degree of closure is required in each scenario. As such, the level of skill with which the actor intervenes must also change depending on the scenario involved. Figure 3.3 shows how I propose the presence and level of skill are related to the closing of the gaps.

In the upper right hand quadrant the presence of an intervention is high, and the skill level with which supports are administered is also high; this I propose increases the likelihood of generating a spinoff or licence. In the lower left hand quadrant the presence of intervention is low, and the skill level with which supports are administered is also low; this I propose decreases the likelihood of generating a spinoff or licence. The impact of the supports in the other two quadrants is indeterminate.

---

\(^3\) A service mark owned by Carnegie Mellon University
In summary, I propose the following additions to the model set forth by Verganti and Landoni based on the literature review carried out in chapter 2:

- There are three possible process outcomes; a spinoff, a licence or, no commercial outcome.
- There are four scenarios, and the gaps that need to be overcome to deliver a commercial outcome differ according to the scenario involved.
- Interventions by actors help to close these gaps based on the willingness of industry to engage with the university and a supportive government.
- When an actor intervenes, the greater the impact on the closing of the gaps (and vice versa).
- The higher the skill level with which the actors intervene, the greater the impact on the closing of the gaps (and vice versa).
- There are different degrees of closure associated with the three different outcomes of the process.
- The inclusion of two new gaps: a market knowledge gap and an idea uniqueness gap.

### 3.2.3 Boundaries to the proposed model

In this thesis, the most important boundary is where I consider the process of commercialisation to start. Figure 3.4 shows the timeline of a typical commercialisation project. The starting point is where the academic has an idea he/she wishes to commercialisation. The origin of this idea is outside the scope of my interest. The academic then applies to government for funding and if successful, the project runs for the given duration, at which point further funding may be provided by government.
The university has a number of roles to play during the life time of the project, as described in chapter 2. Typically, it is the TTO that acts on behalf of the university. In its first role, the TTO protects the technology by patenting its novel aspects, while in its second role it markets the technology to industry in the hope of generating a licence deal. Alternatively, if the academic wishes to set up a new spinoff company, they negotiate access to the technology with the TTO. Beyond these settings is outside of the scope of my interest.

Figure 3.4 Timeline of the projects

3.2.4 Explanation of proposed relationships

Finally, Forza (2009) suggests that the researcher should explain why we expect to observe the proposed relationships based on the existing theory. Using the literature reviewed in Chapter 2, and Table 3.2, I list the possible relationships that exist based on my conceptual model, and include the authors who contend that these relationship exists.

Table 3.2 should be read in the following manner; the relationship column outlines how the actors (in the first column) help to close the gap in the last column. The literature column provides a reference to the papers on which the relationship is based. The relationships shown in Table 3.2 were developed from the variables included in Table 3.1.
### Table 3.2 Explanation of relationships

<table>
<thead>
<tr>
<th>Actor</th>
<th>Relationship</th>
<th>Literature</th>
<th>Gaps they can overcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Institutions</td>
<td>Offer funding to overcome gap, VCs pick winners&lt;br&gt;Offer business advice, can put person on company board</td>
<td>Calantone and di Benedetto (1988), Luthje and Franke (2003), Druilhe and Garnsey (2004) and Landry, Amara et al., 2006</td>
<td>Funding&lt;br&gt;Knowledge</td>
</tr>
<tr>
<td>Industry</td>
<td>Offers networks of contacts&lt;br&gt;Can provide a surrogate entrepreneur</td>
<td>Chiesa and Piccaluga (2000), Cesaroni, Conti et al. (2005), Lockett, Siegel et al. (2005), and O'Shea, Allen et al. (2005)</td>
<td>Entrepreneurship</td>
</tr>
</tbody>
</table>

### 3.3 Conclusions

Using Verganti and Landoni as a starting point, and adding the propositions outlined in the previous section, the conceptual model to be investigated by this study was developed. Shown in Figure 3.5 and Figure 3.6 the proposed conceptual model is made up of two parts.
Figure 3.5 Proposed conceptual model

Figure 3.6 Outcomes based on degree of gap closure

Figure 3.5 shows that in the process of commercialisation four gaps must be overcome: 1) funding, 2) knowledge, 3) entrepreneurship and 4) idea uniqueness. It also shows that there are five actors who may have a role to play in closing these gaps. They are: 1) government, 2) financial institutions, 3) industry (collective name for other firms), 4) the university and 5) the principal investigator.
The funding gap refers to the money needed at different points of the project to buy the necessary resources. The knowledge gap is made up of three elements, managerial, marketing and technological, and it defines the managerial and technical skills the team must display to commercialise their research, as well as the market knowledge needed to sell a unique superior product. The presence of which is defined by the unique superior idea gap. Finally, the entrepreneurial gap is made up of the social links the academic PI must have to mobilise the necessary resources, and the commitment that the academic PI must display over the life of the project to ensure it is commercialised.

The five actors have different roles to play depending on the scenario involved. Primarily, government acts as a source of funds, as well as legislator and regulator. The financial institutions provide capital, while industry acts as a pull on the technology and a potential licensee. In its various personae, the university acts to regulate the commercialisation process and to provide support and training to academics wishing to commercialise their research, and offers incentives (royalties and leave of absence) to encourage commercialisation activities. Finally, the Principal Investigator is responsible for driving the project and is typically the lynchpin in the process. I expect, that without a committed Principal Investigator, a project will not be commercialised.

Figure 3.6 shows the three possible outcomes of the process: 1) a spinoff, 2) a licence, or 3) no commercial outcome. It also proposes that to realise a spinoff or licence an increasingly higher threshold needs to be overcome for each of the four gaps. For example, in the case of the funding gap, a spinoff has a greater need for funding than a licence, so a higher threshold exists. If this threshold is not overcome, then a spinoff will not be realised. However, a licence may still be possible. By extension, the failure to reach the threshold required for a licence results in no commercial outcome.

It is the role of the various actors to identify and provide the necessary degree of closure, e.g. level of funding. If the actors do not identify the appropriate level of support they need to provide, then it is unlikely the desired outcome (spinoff or licence will be achieved).

The next chapter discusses how the research was designed to answer the research questions. This includes what research tools and techniques were employed, and how the data was accessed, gathered and analysed.
CHAPTER 4: DESIGNING THE RESEARCH

4.1 Introduction
This chapter provides a detailed description of the considerations influencing my research design. It is presented in six sections: the first reviews the literature for guidance on research design, and the types of assumptions that have to be made by the researcher. The second and third sections deal with the decisions I have taken in light of this, while the fourth and fifth present the data gathering and analysis techniques. The final section provides a summary and conclusions.

4.2 Design assumptions
How a research study is carried out and what the researcher's underlying philosophy is are important. Two ends of the philosophical spectrum are positivism and relativism.

A researcher with a positivist philosophy believes that human behaviour can be defined by quantifiable variables that can be studied, and about which theories can be developed to explain *cause and effect* relationships. The ability to generalise from their results is a key driver of a positivist researcher. Positivism characterises epistemologies that 'seek to explain and predict what happens in the social world by searching for regularities and causal relationships' (Burrell, 1996). In a positivist study the research neither affects, nor is affected by, the subject under investigation, and the methods used are primarily experimental and quantitative (Guba and Lincoln, 1994).

Relativism on the other hand claims that the real world is too complex to be defined by a set of variables and associated rules. Instead, relativists are usually only interested in a specific case, and do not care if their results can be generalized or not (Guba and Lincoln, 1994). According to Pole and Lampard (2002) it is a common criticism of research designs to say they suffer from relativism, e.g. that different researchers may find different results using the same methods.

Given that different research philosophies exist, in order to understand the researcher's choice of philosophy we need to consider what defines a philosophy. Research philosophy is concerned with questions such as, what procedures should the researcher follow, and what conditions must be satisfied for the scientific explanation of the phenomenon under investigation to be correct. Burrell and Morgan (1979), Guba and Lincoln (1994), Creswell (1998) and Smith (2000) all contend that the
researcher’s philosophy is based on their ontological and epistemological assumptions. These assumptions can be thought of in light of the following questions:

- What is the researcher’s ontological perspective of the world?
- What is the researcher’s epistemological view of knowledge?
- What methodology is behind the choice of methods?
- What methods will the researcher use?

Figure 4.1 shows the relationship between the four assumptions.

Figure 4.1 Four elements of research

4.2.1 Ontology

Ontology is best described as how the researcher views the world around him/her, whether, for example, the world around the researcher is real or a product of one’s mind (Burrell and Morgan, 1979). The assumptions the researcher makes with respect to ontology concern the very nature of the phenomena under investigation, whether reality is a given out there in the world, or the product of one’s mind (Burrell and Morgan, 1979).

4.2.2 Epistemology

Epistemology refers to the relationship between the researcher and what he/she is studying. For example, does he/she believe ‘knowledge can be transmitted to others in a hard tangible form’ or ‘knowledge is of a softer, more subjective, spiritual or even transcendental kind, based on experience and insight of a unique and essentially personal nature?’ (Burrell and Morgan, 1979). According to Guba and Lincoln (1994), both have important implications on how we go about investigating a phenomenon and obtaining knowledge about it.

Epistemological assumptions entail ideas about what forms of knowledge can be obtained, and how one can sort out what is to be regarded as true, from what is to be regarded as false (Burrell and Morgan, 1979).
4.2.3 Methodology

The purpose of the methodology is to help us understand the world by obtaining first hand knowledge of the subject under investigation (Burrell and Morgan, 1979). Ontology and epistemology both have direct implications of a methodological nature according to Stone (1978). Each has important consequences for how we attempt to investigate and obtain knowledge about the social world, and differences in ontology and epistemology lead to differences in methodology (Stone, 1978 and Burrell and Morgan, 1979).

To decide which methods best suit my research I look to Yin (2003) who provides an excellent template to help choose methods (see Table 4.1).

Table 4.1 Research strategies used in the social sciences

<table>
<thead>
<tr>
<th>Research Strategy</th>
<th>Form of Research Question</th>
<th>Requires control of behavioural events?</th>
<th>Focuses on Contemporary Issues?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>How? Why?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>History</td>
<td>How? Why?</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Case study</td>
<td>How? Why?</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

4.3 My research design

Based on a view that the outcomes of the phenomenon I am investigating can be measured, I have a realist ontology. I believe that the world exists independent of the individual, and that it is made up of hard, tangible and relatively immutable structures (as spinoffs and licences are tangible results) (Burrell and Morgan, 1979). I also believe that the phenomenon can be analysed objectively, and that my presence as a researcher does not influence the outcomes.

My epistemology is based on empiricism which emphasises the role of experience, and which works with observable facts. The basis of this epistemology is my view that knowledge is based on positive information gained from observable experiences. I use a nomothetic methodology as it is consistent with my ontological and epistemological view points. A nomothetic methodology is based on the assumption that the researcher can conduct the research without affecting the phenomenon under investigation. My methods are consistent with these three assumptions and are discussed later in this chapter.
The assumptions discussed above are coherent in that they form the basis of the *positivist* philosophy (Burrell and Morgan, 1979 and Guba and Lincoln, 1994) which is consistent with the aims of this study.

### 4.3.1 My choice of methods

I use a two phase multiple methods approach to my study. The first phase is a pilot survey to gain a better insight into the phenomenon, the results of which allow me to choose the most appropriate cases for the second (case based) phase of the research, which investigates the phenomenon in more depth. Both survey and case research fit within the positivist philosophy, as they both allow for a realist ontology. Both methods also fit within an empirical epistemology, and both are nomothetic.

My use of multiple methods is not uncommon as Gill and Johnson (2002) tell us that 'there is no single method that generates scientific knowledge in all cases'. There are many different approaches we can take in social scientific research, none of which is perfect; each having its own individual strengths and weaknesses. However, as the flaws of the different social science research methods are not the same, using multiple methods allows us to gain from their combined strengths, while helping to overcome the weaknesses of the individual methods (Brewer and Hunter, 1989 and Singleton, Straits et al., 1993).

I use a multi-method approach as it facilitates the use of two distinct phases in this study. The first phase is to carry out a survey of the entire population to investigate whether the conceptual model developed from the literature is a good representation of the phenomenon. The second phase is to conduct a number of case studies that will allow for a much more in depth investigation of the conceptual model. Without the initial survey phase it is possible that the case studies will ignore key areas as they have not been identified by the current literature. For that reason, I use the survey first, and the cases second.

The use of a multi-method approach also has a number of other advantages. First, it allows the researcher to 'improve the accuracy of their judgements by collecting different kinds of data bearing on the same phenomenon' according to Jick (1979), something I make use of in this study. I also use triangulation to increase the validity of the results (Voss, 2009). Maxwell (2005) argues that triangulation reduces the risk that one's conclusions will reflect only the systematic biases or limitations of a specific source or method, and allows one to gain a broader and more secure understanding of
the issues under investigation. Second, the use of more than one method ensures that variance in the analysis reflects that of the phenomenon under investigation, not of the methods I use (Jick, 1979).

4.3.2 Potential biases of the author
A further threat to the validity of this study comes from the potential biases that I, as the researcher bring to the study. Maxwell (2005) defines bias as 'what you bring to the research from your own background', and suggests that 'its influence needs to be eliminated from the design' to avoid contaminating the results. Other authors argue that the use of previous experiences can be useful (Jansen and Peshkin, 1992).

'The test of your bias is openness to contrary findings' according to Yin (2003). So as long as the researcher does not close their mind to contrary findings, their background should not be excluded from the research.

As an employee of Enterprise Ireland, which funds the ATRP / CFTD, I play an active role in the commercialisation of projects. This role provides me with many insights into the process, whilst giving me first hand knowledge of many of the participants in the process. This knowledge is useful, as it allows me to filter data in a way that an outside trying to conduct a similar study could not.

To eliminate potential sources of bias from my background any project that I had a significant role in was excluded from the choice of case studies. Similarly, all communication to participants came via my student email, and I represented myself as a student to anyone who did not already know I was an Enterprise Ireland employee.

4.3.3 Summary
While the use of multiple methods helps overcome a number of design flaws, a number of other potential threats to the validity of outcomes of my research design exist. One in particular was the bias introduced by the nature of my background. Rather than viewing this as a threat, I used my experiences to add depth to the analysis. The next section describes the research methods chosen in more detail and considers the threats and opportunities associated with each.
4.4 Elements of my research design

This section discusses the various elements of my research design, including the choice of unit of analysis, and the instruments used to gather and analyse the empirical data.

4.4.1 Unit of analysis

Singleton, Straits et al. (1993) define the unit of analysis as simply the what or who that is being described or analysed in the research. As the focus of my research was on the academics, and the technologies they were attempting to commercialise, it was essential that data was available at a project level. Ideally, the projects should also have had equal access to funding and other supports to ensure such differences did not influence the research outcome. As such, a state funded scheme was very appropriate.

The Irish government supported the commercialisation of applied research through the state’s enterprise board, Enterprise Ireland. A number of schemes were available from Enterprise Ireland for academics to carry out applied research, however only one, the Commercialisation Fund: Technology Development (CFTD) (previously called the Advanced Technology Research Programme, ATRP) provided 100% funding to the academic. The stated aims of the ATRP / CFTD were to provide funding to academics to help them commercialise their research. As such, this made the use of individual ATRP / CFTD projects an appropriate unit of analysis for my study. An advantage of using individual ATRP / CFTD projects was that it also provided a population of academics to study. Therefore, I chose the ATRP / CFTD funded projects as the unit of analysis for this research.

The ATRP was first offered to academics in 2001 when government policy was changed to encourage academics to contribute to economic development through the commercialisation of their research. The name was changed to the Commercialisation Fund: Technology Development (CFTD) in 2003. The rules of the ATRP/CFTD gave ownership of the IP developed during the project to the institution, so in this respect it followed the Bayh-Dole model.

4.4.2 Survey research

The first phase of my research was to carry out a pilot survey to identify areas of interest for the second (case based) phase of my research. According to Forza (2009) a survey 'involves the collection of information from individuals about themselves, or about the social units to which they belong'. It can take many forms according to the
intentions of the researcher, or the point in the research study in which it takes place. Forza’s strategy for carrying out survey research is shown in Figure 4.2. How this research followed each of these steps is outlined in the survey protocol included as appendix 1 to this thesis.

Figure 4.2 Strategy for carry out survey research

<table>
<thead>
<tr>
<th>Link to the theoretical level</th>
</tr>
</thead>
<tbody>
<tr>
<td>construct \→ operational definitions</td>
</tr>
<tr>
<td>propositions \→ hypotheses</td>
</tr>
<tr>
<td>boundary \→ unit of analysis &amp; population</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>• consider macro constraints</td>
</tr>
<tr>
<td>• specify information needs</td>
</tr>
<tr>
<td>• define target sample</td>
</tr>
<tr>
<td>• select data collection method</td>
</tr>
<tr>
<td>• develop measurement instruments</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pilot test</th>
</tr>
</thead>
<tbody>
<tr>
<td>• test survey administration procedures</td>
</tr>
<tr>
<td>• test procedures for handling non-respondents, missing data &amp; data cleaning</td>
</tr>
<tr>
<td>• assess measurement quality in an exploratory way</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collect data for theory testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• administer survey</td>
</tr>
<tr>
<td>• handle non-respondents &amp; missing data</td>
</tr>
<tr>
<td>• input &amp; clean data</td>
</tr>
<tr>
<td>• assess measurement quality</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analyse data</th>
</tr>
</thead>
<tbody>
<tr>
<td>• preliminary data analysis</td>
</tr>
<tr>
<td>• test hypothesis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Generate report</th>
</tr>
</thead>
<tbody>
<tr>
<td>• draw theoretical implications</td>
</tr>
<tr>
<td>• provide information for replicability</td>
</tr>
</tbody>
</table>

Forza (2009) believes surveys can be exploratory, confirmatory or descriptive. A descriptive survey is the most appropriate for this study as it is used to understand the relevance of a phenomenon, and to describe the distribution of the phenomenon in the population. As such, a descriptive survey would allow me to find out more about population and understand the phenomenon in more detail before using the cases to explore it in much more depth.

4.4.2.1 Issues with survey research

Forza (2009) lists four types of error that the researcher must consider when designing a survey. These errors are listed in Table 4.2 along with the strategies I used to avoid these errors.
### Table 4.2 Sources of error in survey research (Forza, 2009)

<table>
<thead>
<tr>
<th>Source of error</th>
<th>Dealing with the potential errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling error</td>
<td>One of the benefits of using a survey is that the researcher has access to the whole population under investigation. To avoid sampling errors, I surveyed the whole population of 111 projects</td>
</tr>
<tr>
<td>Measurement error</td>
<td>I operationalised the model using the same measures outlined in the literature. This helped to ensure that the measures were linked to the correct factors, and the data collected measured the correct factors. I also used closed questions were possible to reduce the chance of extraneous answers. I used multiple questions to collect data on the same factors.</td>
</tr>
<tr>
<td>Statistical conclusion error</td>
<td>In the analysis of the data I only accepted findings with a significance level of 95% or greater to reduce the probability of Type I error ($\alpha$). Type II error is $1-\beta$. $\alpha$ and $\beta$ affect the power of the survey, in general the size of the sample is used to control the power. I used the whole population, so I could control the power of the analysis and set the significance at 0.05, which is generally accepted as an appropriate level</td>
</tr>
<tr>
<td>Internal validity error</td>
<td>To ensure the validity of the survey results, I asked the same questions of all respondents. To ensure the validity of my results I piloted the survey to ensure the data I gathered did not suffer from these threats to validity</td>
</tr>
<tr>
<td>Response rate and non-respondents</td>
<td>Forza suggest that 50% is the figure agreed by researchers in the field of operations management, while other disciplines in the social sciences set the target at 20%. I believed a target of 50% was more appropriate than 20% (to allow for statistical manipulation of the results). However, I was prepared to accept less than 50% as an acceptable response rate. I encouraged respondents to reply until I was satisfied I could not get a higher response rate. I surveyed the whole population and I knew the breakdown of the population, so I had full information about the non-respondents</td>
</tr>
</tbody>
</table>
| Reliability                          | I used a research protocol (Yin, 2003) and multiple methods to ensure the reliability of my findings. The protocol described the field procedures followed by the survey and considered the following specific questions:  

- Who will collect the data?  
- How will they collect the data?  
- From whom will they collect the data?  
- When will they collect the data?  
- How will they record the data?  

The protocol was set out in a number of sections that considered each of these questions, and presented how I intended to carry out the research. The protocol was based on the operationalisation of the conceptual model, and the questions used in the survey were developed based on this operationalisation. Included in the protocol were separate PI and TTO related questionnaires. |
4.4.3 Case research

The second phase of this research explored the findings of the pilot survey in more detail using case research. Case research is the most appropriate strategy to use as it allowed me to answer the 'how' and 'why' questions, whilst taking the context in which they occurred into account (Voss, 2009 and Yin, 2003).

According to the literature, case research is defined as 'an empirical inquiry of current or past phenomenon drawn from multiple sources in a given context' (Yin, 2003 and Leonard-Barton, 1990). Table 4.3 shows how the use of multiple case studies matched the theory testing element of my research.

Voss (2009) cited three distinct benefits in using case research put forward by Benbasat, Goldstein et al. (1987), all of which supported the use of the case based research in my study (see Table 4.4).

Table 4.3 Matching my research purpose with methodologies

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Research Question</th>
<th>Research Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>To uncover areas for research and theory development</td>
<td>Is there something interesting enough to justify research?</td>
<td>Pilot case studies</td>
</tr>
<tr>
<td>Theory building</td>
<td>Identify key variables, linkages between variables and why relationships exist</td>
<td>What are the key variables? What are the patterns or linkages between variables? Why should these relationships exist?</td>
<td>In depth field studies</td>
</tr>
<tr>
<td>Theory testing</td>
<td>Test the theories developed in the previous stages, predict future outcomes</td>
<td>Are the theories we have generated able to survive the test of empirical data? Did we get the behaviour that was predicted by the theory or did we observe another unanticipated behaviour?</td>
<td>Multiple case studies</td>
</tr>
<tr>
<td>Theory explanation / refinement</td>
<td>To better structure the theories in light of the observed results</td>
<td>How generalisable is the theory? Where does the theory apply?</td>
<td>Case studies</td>
</tr>
</tbody>
</table>

4.4.3.1 Issues with survey research

One of the most frequent criticisms of case research is that it is often perceived to provide poor validation and questionable generalisability (Meredith, 1998). Other issues associated with case research include the historical nature of the data collected, and the bias of the recorder or observer (Leonard-Barton, 1990; Meredith, 1998; Yin, 2003 and Voss, 2009). Although historical data provides an opportunity to view phenomena over time, Leonard-Barton (1990) warns of the
danger in using historical events, as people can forget important data, or their recollections can become subject to biases.

Table 4.4 Benefits of case research

<table>
<thead>
<tr>
<th>Benefits of case research</th>
<th>The case method allows the much more meaningful question of why, rather than just what and how, to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon</th>
</tr>
</thead>
<tbody>
<tr>
<td>The phenomenon can be studied in its natural setting and meaningful, relevant theory generated from the understanding gained through observing actual practice</td>
<td></td>
</tr>
<tr>
<td>The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not at all understood.</td>
<td></td>
</tr>
</tbody>
</table>

This section deals with each of the issues, and outlines how my design overcomes or reduces the impact of these issues on the conclusions of my research (see Table 4.5).

4.4.4 Triangulation

To ensure that *single respondent bias, post rationalisation*, or the other threats to validity discussed earlier did not influence the findings of this research, I used methods of triangulation in both the survey and cases where possible.

In this study I used a number of forms of triangulation. First, I used multiple sources of data where possible to ensure single respondent biases were not included. Second, I used multiple data collection and analysis techniques which, according to Jick (1979), 'help to improve the accuracy of a researcher's judgements, by collecting different kinds of data bearing on the same phenomenon'. I conducted the survey first to gather broad answers that could be investigated in more depth using the cases which allowed for triangulation between the two methods.

4.5 Data collection

This section outlines how the empirical data were collected in both the survey and case elements of my research.
Table 4.5 Strategy for dealing with sources of error

<table>
<thead>
<tr>
<th>Source of Error</th>
<th>My strategy for eliminating error</th>
</tr>
</thead>
</table>
| Validity        | Validity is best defined as 'how might the researcher be wrong?' (Maxwell, 2005). It refers to how credible the conclusions of the research are, as they cannot be proven statistically to be one hundred percent accurate. There are three elements to be consider:  
*Construct Validity:* I used multiple sources of evidence, established a chain of evidence and had key informants review draft case study report  
*Internal Validity:* I used pattern matching, explanation building and addressed rival explanations  
*External Validity:* I used replication logic in multiple case studies |
| Reliability     | Reliability of the results refers to the consistency of the research findings (Gill and Johnson, 2002). I used a research protocol and multiple methods (Singleton, Straits et al., 1993) to ensure the reliability of my findings. |
| Researcher bias | Researcher bias is the term used when the researcher’s own biases shape what they record (Voss, 2009 and Maxwell, 2005). I used a tape recorder to overcome researcher bias, and multiple cases to overcome recorder or observer bias (Leonard-Barton, 1990). |
| Reactivity      | Reactivity refers to the phenomenon when the observer influences the participants’ behaviour. This was not an issue in this study as the data was collected on events that happened in the recent past. |

4.5.1 Sources of data and access

I surveyed the complete population of 96 academics and 111 projects funded by the ATRP / CFTD in 2001, 2002 and 2003. Therefore the 96 academics who received funding provided the main source of data. However, where it was impractical to gather data from the PI, I accepted responses from the Project Manager or other senior member of the project team.

This study also used a second questionnaire (based on the first) to gather data from the TTO staff on the universities’ policies and supports. These data were used as a source of triangulation with the PI data to judge the accuracy of the PIs’ knowledge.

Being based in a university, and working daily with the population of researchers and TTO staff provided me with easy access to the data. My knowledge of the academics and TTO staff helped to increase the response rate of my survey.
4.5.1.1 A short pilot

To ensure the factors in my conceptual model related to the commercialisation of academic research I conducted a small pilot study. The pilot was case based and focused on a small number of completed ATRP projects from a single university. Interviewing the PIs provided information on whether data on the conceptual model could be gathered or not.

The chosen projects all came from the 2001 round of the programme as they were complete at the time of the data collection and could easily be reviewed in terms of their outputs. The projects were chosen from a single university to help ensure that inter-university differences were not introduced as a confounding variable. The results were used to refine the survey questionnaire.

4.5.2 Methods of data collection in a survey

There are many ways to collect data in a survey. It can be conducted via interviews or questionnaires, each of which can be administered in many ways. Interviews can be face to face or via the telephone, while questionnaires can be sent via the post, e-mail or more recently over the internet (Klassen and Jacobs, 2001).

Each method has its own advantages and disadvantages (Klassen and Jacobs, 2001). Interviews can help ensure all questions are answered and the survey is complete. However, with a population of 96 PIs it would have been difficult and time consuming to attempt to interview each of them. Questionnaires on the other hand allowed the survey to be administered to the whole population at once. There are also issues with response rates as traditionally, postal and email questionnaire suffer from low response rates and take time to receive responses (Klassen and Jacobs, 2001).

To overcome the various issues, I used a combination of face to face interviews and a postal survey to collect the data in this survey. Where I had easy access to the PIs I used a face to face interview to administer the survey. All questions were asked in the order they appeared on the survey, and all responses recorded. In all other cases I posted the survey with a letter of introduction and a stamped addressed envelope to encourage the academics to fill out and return the survey.

To gather accurate data on the TTO and university policies I used a second survey. Due to the smaller population of TTOs I interviewed staff from each TTO, typically the director. Once again, I piloted the questionnaire in UL to ensure it collected the data necessary for my study. Where appropriate, changes were made to the questionnaires.
before they were rolled out to the entire population. Both questionnaires are included in appendix 1.

4.5.3 Methods of data collection in case research

The data were collected by way of structured interview based on the protocol included in appendix 2. Each interview was based on the list of questions included in the protocol to ensure the same data was gathered on each project. Where the interviewees raise points of interest not predicted by the protocol, I deviated from the set list of questions to investigate these issues in more detail, before returning to the original questions. All interviewees were asked the full list of questions and all interviews recorded using a dictaphone, after which the information was transcribed verbatim.

To avoid biases in respondent data I interviewed at least two people associated with each project. Ideally this included the PI and the Project Manager; however, where the roles in the project were not allocated in such a formal manner, I endeavoured to interview the people who best fit these roles.

To ensure that the appropriate relevant evidence was collected, I carried out a pilot case in UL before continuing with the remaining projects. The questions and protocol were adapted according to the results of this pilot. Before starting the analysis of the data, I sent the transcripts to the interviewees to ensure they were an accurate reflection of what was said in the interview.

4.5.3.1 Access to the data

Before starting to collect the data, I considered what sources of data were available, and what evidence could be gathered from the individual data sources. There were many sources of data that were applicable to my research study. These included interviews, documents, archival records, direct observations, participant observations and physical artefacts (Yin, 2003). For this study, the majority of the data were gathered via the interviews with the project participants and the TTO staff. I also spoke to a number of appropriate Enterprise Ireland staff to gather project related data. I used documents and direct observations where relevant and available.

I have worked on the University of Limerick (UL) campus for ten years and as a result had excellent access to all the PIs eligible for inclusion in my study. I made use of this access to conduct my pilot study, as I could approach any of
these academics a number of times to gather the data. I also had good access to
the PIs in Trinity College, and the majority indicated a willingness to participate
in the case studies.

4.5.4 Case selection and eligibility
According to Voss (2009), the number of case studies included in a research study
depends on the resources available to the researcher. Fewer case studies allow for a
more in depth study. Single cases are often used for longitudinal studies, while a
higher number helps to lower the risk of misjudging single events. There is no ideal
number for every study, however it is generally accepted that four is an acceptable
number to allow for generalisation of the results (Eisenhardt, 1989).

My first step in choosing the case studies was to decide which members of the
population were eligible for inclusion in the research. As the literature and findings of
the survey suggested a number of factors influenced the outcome of the
commercialisation process, the choice of cases had to ensure each of these factors
could be explored in detail. Similarly, the cases had to include projects that attempted
to spinoff, or licence their research. To avoid collecting irrelevant data, the choice of
cases was restricted to the PIs who replied to the survey.

4.5.5 Summary of data gathering methods
Based on nature of the study I was undertaking, I chose a multiple methods research
design to use the combined strengths of both methods, and to help overcome the
weaknesses of them individually. The use of multiple methods also helped overcome
other important issues, such as the threats to the validity and reliability of my findings
(Brewer and Hunter, 1989). The two methods I chose were survey and case research.

4.6 Data analysis
The purpose of the data analysis design section of this chapter was not only to test
the theory developed from the propositions in the conceptual model, but to ensure
that the errors described in Table 4.2 were not introduced into the findings of the
research. This section describes the data analysis techniques used for each phase of
the research.

4.6.1 Analysis of the survey data
The data from the survey was analysed in line with Figure 4.3 using the relevant
statistical techniques. Non-respondent data and missing data were dealt with before
the data was entered into a statistical analysis tool. The exact statistical techniques employed depended on the type of data, e.g. nominal, interval, ordinal or ratio-metric (Pole and Lampard, 2002).

For effectiveness, the tests were performed on the highest aggregation level first. The first technique was the *Chi Squared* test. This was used to investigate if a relationship existed between factors and the outcome of the projects. The second test was the *Correlation* test to determine whether two variables were correlated, and to indicate the strength and the direction of the relationship. The third analysis step was to examine if I could say that there was a *difference in the means* between two variables with 95% confidence.

To identify factors that allowed an outcome to be predicted, I used a *Regression* test. Regression testing was appropriate as the dependent variable in this study was categorical and binary (whether project outcome was commercialised or not), so I chose the *logistical regression* model that was specifically developed to deal with such data (Montgomery, Peck et al., 2001).
4.6.1.1 Dealing with missing data
Where data were missing from a questionnaire I used two methods to overcome the problem. Where possible I used other sources, such as Enterprise Ireland or university data, to answer questions on the projects. Where the information could only be provided by the academic I contacted them to try to gather the missing data. Where it was not possible to gather this missing data, I decided on a case by case basis whether to include or exclude the project from the analysis.

4.6.2 Analysis of case data
In case research, data analysis consists of examining, categorising and tabulating the evidence gathered. It typically takes place in two steps (Eisenhardt, 1989 and Yin, 2003). The first step is to develop a detailed description of each case and the themes within the case, called within-case analysis. This is followed by a thematic analysis across the cases, called a cross-case analysis (Creswell, 1998). The results of the analysis are then used to help refine the theory.

While I followed the two step strategy presented above, I also presented the analysis of the cases in two parts. The university level data was analysed first, before the project level data was considered. I took this approach as much of the data gathered on each case was university related so it was more sensible to consider these data together, rather than individually, to help identify patterns.

4.6.3 Data analysis techniques
There are many different analysis techniques to choose from, the most common of which are; pattern matching, explanation building, time-series analysis and cross-case synthesis (Yin, 2003).

As my third research question asks what patterns exist amongst the factors that influence commercialisation, pattern matching was an obvious choice of analysis technique. Pattern matching compares an empirical pattern with a predicted one developed from the theory. If the patterns coincide, then the results help to strengthen the internal validity of the case study (Yin, 2003). Where the patterns do not coincide, then rival hypothesis need to be considered to determine whether they account for the difference. I also used cross case synthesis to look for the patterns across projects.

Before the analysis was conducted, an initial descriptive coding exercise was required to ensure that the data gathered from the interview could be matched to the
indicators of the variables under investigation (Voss, 2009). To do this, measures for each variable were developed prior to the start of the data gathering exercise. The operationalisation of the variable is described in the protocol attached as appendix 2.

4.6.4 Coding the data

The predefined codes were developed from the operationalisation of the variables as described above. The sample presented in Table 4.6 shows how the university policy factor was coded. The codes were broken down by the variables and measures according to the operationalisation included in appendix 2, while the impact on commercialisation (positive or negative) was included to indicate whether the interviewee felt the factor enabled or hindered the commercialisation of their project outcomes. Where other factors not predicted by the literature or survey became evident, additional codes were added to the coding template to account for their presence. The full coding template is included as appendix 4.

Table 4.6 Sample of the pre defined coding template

<table>
<thead>
<tr>
<th>Code</th>
<th>Factors</th>
<th>Variable</th>
<th>Category Definition</th>
<th>Impact on commercialisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1.1</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Well defined strategy and well communicated across institution</td>
<td>Positive</td>
</tr>
<tr>
<td>1.1.1.2</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Well defined strategy and well communicated across institution</td>
<td>Negative</td>
</tr>
<tr>
<td>1.1.2.1</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Define strategy but not well communicated across institution</td>
<td>Positive</td>
</tr>
<tr>
<td>1.1.2.2</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Define strategy but not well communicated across institution</td>
<td>Negative</td>
</tr>
<tr>
<td>1.1.3.1</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Ill defined, or no strategy and not communicated across institution</td>
<td>Positive</td>
</tr>
</tbody>
</table>

4.7 Summary

This chapter presented the reasons behind the choice of tools and techniques used to gather the empirical data for this study. It also discussed the merits and pitfalls of each, to ensure my research design accommodated methods for overcoming any sources of error in my research.

My research design was planned in two parts; a pilot survey of 111 ATRP projects to examine the factors that influenced the commercialisation of applied research in Irish universities, followed by six case studies that examined the phenomenon in more
detail. The six cases were chosen based on a number of criteria to ensure the necessary data could be gathered.

Figure 4.4 shows a map of how my research was carried out. The initial theory was developed in Chapter 3 based on the literature from Chapter 2. This was modified using the findings of the survey in Chapter 5. Chapters 6 and 7 present the within case analyses in UL and TCD respectively, before Chapter 8 presents the cross case analysis case and modifies the theory. Chapter 9 discusses this contribution to the theory, while Chapter 10 develops policy implications for the actors in the process.

Figure 4.4 Map of my research

The next chapter of this thesis presents and discusses the findings of the pilot survey.
CHAPTER 5 : PRESENTATION AND ANALYSIS OF SURVEY DATA

5.1 Introduction
In the previous chapter I indicated the use of two surveys (of the PIs and TTOs) to gather data on the projects funded by the ATRP / CFTD from the calls for proposals published in 2001, 2002 and 2003. This chapter presents and analyses the data gathered from those surveys.

The presentation of data in this chapter is in three sections. The first section provides the background to the number of projects funded by the scheme, characterised by areas such as: outcome, year of funding, institution, industrial sector and researcher profile. The second analyses the data with respect to the conceptual model to determine whether factors or variables could be shown to influence commercialisation. The third and final section summarises the findings of the survey and discusses the selection of projects for use in the second (case research) phase of this thesis.

5.2 Survey development and deployment
To gather data on the projects, two surveys were developed in accordance with the research design outlined in Chapter 4. The PI survey was piloted in May 2006 using a project in UL that I was familiar with. This allowed me to determine whether the questionnaire elicited the necessary data. Similarly, the TTO survey was also piloted in UL at the same time. Small modifications were made to both surveys following the pilot.

Once modified to include the feedback from the pilot, the PI questionnaires were posted in June 2006, with a letter of introduction explaining the nature of my research, and requesting the PIs to complete the questionnaire based on their ATRP / CFTD project(s). Where a PI had multiple projects, they were asked to fill out Section 2 only (Project Profile) for subsequent projects. A stamped addressed envelope was enclosed to encourage the PIs to reply. In the case of UL and TCD, the surveys were completed via face-to-face interviews during the months of July and August 2006. In these cases I contacted the PIs and made an appointment. For reference, both questionnaires and the letter of introduction are included in Appendix 1.

For the face-to-face interviews, the interviewees were each given a copy of the questionnaire so they could read the questions and provide the relevant answers (to the multiple choice questions). I recorded their answers on a second identical
questionnaire. Each interviewee was asked every question in sequence and all responses were recorded.

Where responses to the postal questionnaire were not received in the first month, two follow up emails (including an electronic copy of the questionnaire) were sent to the PIs in July and August 2006. Where possible, I also rang the PIs or asked colleagues based in the relevant institutions to encourage the PIs to complete and return the questionnaire. During this follow up process, I discovered that four PIs were no longer contactable, as two had left their institutions and two had retired. This changed the usable population to 107 projects.

The survey of the TTOs was conducted using face-to-face interviews with the TTO directors, using the same procedures outlined above.

5.3 ATRP /CFTD project characteristics
This section presents the data gathered on the administrative aspects of the projects, e.g. the size of the projects, and whether the projects were commercialised or not. It also discusses response rates to the survey and the characteristics of the non-respondents.

5.3.1 Project characteristics
The project approval process used by Enterprise Ireland was based on an independent appraisal of the projects. All proposals were scored by at least four experts (two technological and two commercial) against a predefined set of technical and commercial criteria. Typically the assessors were academics with expertise in the given field, or industrialists with relevant experience. Where practical, at least one of the assessors was from outside Ireland, although this was not mandatory. A minimum score of 75 out of 100 had to be achieved against both criteria for a project to be considered for funding. Where there was a significant difference between the scores of the reviewers, a panel adjudicated on the conflicting scores. Funding recommendations were then made to a committee who made the approval decision. Copies of the application form and the technical and commercial assessment templates are included as Appendix 3 to this thesis.

The assessor scores for each project were averaged to rank projects on a single list. Projects that passed the funding threshold were recommended for funding, which occurred in descending order until the budget was spent. As the budget for the scheme was fixed between 2001 and 2003, a number of the recommended projects
had their budgets revised downwards to try to fund additional projects. The size of the budget governed the number of projects funded.

During the period 2001 to 2003, 111 projects were funded across twelve institutions, to 96 different PIs. There were 31 commercial outputs reported (by the TTOs) to Enterprise Ireland from these projects. The breakdown of the 111 projects is shown in Table 5.1. The projects are also grouped according to the three industrial sectors used by Enterprise Ireland; Biotechnology (Bio), Informatics (ICT) and Industrial Technologies (Ind. Tech).

Table 5.1 Breakdown of projects by institution

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of Projects</th>
<th>Number of PIs</th>
<th>Commercial Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dublin City University</td>
<td>13</td>
<td>10</td>
<td>2 Ind. Tech. Spinoffs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 ICT Spinoff</td>
</tr>
<tr>
<td>Dublin Institute of Technology</td>
<td>2</td>
<td>2</td>
<td>2 ICT Licences</td>
</tr>
<tr>
<td>NUI Galway</td>
<td>18</td>
<td>16</td>
<td>1 Bio Spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 ICT Spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 Ind. Tech. Licences</td>
</tr>
<tr>
<td>NUI Maynooth</td>
<td>3</td>
<td>2</td>
<td>None</td>
</tr>
<tr>
<td>Sligo Institute of Technology</td>
<td>1</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>Teagasc</td>
<td>5</td>
<td>4</td>
<td>1 Bio Spinoff</td>
</tr>
<tr>
<td>Trinity College Dublin</td>
<td>14</td>
<td>11</td>
<td>3 Bio Spinoffs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Ind. Tech. Spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Ind. Tech. Licence</td>
</tr>
<tr>
<td>Tyndall Institute</td>
<td>11</td>
<td>11</td>
<td>4 Ind. Tech. Licences</td>
</tr>
<tr>
<td>UCC</td>
<td>8</td>
<td>8</td>
<td>1 Bio Spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Ind. Tech. Licence</td>
</tr>
<tr>
<td>UCD</td>
<td>22</td>
<td>18</td>
<td>3 Bio Spinoffs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 Ind. Tech. Licences</td>
</tr>
<tr>
<td>University of Limerick</td>
<td>13</td>
<td>12</td>
<td>3 Ind. Tech. Spinoffs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Ind. Tech. Licence</td>
</tr>
<tr>
<td>Waterford Institute of Technology</td>
<td>1</td>
<td>1</td>
<td>None</td>
</tr>
<tr>
<td>Totals</td>
<td>111</td>
<td>96</td>
<td>17 Spinoffs, 14 licences</td>
</tr>
</tbody>
</table>

4 Defined as licence or spinoff submitted to the Enterprise Ireland Exploitation Consent Committee for approval by the institution. This is the oversight process included in the funding contract.
5.3.1.1 Commercial outcomes
Of the 111 projects, fourteen licences and seventeen spinoffs were reported by the PIs via the survey, a commercialisation rate of 28% by project, or 32% by PI. In all cases, the claims made by the PIs coincided with the requests made by the institutions to the Exploitation Consent Committee (ECC) for approval. The spinoffs also had to sign a licence with the university to access the technology, as the ATRP / CFTD rules gave ownership of all IP to the university. For the purpose of this study, I did not include these licences, as that would be double counting commercial outcomes.

NUI Galway (NUIG) and Trinity College (TCD) each generated five commercial outputs, though the breakdown of spinoffs and licences differed between each. Based on responses from the PI questionnaires, NUIG generated two spinoffs and three licences, while TCD generated four spinoffs and one licence. The next most successful institutes were UL and Tyndall which generated three spinoffs and one licence, and four licences respectively.

TCD generated the highest number of commercial outcomes as a percentage of projects funded, with five outcomes from fourteen projects (35.7%). NUIG’s five commercial outcomes came from eighteen projects, representing a commercialisation rate of 27.8%. The Tyndall Institute had the highest commercialisation rate (36.7%), generating four licences from eleven projects.

5.3.1.2 Profile by Principal Investigator
Of the 96 PIs who received funding, seven had two applications funded, while another four had three projects funded. Table 5.2 provides details of these eleven PIs by their institution, industrial sectors and year of funding. The Tyndall Institute was the only institution with more than two projects not to have a PI with more than one project funded. An academic based in TCD was the only PI to have two commercial outcomes, a spinoff from each of the two projects funded under the programme.

5.3.2 Project characteristics by funding levels
As described earlier, the intention of the ATRP / CFTD was to encourage academics to commercialise the results of their research. The scheme was renamed in 2003 to emphasise these aims, as Enterprise Ireland felt that many academics did not appreciate that the grants they received were on the condition that they would attempt to commercialise their research outputs. Many academics thought it was
provided under the same rules (which did not require commercialisation) as funding to the Programmes in Advanced Technology (PAT), through which many had previously received funding. This view became evident via the interactions with the PIs at the regular project review meetings, which took place to monitor the progress of the projects.

Table 5.2 Details of PIs with more than one project

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of PIs with 2 projects</th>
<th>Number of PIs with 3 projects</th>
</tr>
</thead>
</table>

The data gathered from the PI questionnaires showed that the typical project funded by the scheme was 36 months in duration (maximum allowed) and received, on average, a grant of €335,000. Funding ranged from €200,000 to €500,000. The majority of projects sought circa. €350,000, as this was the nominal maximum outlined in the application guidelines. Figure 5.1 shows the funding levels of the projects that responded to the survey.

Figure 5.1 Histogram of project funding (by survey respondents) n=35
5.3.3 Response rates

In total, I received responses covering 40 projects, from 34 different PIs, in ten different institutions. This represented a response rate of 37% for the 107 available projects, or 37% of the available (92) PIs. The breakdown of respondents by institute is shown in Table 5.3. There were eleven licences or spinoffs generated from these forty projects, by ten PIs.

Table 5.3 Survey responses by institution

<table>
<thead>
<tr>
<th>Responses by Institute</th>
<th>Number of Responses</th>
<th>Number of PIs</th>
<th>Number of Spinoff or Licences</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL</td>
<td>11</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>DCU</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Teagasc</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>NUI Galway</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>UCC</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>NUI Maynooth</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>TCD</td>
<td>11</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Tyndall Institute</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>UCD</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>DIT</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>40</td>
<td>34</td>
<td>11</td>
</tr>
</tbody>
</table>

5.3.3.1 Response profile by year of application

Using the project start dates as a surrogate for the year of application, I found that sixteen responses related to projects approved in 2001, twelve to projects from 2002 and twelve to projects from 2003 (see Table 5.4). On a percentage basis this represents response rates of 38%, 39% and 32% for the years 2001, 2002 and 2003 respectively. Table 5.5 shows the percentage of these respondents that generated either a spinoff or licence.

Table 5.4 Response rates by industrial sector and year of application

<table>
<thead>
<tr>
<th>Sector</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio</td>
<td>31% (4/13)</td>
<td>25% (2/8)</td>
<td>22% (2/9)</td>
<td>27% (8/30)</td>
</tr>
<tr>
<td>ICT</td>
<td>25% (2/8)</td>
<td>20% (2/10)</td>
<td>0% (0/10)</td>
<td>14% (4/28)</td>
</tr>
<tr>
<td>Ind. Tech.</td>
<td>50% (8/16)</td>
<td>56% (10/18)</td>
<td>54% (10/19)</td>
<td>53% (28/53)</td>
</tr>
<tr>
<td>Total</td>
<td>38% (14/37)</td>
<td>39% (14/36)</td>
<td>32% (12/38)</td>
<td>36% (40/111)</td>
</tr>
</tbody>
</table>
Table 5.5 % Respondents who generated a commercial output

<table>
<thead>
<tr>
<th>Sector</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bio</td>
<td>75% Spinoff</td>
<td>50% Spinoff</td>
<td>0%</td>
<td>50% (4 spinoffs)</td>
</tr>
<tr>
<td>ICT</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Ind. Tech.</td>
<td>12.5% Spinoff</td>
<td>20% Spinoff</td>
<td>40% Licence</td>
<td>25% (3 Spinoff &amp; 4 Licences)</td>
</tr>
</tbody>
</table>

The survey reported eleven commercial outcomes (four licenses and seven spinoffs) which was 36% of responses. This was only 1% different from the general response rate, suggesting that commercial outcomes were evenly distributed amongst projects that did, or did not, respond to the survey.

5.3.4 Non-respondents

There were 58 PIs who did not respond to the questionnaire spread across twelve institutions (see Table 5.6). NUI Galway and UCD had the highest non-respondent rates, with 13 out of 16, and 14 out of 18 respectively who did not respond. UL and TCD had the lowest non response rates. This was expected as I had better access to these universities.

Table 5.6 List of non-respondents by university

<table>
<thead>
<tr>
<th>Institution</th>
<th>Number of non-respondents</th>
<th>Number of respondents</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL</td>
<td>2</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>DCU</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Teagasc</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>NUI Galway</td>
<td>13</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>UCC</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>NUI Maynooth</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>TCD</td>
<td>3</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Tyndall Institute</td>
<td>9</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>UCD</td>
<td>14</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>DIT</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>WIT</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sligo IT</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

From my work as a Commercialisation Specialist with Enterprise Ireland I had knowledge of the complete population, and as such had a detailed knowledge of both the respondents and non-respondents. From this knowledge I was able to determine
that there were no differences in those that did and did not respond to the survey in terms of commercialisation activity. Nor did the non-respondents make up a bigger or smaller percentage of PIs who attempted to commercialise their research. As such, this was a good response rate, and a fair sample of the population.

5.4 Survey Findings

Using the analysis techniques outlined in Section 4.6.1, the data collected from the two surveys were analysed. The aim of the data analysis was to determine if links between the factors (and variables) in the conceptual model and the commercialisation of research were supported by the data. This section presents the analysis that shows confirming or disconfirming evidence to support the presence of factors and variables in the conceptual model. Tests that were inconclusive are not presented in this thesis.

The analysis is presented in three sections, the first relates to those factors or variables that were found to differentiate between a successful or unsuccessful attempt to commercialise a project. The second presents those factors or variables that were found to differentiate between the creation of a spinoff or licence. The final section presents the results of the regression tests used to identify factors that could predict outcomes.

5.4.1 Factors differentiating between success and failure

This section discusses the factors and variables found to differentiate between the creation of a spinoff or licence and no commercial outcome.

5.4.1.1 Academic's commercial knowledge

When the data from the questions relating to the skills of the PIs and their commercial knowledge were analysed, the factor was found to differentiate between the successful / unsuccessful commercialisation of the research outcomes, as shown in Table 5.7.

When the Spearman's test was carried out on the skill of the inventor acting as an entrepreneur, the result (0.033) showed the variable was correlated with the commercialisation of project outcomes. The Pearson's Test result (0.033) supported this finding. The strength of the correlation was 0.366, which showed a moderate positive correlation between the skill of the inventor acting as an entrepreneur and the commercialisation of project outcomes.
Table 5.7 Spearman's Test: Academic's commercial knowledge

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>Actual project outcome reported to EI</th>
<th>Correlation Coefficient</th>
<th>Actual Inventor as an entrepreneur proficiency</th>
<th>Strength of network proficiency</th>
<th>What is academics previous business skill</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual project outcome reported to EI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.000</td>
<td>.366*</td>
<td>.142</td>
<td>.015</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.033</td>
<td>.423</td>
<td>.934</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

The Spearman / Pearson (correlation) tests indicates whether two variables are correlated and indicate the strength and the direction of the relationship between the pair of variables under test. A correlation test result of zero indicates no correlation, while a result of modulus one suggests a perfect correlation between the factors or variables tested. The Spearman test is used for non-parametric data, while the Pearson test is the parametric equivalent. As the data under analysis were non-parametric, it was only appropriate to use the parametric equivalent test to support the findings of the non-parametric test. It was not appropriate to use the parametric tests to develop an argument.

5.4.1.2 PI knowledge of ATRP & availing of supports
When the Chi Squared test was performed on the data relating to why the academics chose the ATRP/CFTD? as a source of funding, the Cramer's V result was 0.034 (see Table 5.8), which suggests that the academics who generated a spinoff or licence chose the ATRP/CFTD fund because they were interested in commercialisation.

Table 5.8 Chi-Square Tests Choice of ATRP / CFTD

<table>
<thead>
<tr>
<th>Value</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal by Phi</td>
<td>Cramer's V</td>
</tr>
<tr>
<td>.598</td>
<td>.034</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td></td>
</tr>
</tbody>
</table>

The Chi Squared test (Bryman and Cramer, 1990) is used to investigate if a relationship exists between factors and variables and the commercial outcome of the projects (e.g. success of failure). The Chi Squared test is based on the Null Hypothesis that assumes that each of the expected outcomes is equally likely.
The Chi Squared test looks at the observed outcomes, and compares the observed values to the expected values. If the difference between the observed and expected value was large then I could reject the Null Hypothesis. However, if the difference was small, then I failed to reject the Null Hypothesis. The Chi Squared test result is called the Cramer's V. Values of less than or equal to 0.05 meant I could reject the Null Hypothesis with 95% confidence, while values greater than 0.05 meant I failed to reject the Null Hypothesis (Bryman and Cramer, 1990).

The failure of the Spearman's correlation test and the Mann-Whitney U test to support the findings of the Chi Squared test was interesting. (The Mann-Whitney test examines if there is a difference in the means between the two variables under test with 95% confidence. The Mann-Whitney U test is a non-parametric test that compares the number of times a score from one sample is ranked higher than a score from the other (Bryman and Cramer, 1990)).

As mentioned in Chapter 4, the Chi Squared test was the bluntest instrument of the three tests, so it may be that the findings of the Chi Squared test were indicative of a trend. However, there was insufficient evidence for the more refined Correlation and Mann-Whitney U tests to support this finding. The use of the cases in the second phase of this research investigates this in more detail.

To test the hypothesis that the academics' understanding of the scheme was related to their ability to commercialise their research, the Chi Squared test was also performed on the data relating to the PIs' understanding of the ATRP / CFTD. The resulting Cramer's V of 0.011 shown in Table 5.9 supported this hypothesis. However, a lack of supporting evidence in the Correlation and Mann-Whitney U tests may be indicative of the same phenomenon evident above. To overcome this issue, I rely on the cases to determine whether this was a spurious finding or not.

Table 5.9 Chi-Square Test Academic's understanding of ATRP/CFTD

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Approx. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal by Nominal</td>
<td>Phi</td>
<td>.608</td>
</tr>
<tr>
<td></td>
<td>Cramer's V</td>
<td>.608</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.10 Chi Squared Test results for Academic Entrepreneurship
The Spearman’s tests results also showed that the unique superior idea (0.004) was correlated with the commercialisation of project outcomes (see Table 5.11). The Pearson’s test results supported this with a correlation result of 0.004. The strength of the correlation (0.4779) showed a moderate correlation between the presence of a unique superior idea and the commercialisation of project outcomes (see Table 5.12).

Table 5.11 Spearman’s Test: Project Outcomes and Academic Entrepreneurship

<table>
<thead>
<tr>
<th>Spearman’s rho</th>
<th>Actual project outcome reported to EI</th>
<th>Unique superior idea</th>
<th>Inventor working as entrepreneur</th>
<th>Strong Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual project outcome reported to EI</td>
<td>Correlation Coefficient</td>
<td>.479(**)</td>
<td>.391(*)</td>
<td>.091</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.004</td>
<td>.022</td>
<td>.608</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Unique superior idea</td>
<td>Correlation Coefficient</td>
<td>-.479(**)</td>
<td>1.000</td>
<td>-.236</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.004</td>
<td>.180</td>
<td>.445</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Inventor working as entrepreneur</td>
<td>Correlation Coefficient</td>
<td>.391(*)</td>
<td>-.236</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.022</td>
<td>.180</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Strong Network</td>
<td>Correlation Coefficient</td>
<td>.091</td>
<td>.135</td>
<td>.552(**)</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.608</td>
<td>.445</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>
When the outcomes were split into spinoffs and licences, the significance values were 0.003 and 0.003. The results of the Mann-Whitney U test, and the T-test had significance values of 0.006 and 0.025 respectively, which supported the earlier findings (see Table 5.13).

Table 5.12 Pearson’s Test: Project Outcomes and Academic Entrepreneurship

<table>
<thead>
<tr>
<th>Actual project outcome reported to EI</th>
<th>Unique superior idea</th>
<th>Inventor working as entrepreneur</th>
<th>Strong Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.479(***)</td>
<td>.387(*)</td>
<td>.093</td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Unique superior idea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.479(***)</td>
<td>-2.236</td>
<td>.136</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.004</td>
<td>.180</td>
<td>.443</td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Inventor working as entrepreneur</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.387(*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.024</td>
<td>.180</td>
<td>.001</td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Strong Network</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson Correlation</td>
<td>.093</td>
<td>.136</td>
<td>.552(**<em>)</em></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.601</td>
<td>.443</td>
<td>.001</td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

Table 5.13 Mann-Whitney U Test: Academic Entrepreneurship

<table>
<thead>
<tr>
<th></th>
<th>Unique superior idea</th>
<th>Inventor working as entrepreneur</th>
<th>Strong Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>57.000</td>
<td>68.500</td>
<td>108.000</td>
</tr>
<tr>
<td>Wilcoxon W</td>
<td>357.000</td>
<td>123.500</td>
<td>163.000</td>
</tr>
<tr>
<td>Z</td>
<td>-2.753</td>
<td>-2.246</td>
<td>-.524</td>
</tr>
<tr>
<td>Asymp. Sig. (2-tailed)</td>
<td>.006</td>
<td>.025</td>
<td>.600</td>
</tr>
<tr>
<td>Exact Sig. [2*(1-tailed Sig.)]</td>
<td>.016(a)</td>
<td>.050(a)</td>
<td>.669(a)</td>
</tr>
</tbody>
</table>

The identification of the unique superior idea as an influencing factor also highlighted the need for the academic to have knowledge of what the market place wanted. Having a unique superior idea and knowing how to fulfil customers’ needs were critical elements for a product or process to be successful.
5.4.1.3 Summary of findings related to success and failure

The analysis of the data failed to support the majority of the hypotheses developed from the propositions in Chapter 3. While this was likely due to the lack of confirming evidence in the data, there was no disconfirming evidence to suggest the hypotheses were incorrect. As a consequence we cannot rely on the survey data alone to draw conclusions.

Instead, the need for the case research mentioned in Chapter 4 became clearer. The case research was required to allow for a more in depth investigation of the conceptual model and its associated propositions. The cases also allowed for an investigation of factors not predicted by the literature, i.e. that the presence of a unique superior idea was a differentiator between successful and unsuccessful attempts to commercialise project outcomes.

5.4.2 Differences between spinoffs and licences

This section discusses the findings of the analysis that differentiate between the creation of a spinoff or licence as the route to commercialisation of a project.

5.4.2.1 Entrepreneurial skills of academic

When the data from the projects with successful outcomes were broken down into spinoffs and licences and analysed in Table 5.14, the Chi Squared tests on the factor *Academics' commercial knowledge* had a Cramer's V of 0.017. This showed that the factor differentiated between the creation of a spinoff or a licence. The individual variable *inventor working as an entrepreneur* also had a Cramer's V of 0.002, supporting the hypothesis that the academics' commercial knowledge was related to the generation of a spinoff or a licence.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cramer's V</th>
<th>Cramer's V (spinoff &amp; licence separated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academics' Commercial Knowledge</td>
<td>.174</td>
<td>.017</td>
</tr>
<tr>
<td>Inventor working as an entrepreneur</td>
<td>.077</td>
<td>.002</td>
</tr>
</tbody>
</table>

The results of the Correlation tests on the variable *inventor working as an entrepreneur* had a significance value of 0.023 (see Table 5.15). The correlation value was 0.389 which identified a moderate correlation. This suggests that the
presence of an entrepreneur, and his/her skill level were related to whether he/she generated a spinoff or a licence.

Table 5.15 Spearman's Test: Project Outcomes and Academics' Knowledge (Spinoff and licence separated)

<table>
<thead>
<tr>
<th>Spearman's rho</th>
<th>License versus spin off</th>
<th>Inventor as an entrepreneur</th>
<th>Strength of network</th>
<th>What is academics previous business skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>License</td>
<td>Correlation</td>
<td>Coefficient</td>
<td>Sig. (2-tailed)</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>License</td>
<td>versus spin off</td>
<td>Correlation</td>
<td>Coefficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>License</td>
<td>.389(*)</td>
<td></td>
<td>.177</td>
<td>.078</td>
</tr>
<tr>
<td>Correlation</td>
<td>.1.000</td>
<td></td>
<td>.023</td>
<td>.316</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
<td>.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Inventor as</td>
<td>.389(*)</td>
<td>1.000</td>
<td>-.452(**)</td>
<td>.353(*)</td>
</tr>
<tr>
<td>an entrepreneur</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>.389(*)</td>
<td>1.000</td>
<td>-.452(**)</td>
<td>.353(*)</td>
</tr>
<tr>
<td>Coefficient</td>
<td>.389(*)</td>
<td>.</td>
<td>-.452(**)</td>
<td>.353(*)</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>Strength of</td>
<td>.177</td>
<td>-.452(**)</td>
<td>1.000</td>
<td>-.651(**)</td>
</tr>
<tr>
<td>network</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>.177</td>
<td>-.452(**)</td>
<td>1.000</td>
<td>-.651(**)</td>
</tr>
<tr>
<td>Coefficient</td>
<td>.177</td>
<td>-.452(**)</td>
<td>1.000</td>
<td>-.651(**)</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
<tr>
<td>What is</td>
<td>.078</td>
<td>-.353(*)</td>
<td>-.651(**)</td>
<td>1.000</td>
</tr>
<tr>
<td>academics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>previous</td>
<td>.078</td>
<td>-.353(*)</td>
<td>-.651(**)</td>
<td>1.000</td>
</tr>
<tr>
<td>business skill</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>.078</td>
<td>-.353(*)</td>
<td>-.651(**)</td>
<td>1.000</td>
</tr>
<tr>
<td>Coefficient</td>
<td>.078</td>
<td>-.353(*)</td>
<td>-.651(**)</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>34</td>
<td>34</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

5.4.2.2 University’s policies and supports

Similarly, when the successful outcomes were broken down into spinoffs and licences, the results of the Mann-Whitney U test, shown in Table 5.16, on the variables academics' understanding of the commercialisation process, supports on offer from the TTO and the TTO communicates policies had significance values of 0.011, 0.038 and 0.038 respectively. The results of the T-test shown in Table 5.17 supported these findings (0.005, 0.030 and 0.030 respectively).
Table 5.16 Mann-Whitney U Test: University's policies and supports (spinoff and licence separated)

<table>
<thead>
<tr>
<th></th>
<th>Academics understanding of comm. process</th>
<th>Supports on offer from TTO</th>
<th>TTO communicates policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>3.500</td>
<td>6.000</td>
<td>6.000</td>
</tr>
<tr>
<td>Wilcoxon W</td>
<td>39.500</td>
<td>42.000</td>
<td>42.000</td>
</tr>
<tr>
<td>Z</td>
<td>-2.552</td>
<td>-2.073</td>
<td>-2.073</td>
</tr>
<tr>
<td>Asymp. Sig. (2-tailed)</td>
<td>.011</td>
<td>.038</td>
<td>.038</td>
</tr>
<tr>
<td>Exact Sig. [2*(1-tailed Sig.)]</td>
<td>.028(a)</td>
<td>.109(a)</td>
<td>.109(a)</td>
</tr>
</tbody>
</table>

Table 5.17 T- Test: The Process of Commercialisation Factor (Spinoff and licence separated)

<table>
<thead>
<tr>
<th></th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
</tr>
<tr>
<td>Supports on offer from TTO</td>
<td>Equal variances assumed</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
</tr>
<tr>
<td>TTO communicates policies</td>
<td>Equal variances assumed</td>
</tr>
<tr>
<td></td>
<td>Equal variances not assumed</td>
</tr>
</tbody>
</table>

These tests indicated that the academics' knowledge of their university's policies was related to their decision to opt for a spinoff or a licence agreement, something that was not predicted by the literature. They also showed that the
effort the TTO put into communicating their policies to the academic community impacted on the academics' decision on their chosen route to commercialisation. In this respect, the two variables may be interconnected. What actual relationship or interconnection existed between the variables academics' level of knowledge, the communication of the policies, and the choice of the route commercialisation will be examined via the case studies.

5.4.2.3 TTO Structure

The Mann-Whitney U test results in Table 5.18 on the TTO structures showed a difference in means between the spinoff and licence subgroups. The significance value for the definition of policies was 0.038, while the variable TTO Structure had a significance value of 0.009.

Table 5.18 Mann-Whitney U Test: University Mission Alignment (Spinoff and licence separated)

<table>
<thead>
<tr>
<th></th>
<th>Definition of policies</th>
<th>TTO Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>6.000</td>
<td>2.500</td>
</tr>
<tr>
<td>Wilcoxon W</td>
<td>42.000</td>
<td>38.500</td>
</tr>
<tr>
<td>Z</td>
<td>-2.073</td>
<td>-2.614</td>
</tr>
<tr>
<td>Asymp. Sig. (2-tailed)</td>
<td>.038</td>
<td>.009</td>
</tr>
<tr>
<td>Exact Sig. [2*(1-tailed Sig.)]</td>
<td>.109(a)</td>
<td>.016(a)</td>
</tr>
</tbody>
</table>

This result suggests that there was a difference in how academics who chose a spinoff or licence viewed the universities' commercialisation policies, and how the TTOs were structured. How the policies of the universities and the structures of the TTOs were actually related to the route to commercialisation chosen by the PI will also be investigated using the cases.

5.4.2.4 Size of TTO and previous experience of staff

The results of the Chi Squared tests in Table 5.19 showed that the previous marketing experience of the TTO staff and the patenting, licensing and technical experience of the TTO staff (Cramer's V = .029) were related to the choice of route to commercialisation when spinoffs and licences were separated.
Table 5.19 TTO Size and Experience

<table>
<thead>
<tr>
<th>Factor</th>
<th>Cramer’s V</th>
<th>Carmer’s V (Spin off &amp; Licences Separate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous marketing experience of TTO staff</td>
<td>.374</td>
<td>.029</td>
</tr>
<tr>
<td>Experience in patent law and licensing or technical expertise of TTO staff</td>
<td>.374</td>
<td>.029</td>
</tr>
</tbody>
</table>

The Mann-Whitney U test and T-test also showed a difference in means between the TTO staff marketing experience, and TTO staff patent, licensing and technical experience variables with significance values of 0.006 for each variable (see Table 5.20). This suggests that the experience of the TTO staff was related to the decision by the PI on whether to commercialise their research via a spinoff or licence. The Mann-Whitney U test on the variable number of TTO staff also had a significance value of 0.038, suggesting that the number of TTO staff was also related to the PI’s decision.

Table 5.20 Mann-Whitney U Test: TTO Experiences (Spinoff and licence separated)

<table>
<thead>
<tr>
<th></th>
<th>TTO staff marketing experience</th>
<th>TTO staff patent licensing technical experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mann-Whitney U</td>
<td>2.000</td>
<td>2.000</td>
</tr>
<tr>
<td>Wilcoxon W</td>
<td>38.000</td>
<td>38.000</td>
</tr>
<tr>
<td>Z</td>
<td>-2.775</td>
<td>-2.775</td>
</tr>
<tr>
<td>Asymp. Sig. (2-tailed)</td>
<td>.006</td>
<td>.006</td>
</tr>
<tr>
<td>Exact Sig. [2*(1-tailed Sig.)]</td>
<td>.016(a)</td>
<td>.016(a)</td>
</tr>
</tbody>
</table>

The data suggests that the level of experience amongst the TTO staff was important in how the academic chose between a spinoff or licence as the route to commercialisation. This was an interesting finding as the literature predicted that the size of the TTO etc. was directly related to the outcome of the commercialisation process, rather than indirectly via the choice of route to commercialisation.

The analysis performed above shows that the number of staff working in the TTO was related to the choice of spinoffs or licences. It would be interesting to see if the TTOs with higher staff numbers generated more spinoffs and licences than those with fewer staff, and whether institutions favoured spinoffs over licences or
vice versa. This is something that will need to be addressed by future research using a longitudinal study.

5.4.3 Availing of supports

When the outcomes were split into spinoffs and licences in Table 5.21, the results of the correlation analysis tests showed that the variable *availing of incubator supports* (with a significance value of 0.040) were related to the commercialisation of research. The correlation value was 0.326, which showed that academics who commercialised their research via a spinoff were more likely to avail of the incubator supports than those who licensed their project outcomes. The T-test results supported this finding.

Table 5.21 Spearman’s Test: Project Outcomes and the Process of Commercialisation Factor (Spinoff and licence separated)

<table>
<thead>
<tr>
<th>Academics availing incubator supports</th>
<th>License versus spin off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation of Coefficient</td>
<td>.326</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.040</td>
</tr>
<tr>
<td>N</td>
<td>40</td>
</tr>
</tbody>
</table>

5.4.4 Availability of local VC funds

The results of the Mann-Whitney U test on the variable *access to local VC funding* had a significance value of 0.038 (see Table 5.22). This suggests that the availability of local VC funding was related to the decision by the PI to choose the spinoff or licensing route to commercialising their research.

Table 5.22 Mann-Whitney U Test: Availability of Local VC funding (Spinoff and licence separated)

<table>
<thead>
<tr>
<th>Availability of local VC funding</th>
<th>Mann-Whitney U</th>
<th>Wilcoxon W</th>
<th>Z</th>
<th>Asymp. Sig. (2-tailed)</th>
<th>Exact Sig. [2*(1-tailed Sig.)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.000</td>
<td>42.000</td>
<td>-2.073</td>
<td>.038</td>
<td>.109(a)</td>
</tr>
</tbody>
</table>

This suggests that where a PI had access to local VC, they were more likely to pursue a spinoff as their preferred route to commercialisation. On the other hand, they were more likely to pursue a licence if they did not have access to local VC.
5.4.5 Summary of factors differentiating between spinoffs and licences

The survey found that the entrepreneurial skills of the academics, the supports on offer from the TTO, and access to local VC funds were related to the commercialisation route chosen by the PI. This was not predicted by the literature. Similarly, the survey also found that the number and experience level of the TTO staff were related to the academics' choice of spinoff or licence. Both findings will be investigated in more detail using the cases presented in the next chapter.

5.5 Regression Analysis

The first three steps of the analysis path outlined in Figure 4.3 helped to determine retrospectively what factors and variables were related to the commercialisation of the project outcomes. To determine what factors may help to predict process outcomes, the fourth and final step in the analysis path (a Logistical Regression) was performed on the factors included in the conceptual model.

The logistical regression test was developed for the particular situation where the two possible outcomes were success and failure (Montgomery, Peck et al., 2001), and was used by Thursby and Thursby (2003) in a similar study to investigate 'patterns of research and licensing activity' in a sample of American universities. This made it an ideal test to use in my study.

The operationalisation of the conceptual model listed 34 different variables thought to influence the commercialisation of research. Testing a model with 34 factors would have been difficult, and would have required a much larger population than available. To overcome this, the model was analysed using the eleven factors from the conceptual model.

Given that 40 responses to the survey were received, the analysis had 39 degrees of freedom. The literature suggested that I use 24 of these degrees of freedom to represent the residual error in the model so I was left with a maximum of fifteen degrees of freedom that could be included in the model to represent the independent variables (Reno, Aiken et al., 1991), eleven of which were used to represent the factors in the conceptual model. Analysing the data in this way gave me confidence that the results would be rigorous, repeatable and reproducible, and meant that the power of the test was high (Reno, Aiken et al., 1991).

The results of the regression analysis all indicated that only one of the eleven factors tested may influence the successful commercialisation of applied research from an
Irish university. When looking at the results for the other ten factors, none of the significance results were close to the 0.05 result that would allow their inclusion in the model with 95% confidence. The most plausible reason for this is the low sample number used for the test.

While the literature suggested that the 15 degrees of freedom available to me were adequate to perform the test (Reno, Aiken et al., 1991), in practice a much higher number is required to ensure the sensitivity of the test is not compromised. In this case, the low number of samples (40) meant the sensitivity of test was too low to give a clear answer as to whether each factor was related to the commercial outcome. This issue once again highlights the need for the case study element of this research.

The only factor included in the model by the logistical regression test was the commercial knowledge of the academic as shown by Table 5.23. From the definition of this factor, we see that the variables included in this factor were the inventor acting as an entrepreneur, the strength of the network the academic had with industry, and the prior business experience of the academic. Using this information, the cases will be used to investigate these variables in more detail, as well as the other ten factors.

Table 5.23 Variables in the Equation

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>B</th>
<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>Sig.</th>
<th>Exp(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(a)</td>
<td>Commercial Knowledge</td>
<td>1.057</td>
<td>.554</td>
<td>3.639</td>
<td>1</td>
<td>.056</td>
<td>2.878</td>
</tr>
<tr>
<td></td>
<td>Constant</td>
<td>-1.736</td>
<td>1.320</td>
<td>1.730</td>
<td>1</td>
<td>.188</td>
<td>.176</td>
</tr>
</tbody>
</table>

a Variable(s) entered on step 1: Knowledge_f.

The Log Likelihood result of 23.325 shown in Table 5.24 indicated that the chances of a success were 23 times more likely than a failure. This meant that a PI with excellent commercial knowledge, and a strong network was 23 times more likely to generate a commercialisation outcome, than not.

Table 5.24 Model if Term Removed(a)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model Log Likelihood</th>
<th>Change in -2 Log Likelihood</th>
<th>Df</th>
<th>Sig. of the Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1 Commercial</td>
<td>23.325</td>
<td>4.021</td>
<td>1</td>
<td>.045</td>
</tr>
</tbody>
</table>

a Based on conditional parameter estimates
5.5.1 Summary of findings and revised conceptual model

The analysis of the data from the survey found evidence to support a number of the hypotheses developed from the literature. In particular it highlighted three variables related to the commercialisation of applied research. They were:

1. The presence of a unique superior idea.
2. The knowledge of the commercialisation process by the academic.
3. The presence of an academic entrepreneur.

The survey also found a number of other variables that were related to the academics decision to chose a spinoff or licence as their route to commercialisation. The case studies were used in the next step to gather additional data to confirm these findings.

The survey also found evidence to show that the choice of spinoff or licence as the route to commercialisation was related to a number of the variables, something that was not predicted by the literature. The cases were also used to understand how and why these variables were related to the academic's decision to pursue a spinoff or licence.

A number of hypotheses developed from the literature and predicted to influence the commercialisation of applied research from Irish universities were not supported by the data gathered during the survey. This was an unexpected outcome, but may be explained by the immaturity of the phenomena of the commercialisation of research from universities in Ireland. In general, the literature was based on the United States and a small number of European countries, where the commercialisation of research was more mature and the processes had more time to evolve. The lack of support for the hypotheses in this study may have been as a result of the absence of data to support them, rather than an absence of any influence. Only time will determine which of these is the reason the hypotheses were not supported by the survey data.

When these findings were applied to the conceptual model developed in Chapter 3, Figure 5.2 was produced to show that the findings of the survey helped to confirm that a number of gaps existed in the process of commercialisation that had to be overcome to generate a spinoff or licence (e.g. commercial knowledge and entrepreneurial skills of the academic). The survey findings also suggested that the presence of a unique superior idea was a differentiator between success and failure, inferring the presence of an idea uniqueness gap.
It is evident from the survey findings that there were differences in how spinoffs and licences were generated, which suggests that the gaps were also different. This also confirms the proposition that a number of scenarios exist. This is one the issues highlighted by the survey that will be investigated by the cases.

The survey data also confirmed that the closing of the gaps was influenced by the interventions taken by the actors. There was insufficient evidence to confirm the role of some actors (government and industry), while the data supported the role played by others (the PI, TTO and VCs).

Using these findings, the conceptual model presented in Chapter 3 was revised in Figure 5.2 to account for the inclusion of the PI as an actor who can close gaps, and the presence of an idea uniqueness gap. The faded areas of the model are used to show a lack of confirming or disconfirming evidence from the survey data.

Figure 5.2 Revised conceptual model

5.6 Case selection

As highlighted above, the survey data did not confirm or disconfirm many of the propositions from the conceptual model. To investigate the model in more detail, I proposed in Chapter 4 to carry out a second (case based) phase to my research. This section discusses the choice of cases.
The analysis presented above highlighted three variables that were found to directly influence the commercialisation of applied research from Irish universities. They were:

1. The presence of a unique superior idea.
2. The knowledge of the commercialisation process by the academic.
3. The presence of an academic entrepreneur.

The survey also found a number of other variables that influenced the academics' decision on their route to commercialisation. In choosing which projects to include as cases, it was important that the projects offered an opportunity to focus on these factors and variables. As such, the first selection criterion was to choose projects from PIs who responded to the survey, and offered interesting insights into the phenomenon. The second criterion was to choose projects that resulted in the different possible outcomes. Third, as some factors were found to be university and PI specific, it was important to include a number of different institutions and PIs. Finally, at least one project that was not commercialised was included for comparative purposes. The list of criteria was then as follows:

- The PI must have responded to the questionnaire.
- The cases had to allow for the collection of relevant data to help investigate the conceptual model.
- The cases had to include at least one project that attempted a spinoff, one that attempted a licence and one project that was not commercialised.
- The cases had to come from more than one institution to allow for inter-institutional differences to be considered.

Once their eligibly was established, to investigate the inter-institutional differences I chose UL and TCD as the two institutions, as I had access to the academics in both institutions. I then reviewed the survey responses from both institutions to look for interesting projects, i.e. ones that clearly supported findings of survey, or ones that appears to provide disconfirming evidence.

Projects UL1 and TCD1 were chosen as the PIs made it clear that they thought a spinoff would arise from the projects\(^5\). In fact UL1 had already generated a spinoff that had received VC investment. UL2 and TCD2 were chosen as the PIs claimed licence deals were imminent, while UL3 was chosen as the PI had successfully set up a spinoff.

\(^5\) The cases were chosen based on information provided in the survey in 2006 so the outcomes were not as obvious as they were at the time of writing
in the past, and appeared to understand what it took to generate a spinoff. Unfortunately, he did not generate a spinoff or licence, so he was an interesting case of an experienced PI who generated no commercial outcome. PI TCD3 was an example of a project used as a proof of concept so it offered an interesting juxtaposition to the others. It generated no commercial outcome so it could be compared and contrasted with the others who did. In total, I chose six cases, three each from UL and TCD (see Table 5.25).

Table 5.25 Initial choices of case studies

<table>
<thead>
<tr>
<th>Case number identification</th>
<th>Expected outcome at time of case research</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Limerick</td>
<td></td>
</tr>
<tr>
<td>UL PI1</td>
<td>Spinoff</td>
</tr>
<tr>
<td>UL PI2</td>
<td>Licence</td>
</tr>
<tr>
<td>UL PI3</td>
<td>Spinoff</td>
</tr>
<tr>
<td>Trinity College</td>
<td></td>
</tr>
<tr>
<td>TCD PI1</td>
<td>Spinoff</td>
</tr>
<tr>
<td>TCD PI2</td>
<td>Licence</td>
</tr>
<tr>
<td>TCD PI3</td>
<td>No commercial outcome</td>
</tr>
</tbody>
</table>

The next two chapters of this study are used to present and analyse the data relating to these six cases. Chapter 6 presents the data on the three cases from UL, while Chapter 7 deals with the three TCD cases.

Once presented, the data from the individual cases were analysed as per the strategy outlined in Figure 4.3 in Chapters 6 and 7. The analysis of the data is presented in Chapter 8.
CHAPTER 6 : PRESENTATION AND ANALYSIS OF UL CASE DATA

6.1 Introduction

The use of six cases to investigate the phenomenon of commercialisation from Irish universities was discussed in the last chapter. This chapter presents the data gathered from the three UL case studies, while Chapter 7 presents the three TCD cases. Each chapter presents the data on the individual cases before analysing the data as per Section 4.6.2.

As elements of the case data were university specific and therefore varied little between cases, these data are presented in advance of the individual case data to avoid duplication. Where case specific data was relevant, it is included in the description of the case.

As described in Chapter 5, the six projects were chosen as they offered the ability to probe the areas of interest identified by the survey in more detail, and to allow the projects to be compared and contrasted with the each other.

In total there were twelve people interviewed across the six projects; these included the six PIs, three TTO staff, two project managers and the CEO of a spinoff. The interviews took place between the 30th of April and the 26th of June 2007. Ten of the interviews were face to face, while two were via the telephone to facilitate the interviewees. The interviews were recorded using a dictaphone to allow the interviewer to concentrate on the answers, so that unexpected responses could be pursued. All data is anonymous to protect people’s identities.

6.2 Methods of data analysis used

Before the analysis of the data commenced, each of the interviews was transcribed from the audio recordings before being coded according to the template outlined in Appendix 3. Where evidence of other variables (not predicted by the literature or the survey) existed to show that they influenced the commercialisation of the project outcomes, that evidence was also marked and coded.

All coding was done manually as the exact terms used to describe the variables varied by interviewee. In this respect the use of an automatic coding tool such as N’vivo was not practical, as N’vivo cannot identify the subtleties of language that exist in the responses, particularly as two of the interviewees were not native English speakers.
A sample of the coding template used is shown in Table 6.1. The codes were assigned according to the factor, variable, categorisation of the variable and the impact it had on commercialisation. In total there were ninety two predetermined codes; thirty additional codes were added to account for the addition of unexpected variables identified in the data. The full coding table is included in Appendix 3.

Table 6.1 Sample of coding template

<table>
<thead>
<tr>
<th>Code</th>
<th>Construct</th>
<th>Factor</th>
<th>Categorisation</th>
<th>Impact on Commercialisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1.1.1</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Well defined strategy and well communicated across institution, supports commercialisation of research</td>
<td>Positive</td>
</tr>
<tr>
<td>1.1.1.2</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Well defined strategy and well communicated across institution, supports commercialisation of research</td>
<td>Negative</td>
</tr>
<tr>
<td>1.1.2.1</td>
<td>University Policies</td>
<td>Alignment of policies</td>
<td>Defined strategy but not well communicated across institution, neutral support for commercialisation</td>
<td>Positive</td>
</tr>
</tbody>
</table>

The analysis started by characterising the data gathered via the interviews, and looking for evidence of gaps, and interventions by actors in the data. To avoid duplication, the analyses of the data relevant to the TTOs were grouped by institute rather than case.

6.3 The University of Limerick (UL)

This section presents the data on the TTO in UL, the policies of the university, and the supports available to academics wishing to commercialise their research.

6.3.1 TTO Structure, size and experience

At the time of this research, the TTO in UL was called the University Technology Enterprise Division (UTED) and was a sub-office of the Research Office. The Director of the TTO reported directly to the Vice President of Research, who then reported to the President and the Governing Authority. From its inception in 2000, the office consisted of one administrator, a part-time Technology Transfer Consultant (who was a retired employee of the university), and a director who was responsible for negotiating all deals on licences and spinoffs, and protecting all IP.

The Director of the TTO (UL TTD) said he had previous experience as a participant in a spinoff from the university. Then, as Director of the TTO he had dealt with a number
of successful spinoffs and licences. It was via these deals that he gained the majority of his knowledge. He also had attended a number of formal courses on IP protection and licensing in Ireland and the UK.

6.3.2 Alignment of policies and actions

At the time of the ATRP / CFTD projects, the university had no written procedures or policies on the commercialisation of research, although there were two local agreements that appear to have been well understood by the academics. The first was that royalties from licence income were shared with the inventors of the technology, while the second was the availability of leave of absence to those who wished to join a spinoff. In the interview with UL TTD, he outlined a number of new policies that were being implemented, and how he intended to communicate these to the academics. He also said that UL would monitor the effectiveness of the policies, and their implementation, via a Quality Management System.

UL had no policies that recognised the academics’ achievement in registering a patent, or successfully setting up a spinoff company. Neither was included in the criteria for promotion published by UL, and as one of the PIs interviewed said, theoretical papers counted for much more than any licence or spinoff if you wanted to get promoted.

*If you really want to get promoted you could easily have 2-3 students and write journal papers that are academically [focused] and you’d be better off*

Due to the lack of adequate resources, the director said it was common for him to have to outsource much of the work on patents and licence agreements to third parties.

*As a university here we have found it very hard to get good legal IP advice ourselves and have moved [suppliers] quite regularly. We are using three different legal advisors today. I suspect we may move again to using US legal advisors on IP deals.*

At the time of the survey and case data collection, the TTO in UL was funded directly from overheads received from the national research funding bodies (Enterprise Ireland and SFI), not from the university’s own funds. UL TTD said the office was being expanded, but that the cost of this was being borne by Enterprise Ireland via the Technology Transfer Strengthening Initiative (TTSI), rather than the university. The TTSI was a €36 million (5 year) fund to help expand the TTO staff numbers and grow their skill levels.
6.4 Presentation of case data

This section presents the data on the individual cases. Table 6.2 lists the three cases from UL and describes the outcomes expected at the time of the research. To aid the presentation of these data, each case is considered under the headings, the role of the university, access to Venture Capital (VC), the academic's knowledge and entrepreneurial skills, a unique superior idea, and other process related data. In all cases the names of individuals and companies are coded to protect their identities.

Table 6.2 List of UL Cases

<table>
<thead>
<tr>
<th>Case number</th>
<th>identification</th>
<th>Expected outcome at time of case research</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Limerick</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UL PI1</td>
<td></td>
<td>Spinoff</td>
</tr>
<tr>
<td>UL PI2</td>
<td></td>
<td>Licence</td>
</tr>
<tr>
<td>UL PI3</td>
<td></td>
<td>Spinoff</td>
</tr>
</tbody>
</table>

6.5 Case study one: Introduction to UL1

UL1 was a successful spinoff that was formed by a team of academics based on an ATRP project funded in 2002. The company was formed in 2006, following the negotiation of a licence from the university. According to the company's website, UL1 was a 'privately funded fabless semiconductor company that specialised in digital energy control'.

There were a large number of multinational companies who were interested in the market opportunities this technology could offer, including several who were based in Ireland; these included American Power Conversion (APC), PowerOne, and Tyco. Similarly, there were also a large number of semiconductor companies interested in producing a similar technology; they included Analog Devices, National Semiconductor and Texas Instruments (Darnell Group, 2006). Many of these companies offered stiff competition to UL1, who responded to this possibility by partnering with potential end users (such an Intel) in its product development process.

UL1's strategy was to provide digital solutions to the power conversion market. The use of digital control was considered a new technology, which offered a first to market advantage to the company. The potential in the market was great with the 'the worldwide Digital IC market (which includes VR Loop Controllers, Non-VR Loop Controllers, PFC Loop Controllers, Converter Management ICs and System ICs) expected to increase to $796 million in 2011, at a compound annual growth rate of 36.4%' (Darnell Group, 2006).
The UL1 technology was a new to the market technology, because power conversion was at that time achieved using analogue technologies. The use of digital technology offered substantial size, performance and cost benefits to users. The UL1 team believed that the company that was first to offer digital control would have considerable first mover advantage in the market. The Chief Executive Officer (CEO) of UL1 (UL SE1) was, until April 2005 CEO of PowerCompany in Ireland, which itself was working in the area of digital control. UL SE1 said he left PowerCompany after a disagreement with the corporation on how they should pursue their digital strategy.

I'd finished up at PowerCompany as I had a difference of opinion, so it was time to leave.

Since its inception, UL1 has taken a second licence on a similar technology from UL, and successfully negotiated investment of $20 million from a consortium of VCs led by Intel Capital.

The team that commercialised the technology included the Principal Investigator, UL PI1, who became the VP of Analogue and Digital Design in the spinoff; the manager of the research centre, UL A2, who became the Chief Operations Officer (COO); and UL A3, who was a researcher on the project and who became Vice President of Digital Design. The final member of the management team was UL SE1 who became CEO of the spinoff. How UL SE1 became involved in the team will be discussed later. In 2007 UL1 hired a dedicated sales person with substantial experience in the relevant industrial sector (he also came from PowerCompany). An organisation chart is shown in Figure 6.1 to represent the roles of the key individuals in this project. Interviews on the UL1 case were carried out with the Principal Investigator, UL PI1, the CEO, UL SE1 and the director of the Technology Transfer Office, UL TTD.

Figure 6.1 UL1 Organisation Chart
6.5.1 Role of the university

This section presents the data relating to the role played by the university, including its policies on commercialisation, the supports offered by the TTO, the academic's knowledge of those supports, and the influence they had on the academic's choice of route to commercialisation.

6.5.1.1 Alignment of policies

UL SE1 claimed that the aims of the university were at odds with the needs of the potential spinoff. He said that the university's aims were to extract the most value it could from either the licence or the spinoff, which often had a detrimental impact on the potential spinoff (the university asked for 15% equity in a spinoff). UL SE1 thought that the university was more interested in its short term gains than the long term sustainability of the company.

The university's goal is to extract as much value from the licence deal that it possibly can, so that immediately puts it at odds with the company trying to arrange a spin out.

The university also appeared to be in a hurry to get the new company off site as soon as possible. There were issues associated with personnel from the research centre from which the spinoff emerged, who were not part of the spinoff. As a result, the university wanted the spinoff to move off site as soon as possible.

...as soon as we formed the company there was almost a mood change in the university. The impetus seemed to be get [us] out of UL within a couple of weeks rather than have some kind of incubation. There was absolutely no assistance whatsoever; in fact it was all very negative.

UL SE1 also thought the university had an issue with the continuation of projects from which licences were generated. In the UL1 case, if the team got an exclusive licence, then the university had to shut down a number of related project under the terms of its contract with Enterprise Ireland (even if the projects were not finished). UL SE1 found this to be another barrier that the team had to be overcome.

...it's incredibly difficult to do an exclusive licence because... the university does not have any interest in licensing if it's going to shut down a couple of other projects, or these projects have to be re-scoped.

Losing the Enterprise Ireland funding meant the university risked losing the associated contribution to its own metrics (number of masters, PhDs and
academic papers) unless it could find replacement funding. In general, *UL SE1* thought the possible loss of research monies appeared to outweigh the benefits of a spinoff to the university. *UL TTD* agreed with this assessment.

*We had a lot of problems with the UL1 deal in that we had 3 other projects using the technology. UL1 wanted an exclusive licence or the backer would not invest, if we had put that licence in front of EI they would have had to terminate the other three contracts.*

To overcome this problem involved a lot of time and effort on behalf of the TTO, which they did not seem to want to have to do. *UL TTD* said

> It took a huge amount of effort and time on the part of my office to re-jig all those projects and this slowed the deal down to the point that I thought the deal was done in June. We did not actually sign it until September.

Another reason why the universities did not appear to favour spinoffs was the possibility that they would lose the researchers who joined the spinoff. In that sense the university seemed reluctant to support a spinoff even though its policies suggested it was in favour of them. *UL SE1* felt that this was a real issue in UL.

### 6.5.1.2 University supports

When looking at the supports the university offered the team to help it commercialise its research, all three interviewees had different opinions on the levels, and usefulness, of the supports. To start with, *UL PI1* thought the TTO was under resourced in terms of the support it could offer them, but recognised the assistance they received in patenting the technology.

*I got the impression they were understaffed*

*UL PI1* was on leave of absence, so he believed the university was supportive of his efforts to commercialise his research by providing him with the ability to maintain his ties with the university.

*I'm on a leave of absence at the moment ... so that made the transition to the spinoff much easier.*

However, he said that the only support the team availed of was in patenting the technology. This was because the university did not offer any other supports that may have been useful to the team.
Early support in terms of [patent] protection, and then when we were in the later phase of commercialisation UL TTD made himself available whenever there were questions.

UL SE1’s views of the supports were quite different because his involvement was around the team’s attempts to commercialise the technology, which he found slow and frustrating. The first gap in the support offered by the university according to UL SE1 was the lack of incubation space (although UL did have an arrangement with Shannon Development, a local development agency, which ran a local Innovation Centre for new start up companies). The university provided UL SE1 with temporary access to an office, but did not deal with the issues this caused, i.e. how to cope with the people who were part of the research centre, but not part of the spinoff.

[I was] given an office to work out of... but the whole environment for commercialisation was somewhat negative because people knew that some of the key people were going to leave and that was not helpful for the [research] centre, so there was a lot of negativity.

UL TTD recognised that this was an issue that needed to be dealt with better in the future.

I had separate visits from people within the centre that were unhappy with what was going on ... I think in future we will put processes in place in our spinoff procedures which force decisions on those [personnel issues].

UL SE1 thought the university wanted to get the team out of the university as quickly as possible rather than offering them incubation space and time to help them to build value in the technology.

The impetus seemed to be to get [us] out of UL within a couple of weeks rather than have some kind of incubation ... UL just wanted to get us out.

Access to the TTO was also an issue for UL SE1, and he said it was almost impossible to get time with UL TTD. UL SE1 suggested that UL TTD was only willing to give the team his time once he was convinced that the team had an investor in place.

You cannot get the bandwidth of the TTO; they’ll only talk to you when you’ve got a one million euro investment.
UL TTD did not agree with this perspective and said there was an unwritten agreement between his office and the team to licence the technology to any spinoff they created.

... the view was that my office had given clear signals that we were supporting their activities and we were not going to licence this technology to some other party.

UL SEI did not think this was appropriate for the situation. UL SEI also found it difficult as he was treated as an outsider in the negotiations for the licence. To him, this was another example of how unsupportive the university policies were of spinoffs.

6.5.1.3 Academic's knowledge of the university policies
While UL PI1 had an accurate knowledge of the aims of the ATRP, he did not have any knowledge of the university policies on commercialisation at the start of the project.

I was aware of certain guidelines regarding protection of IP but regarding commercialisation I would not know.

This was not that surprising, as at this time he was attempting to commercialise his research, these policies were only being developed by UL. UL TTD said during his interview that there were gaps in the policies UL had.

We are not communicating our policies very clearly, we have major policy gaps.

6.5.1.4 Impact of the policies on choice of spinoff versus licence
The choice of spinoff versus a licence seems to have been resolved at a very early stage in the project, and was not directly influenced by the universities policies. UL PI1 suggested that the team always had an open mind, but the actions of the team suggest they only ever pursued the spinoff option.

In the early days we considered both, we had an open mind.

UL PI1's comments suggested that the team was prepared to look at licensing if the spinoff did not work; however the addition of UL SEI to the team provided the necessary skills to help drive the spinoff. UL PI1 said that it was during the
C+\(^5\) (where UL SE1 became involved) that the team decided to actively pursue the spinoff option.

*In the C+ programme, that’s where we finalised the decision on how to commercialise it best. A spinoff really gave us all the freedom to best implement the ideas.*

UL SE1 needed a salary when the C+ finished, so he favoured a spinoff as there was nothing in it for him if the technology was licensed to a third party, as he was not one of the inventors and would not have benefited under the university’s royalty policy. Through the C+ he saw he could work with the team, which may have prompted him to encourage the team to opt for a spinoff.

*It was a group decision. I think people felt they could work together. Clearly I had no interest unless the core team were involved because it’s not about the patents and the design files; it’s about the knowledge and ability to execute on what’s going to happen going forward.*

According to UL TTD, the university thought there were issues with the deal UL1 had negotiated, but they were still prepared to let the team ‘have a go’.

*The initial monies that came from the VC were in our view very damaging and expensive terms. But the view was... let them have a go.*

The university were happy to allow the team to start a spinoff because they felt the team had the necessary skills to succeed. UL TTD did not think this would always be the case, as most academics lacked the commercial knowledge necessary to succeed. UL TTD said that in future the university’s starting position would be to suggest a licence, and challenge the academic to show why a spinoff was more appropriate.

*I think the way we will approach it [commercialisation] is that we will presume a licence is the way forward and we will put it up to the promoters to argue why a spinoff is better.*

### 6.5.2 Access to Venture Capital (VC) funding

One of the biggest gaps companies face when starting out is access to capital. In the case of a spinoff from a university in Ireland, there were generally four sources of finance. The *first* was private investment, either via business angels or the promoters’ own investment. This accounted for the initial €100,000 investment in UL1. The

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\(^6\) The C+ is an invitation only top up fund provided by Enterprise Ireland in situations where a clear avenue to commercialisation is apparent.
second was money from the university, which was not forthcoming in this case. The third was money from Enterprise Ireland in terms of an equity stake, which UL1 did receive, although for operational reasons the monies were channelled via Shannon Development. The fourth and often most difficult source of finance was from VCs, and in many cases the other investors would not put money into a company until they saw a VC had invested. This was because the VC did a forensic audit of the company before investing, and only invested in companies it believed offered the potential for large returns on its investment.

At the time of this research, the VC market in Ireland was very small in comparison to other countries such as the UK and USA; the main players at the time were 4th Level Ventures, Delta Partners and European Venture Capital. A large portion of the VC's finance also came directly from Enterprise Ireland (via a fund-of-funds). UL SE1 was critical of the role Enterprise Ireland played in this arena.

The disadvantage is that there's no seed money in the country at the moment and its getting worse because EI have essentially shut down the smaller VCs by forcing them to raise money up to €30 million.

In attempting to secure VC investment UL SE1 had over 70 meetings with VCs both in Ireland and abroad. He said that customer testimonials were vital in securing investment. The biggest problem UL1 had from the VC's perspective was the market was not big enough as it was fragmented, making it difficult to generate large sales from a small number of customers.

One of the particular issues was that it's actually not as big a market as you'd like. VCs want to see a billion [dollar] market. And it's very difficult to architect a strategy that will actually service a market of a billion because the power market is so fragmented.

More importantly, UL SE1 said that the UL offering was still too early for most seed funding. However, the fact that they had already secured funding from Enterprise Ireland allowed them to leverage an initial investment from 4th Level Ventures.

...we were still too early for 9 out of 10 VCs. Seed money is absolutely critical and we were just fortunate enough that we did get some and we able to leverage that off Enterprise Ireland money.

UL TTD thought that this need to get seed funding was a preoccupation of the team, and that they rushed into the deal with the 4LV too early. He thought that the deal
they negotiated would be bad in the long term, and that any subsequent investor would want the original deal restructured to give more equity back to the promoters (to ensure they were motivated to succeed).

*I do not think they have considered the impact of those terms and I think those terms may have a downstream impact which could damage or handicap the business. I would suggest UL 1 have done deals which have damaged the equity structure.*

Starting up the company was an important factor in negotiating with the VCs. The academics noticed a change in the reaction of potential investors, and *UL TTD* felt this was a changing point in their view of how they moved forward.

*What was clear from the promoters was that while they were just a group of people inside UL they were getting a listening to, but when they formed a company with an address, an image and a business card, they found that they got a completely different reception [from the VCs].*

6.5.3 Academic’s knowledge and entrepreneurial skills

This section presents the data gathered from the interviews with the various parties relating to the PIs commercial knowledge and entrepreneurial skills.

6.5.3.1 Academic’s knowledge of the ATRP

*UL PI1* appeared to have a good knowledge of the aims and objectives of the ATRP programme. He accurately said that he thought it was to help academics carry out research that had the potential to be commercialised.

*The aim, as far as I understood it, was to carry out research, developing ideas which could then be commercialised in a suitable way, licensing or a spinout.*

He was also motivated to apply for funding under the ATRP by a real desire to commercialise a technology he had been interested in while working in industry.

*I brought ideas into a research centre in UL and it just seemed an obvious choice in terms of getting research funding with a commercial background.*

6.5.3.2 Presence of an entrepreneur and social links

*UL PI1* had previous experience working in industry and was director of a small company called *MedicalCompany*, in which he owned shares. *MedicalCompany* was not a spinoff from a university, and was in a different industrial sector to *UL1*, but *UL PI1* said it gave him good exposure to the world of business. *MedicalCompany* was a distributor of medical devices within the Irish market.
It's a small organisation, there are five people and I'm one of the directors. It's basically an agency and distributor for medical devices...

UL TTD believed UL PI1 was motivated by his previous industrial experience and felt that UL PI1's return to the university was, in part, with the intention of trying to develop a technology to a point where it could be commercialised.

I think UL PI1 joined UL as a faculty member only four years previously. My suspicion was UL PI1 joined UL with developing this breakthrough technology in mind.

Through the academic team's involvement in the Power Electronics Industry Group (PEIG) (a National Industry Led Network) they approached a local businessman to do a market analysis for them under the C+. He suggested UL SE1, who joined on a six month contract. His intention was to spend six months developing the business plan for the team, and to leave to pursue other interests. UL PI1 said

UL SE1 was well known in the industry and with a very strong background in commercialising IP. It just seemed an obvious choice for us to take on such a high calibre person to carry out that market research.

At the time, the C+ paid UL SE1 a salary while he considered his options. He said he had no preconceived opinions on the potential of the project.

In other words they'd have a clear strategy and a clear business plan and then I'd walk away. Essentially that was the initial contract.

UL TTD saw the inclusion of UL SE1 in the team as the turning point in the commercialisation of the project. He says that up until UL SE1 was involved, the business plan was unrealistic, as it was based on aspirations rather than actions.

...we'd find the business plan and we'd find the market opportunity and how the product would be placed.

UL TTD said that UL SE1 brought a hunger to the team that was not there before, because the academics were all drawing salaries from the university, and had not the necessary hunger to make it work. UL SE1, on the other hand, had no job once his six-month contract was over, so he had a greater motivation in attempting to make a spinoff company work.
UL SE1 decided this was a job for him and he needed it to work. UL SE1 had no work when the C+ was over, which was not necessarily a problem for UL SE1, but UL SE1 saw a business opportunity... and I think it comes down to hunger.

The academics were enthusiastic enough to invest their own money when it came to starting up the company. This was done under the Business Expansion Scheme (BES), where the promoters of a company could claim back their PAYE (Pay As You Earn) tax from the previous five years.

...in fact we ended up investing in the company to cover costs in terms of legal expenses. That was €100k we put in.

UL PI1 said he felt that by the end of the ATRP the technology was at a point where it could be licensed into the spinoff or a third party. However, other than the work to win a business plan competition run by the university and Shannon Development, very little commercialisation work had taken place.

...they [the technical deliverables] were complete to a degree where we were happy to bring them into a licence or spinout.

The academics had already attempted to sell the idea to some VCs during the ATRP, but with no success. UL TTD believed that one reason for this was that the promoters were perceived as a group of academics lacking commercial skills.

They had a business plan and I think they were out touting it to VC's ...I think it was clear the VCs saw there was no [skilled management] team, they were all techies.

Hiring UL SE1 helped to overcome this gap, although UL SE1 was initially hired to carry out a market analysis defined by the C+, and he was supposed to leave after that.

There was a clear spec on what I was going to do, which was like a macro market analysis, a micro market analysis some customer validation in there ...a business plan and that was really meant to be the end of it.

Although UL SE1 saw potential in the technology, he said there were a number of issues that had to be overcome. He thought the initial business plan was immature, and the team were unrealistic in their product roadmap.

Their business plan that they had was very immature. In actual fact it was basically that they had this technology and it was so great that they were going to penetrate every power application, and it was going to be so cheap that they
were going to start off in the low cost and then penetrate upwards; which was completely the wrong way to do it...

UL SE1 had experience in commercialising technology in the past, so he knew the process that the team needed to follow to be successful. He also knew the risks involved with the process, and therefore the steps that could and could not be left out.

I had the experience of attempting to do this [commercialisation] with quite a lot of success in some respects. So I was very familiar with that space. And the risk as well.

UL SE1 recognised the importance of talking to customers as he said without their involvement it would be impossible to attract investment

...it's only about customers and that's all that matters. VCs do not care about anything except customer testimonials, preferably customers worldwide: including Asia and the US. If you cannot get customers to endorse what you're doing you've absolutely no chance.

Using his contacts within the industry, UL SE1 approached a number of companies such as Cisco, Huawei and Phillips NXP with a draft technical specification of the product. He used the specification to develop their interest, and to find out who might be potential customers for the final product.

So [we] drafted what looked like final data sheet specifications and presented them to those companies.

Mainly through UL SE1's perseverance, the team eventually got VC funding from 4LV, but found the whole process very frustrating. UL SE1 blamed the university and Enterprise Ireland for some, if not all, of the issues that led to the delays. UL SE1 said that Enterprise Ireland were unrealistic in how they expected a potential spinoff to be able to attract VC funding. He also said the rules governing what the C+ could be used for were too restrictive and hindered his ability to attract investment.

We had got some initial interest from VCs but actually that was beyond the scope of the [C+] project because the view of EI was if you produce a business plan and the business plan is good enough the VC's will come, which is ludicrous.

6.5.4 Unique superior idea

Competing power conversion technologies were based on analogue technology. If this new digital technology could be brought to the market it had the potential to be a
disruptive technology. This was a perfect example of a unique superior idea that could be developed into a unique superior product.

_It's satisfying to be able to compete at a global level which basically means we had to have the best technology in the world and we had to have the capacity to commercialise it on a worldwide basis._

### 6.5.5 Process related data

The following data are presented under the heading of _process related data_ as they do not fall neatly under the other headings. However, these data highlight issues associated with the project that add depth to our knowledge of the roles played by the different actors. The issues highlight the relationships between the actors, and as such could not have been anticipated when developing the conceptual model in Chapter 3. These data are used specifically in Chapters 8 and 9 to discuss the relationships between the actors, and the patterns in their interactions. The same heading is used in all six cases to review similar data.

When trying to negotiate an exclusive licence from the university, which was a key requirement from the VC before they would invest, _UL SE1_ says he could not get enough of _UL TTD’s_ time, and said it took far too long to find out what terms the university wanted for the licence. He said _UL TTD_ was not interested in talking about the licence until the team had an investor, but obviously the investor would not commit until they knew the team had exclusive access to the technology.

> And then you get into the rather bizarre situation where the Industrial Liaison Officer will not deal with the start up company unless there's money on the table, but you cannot get money on the table unless you've got a licence deal. The licence deal will not be articulated until the company is formed and there's capital invested or a commitment to capital. And you cannot get commitment to capital unless you got the licence content worked out.

Then when _UL TTD_ did give the team the terms for the licence, it turned out that the university were not prepared to offer exclusive terms, which further delayed (and nearly killed) the deal with 4LV.

> ...the major hurdle is the technology cannot be licensed exclusively which is the only thing that interests any start up.

Similar problems with getting approval from Enterprise Ireland also delayed the signing of the licence.
... we had a major hiccup whereby the licence terms that were articulated included an option on another project, and you know we were given strong assurances that this would be approved. But it got pushed back by EI at the last minute, which again nearly killed the deal.

When asked if he thought this was deliberate policy on behalf of the university, UL SE1 said he did not think the university had any policies. He also suggested that even when the team had invested their own money it was not enough to get the attention of the TTO.

Not really, there's no policy. We just went ahead on good faith ... in fact we ended up investing in the company ...€100k was put in, but that's not enough to justify the ILO spending his time on a licence agreement or putting it in front of EI.

The team felt they were expected to go along with the TTO on good faith when all the financial risk was on their side. UL SE1 said the fact that they had already invested their own money put them in a very disadvantageous position. The university then knew the team would have to do a deal, and UL SE1's perception was that that could be used against the team in a negotiating context.

...the risk is borne by the promoters... you basically have to put skin in the game [invest money] before you can get a licence articulated. At that stage you're over a barrel, you do not even have a negotiating position... you're going to have to take whatever licensing terms they [the university] give.

UL TTD said he saw no such delays and believed he was clear in telling the team that the university would support them. However, he agreed that the university never articulated the terms of the deal to the team during their attempts to secure VC funding. He believed he clearly articulated the university's support to the team, and thought that the final agreement of the terms would be a formality.

There was no delay in doing the licence, I think... there was a level of trust going on between the university and the guys...we're [the university] supporting you and when you need the licence we'll do the licence.

UL TTD did see issues with the process of how the terms were agreed, but thought these were associated with the need to report the terms to Enterprise Ireland, rather than with anything his office was responsible for. He thought the need to pre-approve deals with Enterprise Ireland was unnecessarily cumbersome, and was a barrier in allowing the university to do its part of the deal.

...I think the Exploitation Consent Committee causes a problem...
6.5.6 Post spinoff from the university

Once the promoters left the university they went about trying to secure the sustainability of the company. To do this they hired a Sales Director to give them access to more potential customers. The individual in question had previously worked with UL SE1, so UL SE1 knew he would work well with the team. His background in the relevant industrial sector was a critical factor in his appointment.

The promoters also started to approach the VC community for a second round of funding, as they knew the initial investment would not be sufficient to keep the business running until it generated sufficient sales income. In December 2007, UL SE1 successfully negotiated a deal worth $10 million from Intel Venture Capital, on the basis that the company would source $5 million in matching funding to an investment of $5 million by Intel. Using Intel’s commitment as leverage, UL SE1 was able to put together a consortium of three international VCs (and the original Irish VC) to provide the necessary matching funding. In July 2009, the company announced a further $10 million investment from the same VCs. At that time it employed over thirty employees in Ireland, and had international offices in Taiwan and the US.

6.5.7 Summary of Case UL1

UL PI1 returned to UL from industry with an idea that he wanted to pursue. He was successful in 2002 in his application for funding from Enterprise Ireland, and spent the next two to three years working on the technology and attempting to commercialise it.

Alongside the operations manager of the research centre, UL A2, UL PI1 visited many companies and VCs in the hope of setting up a new company. During these visits it became obvious to the team that they lacked the commercial experience to attract external investment.

At the same time, Enterprise Ireland agreed to provide additional funding to allow the team to hire a consultant to help them work on their business plan. The intention of this funding was to provide short term expertise to allow the team to overcome their knowledge gap, and to attract external investment.

Through their involvement in a local industry network group, the team hired UL SE1 for six months to develop their business plan.

UL SE1 joined the team on a short term basis while he looked for another opportunity. While working on the new business plan, UL SE1 recognised the potential in the
technology, but also saw that the plans the team had to commercialise the technology were unrealistic. Using his network of contacts and marketing expertise, UL SE1 set up tens of meetings with potential customers and investors. These meetings confirmed the new market approach suggested by UL SE1, and also secured the team's first external investment: a €400k loan note from 4LV, a local VC.

In tandem with these negotiations, the team also had to negotiate a licence with the university, and get approval for the spinoff from both UL and Enterprise Ireland. UL SE1 found these negotiations tiresome and said that on many occasions that he found the UL and Enterprise Ireland processes unhelpful, or worse, overly restrictive.

To fund the activities required to set up the company, the team invested €100k of their own money via a government tax incentive scheme. This allowed them to operate until the loan note from 4LV was realised. The spinoff company was incorporated in early 2006.

As soon as this initial investment was secured, UL SE1 pursued a second larger investment, while the other team members concentrated on delivering the technology. Intel Venture Capital agreed to provide $5 million if the team could secure matching funding from other investors. Given the prestige of securing investment from Intel VC, it was easier to persuade other investors to come on board. By December 2007 the team had secured the full $10 million investment. In early 2009, the company had its first design wins (successful product realisation), and in July 2009 announced a further $10 million investment from the same investors.

### 6.6 Analysis of UL1

The data above was analysed according to the strategy outlined in section 4.6.2 to look for evidence confirming / disconfirming the presence of gaps from the revised conceptual model, and the role the actors may have had in closing gaps that existed.

#### 6.6.1 Existence of gaps

- **Idea Uniqueness gap**
  
  An idea uniqueness gap existed as current applications relied on analogue technology to control power circuitry. The UL1 technology was digital and acted as a discontinuous innovation that would change the market place. It created a niche in the market that had not existed due to technology limitations.

- **Funding gap**
A funding gap was evident as without the ATRP funding, the team would not have been brought together to work on the project. Similarly, UL SE1 could not have been hired without the additional C+ funding provided by Enterprise Ireland. A funding gap also existed when the team were attempting to set up the spinoff. They needed money to pay for office space, travel and legal advice (when negotiating the licence deal). They also needed to pay the salaries of the spinoff staff.

- **Knowledge gap**
  
  Prior to the C+ (when UL SE1 joined the team), it was evident that managerial and market knowledge gaps existed in the team. Their business plan was flawed accorded to UL SE1, and the VCs thought they were a group of academics who lacked commercial experience. A technological knowledge gap existed in so far that this technology did not exist prior to the start of the project and had to be developed.

- **Entrepreneurial gap**
  
  While UL PI1 had the social links that allow him to hire UL SE1, he (and the other researchers) lacked UL SE1’s industrial network. Without this network, the team would not have met the potential customers UL SE1 had access to, and it was this interaction that helped reshape the business plan and convince the VCs that a market existed for the technology. Similarly, if the researchers had not displayed their commitment to the idea of the spinoff at all times, Enterprise Ireland would not have invested in the C+, and UL SE1 said he would not have joined the team either.

### 6.6.2 Interventions by actors to close gaps

- **Government**
  
  Government had a number of roles to play in closing the gaps in UL1. **First,** it helped overcome the funding gap by making ATRP and C+ funding available via Enterprise Ireland. **Second,** it invested in fund-of-funds that supported the VC community. **Third,** the rules of the ATRP (which gave ownership of the IP to the university) influenced the PIs decision to pursue a spinoff.

- **Financial Institutions**
  
  Once convinced that a market existed, and a suitable management team was in place, the VC community invested in the company. To date, they have committed over $20 million to the spinoff.

- **Industry**
  
  Using his contacts with industry, UL SE1 met with several large multinational corporations to sell them the concept of the technology. Their feedback on the
product (and their demand for such a product) was critical in convincing the VCs to invest in the technology.

- **University**

  UL SE1 and UL TTD had different opinions on the levels and usefulness of the assistance given by UL (via the TTO). While the technology was licensed at a reasonable cost, the time and effort UL SE1 had to spend negotiating the deal nearly caused the collapse of the spinoff. UL SE1 said that the university wanted the spinoff team offsite as soon as possible, and did not offer them incubation or office space. UL TTD on the other hand thought it made it clear to the team he would offer help and support where he could.

- **Principal Investigator**

  UL PI1 showed commitment and drive through the process of realising the spinoff. The project concept was based on his identification of a market opportunity, and his technology knowledge of what was possible using digital technology. He secured the initial project funding, and convinced Enterprise Ireland to provide further funding via the C+, which allowed UL SE1 to join the team. UL SE1 was chosen as he was known to UL PI1 through his industry network.

From the data presented above, Table 6.3 was developed to show the supports and interventions made by the various actors to close the gaps in UL1. From this, we see clearly that all four gaps were closed allowing for the generation of a spinoff from the project.

**Table 6.3 Summary of UL 1 case**

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td></td>
<td>Team visited customers to get feedback</td>
<td>Used feedback from other actors to develop idea</td>
<td>Helped focus the idea</td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>ATRP / CFTD, C+, Patenting funding from Enterprise Ireland</td>
<td></td>
<td>Personal investment by the PI and other team members; applied for ATRP</td>
<td>VC provided investment</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Enterprise Ireland knowledge, expertise and contacts</td>
<td>Market pull, experience of the surrogate entrepreneur, technological competent</td>
<td>Where knowledge was lacking used surrogate to bridge the gap</td>
<td>TTO support, TTO’s external network</td>
<td>Funding market pull only</td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Commercialisation specialists provided networking support</td>
<td>Customers gave feedback on what they wanted</td>
<td>Commitment to pursue funding via 70 meetings, social network to meet customers, VCs and SE</td>
<td>TTO’s external network</td>
<td>PI had to show commitment to get funding</td>
</tr>
</tbody>
</table>

Page 121
Using these data, Figure 6.2 is presented to show what gaps existed and which actors played a role in their closure in UL1. The sizes of the gaps were specific to UL1, and varied at different times in the project. For example, the funding gap grew once the decision to pursue a spinoff was made, as money to hire a business consultant was required. The gap grew further when the spinoff needed office space and legal advice on negotiating the licence from UL.

Figure 6.2 Elements of conceptual model evident in UL1

Figure 6.2 clearly demonstrates the added value of the case approach as the case data has removed the veil of uncertainty associated with the survey results. The data from UL1 has allowed the fading from the revised conceptual model (Figure 5.2) to be removed, adding clarity to our knowledge of the phenomenon. The implications of this for a further revised conceptual model following the presentation of all six cases will be dealt with in Chapters 8 and 9.

The bidirectional arrows between the actors show the influence of interventions by one actor on all others, not just those adjacent to them in the figure. Similarly, the bidirectional arrows between the gaps show how closing one gap could impact on the size of another gap, not just those adjacent to it, as evident from the data.
Figure 6.3 was also developed to show the gaps overcome to realise a spinoff from project UL1. The green boxes represent those gaps that were closed. The underlying premise in this figure was that a failure to close any, or all, of these gaps would have meant it was impossible to generate a spinoff.

Figure 6.3 Gaps closed by actors in UL1

6.7 Case study 2: Introduction to UL2

The second case from UL was a successful licence deal signed between the university and an Irish software company, Company A (the owner of which was an entrepreneur of national recognition). The licence deal was signed in summer 2006, just before the end of the project. After the completion of the project there was also an Innovation Partnership project agreed with Company B that also used the knowledge developed by the team during the project.

The background to the project was the difficulty Small and Medium Enterprises (SMEs) experienced in replying to Request for Quotations (RFQ) from large multinationals or Original Equipment Manufacturers (OEM). The available systems were unable to account for fluctuations in volumes, order schedules and delivery schedules, and a myriad of other variables that affected the SME's manufacturing processes. The intention of UL2 was to develop a software tool that would help the SME understand how different variables affected their manufacturing costs. The SME could then more accurately calculate the contract price necessary to make an adequate return on sales.
At the time, there were no tools in the market that captured the operational costs of a contract, and none that could model the risk associated with a contract price. However, it was not possible to sell a tool with only this level of functionality. The tool only made commercial sense if packaged as part of a larger software tool, such as a Material Requirement Planning (MRP), or an Enterprise Resource Planning (ERP) system. The simulation tool would be an add-on to the Supply Chain Module that was contained in most ERP systems. The market leaders in MRP and ERP systems were SAP (Systemanalyse und Programmentwicklung) which had revenues of €9.4026 in 2006 (www.sap.com). Its products were sold for prices of up to one million euro, depending on the size of the enterprise, and the level of functionality included.

Interviews were carried out with the Principal Investigator, UL PI2, the Project / Commercialisation Manager, UL PM2, and the director of the Technology Transfer Office, UL TTD. Figure 6.4 shows the reporting lines of the project and the responsibilities of the key personnel.

Figure 6.4 Organisation Chart for UL2 Project

6.7.1 Role of the university
This section presents the data relating to the role played by the university; including their policies on commercialisation, the supports offered by the TTO, the academic’s knowledge of those supports and the influence they had on the academic’s choice of route to commercialisation.

6.7.1.1 Alignment of policies
As discussed in case UL1, UL claimed to be supportive of commercialisation but did not always provide the supports the PIs though they required. UL PI2 in particular felt that the university was not supportive of academics who wished to commercialise their research. He thought that the university would rather the academics did not get involved in it, because it only led to more work for them.
I'd say they'd [the TTO] be nearly happier ... if you did not do it [commercialise your research], it's just hassle for them.

UL PI2 believed that other institutes were more proactive in terms of supporting the commercialisation of research, and that this became evident to him when he attended an Enterprise Ireland research seminar in 2006. He believed that the other universities had a vision on how they intended to include the commercialisation of research as an element of the universities' missions, and that they had a strategy to deploy this vision. He did not think UL had an equivalent vision or strategy.

They [the other universities] were impressive; they seem to have a vision of where they're going, what they're doing was part of the university strategy.

UL PI2 said it was of no value to his career to have generated a licence. He said he would have been better off writing academic papers, as they were what he was measured on in the university, and that is what would get him promoted, not patents or licences. He did not believe the university system was supportive of commercialisation, as it was not a criterion for promotion. This was evidence of a what get measured, gets done approach.

He was only happy to try to commercialise the outputs of the CFTD as it helped to maintain a source of funding via Enterprise Ireland, who focused on the previous record of the PI when awarding funding.

I'd be better off if I had a few papers published in a world class journal even if they did not relate to anything to do with reality. In terms of internal promotion, the effort that you need to put in to shine in commercialisation is not worth it.

UL PI2 also said he did not believe that UL was supportive of spinoffs because it feared losing its core research capability if the best researchers left to start up companies.

If I started up a company and spent all my time in the company and then I left. Is that what the university want? I'm not too sure.

6.7.1.2 University supports

UL PM2 was moderately complementary of the support given by the TTO. He mentioned a number of seminars on commercialisation run by the TTO that he attended.
They ran seminars in terms of licensing, general commercialisation and legal issues.

However, that was the extent to which he thought the TTO was proactive. While critical of the reactivity of the TTO, and the delays in receiving the support the project needed, UL PM2 recognised that the TTO was resource constrained, and could only offer advice on where to get help in most cases, rather than giving it himself.

*I know they’re under a significant amount of pressure given the resources that are there.*

The TTO did attend meetings with potential licensees when requested by the team, and UL TTD offered advice to the team on how to negotiate the licence terms.

...*we had a representative from the TTO at a number of the meetings we had with potential licensees.*

UL PM2 suggested that in this sense, the support from the TTO was more permission to go and get a company interested, once the guidelines for a licence set down by the TTO were adhered to.

*It was more advice in terms of here’s what’s possible, they’re the parameters in which you can work and here’s what I advise you to do.*

In general, UL PM2 said he was unfamiliar with the actual supports offered by the university, other than the seminars which were advertised via email. Even though he was a significant player in the negotiation of the licence, he said that even at the end of the project, he was still unsure of the policies.

*I was not fully aware [of the policies]... I was aware of the broad parameters of what was involved in the commercialisation, but in terms of what supports were available from the university, I would not have been aware of it then and I still do not know.*

6.7.1.3 Academic’s knowledge of the university policies

When asked if he knew if the university had policies on the commercialisation of research, UL PI2 said he was not familiar with them even after the project had ended.
No, not particularly but it would have helped... if you were made aware of this policy and that you had meetings with representatives in the university [to explain them to you].

6.7.1.4 Impact of policies on the choice of spinoff versus licence

The research team decided early in the project not to pursue a spinoff. This was for two reasons, neither of which was influenced by the universities policies on commercialisation. The first was that nobody in the team wanted to lead a spinoff according to UL PM2.

...we had discussed spinoff companies in terms of who was willing or interested in taking this [research] out and starting a company... and nobody put their hand up to say that 'I'm going to jump ship with this project'.

The second was the lack of follow on technologies or products that would help sustain the business in the long term. From a previously unsuccessful attempt to set up a spinoff, UL PM2 said he got good insights into the difficulties of setting up a spinoff in the ICT sector, which included the need for a strong product road map (which was not present in UL2).

There was not a suite of products or services coming through... it was more a single product, and to me that would not have been enough to launch a start up company.

UL PI2 was also aware of the difficulties that would be associated with a new small company in what was a mature market, with a number of very large players (SAP and Arriva). As the UL2 project output was a module that would fit into a larger MRP or ERP system, the team felt it was more practical to consider the licensing route, as the big companies would also have the capability to market the technology.

A spinoff would be very difficult because you're working in an area where there is a huge amount of software already. You have Arriva and SAP who both have a whole infrastructure already in place. So it's very difficult to start from scratch.

6.7.2 Access to VC funding

There was no data unique to this project under this heading. As the team never considered a spinoff they made no attempts to contact any VCs during the project.
6.7.3 Academic's knowledge and entrepreneurial skills

This section presents the data gathered from the interviews with the various parties relating to the PIs commercial knowledge and entrepreneurial skills.

6.7.3.1 Academic's knowledge of the ATRP / CFTD

When questioned on his knowledge of the ATRP / CFTD and its aims and objectives, UL PI2 displayed an excellent understanding of the requirements of the ATRP / CFTD. He also understood what the bigger picture was in terms of how Enterprise Ireland hoped the commercialisation of research from Irish universities would have a positive impact on the economy.

"It's to bring ideas from university into the commercial arena... to do research in an area that has commercial goals of some fashion ... that would obviously lead to metrics like increased employment, new company start ups etc."

So, with this knowledge UL PI2 saw the ATRP / CFTD as a good way of getting funding to develop his research interests, and as a way to keep together a good research team that was not too onerous.

"Yes, and not lose the expertise we had."

He was able to persuade the Project Manager, UL PM2 to join the project team, and in doing so, delegated the commercialisation deliverables to him. UL PM2 explained that UL PI2 asked him to join the project and to take care of the project management and commercial aspects of the project.

"It was UL PI2; he came to me with an idea. And I said 'that's a good idea lets go and put a commercialisation fund proposal together' because he was on the technology side and I was primarily on the project management and commercialisation side."

This was the ideal situation for UL PI2 who could then focus on the research, and ensure that the researchers got their masters or PhD's, which was a more important metric of his performance within the university.

"While it would be great to think that you could start a company and make money, our immediate aims were to get prototypes and qualifications...The outputs of the project were several, one was papers, two was post grads, the third thing was commercialisation."

UL PM2 also fully understood the aims of the ATRP / CFTD, as he was an Enterprise Ireland employee working in the Advanced Manufacturing Technologies (AMT Ireland) PAT in UL. At that time he was part funded by
Enterprise Ireland, and needed to generate 50% of his salary from research funding under a Service Level Agreement (SLA) between Enterprise Ireland and UL. He was also involved in the project because as it helped him to remain working with an e-learning development team he managed within AMT Ireland.

...there were some ancillary activities, around project management, web design and other multimedia activities that the group I was involved with were able to do.

6.7.3.2 Presence of an entrepreneur and social links

UL PI2 had never worked in industry, and had no previous experience of the commercialisation process. It was probably for this reason that he asked UL PM2 to be involved in the project, as he realised he did not have the skills (and maybe the interest) necessary to successfully commercialise the project. UL PI2 admitted his main concern was in getting funding to build up a research team. He was aware of the aims of the ATRP, and included a project manager on a part-time basis to ensure someone else was looking after the commercial issues.

My motivation was just to keep the research alive and I suppose to try and ensure that the project was successful [commercially], but it was primarily to keep the background knowledge alive.

The presence of UL PM2 as the project / commercial manager was a key factor in the successful generation of a licence. UL PM2 had prior industry experience, and had excellent contacts within the relevant industrial sectors, which he used to generate the licence.

As mentioned above, at the time that UL2 was funded, UL PM2 was thinking of starting an e-learning spinoff company from another group he was involved with. However, when the dot com bubble burst there was no market to support such a company. He said that the knowledge he gained in this attempt was very useful in managing the commercial aspects of UL2, and the experience convinced him that a licence deal was the most practical route to commercialisation.

I was involved in attempting to spinoff a new company but that was shelved... We were looking at an area of technology that was very much affected by the Dot Com bubble burst. So it was decided that the time was not right to commercialise that.
6.7.4 Unique superior idea

As discussed in the introduction to this case, there were a plethora of companies that provided ERP and MRP systems. However, none of the products available at the time included functionality similar to, or competing against, the system the team were developing. UL2 would allow the SME to understand how different variables affected their manufacturing costs, so that they could more accurately predict the contract price, which was unique at the time of the research.

6.7.5 Process related data

The initial starting point of the project was to develop a simulation based prediction tool that would allow SMEs to more accurately predict the contract price necessary for them to make an adequate return on sales. The idea for the project came from the interactions the team had with local industry. UL PM2 and UL PI2 said it was important that the project solved a real problem, not just a theoretical one. To do this they started by talking to a number of companies.

We did a little bit of it before the proposal, in the sense we went down to three companies and asked them if this was an issue? and they came back and said 'yes' and that helped greatly in writing the proposal.

The team decided from the outset that they were not interested in a spinoff for the reasons discussed above. This allowed them to focus on the licence route, and with this focus, UL PM2 was able to ensure that the companies they approached gave them the information they needed on the problem, whilst also nurturing their interest as potential licensees.

I felt ... it was ensuring that the right potential licensees were at the table and they were 'wowed' to ensure they came on board the project and bought into what was happening in the project.

In terms of the day to day development of the tool, UL PM2 said that in his role as project manager he ensured that the technical deliverables were on target.

I was project manager / commercialisation manager, that was to make sure things were kept on track in terms of time frame and deliverables... I was just making sure that deliverables etc were on target...that the research activities that were to be conducted were as close to market as possible.

As part of the greater role he played in the project, UL PM2 had regular industrial contact, and it was via these contacts that the team were able to get a number of local companies to help with the customer requirements gathering and testing of the
product. So when developing the product, the team had an excellent knowledge of the market needs.

UL PM2 set up meetings with a number of companies to get customer feedback; these included Cregg, Sanmina SCI, Becker, Dell, Apple, Advanced Innovations Ltd, Lucent, SerCom and Company A, who was the eventual licensee. In total, the team had fifty-four separate minuted meetings with these companies over the lifetime of the project.

... we talked to Apple, Dell, and Lucent and then we went to first tier and second tier companies.

To get the companies interested was very difficult according to UL PI2, and it was necessary to visit them a number of times to convince them that getting involved would be of benefit to them. Company A and Company B were shown demonstrators of the technology, which showed its functionality and encouraged them both to start other projects with the team. In effect, the team had to sell the project technically before they could sell it commercially.

in both cases we really had to sell it very hard ...it needed strong interaction with Company A where we visited them two or three times and built a small model for them to show them the concept and what the product could do.

The licence agreement with Company A was to integrate the tool into their current product. Company A were an outsourcing company who offered a full Supply Chain Management (SCM) service to companies. They specifically sourced components from China for delivery around the globe. They provided logistical, technical and project management supports to ensure that their clients' needs were serviced efficiently and effectively from China.

Neither the team, nor the TTO, initially thought to sign a licence deal with Company A. It was primarily at the suggestion of the local Enterprise Ireland Commercialisation Specialist that the PI approached the TTO about a licence deal. The Commercialisation Specialist told UL PI2 that his track record would be improved if the deal generated a licence. UL PI2 then approached the TTO who was reluctant to pursue a licence agreement.

It took a lot of effort to get it signed off.

The TTO director did not believe it was strictly necessary to sign a licence agreement until after the contract research project was complete.
... it was unclear how much of it would finish up in the end product and this is why you need to use an option rather than a licence.

It was also work that he would rather not have to do if he could avoid it, due to the resource constraints in his office. He said on a number of occasions (outside the interview) that unlike Enterprise Ireland, he was not measured on the number of licences that the TTO negotiated, so he had no need to do them. This indicated a complete lack of emphasis on commercialisation in UL.

UL PM2 was complimentary about the role of the Commercialisation Specialist and said he provided good advice on how to commercialise the technology.

We had a representative from the Commercialisation Section of the Industrial Technologies division that came and reviewed the project and looked at where we were ... and when we reviewed the project provided feedback in terms of where the project was at, and what needed to be done to take it to the next stage.

The team also received funding for an Innovation Partnership with Company B based on the outcomes of UL2. Both the Company B project and Company A licence took a considerable time and number of meetings to negotiate. The TTO was present at some of the more important meetings, but was not present at all of them. He gave the team an outline of what was an acceptable deal, and allowed them to negotiate. He became more heavily involved when contracts had to be signed. UL PM2 said

UL TTD was able to advise me as to what the standard [UL] practice was and how to go about negotiating the best deal.

6.7.6 Post licensing of the technology
The licensee's interest in the technology was focused on integrating it into one of their existing applications. To gain access to the technology meant taking a licence for its use. However, the company owner recognised that there was a large amount of know-how associated with the technology, and that he did not have the skills in-house to absorb the technology in a timely manner. As a result, the company and university agreed on a €50,000 project where the PI and the research team would help integrate the technology into the company's existing application.

6.7.7 Summary of Case UL 2
UL PI2 applied for funding to fund a number of post graduate students, which would help improve his internal metrics; number of students supervised and published papers. He knew that neither of these metrics were the goals of the scheme, so he asked UL PM2 to join the team to look after the day to day running of the project, and
to provide access to his extensive network of local companies. *UL PM2* was happy to
join the project team as he needed to part fund his salary at the time.

*UL PM2* had considered a spinoff company a year earlier, so he was familiar with the
barriers that existed in creating a spinoff. When he raised the opportunity with the
team, nobody showed any interest in leading a spinoff. On this basis, *UL PM2* argued
that the project should focus on licensing the technology, rather than wasting time
pursuing a strategy nobody was interested in.

Other factors that influenced the decision not to pursue a spinoff were the presence of
a number of large multinationals who were direct competitors. To compete against
them, the team would have required a multimillion euro investment to simply match
their sales and marketing forces. Similarly, the technology under development was
only sufficient for a single product, and did not offer a roadmap of future products on
which to base a company.

In his previous role in UL, *UL PM2* was business development manager of the AMT
Ireland PAT. This provided him with an extensive network of local and national
companies that he could approach as potential licensees. Considering the technology
and the type of company who would be interested in it, a short list of companies were
approached. These included multinationals such as Lucent and Apple and other SMEs.

*UL PM2* used his network to set up meetings with local SMEs who were interested in
Supply Chain Management. One such company, *Company A*, had its own software tool
that they used to manage their business. Through a series of both technical and
commercial meetings the company agreed to pay the team to integrate its technology
into their current tool. The result was a licence deal where the company paid for
access to the technology, and for the work to be completed. The result was a
successful deployment of the technology and a licence agreement.

6.8 Analysis of *UL2*

The data above was analysed to look for evidence confirming / disconfirming the
presence of gaps from the revised conceptual model, and the role the actors may have
had in closing gaps that existed.

6.8.1 Existence of gaps

- *Idea Uniqueness gap*
An idea uniqueness gap existed in so far as the concept behind the project was unique to the market place. However, the final project outcome was not a stand alone product that could be sold independent of other Enterprise Planning tools.

- **Funding gap**
  The original funding gap was evident in the need for funds to carry out the project. A second funding gap materialised when the team negotiated the licence with *Company A* and required funding to integrate their technology into the company's product. Without the ATRP funding, and the willingness of the licensee to pay for further development, the project would not have delivered a commercial outcome.

- **Knowledge gap**
  Marketing and *managerial* knowledge gaps were seen to exist as the PI required the assistance of *UL PM2* to run and commercialise the project. No technological knowledge gap was evident as the team had the skills to develop the technology to the point it was licensed.

- **Entrepreneurial gap**
  Similarly, a *social links* gap was present as *UL PI2* knew he did not have the same industrial network or contacts that *UL PM2* brought to the project. *UL PM2* had the drive and contacts necessary to set up over 50 meetings with potential customers. It is unlikely that a licence would have been generated if he were not *committed* to commercialising the project.

### 6.8.2 Interventions by actors to close gaps

- **Government**
  Government helped overcome the funding gap by making the funding available through the ATRP scheme. The rules of the ATRP which gave ownership of the IP to the university also influenced the PIs decision to apply for ATRP funding in the first instance. The Enterprise Ireland Commercialisation Specialist in UL also met with the team regularly to give them advice on commercialisation, and persuaded them to pursue the licence deal through the TTO.

- **Industry**
  Using his contacts with industry, *UL PM2* set up over fifty meetings with potential customers to get their feedback on the technology, and to sell them the concept of the new product. These meetings helped refine the project outcomes and led to two follow-on projects, one of which generated the licence to *Company A*.

- **University**
**UL PM2** said that the TTO gave him permission to start negotiations with potential licensees based on a standard set of terms and conditions. Due to resource constraints, both **UL PI2** and **UL PM2** said the supports they received from the university were limited. However, when necessary to progress the licence deal, the TTO were present at meetings.

- **Principal Investigator**
  From the outset of the project, **UL PI2I** realised that he did not have the skills necessary to commercialise the project outcomes. He had the technological competence to lead the development of the product, but required assistance from someone with the commercial skills and industry network. He was a key part of the team that sold the technology to the licensee, as the company only became interested in licensing the technology once they fully understood it's technical capability.

- **Financial Institutions**
The financial institutions played no role in this project.

From the data presented above, Table 6.4 was developed to show the supports and interventions made by the various actors to close the gaps in **UL2**. From this, we see clearly that all four gaps were closed sufficiently to allow a licence to be generated from the project.

**Table 6.4 Summary of UL 2 case**

<table>
<thead>
<tr>
<th>Gap / Actor</th>
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<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>ATRP funding via Enterprise Ireland</td>
<td>Feedback on Product</td>
<td>Knowledge of Market</td>
<td>Applied for ATRP funding</td>
</tr>
<tr>
<td>Funding</td>
<td></td>
<td></td>
<td>Technological competence, surrogate provided managerial and marketing competences</td>
<td>TTO run seminars</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Marketing reports and commercialisation specialist advice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Social network of PM via PAT</td>
<td></td>
<td>Surrogate had social links and commitment</td>
<td>Policies discouraged academics</td>
</tr>
</tbody>
</table>

Using these data, Figure 6.5 is presented to show what gaps existed and which actors played a role in their closure in **UL2**. The sizes of the gaps were specific to **UL2**, and varied at different times in the project. For example, the funding gap increased once **Company A** signed the licence and the team needed to work on the integration of the technology into **Company A's** own product.
The financial institutions are missing from this figure as they played no role in funding the licence deal from the data evident in \textit{UL2}. Similarly, a technological gap was not evident from the data, so that element of the knowledge gap is not included in Figure 6.5. The data has again allowed the fading from the revised conceptual model to be removed, adding clarity to our knowledge of the phenomenon.

The bidirectional arrows between the actors show the influence of interventions by one actor on all others, not just those adjacent to each other in the figure. Similarly, the bidirectional arrows between the gaps show how closing one gap could impact on the size of another gap, not just those adjacent to it, as evident from the data.

Figure 6.6 was also developed to show which gaps were overcome to generate a licence from project \textit{UL2}. The green boxes represent the gaps that were closed. The underlying premise was that a failure to close any, or all, of these gaps would have meant it was impossible to generate a licence.
As before the case data from UL2 has provided a more in depth picture of the phenomenon than was available from the survey results. The combined case findings will be discussed in Chapters 8 and 9.

6.9 Case study three: Introduction to UL3

The third and final case from UL was an example of a project that, at the time of the research, had yet to be commercialised. The PI was pursuing a number of avenues and hoped to commercialise the outcomes within the near future.

The output of the project was a system of vascular grafts that had a longer useful life than existing technologies. According to the PI, the market for grafts was large, but significantly was not considered high growth by the VC community (as they favoured newer technologies), which made it unattractive to them as an investment.

The newer graft technologies favoured by the VCs made use of less invasive techniques than the technology pursued by UL3. These were becoming more popular as they did not require the patient to stay in hospital for as long after the procedure. Typically the patient’s stay in hospital was reduced from ten days to three, which resulted in large saving for the medical insurance companies. In the US, acceptance of a technology by the medical insurance industry determines if they are commercially successful or not. If the insurance companies will not pay for a technology, then the surgeons will not use it.
A sample of companies who were involved in the vascular grafts market included Atrium Medical Corporation, Johnson and Johnson, Smith Medical, Abbot Labs, Medtronic, Cook, Datascope, Guidant and Boston Scientific, most of whom had manufacturing facilities in Ireland. The combined market in the United States of America alone for vascular stents and grafts was $855.5 million in 2005, and was expected to reach $2,632.5 million in 2012, a compound growth rate of 16.8% (Frost & Sullivan, 2006).

The project had not been commercialised at the time of writing, but the PI said he was still working on it in the hope of generating a licence. The project had successfully delivered on its technical outcomes, but the issue in terms of commercialisation was the time and financial investment required to prove to a customer that the product offered a competitive advantage over current market offerings.

Interviews on the case study were carried out with the PI UL PI3 and the director of the TTO, UL TTD. Figure 6.7 shows how the project was managed in the form of an organisation chart.

Figure 6.7 Organisation Chart for UL3

![Organisation Chart](image)

6.9.1 The role of the university

This section presents the data relating to the role played by the university, including their policies on commercialisation, the supports offered by the TTO, the academic’s knowledge of those supports and the influence they had on the academic’s choice of route to commercialisation.

6.9.1.1 Alignment of policies

As discussed earlier, the TTO in UL suggested that the university was in favour of the commercialisation of research. However, UL PI3 did not agree with this statement. He thought the university asked for an excessive equity stake in the
spinoff. He was also unhappy that they would not share the thirty percent overhead provided by Enterprise Ireland on the CFTD.

*In the early company I was not happy with what the university took in terms of equity, it was too large for what they gave.*

*The university receives overhead associated with these projects. I've communicated with the Vice President for Research but we have not successfully attracted any of that funding to our group.*

6.9.1.2 University Supports

*UL PI3* was very knowledgeable on the policies and supports on offer from the university, but did not believe they were to the benefit of academics trying to commercialise their research. The only support that *UL PI3* said he got in this project was patenting support, which was actually paid for by Enterprise Ireland's Patent Fund. He said he got no other support from the university.

*When it comes to the practicalities I think the university tends not to deliver on the supports.*

The supports on offer from the TTO were in providing standard advice on patents and Non Disclosure Agreements (NDA), which at that point in his career *UL PI3* said he was already very familiar with. *UL PI3* said he needed marketing supports to try to find a potential licensee, but the TTO was unable and unwilling to provide this.

*The most significant professional support had to do with the patenting activity. Other than that, we do have discussions around NDAs, but I know how to do that at this stage. They have not been actively involved in trying to sell the technology to other parties.*

*UL PI3* said the TTO suffered from a lack of industry specific knowledge which also hampered its ability to provide the supports he thought he needed.

*...because they do not know the industry space.*

*UL PI3* did say that Enterprise Ireland helped market the technology by helping him create a one page *technology offer*, which they then put on their website and also placed into various Enterprise Ireland publications.

*Trying to sell the technology to other parties, that's largely done through Enterprise Ireland.*
6.9.1.3 Academic’s knowledge of the university policies

UL PI3 was very familiar with the policies of the university on commercialisation, as he had been involved in a previous spinoff company from the university. As a result of this experience, UL PI3 thought the university asked for too much equity, and he said he would try to bargain down their equity stake considerably if involved in another spinoff.

In the early company I was not happy with what the university took in terms of equity, it was too large for what they gave. So if I was doing it again I’d be arguing the university’s position down a lot.

UL PI3 said that he believed his previous project was the pilot for the development of the universities policies on commercialisation, so he was very familiar with them.

I think I was one of the pioneers in this university... so I suppose at some level I helped to develop the guidelines.

6.9.1.4 Impact of the policies on the choice of spinoff versus licence

When writing the proposal, UL PI3 did not have a preconceived view of which route to commercialisation he would pursue. He said he was open to either.

So whether we got a licence or a start up were not critical to the awarding of the fund... either route was optional... we actually left both channels open.

At the time of the interview, UL PI3 had not decided which route to pursue, and he said he was still actively considering a spinoff. In that respect the policies could not be said to have influenced his decision one way or the other. However, UL PI3 thought that a licensing agreement was probably the best option, as he was not happy with the university's policies on spinoffs.

Throughout this project, we've always felt licensing was the best option. A large multinational with your product in their bag with an upfront fee and some royalty agreement is the best way of getting this type of technology to the market I think.

UL PI3 said the consultant who was working with him to try to commercialise the project believed the licensing route was the best avenue for commercialisation, but UL PI3 said he still had not ruled out the possibility of a spinoff.

He still feels that licensing is the best channel and we've discussed that at some length. But he's still open to the idea of a start up.
The choice of the licensing route was based on a very pragmatic view that a large multinational would have larger marketing, sales and distribution networks that a small start up could not match.

_We think, based on discussions with a number of parties that licensing is the best route for this technology. Licensing into a large / medium sized multinational ... as they have the marketing department._

The greatest barrier to commercialising the technology was having the clinical data to prove the technology worked. When discussing the potential routes to commercialisation towards the end of the interview, UL PI3 mentioned that he believed that the best way to commercialise the project was via the promotion available from a first sale. Even though his intention was to attract a licensee via a first sale, it would probably require the creation of a spinoff in the short term to achieve this, as the university would be unlikely to become directly involved in the sale due to the potential commercial insurance issues that would entail.

_The best way to hit the radar in the medical device technology market would appear to be the generation of sales. The fact that you are selling a product into a hospital will make the larger companies sit up and take note._

So, although the preferred route to commercialisation may have been via a licence, UL PI3 was still considering the creation of a spinoff in an attempt to ensure the technology was commercialised. To achieve this, he had become involved with a European company that was trying to break into the US market, and that wanted the technology from this project to boost its product portfolio.

_However, we are also looking at a start up situation with a medium sized European based company which does not have a product or a significant presence in America._

### 6.9.2 Access to Venture Capital

Having already spoken to a number of large and small multinationals to understand their needs and to assess their interest, UL PI3 spoke to a number of VCs in Ireland in an attempt to attract seed funding. The initial feedback from the Irish VCs was not positive, as they thought the market for the final product was not high growth. They viewed the product as a _replacement technology_ rather than a new _breakthrough technology_. As a result, UL PI3 did not approach any international VCs.

_The Irish VCs were mildly enthusiastic ... they felt that this was a technology that was not moving into a large growth market. We have not actually exposed_
this technology to the VC community internationally, partly based on the experience we had with the Irish VCs.

It may be the negative reaction from the VCs that encouraged UL PI3 to consider the licence as the preferred route to commercialisation, as he realised that getting investment from the VC would be difficult. The VC did suggest that they would consider investing in partnership with a large multinational. This was probably because they believed that the marketing effort that would be necessary to sell the technology could only be leveraged via an existing, and preferably large company.

...none of them would do it on their own...they would only go ahead as a co-investor with a large company...

So, the lack of growth, and the desire by the medical insurance companies to use newer less invasive technologies meant the VC companies were less keen to invest in this mature technology. Coupled with the cost of extensive clinical trials to prove the technology, this meant the project was not attractive to the investment community.

The difficulty we have is to prove that in a clinical environment would require an extensive clinical study and that’s another area where the VC / major multinational backs off.

6.9.3 Academic's knowledge and entrepreneurial skills

This section presents the data gathered from the interviews with the various parties relating to the PIs’ commercial knowledge and entrepreneurial skills.

6.9.3.1 Academic’s knowledge of the ATRP

UL PI3 had a good knowledge of the aims of the ATRP, and was able to accurately describe the aims of the programme.

... as I understood it, it was to take good quality academic research from the university into a company, whether the company was a non Irish multinational, or an indigenous company did not matter. The objective was to get the technology out and into commercial practice.

6.9.3.2 Presence of an entrepreneur and social links

As mentioned earlier, UL PI3 was involved in a previous spinoff from UL, and had experience of the commercialisation process. This experience also meant that UL PI3 was open to either route to commercialisation to ensure one was successful.
He was prepared to leave both options open to ensure he did not miss an opportunity.

*I'd been involved in a start up with the university in a prior activity.*

UL PI3 also realised he was not the ideal candidate to lead a spinoff, so he used his contacts in industry to get a consultant to provide support and guidance on how to licence the technology or develop a spinoff. This consultant was paid for by the university from the C+ funding which UL PI3 received from Enterprise Ireland. The C+ was awarded to help UL PI3 generate as much clinical data as possible, in an attempt to increase the value of the technology.

*The C+ was to enable us to go further with animal studies than we had at that point and also to ... push the commercialisation a bit further. We engaged the consultant at that point.*

When asked if he had contacts with industry, UL PI3 said he had very strong links with industry and that he would not have been able to develop his technologies without them.

*Huge... I could not do anything else without them.*

### 6.9.4 Unique Superior Idea

According to UL PI3, the product had a number of unique selling points; it had potential for use in both the upper and lower limbs, and more importantly it offered longer lifetime than current market offerings.

*The market advantage we believe will be that it prolongs the life of a graft. We think it could push it out by a couple of years. So the clinical benefit might be significant.*

However, the graft was based on existing technologies and used existing surgical procedures. In that sense it was not unique; however, the ability to extend the lifetime of the graft offered the potential of a superior product in the market place.

### 6.9.5 Process related data

From the outset of the project, UL PI3 involved a local clinician in the project to provide guidance on the needs of the surgical community. The initial commercial step in the project was to patent the technology developed during the project.
We also had strong involvement with a local clinician who provided us with guidance and he's a co-inventor on the patent. We felt that there was a need, a real clinical need that this technology would address.

According to UL PI3, the product had a number of unique selling points, however the technology was invasive, and health care companies were more interested in minimally invasive technologies, as they were perceived to reduce the time patients needed to spend in hospital compared to existing technologies. This offered the medical insurance companies a benefit, as it could reduce the cost to them of providing this type of cover to their customers. The insurance companies did not appear to care if the minimally invasive technology was clinically as effective in the long term, if it saved money in the short term.

Clinicians want it because it reduces bed time, in and out in three days as against ten days ... and obviously the health economics groups, like the HSE [Health Service Executive, the Irish public health service provider] want people in and out of hospitals quickly. So there's a commercial and economic driver that pushes towards minimally invasive technologies.

As a result, the growth potential in the newer technologies was high, which had a negative impact on the growth in the technology UL PI3 was developing.

Market growth [in the minimal invasive technology] is truly phenomenal... its 20% a year growth

UL PI3 said that although his technology was invasive, and was therefore not considered as innovative, he felt there were benefits in the features of the product that did make it innovative. However, convincing a potential investor that there was a high degree of innovation in the technology, and that it was not just a replacement or substitute for the current technologies, was the challenge UL PI3 had to overcome.

Some of the features of our products are unique so therefore we think there's a mix of being replacement and a high level of innovation. Most of the bigger companies are looking for... minimal invasive technologies which the vascular graft does not provide.

The perceived higher level of innovation in the newer technology meant it was perceived as being of higher value than the existing technology, and could therefore be sold at a significantly higher price. This in turn helped to make it more attractive to a potential investor, who could see a greater return on their investment. The insurance companies were willing to bear the extra unit price costs, as the overall cost per patient was significantly reduced by the elimination of several nights the patient stayed in hospital receiving care (reduced from ten to three).
A vascular graft typically sells at €600-800 while a minimally invasive device sells at €5,000. So there's a huge multiple as a result of minimally invasive technology, and I can see why the companies want that.

UL PI3 also recognised the importance of having a technology roadmap when trying to seek external investment. He said he had a second project funded by Enterprise Ireland that was helping to develop more products for a technology portfolio.

We're bundling the technology now because we have a second CFTD so we're saying we have a vascular graft form book, ... the second generation of it would appear to be more attractive ... and the third product is a vascular graft for Aortic aneurisms, so we now actually have a suite of products.

The single greatest challenge in trying to successfully commercialise a technology or product in the life sciences or biotechnology space was the need to do sufficient clinical tests to verify the product worked. In this case the tests were required to verify how long the project outcomes extended the lifetime of the graft.

There were two routes to getting approval to use the product in humans; the first was to go through the Food and Drug Administration (FDA), which could cost millions of euro. The second was to go via the 501K route where a very similar product (with FDA approval) was used to provide substitution data from which the new product piggy backed its approval. As UL TTD said

...companies want to see the technology pushed as far down that route so that they can see the risk level and make decisions.

VCs were slow to invest until a product had FDA approval, so that ruled out the VCs as a source of funding for product approval. The smaller life sciences companies were also slow to invest in this type of technology, as it could take one to two million euro to complete the tests, and there were no guarantees that the product would show significant returns on this investment. While the larger OEMs were reluctant to invest, because they were looking to invest higher sums (tens of millions of euro) in the hope of getting billion euro returns. So the team was caught between the two, and struggled to get the investment needed to complete the clinical trials.

... to convince the market we have a 10% advantage is expensive and they will not go for it. If the clinical trial gives us a 50% advantage they will go for it...It will require a significant clinical study to show that, and nobody is willing to go down that avenue, yet!
Enterprise Ireland provided additional funding via a C+, and according to UL TTD the team was in contact with a company in the Czech Republic that negotiated with a local health service provider a way of getting the necessary clinical data for a fraction of the cost elsewhere in the EU or USA. If the results of the tests were favourable, UL TTD believed the intention was to partner with this Czech company to form a spinoff.

_The C+ has helped him do animal trials in Pittsburgh and ... we have an arrangement with a Czech company who are very interested in all of UL PI3's technology... on the basis that if it works out they're going to take a licence._

However, UL PI3 thought a licence deal with a large multinational would still be the best outcome for him. That way he could continue to do his research, while benefiting financially from this project.

_We think, based on discussions with a number of parties, that the licensing route is the best for this technology. Licensing it into a large / medium sized multinational, as they have the marketing department._

### 6.9.6 Summary of Case UL 3

*UL PI3 had a successful history of commercialising his research, and was part of a previous spinoff company from UL. This experience gave him excellent knowledge of the spinoff process and the policies used by the university.*

The technology he developed using the ATRP was a replacement graft for vascular applications. The advantage of the technology was that it would significantly extend the useful lifetime of the graft, reducing the need for a patient to have repeat grafts.

While this seemed like an attractive option for the market, it suffered a number of significant obstacles. The first was that the process to carry out the graft was based on existing techniques, and was highly invasive. Typically the patient would require up to ten days in hospital after the procedure. New, less invasive technologies were coming to the market at the same time which required a much shorter (three days) hospital stay. While these new grafts did not offer the same lifespan as *UL PI3*s new technology, the cost savings they offered hospitals and medical insurance companies, based on reduced hospital stays, were significant.

Given the age profile of patients who received grafts, the extended life span of the graft was not seen as a significant advantage, as many patients died (of other causes) before their grafts needed replacement.
In light of this, the market for invasive technologies was not a growth market, and UL PI3 failed to secure external investment based on this issue. As a result, UL PI3 changed his focus from spinoff to licensing.

The challenge was to demonstrate to a potential licensee the competitive advantage offered by his technology. To do this would require some level of clinical trials. While Enterprise Ireland provided additional funding via a C+, this was not sufficient to attract a licensee, as more work was required to demonstrate the product advantage.

At this time, UL PI3 was introduced to a Czech company that were keen to break into the US market, and that needed a new product to do so. Using their contacts in the Czech Republic, they were able to assist in running a much larger scale clinical trial with the funds available. These trials were still ongoing at the time of the thesis case research, but UL PI3 was hopeful that the results would encourage the company to take a licence, and to introduce a product based on this technology into the US.

At the same time, UL PI3 was also working on a number of other related projects and he hoped that a patent portfolio would make his technology more attractive.

6.10 Analysis of UL3

The data above was analysed to look for evidence confirming / disconfirming the presence of gaps from the revised conceptual model, and the role the actors may have had in closing gaps that existed.

6.10.1 Existence of gaps

- Idea Uniqueness gap
  The failure of the technology to overcome an idea uniqueness gap was identified by the VCs who thought it was a mature technology that focused on a shrinking market. The failure to realise a spinoff, or to generate a licence was directly linked to the failure to close this gap according to the PI.

- Funding gap
  A funding gap was evident in so far as the project would not have happened without the ATRP and C+ funding. More significantly, funding was required to pay for clinical trials to demonstrate the competitive advantage of the technology. The failure to secure this funding and close the emerging funding gap also contributed to the failure to commercialise the project outcomes.

- Knowledge gap
A market knowledge gap existed to the extent that the PI did not consider the threat posed by alternative technologies prior to his meetings with the VCs. If he had, he may have had a strategy to overcome their reservations on the level of return offered by this technology. This also suggests evidence of a managerial gap. Similarly, a technology gap existed as the competitive advantage of the less invasive technologies could not be overcome.

- **Entrepreneurial gap**
The failure to secure VC funding when sought meant the PI had to pursue other funding routes. Here, the need for commitment and a strong social network were evident.

6.10.2 Interventions by actors to close gaps

- **Government**
  As with the other projects, Government helped overcome the funding gap by making the funding available through the ATRP and C+.

- **Financial Institutions**
The feedback from the VC showed that the technology did not offer a sufficiently large return on investment to attract their investment. They told UL PI3 that they felt the technology was not novel, and that newer less invasive products offered a higher return on their investment.

- **Industry**
  At the time of the interview, a Czech company were in discussion with the PI about a clinical trial. However, at the time or writing, a commercial outcome still looked unlikely.

- **University**
The PI felt the university were unwilling to provide the assistance he needed. He was already familiar with the commercialisation process in UL, having been involved in a previous spinoff. He felt that the university asked for too much equity in a spinoff (for the amount of support they provided). The TTO also had little success in helping to market this technology.

- **Principal Investigator**
  UL PI3 had previously been involved in a spinoff from UL, so he thought he had the commercial skills and knowledge to understand the market place. He also had a strong industry network which gave him access to the VCs, potential customers, and the business consultant who was hired under the C+. He consistently showed commitment and drive throughout the process, but unfortunately this was not enough to attract the investment necessary to
conduct the clinical trials. Without clinical trials results to demonstrate the competitive advantage of the technology, a spinoff or licence was unlikely.

From the data presented above, Table 6.5 was developed to show the supports and interventions made by the various actors to close the gaps in UL3. The gaps were not closed sufficiently to realise either a spinoff or licence from this project.

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>Customers helped focus idea</td>
<td>ATRP, Patent, C+</td>
<td>Applied for ATRP / CFTD</td>
<td>PI persuaded to pursue a licence</td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>ATRP, Patent</td>
<td>C+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Market support from commercialisation specialists</td>
<td></td>
<td>TTO provided marketing support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Used external contacts to hire consultant to do marketing</td>
<td></td>
<td></td>
<td>Helped identified market gap</td>
<td></td>
</tr>
</tbody>
</table>

Using these data, Figure 6.8 was developed to show what gaps existed and which actors played a role in their closure in UL3. The sizes of the gaps were specific to UL3, and varied at different times in the project. For example, the funding gap grew once it was evident that clinical trials would be necessary to convince a VC to invest in the technology, or a company to licence it. As in the previous two cases, the data from UL3 has allowed the fading from the revised conceptual model to be removed, adding clarity to our knowledge of the phenomenon.

The bidirectional arrows between the actors show the influence of interventions by one actor on all others, not just those adjacent to each other in the figure. Similarly, the bidirectional arrows between the gaps show how closing one gap could impact on the size of another gap, not just those adjacent to it, as evident from the data.

Figure 6.9 was also developed to show that the failure to close all four gaps meant the project resulted in no commercial outcome. The green boxes represent the gaps that were closed while the red boxes show the gaps that were not closed sufficiently to generate a commercial outcome. In particular the idea uniqueness and funding gaps were not overcome, so no commercial outcome resulted from the project.
6.11 Summary

This chapter presented the data on the three cases from UL; the first generated a spinoff, the second a licence, and the third no commercial outcome. After the presentation of the data on each case, the within case analyses were conducted to show evidence of the gaps that existed, and the roles played by the various actors in closing these gaps; these are summarised for the three projects in
Table 6.6. As evident from this table, the actor interventions in UL1 and UL2 to close the four gaps ensured the realisation of the spinoff and licence. On the other hand, the inability of the actors in UL3 to close the idea uniqueness gap, and by consequence, the funding gap, meant no commercial outcome was generated. Chapter 7 presents and analyses the data on the three cases from TCD.

Table 6.6 Summary of the gaps evident in the three UL cases

<table>
<thead>
<tr>
<th>Gap</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniq'ness</td>
<td>UL12, &amp;3:</td>
<td>UL1: ATRP / CFTD, C+; Patenting funding from Enterprise Ireland</td>
<td>UL1&amp;2: Used feedback from other actors to develop idea</td>
<td>UL1: Helped focus the idea</td>
<td>UL1: Helped focus the idea PI persuaded to pursue a licence</td>
</tr>
<tr>
<td></td>
<td>UL1: Helped focus idea</td>
<td>UL1: Personal investment by the PI and other team members; applied for ATRP</td>
<td></td>
<td>UL3, PI persuaded to pursue licence</td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>UL1: ATRP / CFTD, C+, Patenting funding from Enterprise Ireland</td>
<td>UL1: Personal investment by the PI and other team members; applied for ATRP</td>
<td>UL1: VC provided investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UL1: Helped focus idea</td>
<td>UL2&amp;3: Applied for ATRP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowl’dge</td>
<td>UL1, 2&amp;3: Enterprise Ireland knowledge, expertise and contacts, including Market reports</td>
<td>UL1: Market pull, experience of the surrogate entrepreneur, technological competent</td>
<td>UL1&amp;2: TTO's external network, TTO run seminars &amp; marketing support</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UL1, 2&amp;3:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneural</td>
<td>UL1: Commitment to pursue funding via 70 meetings, social network to meet customers, VCs and SE</td>
<td>UL1: Commitment to pursue funding via 70 meetings, social network to meet customers, VCs and SE</td>
<td>UL1: TTO's external network</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>provided networking support</td>
<td>UL1: Customers gave feedback on what they wanted</td>
<td>UL2: Policies discourage academics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UL1: Social network of PM via PAT</td>
<td>Used external contacts to hire consultant to do marketing</td>
<td>UL2: Social network of PM via PAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL3: Social network of PM via PAT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>UL1: PI had to show commitment to get funding</td>
<td>UL1: PI had to show commitment to get funding</td>
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</table>
CHAPTER 7: PRESENTATION AND ANALYSIS OF TCD DATA

7.1 Introduction
This chapter presents the data on the three cases from TCD as listed in Table 7.1. As in the previous chapter, the data on the TTO is presented first, the data on the three cases are then presented and analysed under the same headings used in Chapter 6.

Table 7.1 List of TCD cases

<table>
<thead>
<tr>
<th>Case identification number</th>
<th>Expected outcome at time of case research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trinity College</td>
<td></td>
</tr>
<tr>
<td>TCD PI1</td>
<td>Spinoff</td>
</tr>
<tr>
<td>TCD PI2</td>
<td>Licence</td>
</tr>
<tr>
<td>TCD PI3</td>
<td>No commercial outcome</td>
</tr>
</tbody>
</table>

7.1.1 TTO Structure, size and experience
At the time of this research, the TTO in Trinity was called Innovation Services and was part of the larger Research Office. At the time of its inception in 1986, the TTO had one full time Technology Transfer Officer supported by an administrator. When the ATRP scheme started, additional support was provided by TCD T1 who worked for Enterprise Ireland’s Biotechnology PAT in Trinity, but spent a lot of her time helping the TTO. In late 2002 TCD T1 moved from Enterprise Ireland to Trinity to join the TTO.

I was [an] EI [employee] as you know until 2002 but in the years 2001 to 2002 I was working very closely with Trinity because TCD TTD had nobody working with him...and although I was EI Bioresearch Ireland, I was very involved in the Trinity office, I was almost the only person who was there.

In response to the survey questionnaire, the director of the TTO (TCD TTD) said there were twelve full time equivalents working in the TTO, which included six people who worked on commercialisation. This figure was contradicted by the interview response provided by TCD T1 who said that since she joined in 2002, there have never been more than two people.

We have never at any stage had more than two people and that was only for about nine months... we're in a crisis resource wise at the moment.

The director may have included all the staff in the larger research office, rather than just the staff directly involved in technology transfer.
7.1.2 Alignment of policies and actions
While the TTO staff and academics agreed that there was a positive attitude towards the commercialisation of research in Trinity, the TTO was under resourced, and the TTO team struggled to provide the service they felt was necessary to help the academics successfully commercialise their research. TCD T1 said that even though the office was supposed to have four staff members, it never had more than two, and was seriously under resourced.

*Trinity recognised that the correct staffing level for this office would be three Tech Transfer officers and one Industry Liaison.*

According to TCD T1, the university took the contractual obligations of the ATRP seriously, and insisted that the academics made an attempt to commercialise their research.

*Well certainly Trinity... not only encourages but insists that our PIs work with us [Innovation Services] to comply with our contractual obligation. If we take Enterprise Ireland commercialisation grants we have obligations to proactively commercialise [the project outcomes].*

The TTO put policies in place to ensure the academics were aware of their obligations before they were allowed to apply for funding from external sources. This included the academic signing a contract with the TTO that stated the academic would comply with all the requirements of the funding programme, which in the case of the ATRP / CFTD meant attempting to commercialise the project outcomes.

*In Trinity we have a policy that before they even apply for any type of funding that the PI sign a one pager acknowledging that they will comply with the contractual obligations if they are awarded funding.*

TCD T1 said the university’s policies were designed to encourage the academics to commercialise their work by offering leave of absence, or by allowing them to become directors of the spinoff while remaining in their post at Trinity.

*College policy absolutely encourages academics to get involved in campus companies. They can take leave of absence to go to a campus company for up to three years if they want. They can be directors of campus companies while still having their academic appointments in Trinity.*

For those academics that did not want to set up a spinoff and preferred the licensing route, TCD T1 said it was well known amongst the academics in Trinity that they received a generous percentage of any royalties or upfront payments from the licence.
It's also well known that if you do not want to spin out a campus company that if there's a licence for the college that there will be a return to the individual inventor for any upfront payments or royalty payments that are made. So people feel 'well I might get a bonus here if I continue on this commercialisation process'.

But TCD T1 admitted that it was only possible to commercialise the university's research if the academic was willing to be involved.

It's a very difficult thing to do if you do not have an enthusiastic technical expert behind you. I cannot think of an instance where we've successfully done that.

However, not all academics wished to be involved, and even those who signed up to the policies on the ATRP often complained that the patenting rules inhibited their ability to publish. TCD T1 said that publishing was more important than patenting to the academics, as they were rated in terms of the number of papers they published rather than the number of patents they held. Trinity had no policies that recognised patents or involvement in spinoffs when it came to promotion. This was an example of the same what gets measured, get done phenomenon found in UL.

It's a fact that patent applications and commercial activity are not as recognised here as they are in the UK.

7.2 Case study four: Introduction to TCD1

This section presents the data on the first case from TCD. The intended output of this project was a preoperative planning tool that the PI thought surgeons would use to choose the best fit joint replacement geometry based on a patient's individual circumstances, such as activity levels, age, weight, gender etc.

We developed a method for pre-operative planning of hip replacement operations which allowed the user of this product to select a prosthesis best suited to an individual patient using computer simulation methods. The patient's bone geometry, the patient's activity levels all these factors.

The anticipated benefit of the software to the surgeon was a reduction in the number of revisions, the name given to post operative replacements due to prosthesis failure. As a surgeon's career is judged on the percentage of successful procedures he/she carries out, this tool would be attractive if it would help the surgeon increase his/her surgical success rates.

Medical insurance companies would also be attracted to the technology, as the total cost of care for a patient undergoing a revision was ten times the cost of the initial
surgery. So any technology that had the potential to reduce the cost to the medical insurer would attract its support. The final group to benefit were the patients, who would benefit from a better fitting replacement and a reduced risk of implant rejection / failure.

At the time, there were a number of preoperative planning software development companies who had developed software to aid surgeons in orthopaedic surgery. These included Cedara's Orthoworks™ in the United States, and OrthoView's self titled product in the UK. The majority of the companies who manufactured joint replacement implants also had subsidiaries that worked on preoperative planning tools, e.g. Stryker Imaging whose preoperative planning tool was called Advanced CasePlan™. The team had a good knowledge of these companies and had been in contact with a number of them including Cedara, who displayed interest in what the team had achieved. The team were aware of the competition, but the PI felt they were further along the development path than the competition.

*I think other people are trying to do it alright, but we've got further.*

Interviews on the TCD1 case were carried out with the Principal Investigator, TCD PI1, the Project / Commercialisation Manager, TCD PM1, and the two members of the TTO, TCD T1 and TCD T2. Figure 7.1 shows the reporting structures in the project and the main responsibilities of the different team members.

Figure 7.1 Organisation Chart for TCD1 Project

7.2.1 Role of the university
This section presents the data relating to the role played by the university, including its policies on commercialisation, the supports offered by the TTO, the academic's
knowledge of those supports, and the influence they had on the academic’s choice of route to commercialisation.

7.2.1.1 Alignment of policies

According to TCD T1, TCD had a very positive view of the commercialisation of its IP. She said the university actively encouraged academics to get involved in commercialisation by allowing them to take up to three years leave of absence, or to be a director of a company while still employed in TCD.

College policy absolutely encourages academics to get involved in campus companies. They can take leave of absence to go to a campus company for... up to three years if they want. They can be directors of campus companies while still having their academic appointments in Trinity.

She felt that the financial rewards from licensing deals to industry were also well known to the academics. TCD shared the revenue from royalties with the named inventors, once the cost of patent protection had been accounted for.

And its also well known that if you do not want to spin out a campus company that if there’s a licence for the college that there will be a return to the individual inventor for any upfront payments or royalty payments that are made.

TCD T1 and TCD T2 both spoke of a history of commercialisation from TCD that they believed encouraged academics to try to commercialise their research. There were a number of high profile academics who had successfully commercialised their research, and who were well known across the whole university. The higher number of successful spinouts from TCD, in comparison to the other Irish universities, prior to the availability of the ATRP seems to support a suggestion that there was a culture of entrepreneurship at TCD that, while not directly promoted by the university, was not discouraged by its actions.

For example, you’ve got the likes of Stephen Collins and Gerry Lacey who returned back into the college after taking five or six years leave of absence to run campus companies.

TCD T1 also felt that given the necessary resources TCD would endeavour to commercialise IP where the academic inventor was either no longer in the university, or was not interested in being involved.
subject to resources, if they had generated IP and we thought there was something in it we would try and commercialise the output if we had the resources.

TCD PI1 had conflicting views on what the university's mission was with respect to the commercialisation of research. On one hand he thought it was worthwhile as it was for the benefit of society.

*I think the development of spinouts and the interface to society through the development of technology and job creation are really an important role of the university.*

On the other hand, he did not think it was within the scope of the TTO's role in the university to help him find a CEO for a potential spinoff,

*Well the university would not, it's not their job. Their job is to do education and research ... they give you advice, but the headhunting process, getting a person in to this kind of job, is a deal in itself.*

This was an interesting comment, and may have been TCD PI1 speaking on behalf of the university rather than on his own behalf as a potential entrepreneur. Further evidence of this corporate view was evident in comments made by him on the subject on the university's policies on spinoffs, and the availability of resources within the TTO. TCD PI1 said he thought that the 15% equity stake the university looked for in a spinoff was more than reasonable

*I think the university's spinoff terms are acceptable, 15% of the stock owned by the university. I know it can get diluted later when serious investors come along. Putting a university person on the board does not seem to be too onerous, so I think that would not be any block and I would not be interested in getting around that. I think it's perfectly acceptable.*

When offered an imaginary €10 million to resource the TTO to the levels he says were present in UK universities, he suggested that the €10 million might be better spent elsewhere in the university, than on helping to commercialise his research. This suggests that the commercialisation of his research may not have been TCD PI1's number one priority.

*I think if the university had €10 million they'd probably spend it on something different. Because there are so many other things that are under funded, not just commercialisation.*
7.2.1.2 University Supports

According to the TTO website, and the interviews conducted with the TTO staff, the TTO ran regular workshops on all aspects of commercialisation. TCD PM1 attended a number of these once the project received a C+

I began to attend various seminars run by TCD TTD and his colleagues.

The TTO also ran its own Boot Camp for potential entrepreneurs that TCD PM1 took part in. TCD TTD also negotiated with UCD to allow TCD PM1 to attend the UCD Nova Campus Company programme. According to TCD PM1 the team also got a number of other supports from Trinity in terms of access to facilities (this seems to have been a more informal relationship with the Centre of Bioengineering from which the research team came).

We had access to facilities, office space, desk space, which is all vital. We had access to them at an early stage ... I had several post grads roped into doing work on the project as part of their PhD or masters thesis. So we got quite a lot from Trinity.

TCD PI1 also highlighted this support from the host centre when asked why TCD PM1 finally left the project to undertake a Masters in Business Administration (MBA)

We had not run out of money. The centre for Bioengineering had money to pay him. I think it’s ... his career choice.

As the team had access to facilities via the Centre for Bioengineering, they did not have a need for incubation space. Trinity had its own incubator, and spinoffs were offered space there when appropriate. Even thought they offered a range of supports, TCD T1 and TCD T2 recognised that they were not only resource constrained, but that it was impractical to have the necessary industrial knowledge in house for all circumstances, and in certain cases it was better to buy in that knowledge.

It would be nice if Trinity had the resources to do it internally. But no matter how many people we have, or would have, I do not see how we would have the skills in each particular area... and the in depth knowledge in each particular industry that we would be trying to approach.

In the case of TCD1, TCD PM1 said
...the university were aware that at that stage I was working with Consultant 1, and she had far more experience and resources on offer than anyone in the university. So there was no value that they [TTO] could add to me in that scenario.

TCD PM1 was not complimentary about the basic level of knowledge provided by either the TTO or Enterprise Ireland. While he recognised the resource constraints, he felt that they were unhelpful because neither actually had the personal experience of starting their own company. The only support they could offer was to suggest which people to talk to, which was not a useful support in TCD PM1's opinion.

This lack of resources meant that Trinity was restricted in the supports it could offer ... they know who to point you to, which is very valid and obviously important. But, I think none of them have actually done it [create a spinoff] themselves, so when push comes to shove I prefer someone ...who has done it.

In referring to Enterprise Ireland he said:

If you tell me that your title is Commercial Manager I expect you to know about commercialisation of technology, not just a glorified title that sounds good on an organisation chart.

TCD PM1 appears to attach blame on the system for the failure of this project to be commercialised. He thought it was inappropriate to expect academics to do the commercialisation work on their own, without help from the university or Enterprise Ireland. His comment below highlights this, as he suggested it was the Enterprise Ireland Commercialisation Manager's task to commercialise the research with him.

They are trusting three scientists or academics to try and make a shot at this, and the person who nominally had the title of commercialisation manager was an EI employee and he or she has actually no commercialisation experience.

In future he suggested that all projects should be made to include a commercialisation expert before they are funded, because academics should not be expected to have these skills, as well as their technical ability. Where appropriate, he suggested an external consultant be included in all project with their costs included in the project budget.

If you're handing out a huge pot of money that is for a project that you expect to have commercial potential, you have to make sure there is someone that has commercial expertise in that organisation somewhere to support it ... insisting that money is written into the proposal to fund these people.
TCD PM1’s criticisms of Enterprise Ireland were also evident in his praise of Consultant 1, who was the consultant the team hired to help them develop their business plan and offering to potential investors.

Thank God she was not Enterprise Ireland. She’s been the CEO of an Irish company and has run a start-up software company herself, and now offers consultancy for start ups. She’s very experienced and had a great background to help to us get going.

TCD PII’s said support from the university was available when requested; however, TCD PII did not seem to have had enough business knowledge to understand what supports to ask for. TCD PII also appeared to have a more corporate view of the university, and was more supportive of the structures of the TTO. He did not have an issue with the reactive nature of the TTO, which again may indicate he was not driven to start a spinoff.

In the area of IP protection and that kind of thing, there are people in the university who I spoke with (TCD TTD), who were all very helpful.

TCD T1 said that it was the TTO’s policy to encourage academics to enrol on the entrepreneurship course if there was potential for a spinoff in the project.

Absolutely, all the time we would promote our Entrepreneurship course. It’s very much our policy.

7.2.1.3 Academic’s knowledge of the university’s policies

Although both TCD PII and TCD PM1 hoped to commercialise this technology, neither was fully aware of the universities policies on commercialisation. This did change over the period of the project, as TCD PM1 took on the role of commercialisation manager.

At that stage I began to attend various seminars run by TCD TTD and his colleagues.

TCD PII also became more familiar with the policies through this involvement with a previous spinoff from TCD. As a spinoff, Company C had to give TCD a seat on its board, and TCD PII took this seat at the university’s request for five years.

I was on the board of a company called Company C for five or six years.
7.2.1.4 Impact of the policies on the choice of spinoff versus licence

*TCD PM1* and *TCD PI1* said the team always favoured a spinoff over a licence.

*Our firm idea was always to start... a spinoff.*

While *TCD PM1* said the intention was always to start a spinoff, *TCD PI1* expanded on the choice a little more. He said that the decision to favour a spinoff was partially based on the lack of knowledge they had on licensing at the start of the project. This would imply that they thought they knew more about the process of creating a spinoff, but this was not the case, as we will see later in this section.

*I suppose in our minds at the beginning we saw a spinout as the route... probably because we needed to learn more about licensing which we did in the course of the project.*

From her interactions with the team, *TCD T1* was of the opinion that they wanted to set up a campus company, so she was focused on helping them do that.

*In other projects people might say 'you know we'll licence this or maybe do a spinout' without really considering the implications, I felt all along that TCD PI1 was seriously interested in a spinoff*

*TCD T1* also said that she did not think *TCD PI1* would have been interested in the spinoff if he did not think *TCD PM1* was there to help lead the commercial efforts.

*I do not think TCD PI1 would have said it should be a spinoff if there was not someone like TCD PM1 interested in looking into it.*

*TCD PI1* obviously knew he had not the skills, or more importantly the desire, to lead the new spinoff. Finding a surrogate who would become the CEO was another stumbling block in trying to commercialise the technology.

*I think that there could be a successful spinoff if we get the right people to exploit the opportunity... The barrier is getting someone to work with us to commercialise it.*

When the team received the C+, and started to focus their efforts on commercialising the technology, the choice of spinoff was still the favoured option, and it did not appear that either *TCD PI1* or *TCD PM1* ever seriously considered a licence. *TCD PI1* seemed to think that the spinoff would work in...
partnership with one of the existing preoperative planning companies. However, he does not appear to have pursued the partnership route with any vigour.

*I do not think we've ever wavered much from the concept of developing a spinout, ideally in partnership with one of those preoperative planning software developers.*

In making the decision to choose between a spinoff and licence, neither TCD Pl nor TCD PM1 said they were influenced by the university's policies on commercialisation. TCD PI1 knew what the exact terms of the deal the university would ask for were, and thought they were reasonable.

*I think university spinout terms are acceptable.*

### 7.2.2 Access to VC funding

TCD PM1 and TCD PI1 both referred to a number of different meetings they had with VCs in Ireland, which shows they had little difficulty in setting up initial meetings with the VCs. However, these meetings identified a number of weaknesses in the team, and in their value proposition. TCD PM1 comments showed that the Irish VCs were not willing to invest on their own, that they expected to see the team raise some investment from elsewhere before hand.

*We spoke to 4th Level and to Delta, and had preliminary discussions with European Venture Capital with Consultant 1. All again saying 'great idea, love it, love what it felt like, come back to us when you have a one million euro and then we'll talk to you'.*

TCD PI1's comment on their interaction with the VCs supported this view.

*We approached Delta partners, we approached 4th Level Ventures. We had a few others in mind but we did not actually approach them. I suppose the reaction from Delta Partners and 4th Level Ventures led us to believe that we had to do more before we had something that they would buy into.*

TCD T1 and TCD T2 believed that TCDI struggled to get the interest of the VCs because two other projects were being commercialised from TCD at the same time, and the PI of one of those projects had a history of commercialising his research. As a result, he was well known to the VC community, and may have been viewed as a lower risk by the VCs.

*There were three projects around at that time, there was TCD1, Company D and Company E. Company D managed to get a decent round of funding, and probably a lot of that had to do with the fact that Academic X had gone through*
one campus company already, had a good name, and it was recognised in Enterprise Ireland and within the VC community in Ireland that he was a good bet.

TCD T1 also said that the other two projects had identified a first customer, and this was something the VCs looked on very favourably.

I think Companies D and E both identified a first customer very early, so there was some cash flow on both sides, and I do not think TCD1 had a first customer.

TCD T1 said she thought that TCD1's proposition still had some important gaps in the business plan, such as 'who were they going to sell to?'

...whether they'd identified 'who they were going to sell what to'?

7.2.3 Academic's knowledge and entrepreneurial skills
This section presents the data gathered from the interviews with the various parties relating to the PI's commercial knowledge and entrepreneurial skills.

7.2.3.1 Academic's knowledge of the ATRP funding scheme
Both TCD PI1 and TCD PM1 knew what the aims of the ATRP were, and their respective responses to the question showed they clearly understood the need to commercialise their research.

It was to develop technology suitable for licencing and commercialisation and developing a spinoff company.

...we were aware that... we had a certain responsibility under the milestones we'd set for ourselves to investigate some sort of commercial potential.

The team chose to apply for funding to allow them to continue working on a technology that had been developed using a number of basic research grants, and a number of European Union (EU) funded projects. TCD PM1 said they applied to the ATRP with the specific intention of bringing the technology developed via those programmes to the market.

We had just come off the back of a six year EU project. We had developed a lot of technology ourselves and the idea was to get these disparate strands of research and try putting them into one useful tool for surgeons.
7.2.3.2 Presence of an entrepreneur and social links

At the beginning of the project the team had, by their admission, limited commercial knowledge, and very little experience of the business world. As TCD PII admitted

'It was clear that we lacked business expertise. I'm an academic... it was clear that nobody [in the team] had business expertise.'

TCD PII did have some exposure to the running of a successful spinoff company as he was on the board of Company C. This gave him insights into how a spinoff was run, and the unique problems associated with a university spinoff.

'I was on the board of a company called Company C for five or six years.'

TCD PM I had experience of the agricultural sector, but he said neither himself nor TCD PII knew anything about how to go about starting up a spinoff.

'I had some experience ... the farming business, both here and abroad, but again very limited. None of us really had any clue what to do with a start up or how to start one.'

When the project started, TCD PM I was the project manager, while TCD PII was PI. As the commercial potential in the project became evident somebody had to take the role of commercialisation manager and it fell to TCD PM I in the absence of anyone else.

'So your initial role was Project Manager but that morphed to involve, if you like, Commercial Manager. Is that fair to say?'

Yes.

It was impractical at the time for TCD PII to be involved as he was taking up a senior administrative appointment within TCD. This three-year appointment came to an end at the time of the interview, and TCD PII said he intended to give more time to commercialising the project outcomes.

'I will give it more priority and time because I have a sabbatical next year so I've nothing to do almost other than work on this project.'

However, TCD PII said he was not going to be the person to commercialise the technology, and that he wanted someone else to do that for him. So a barrier to commercialisation was the availability of a surrogate entrepreneur who would fill the role of CEO in the new spinoff company.
I'm not going to commercialise this, it's not my skill. I'm not good at it... I would be there ready and only willing to let someone else run with it if we could find such a person.

7.2.4 Unique Superior Idea
The team did not know if they had a unique superior idea as they never tested it in the market. One consultant told them they needed to do the very simple things such as identifying their unique selling point; however, they ignored this advice until they received C+ funding.

We had that draft business plan. We revised that very heavily once we got an experienced person in. The first thing we did was to try and get together what was our Unique Sales Proposition. We went out, we spoke to customers, I went over to Chicago to a huge trade meeting, and met with about 11 different companies.

7.2.5 Process related data
TCD PM1 said that the idea to commercialise the technology was driven by TCD PI1's belief that someone would pay for the technology, and that this belief formed the basis of the application to the ATRP.

TCD PI1 had the brain wave that somebody would pay for this [technology] and said to me 'well off you go and see if you can dig around to see if you can uncover any facts and figures that would support that assertion'.

TCD PI1's belief was based on his own gut feel rather than any knowledge or analysis of the market. TCD PM1 did a small amount of market research using Google and a number of Frost & Sullivan reports (provided by Enterprise Ireland) to support the ATRP application. That was the limit of their market knowledge until they received the C+ funding.

I did some basic research, nothing massive to be honest with you, nothing you could not do using Google and ...a few Frost and Sullivan reports.

At no stage in the project did the team try to confirm these assumptions, or to update the data on which they were basing the decisions to set up a campus company. By their own admission, TCD PM1 said the team spent the majority of the ATRP working on the technology without doing any commercial work in parallel. Nor did the team talk to any potential customers to gauge their reaction to the tool, or to gather data for the functional requirements of the end product.
It [commercial planning] was something we did on day one... then we completely forgot about it for about three or four years whilst we were tackling the technical milestones, which in hindsight was not a good idea.

In fact, when pressed by the external consultant (hired under the C+), and the mentors from the boot camps to talk to customers, TCD PM1 said they steadfastly refused, saying they believed it was too early to do so. This was a clear indication of how lacking in business knowledge the team were, and how naive their attitude was.

*We felt at the time we were far too early for it to come to the market, which was the classic mistake that clueless entrepreneurs make. ... Our mentor kept trying to push us 'to go talk to customers' but we'd push back to him saying 'it's not ready'.*

*TCD PI1* expected his customers to be the pre-operative planning software companies, rather than individual surgeons. He thought that one of these companies would buy the technology and add it to their current package. In this sense, the route to commercialisation may have been a licence to one of these companies, rather than the spinoff the team pursued for so long.

*The people who would buy the software would be the preoperative planning companies... Those are the companies that would buy this as a module that would go into their software, or else jointly operate it with us.*

The lack of customer requirements made it harder to sell the product, as the team did not understand what the market really wanted. It was not until they employed a number of consultants during the C+ that the team realised how important customer feedback was.

*We would have got much more benefit from that [customer feedback] if we'd done it from day one, or if it had been available from day one ... instead of spending two years creating a great piece of software, which it turned out everyone thought was great, but no one was willing to pay for.*

However, the team was able to prove the potential in their technology via a study carried out on historical clinical data from hip replacement patients (going back over twenty years). *TCD PM1* said they were given access to this patient information, which they used blindly to determine what their model would predict in terms of the patient outcome. Using this data, the team claimed to be able to predict 83% of case outcomes accurately.

*These were patients who had been followed for about 20 years so their outcomes were well defined. We used our code to simulate these patients*
operations and to determine whether or not they had hip replacement failures or not, in which we had an 83% success rate.

However, even with this data, TCD PM1 said it was extremely difficult to find out market information that would help them construct their business plan. In particular, pricing levels were an issue that still needed to be resolved at the time of the interviews.

*The big problem we had with our financials was the pricing level. It was very hard to obtain information on how to price a service such as this in the health care sector. That proved to be a stumbling block.*

TCD PM1 said the team only really started to focus on the commercialisation of the project when they were awarded a C+ grant by Enterprise Ireland.

*Things really improved in ’05 when we got a Commercialisation Plus grant which came with a very experienced mentor [Consultant 1], and that’s when things really took off on the commercialisation side of things.*

The C+ came about following a review between TCD PM1 and the Commercialisation Manager (CM1) from Enterprise Ireland where the potential in the technology was discussed openly, and a plan for commercialisation was put in place.

*And then it came up in discussion with our advisor in EI, CM1. We applied for it and thankfully were awarded [it].*

The intention of the C+ was to allow the team the time to talk to potential investors and customers. So the first thing the team needed was some good general business advice. They needed to do the very simple things such as identifying their unique selling point. TCD PM1 said they started to talk to companies to get this information when they received the C+.

*The first thing to do was we had workshops to try and get together what was our Unique Sales Proposition? We went out, we spoke to customers, I went over to Chicago to a huge trade meeting where I met about eleven different companies.*

TCD PI1 said they also started to talk to a number of Irish VCs, however, he told them that he had no intention of leaving Trinity to start the company. These meetings benefited the team as they showed that the lack of someone with the necessary skills to lead the potential spinoff was an important gap that would need to be filled.
We approached Delta partners and 4th Level Ventures...of course they were not impressed when I'd say 'I'm an academic and I'm sticking with my professorship'...So they were looking then to TCD PM1.

TCD T1 said that to overcome the knowledge gap identified by the VCs, TCD PM1 enrolled on the UCD Nova Campus Company and on the Trinity Entrepreneurs bootcamp.

TCD PM1 did our Entrepreneurship course... to get to know a bit more about it [the process of commercialisation] and his project was one of the MBA workout projects as well.

I was also on the NovaUCD Campus Company Development Programme which was very useful...It was TCD TTD who volunteered me for it.

The Nova UCD programme was run over a nine-month period where each delegate was helped to generate a business plan and associated documentation for his or her proposed spinoff. Each delegate was also given a mentor whose role it was to offer support and guidance, where appropriate. As mentioned earlier, TCD PM1 said this advice was not always listened to, but he was complimentary about the programme as a whole.

The Nova [programme] was a nine or ten-month process with monthly workshops on various topics... and one of the guys running the programme was my mentor.

Through Enterprise Ireland, the team also made contact with several external consultants including Consultant 1, who provided them with business support and expertise over the period of the C+. One of the many things Consultant 1 did for the team was to organise a two-day workshop with Consultant 2 who had expertise in this area, and who, according to TCD PM1, helped the team restructure their business plan.

Consultant 2 came into us for two days and really helped us thrash out our USP [unique selling point] and the basis of our business case and a short term action plan ...Putting it into context this guy was buying a business for $17million at the same time he was talking to us... so getting two days of time... was massively useful.

Consultant 1 made it clear to TCD PI1 and TCD PM1 from the onset that she had no wish to become part of a potential spinoff. TCD PI1 described her as a business coach, rather than someone who was going to be the CEO of the spinoff.
Consultant 1’s role in the project has been as a kind of business coach to the rest of us. She’s not going to come in and be the CEO.

These interactions gave TCD PM1 enough knowledge to appreciate how much he still did not know. This, and the unspoken pressure of the team focusing on him as the potential CEO, may have eventually persuaded TCD PM1 that he did not want to lead the project, and may have prompted his decision to enrol on the MBA programme instead. The fact that TCD PI1 had taken on the senior administrative role in TCD would have put more pressure on TCD PM1, as it certainly reduced the time TCD PI1 was able to spend on the project. It was the lack of a clear leader who had the skills to be the CEO that was the main barrier to the successful commercialisation of the project.

7.2.6 Summary of Case TCD 1

TCD PI1 and TCD PM1 had spent a number of years working in the field of CAE, and were successful in their application for an ATRP project in 2001. The motivation for their application was a strongly held belief that there was a commercial opportunity for a product that would help surgeons chose the best fit replacement joint for a specific patient.

This belief was a result of many years spent working in the area, and informal conversations with interested parties. Unfortunately, once they were in receipt of the funding they chose to retreat to the lab, and even when urged to by a number of parties, the team did not engage with clinicians or relevant companies to determine if the approach they were taking to the development of the technology was appropriate.

Instead, the team focused on improving the technical capability of the technology. Using historical data on patients who had undergone a hip replacement over the preceding 20 years, the team were able to demonstrate (blindly) an 83% success rate in predicting the outcome of the patient’s surgery, i.e. was the replacement successful or not? Naively, the team thought that this data would be sufficient to attract investment in their proposed spinoff company.

In pursuing the idea of a spinoff, the team had little or no difficulty setting up meetings with potential investors. However, it soon became clear to potential investors that TCD PI1 was not interested in leading a spinoff and that even if he was, that he did not have the required business knowledge to do so. Similarly, TCD PM1 had no relevant business experience.
In an attempt to overcome this barrier, *TCD PM1* took part in the Trinity entrepreneurs' boot camp, and he also attended the UCD campus company programme. Both programmes provided training and advice for academics who wished to start a spinoff company. When prompted, *TCD PM1* and *TCD PI1* said it was too early to show their technology to potential customers, so they ended up ignoring the advice of their mentors who consistently told them to get out and see as many customers as possible.

At the same time, Enterprise Ireland also provided C+ funding that allowed the team to hire an external consultant to help them develop a business plan. While she was highly experienced in the area, she was not interested in joining the team. Hence the experience gap was never overcome to the satisfaction of potential investors.

When the team did eventually start to engage with potential customers, it soon became clear that the product did not meet their needs. Their failure to engage with industry early in the development of the technology meant that the team developed a product everyone said was great, but that nobody was prepared to pay for.

### 7.3 Analysis of *TCD1*

The data above was analysed to look for evidence confirming / disconfirming the presence of gaps from the revised conceptual model, and the role the actors may have had in closing these gaps.

#### 7.3.1 Existence of gaps

- **Idea Uniqueness gap**
  
  An *idea uniqueness* gap existed as the promoters failed to engage with industry early enough to understand their exact requirements. When they finally did visit customers they discovered they had developed a product that people liked, but nobody was prepared to pay for.

- **Funding gap**
  
  A *funding* gap existed to the extent that the project was only possible as a result of securing the ATRP funding. The gap increased when the early commercialisation efforts made by *TCD PM1* were unsuccessful and a business consultant was required to help the team commercialise the project outcomes.

- **Knowledge gap**
  
  A clear *market knowledge* gap existed throughout the project. When pressed by mentors and Enterprise Ireland to engage with customers, the promoters refused to do so, and as a result they had serious misconceptions about the...
market. The failure to heed good advice also highlights a lack of managerial skill.

- **Entrepreneurial gap**
  The PI used his modest social links to find skilled people to advise him during the project. However, when questioned about his future in the spinoff, TCD PI1 said he was staying in this academic post. Similarly, TCD PM1’s had already decided to pursue an MBA highlighting the presence of a commitment gap.

### 7.3.2 Interventions by actors to close gaps

- **Government**
  As in the UL cases, Government helped overcome the funding gap through ATRP and C+ funding. Through the Enterprise Ireland Commercialisation Specialist assigned to the project, they provided advice on the market, and access to a network of experienced consultants. The two boot camps attended by TCD PM1 were both sponsored by Enterprise Ireland.

- **Financial Institutions**
  The VCs were not interested in the technology without an experienced CEO to lead the spinoff. The PI was unwilling to fill this gap and failed to attract a suitable surrogate during the project, or subsequent C+. This meant he was unable to secure the funding necessary to start a spinoff.

- **Industry**
  The promoters consistently refused to talk to industry under the misguided assumption that it was always too early. The failure to get industry feedback on the functionality of the product meant that once it was finalised, it did not satisfy its needs. On this basis, no company was interested in licensing the technology.

- **University**
  While the TTO offered support, and placed TCD PM1 on a number of boot camps, they do not appear to have helped overcome any of the gaps, other than helping secure C+ funding from Enterprise Ireland. There were two other spinoffs in progress from TCD at the same time, and the weaknesses in TCD1 (in comparison to the others) do not appear to have been communicated by the TTO to the PI or PM.

- **Principal Investigator**
  The PI was overly reliant on TCD PM1 to lead the commercialisation activities, particularly when he knew TCD PM1 had no relevant previous experience. The PI was more interested in his research, and was looking for someone else to do lead the spinoff. However, he was unable to find someone to take on the role of
CEO. It may have been due to this lack of social links, but it is interesting that Consultant 1 made it clear that she did not want to be involved with a spinoff. This may have been because her insights into the project convinced her that a spinoff would not be successful.

From the data presented above, Table 7.2 was created to show the supports and interventions made by the actors to close the gaps in TCD1. Using these data, Figure 7.2 was developed to show what gaps existed and which actors played a role in their closure in TCD1. The sizes of the gaps were specific to TCD1, and varied at different times in the project. As in the UL cases, the data from TCD1 allowed for areas of the fading in the conceptual model to be removed. Similarly, the bi-directional arrows show how the closing of certain gaps impacted on others, as did the interventions of the actors.

Figure 7.3 was also developed to show that the failure to close a number of the gaps meant the project resulted in no commercial outcome. The green boxes in the figure show those gaps that were overcome, while the red ones show those that were not closed sufficiently to generate a commercial outcome. From Figure 7.3 we see that the idea uniqueness gap was not overcome, nor were elements of the entrepreneurial and knowledge gaps, hence no commercial outcome emerged from the project.

Table 7.2 Summary of TCD 1 case

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>ATRP, C+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td></td>
<td>ATRP/CFTD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>PM attended entrepreneurship training. Market support from commercialisation specialists</td>
<td>TTO provided marketing support, access to training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entreprenurial</td>
<td>Networking support from commercialisation specialists</td>
<td>TTO network identified business mentor</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
As in Chapter 6, the case data from TCD1 has provided a more in-depth picture of the phenomenon than was available from the survey results. The combined case findings will be discussed in Chapters 8 and 9.

7.4 Case study four: Introduction to TCD2
The aim of this project was to investigate novel uses for nanotechnologies, such as carbon nanotubes. Carbon nanotubes (CNT) are typically grown using chemical vapour
deposition techniques, which also produce amorphous and useless carbon layers. To make use of the carbon nanotubes, a post-growth purification process is needed to remove the amorphous and useless layers. The output of this project was such a purification method.

Markets for CNTs were on the rise at the time of this research, as CNTs are twenty times stronger than steel, and six times lighter. The initial commercial uses of CNTs were in Asia, as processes to manufacture them in large quantities were still very immature. The production of CNTs worldwide had increased from twenty kilograms worldwide, to fifty tons over the preceding five years. The technologies for processing CNTs struggled to keep up with this growth.

... in the last five years the use of nanotubes has gone from something like 20kg production worldwide, to 50 metric tons worldwide. Cleaning up 20 kilos is not such as issue, but once you’re talking about the 50 tons then it becomes an issue.

The size of the market for nanotubes was hard to judge because it was still in its infancy (Frost & Sullivan, 2007). Academics and industry were investigating potential uses in applications such as semiconductor layers, heat sinks and photodectors (Frost & Sullivan, 2007). There was great potential in the market, but it was difficult to estimate the value of the market.

Interviews on this case were carried out with the PI, TCD PI2, and two members of the Technology Transfer Office, TCD T1 and TCD T2. Figure 7.4 shows the roles undertaken by the various parties in the project.

Figure 7.4 Organisation Chart for TCD 2
7.4.1 Role of the university
This section presents the data relating to the role played by the university, including their policies on commercialisation, the supports offered by the TTO, the academic's knowledge of those supports and the influence they had on the academic's choice of route to commercialisation.

7.4.1.1 Alignment of policies
*TCD PI2* did not think the college's policies were pro-commercialisation, although he recognised that other academics from TCD had commercialised their research in the past. He specifically referred to the machine vision group which emerged out of the AMT Ireland PAT, which was sold to Agilent (a subsidiary of Hewlett Packard) for $96million in 2001-2.

>Those guys dropped their jobs in the university and became active full time in the company. I think that's probably the only way to be successful.

*TCD PI2* had been involved in two unsuccessful spinoff attempts from Trinity, and this experience influenced his opinions of the university's spinoff policies. On both occasions, *TCD PI2* said there were issues with the university, and he did not want to pursue that route again.

7.4.1.2 University Supports
*TCD PI2* had a good knowledge of the supports Trinity offered academics who wished to commercialise their research. However, he did not believe that the university offered the necessary or appropriate supports. When it did offer supports, the help on offer was usually already available to him (at a higher standard he thought) via his networks with industry.

>They run the business plan competition, sometimes there have been courses on how to write business plans and so on. In my case that was not really the issue because Consultant 3 had the experience which is probably more valuable.

*TCD PI2* attended a number of the patenting and commercialisation seminars run by the TTO, but his attendance only confirmed his belief that the TTO staff did not have the knowledge to provide the right supports. They relied on outsiders, who *TCD PI2* thought had an ulterior motive in the supports they offered (looking for business opportunities).
They had to bring in other people. Of course they [the consultants] paddle their own canoe...but the advice was pretty professionally offered, maybe not always at the right level, a lot of the stuff was a bit too simple.

TCD PI2 also thought the TTO was under resourced, and as a result could offer very little help or assistance.

Most of the problems we came up against were because one guy tried to do everything. And thereby by trying to do everything could do very little, or nothing in the end.

7.4.1.3 Academic’s knowledge of the university policies
TCD PI2 had an accurate knowledge of the college’s policies on commercialisation. He was aware that incubation space was available to potential spinoff companies, and he named the committee that approved commercialisation deals. TCD PI2 also knew that this information was included on the Innovation Services website, which would suggest that he was familiar with the website and its contents.

If you go to the Innovation [Services] website it tells you, you apply to the Business and Industry Committee, and then you try to negotiate your licence and you try to get premises.

This familiarity may be as a result of the two previous attempts to set up spinoff companies that TCD PI2 had been involved in. However, these experiences do not seem to have been positive, and TCD PI2 developed a negative view of the system as a result.

7.4.1.4 Impact of the policies on the choice of spinoff versus licence
The decision to focus on a licence rather than a spinoff was directly influenced by the university’s policies on commercialisation, and the difficulties TCD PI2 had with these policies.

I would say yes [they influenced the decision on licensing]. Definitely, because it [creating a spinoff] turned out to be so complicated and cumbersome... and painful in the end.

TCD PI2 was so frustrated by the lack of support from the TTO that he did not want to consider a spinoff from this project. He was more interested in a licence as he viewed it as the easier option.
Because the spinoff turned out to be far too difficult in the Trinity context, we tried it and we had issues that developed into fights and more unpleasant things. So in the end licensing was the softer option.

7.4.2 Access to Venture Capital
When asked if he had tried to attract VC investment at any point in the project, TCD PI2 said that he left that up to a friend (Consultant 3), who was his partner in a previously proposed spinoff. However, by the time it came to looking for investment they agreed (due to market changes brought on by the events of the 11th of September 2001) that a spinoff was not appropriate, and that a licence would be the better route to pursue.

In my case that was not really the issue because Consultant 3 had the experience as he had done it before, this was probably more valuable. In that case the business plan was good except that the VC environment was bad at the time. By the time it got good again we'd taken the licensing route.

7.4.3 Academic's knowledge and entrepreneurial skills
This section presents the data gathered from the interviews with the various parties relating to the PI's commercial knowledge and entrepreneurial skills.

7.4.3.1 Academic's knowledge of the ATRP
TCD PI2 had been the research director of one of Enterprise Ireland's PATs in Trinity, and therefore had excellent contacts with Enterprise Ireland. As such, he would have been personally informed of the objectives of the ATRP in an attempt to encourage him to apply to the programme. Therefore TCD PI2 had an accurate understanding of the aims of the ATRP and was successful in two applications for funding.

To develop something to a level, where you have a basic technology... where you have an extremely good confidence level, in terms of competence and confidence level [that it can be commercialised].

He said he applied for funding under the ATRP for two reasons: the first was that it was originally aimed at the PATs who had previously been funded directly under a scheme that was changed due to EU legislation, the second was that he felt he had good links with industry via the PAT, and that there was commercial potential in his research.

First of all, because it was available. Second of all, because a lot of the research I do... is very close to the industry needs and ... we have a good link
[with industry via the PAT], so if there was an idea which had commercial potential, I had a mechanism where it could get to the company immediately.

**7.4.3.2 Presence of an entrepreneur and social links**

*TCD PI2* had previously been involved in two unsuccessful spinoff attempts and was not afraid to be involved in an attempt to commercialise his research, although he did not want to be the CEO.

*There were two companies. The Company G one was a general one and then after that, a few years later I got together with the guy who started Company H (Consultant 3).*

The first spinout was called *Company G* and was indirectly involved in the attempted commercialisation of *TCD2*. It appears that *Company G* got as far as being incorporated, without ever trading because of differences in opinions between the promoters.

*...the owners of Company G, including myself, essentially we fell out and the company closed.*

The second attempted spinoff was, according to *TCD PI2*, a victim of market conditions. The company was due to launch immediately after the events of September the 11th, 2001, but *TCD PI2* said this disaster had such an impact on the market that the potential start up was abandoned.

*We tried to start the company before 9/11 and that was just bad timing. It was unlucky. It would probably have made a big difference if 9/11 had not happened. We'd probably have it running successful now. But you cannot turn back time.*

*TCD PI2* said that he did not want to leave the university; he would prefer to stay as an academic and have someone else run the company.

*... I never wanted to be the CEO, because I'm a technical guy and I love my job here in the university.*

However, his experience of two failed attempts, set against the successes he saw elsewhere in TCD, suggested to him that the key to success was having someone who was prepared to leave their post in the university to drive the start up, and he did not see himself in that role.
... those guys dropped their jobs in the university and became active full time in the company. I think that's probably the only way to be successful. It's my experience of two failures.

7.4.4 Unique Superior Idea

According to a recent Frost & Sullivan (2007) report 'the support of research that allows further studies in this area is essential to make things easier for commercialization of these materials. Industrial processes that consider optimized and controlled production of CNTs are a plus in this context'. So if the team could demonstrate a working method of cleaning the nanotubes, there was an opportunity in the market place according to this report.

7.4.5 Process related data

TCD PI2 believed that the outcomes of the project were unique and had commercial potential. As a result, he was able to use his network with industry to attract interest from Company F. However, the licence deal agreed with Company F fell apart when the deal was being prepared for the Business and Industry Committee to approve. The TTO found that there were issues with the legal title of the patent, i.e. Company G were incorrectly named as co-inventors of the patent.

Company F had come up with a licence, and the college then decided they [TCD] could not sign it because they [TCD] could not guarantee the title to the patent.

Further problems then arose as Company G had been struck off the Companies Register due to their failure to submit annual returns. This meant there was no legal entity to agree to take Company G’s name off the title.

Subsequently Company G had been struck off the companies register for lack of filing of annual returns. Because there is no Company G, we have no mechanism whereby Company G could rescind any rights to the title.

As TCD T1 explained, the issue of the title was subsequently resolved in the US and Germany (as they were two of the markets with the greatest commercial potential), and a new licence agreement was being pursued with a number of companies.

Suffice to say that the original patent is now granted ...only in the United States and Germany. [There is an] incorrect title everywhere else in the world for various reasons and we are now actively seeking a licensee.
As a result of the incorrect title, the university was unable to sign the agreement, and over time, TCD PI2 said Company F became frustrated with the lack of progress and pulled out of the licence agreement.

There was a contract at some stage couriered to the Provost or a licence agreement from the company, then Trinity dragged their heels and it went on and on and then eventually they [Company F] lost interest.

TCD PI2 was slightly suspicious of this, and thought that Company F's interest in the patent was to block others using it. This may help explain why Company F walked away.

To some degree, the problem with talking to multinationals like Company F, is their main interest was probably not to produce, but their main interest was to block others [using this technology].

How the licence negotiations were able to go so far without the issue with the title being identified is an interesting point. TCD PI2 was not complimentary about the patent agent used by the university, which may be an indication that he blames the university for the error.

We had very bad patent agents.

Neither TCD T1 nor TCD T2 were involved at the time, and TCD T1 viewed this project as a problem child that was only being resolved at the time of the interview.

There's been an extraordinarily long history with that, and some unorthodox transactions early on.

TCD PI2 and the research team subsequently came up with a number of new potential licensees, and at the time of the interviews the TTO were in the process of writing to each of these companies to determine whether they were interested in licensing the technology.

What I've done now is I've come with a huge list of potential companies who might be interested in licensing this.

7.4.6 Summary of Case TCD 2

TCD PI2 had previously been involved in two attempted spinoffs from Trinity. As a result he had a very jaundiced view of the process, and was not interested in attempting it a third time. Instead, he chose to pursue a licence agreement. TCD PI2
was previously the Research Director of a PAT in TCD, and as a result had an excellent network of industrial contacts. He used these in his attempts to attract a licensee.

The aim of the ATRP project was to develop a commercial method of cleaning Carbon nanotubes (CNT). Given the explosion in usage of CNTs at the time, a market for a large scale (>1 ton) method of cleaning CNTs existed.

*TCD PI2* successfully attracted *Company F* as a licensee, and a term sheet was sent by the university outlining the licence agreement. However, when the associated negotiations started between *TCD PI2* and the TTO, a serious issue with the title of the associated patent arose.

*Company G* was included in error in the list of inventors on the patent, so when the error was identified, the TTO had to remove *Company G* from the patent. However, as *Company G* never traded, and never submitted accounts, it had already been struck off the companies register. As it no longer existed, it was not possible to remove it from the list of inventors without signed agreement from all parties. As some of *Company G*’s directors had moved abroad, the process took far longer than *Company F* was prepared to wait.

*Company F* withdrew their interest and the licence deal collapsed. The TTO subsequently corrected the title of the patent in the US and Germany (two of the biggest predicted markets), but it is still unclear in other territories. The TTO are now looking for suitable licensees with the help of the PI.

*TCD PI2* thought the TTO were responsible for the issues that arose in the project, and was not complimentary of their performance. He was not totally surprised that *Company F* pulled out of the deal, as ultimately he thought they were buying a licence to block others from using the technology, rather than to exploit it themselves.

### 7.5 Analysis of TCD2

The data above was analysed to look for evidence confirming / disconfirming the presence of gaps from the revised conceptual model, and the role the actors may have had in closing those gaps.

#### 7.5.1 Existence of gaps

- *Idea Uniqueness gap*
An idea uniqueness gap existed to the extent that this was a technology that was still in its infancy. Techniques for cleaning CNTs were known, but needed to be scaled for mass production. As a result, a clear market opportunity existed.

- **Funding gap**
  A funding gap existed to the extent that the project was only possible as a result of securing the ATRP funding. The gap increased when the early commercialisation efforts made by TCD PM1 were unsuccessful, and a business consultant was required to help the team commercialise the project outcomes.

- **Knowledge gap**
  A managerial gap existed in that the patenting process was not carried out correctly, which led directly to the licensee withdrawing from the negotiations. A technological knowledge gap existed in so far that this type of technology did not exist prior to the start of the project and had to be developed.

- **Entrepreneurial gap**
  The PI used his social links to find the potential licensee, and also had contacts with two consultants who helped him in his attempts to commercialise his research.

7.5.2 Interventions by actors to close gaps

- **Government**
  Government helped overcome the funding gap through the ATRP and C+ funds.

- **Industry**
  A licence deal was the only route to commercialisation considered by the PI. However, the PI was convinced that a large element of potential licensee's interest was driven by their desire to use the patent to block their competition.

- **University**
  The PI did not feel that the supports on offer from the university were relevant to him, as he already had commercial experience from two other spinoff attempts. These attempts appear to have given him a poor view of the TTO and the resources they had available to help him.

- **Principal Investigator**
  The PI used his industrial network to market the technology to potential users, and as a consequence Company F entered into negotiations to licence the technology. The PI also used his network to attract a number of consultants to work with him, both in promoting the technology and attempting to set up a spinoff.
From the data presented above, Table 7.3 was developed to show the supports and interventions made by the various actors to close the gaps in TCD2. Using these data, Figure 7.5 was developed to show what gaps existed and which actors played a role in their closure in TCD2. The size of these gaps was specific to the project, and varied at different times in the project. As in UL2, the absence of the financial institutions implies they had no role to play in closing the gaps in this project.

Table 7.3 Summary of TCD 2 case

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>Feedback on product</td>
<td>ATRP &amp; Patent funding via Enterprise Ireland</td>
<td>Applied for ATRP funding</td>
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<td></td>
</tr>
<tr>
<td>Funding</td>
<td></td>
<td>Marketing reports</td>
<td>Technological, managerial and marketing competences</td>
<td>TTO run seminars</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Social network of Principal Investigator via PAT</td>
<td>Social network and commitment</td>
<td>Policies discouraged academics</td>
<td></td>
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</tbody>
</table>

Figure 7.5 Elements of conceptual model evident in TCD2
The data has allowed the fading from the revised conceptual model to be removed, adding clarity to our knowledge of the phenomenon. The bidirectional arrows between the actors show the influence of interventions by one actor on all others, not just those adjacent to them in the figure. Similarly, the bidirectional arrows between the gaps show how closing one gap could impact on the size of another gap, not just those it is adjacent to, as evident from the data.

Figure 7.6 was also developed to show that the failure to close all four gaps meant the project resulted in no commercial outcome. The green boxes in the figure show those gaps that were overcome, while the red ones show those that were not closed sufficiently to generate a commercial outcome. Examining Figure 7.6 we see that the managerial and marketing competence elements of the knowledge gap were not closed in TCD2, and as a result the project resulted in no commercial outcome.

Figure 7.6 Gaps closed by actors in TCD2

As before the case data from TCD2 has provided a more in depth picture of the phenomenon than was available from the survey results. The combined case findings will be discussed in Chapters 8 and 9.

7.6 Case study six: Introduction to TCD3
This case was chosen as during the survey interview with the PI it became apparent that this project was unique amongst those funded between 2001 and 2003, in that the explicit aim of the project was not to attempt to commercialise the outcomes. It
was to prove a concept in advance of trying to commercialise the technology via a second funding application.

*The goal of that was... as I say a feasibility study...*

Although this usage of the ATRP was not what Enterprise Ireland had intended, it was not against the rules of the scheme at the time. So it was a novel use of the programme by the PI. While it would be unfair to say the rules and the name of the ATRP changed due to this project, the renaming of the ATRP to the CFTD was to ensure that the academics clearly understood the intention of the programme was to fund their efforts at commercialisation, not to prove a concept. That was covered under a separate, smaller fund started in 2003 called the *Proof of Concept*.

In this sense the project was unique, as the PI successfully received funding for a subsequent CFTD project based on the same technology investigated in the original ATRP. It is not possible under the current rules of the Commercialisation Fund to get a second CFTD based on the same research. The smaller Proof of Concept phase of the Commercialisation Fund is used to support the feasibility of technologies. The Proof of Concept scheme offers up to €100,000 over a twelve month period to allow the PI to prove a technology has potential for commercialisation. The PI can then apply for a CFTD.

The technical objectives of this project were to identify treatments for certain forms of cancer using gene therapy, and according to the PI, the ATRP successfully showed that there was commercial potential in the technology.

*We were establishing the system as a viable medical treatment for advanced cancers...the output was a very clear indication that we could commercialise the project, that there were commercial opportunities.*

The interviews on this project were with the PI *TCD PI3* and the TTO staff, *TCD T1* and *TCD T2*. Figure 7.7 shows the reporting structure of the project team.

**7.6.1 Role of the university**

This section presents the data relating to the role played by the university, including their policies on commercialisation, the supports offered by the TTO, the academic’s knowledge of those supports and the influence they had on the academic’s choice of route to commercialisation.
7.6.1.1 Alignment of policies
As TCD PI3 had not attempted to commercialise the outcomes of this project, he had no knowledge of the university’s policies or stance on the commercialisation of applied research. So, he was unable to comment on whether he thought the university’s actions agreed with its written policies.

7.6.1.2 University supports
Even thought TCD PI3 did not try to commercialise the outcomes of the project, and he did not seek any support from the university, he had enough contact with the TTO to have strong view on their competency.

You’ve got to realise how it was in this place then. At that point Innovation Services was under resourced and under staffed and could not do anything.

TCD PI3 said that to get anything done at the time took an extraordinarily long time, and that it usually took months to get even the simplest things done. As a result of the difficulties TCD PI3 had in getting the basic services from the TTO, he developed a poor opinion of their capability.

To get Innovation Services at that time to do anything took months...it was just totally impossible.

7.6.1.3 Academic’s knowledge of the university policies
As a result of the ATRP’s technical focus, TCD PI3 felt he had no need to find out if the university had any policies on commercialisation. Even at the start of the CFTD project, he was still unaware of the university’s policies on commercialisation. However, TCD PI3 said that in contrast to the ATRP, staff from the TTO were involved in the new CFTD project, and that the TTO staff set up regular (quarterly) meetings with him and his team to discuss the
commercialisation of the project outcomes. This had not happened during the ATRP.

You see the system has changed. TCD T1 has quite a lot of input she comes to our meetings... [during] the ATRP there was no university representative.

7.6.1.4 Impact of the policies on the choice of spinoff versus licence
Although there were no commercial activities during the ATRP, TCD PI3 said that he was considering starting a spinoff company once the CFTD was complete.

The goal of this project that we're into now is to end up with... a campus company, and get Venture Capital type companies [to invest]...

The choice of spinoff may have been influenced by TCD PI3's previous experience of trying to licence the outcomes of his research, rather than the university's policies, which he was unaware of. TCD PI3 said that he had tried in the past to licence a technology to two companies, but without success. He found the process of dealing with the companies tiresome and frustrating, and seemed to favour a spinoff as a route to commercialisation, as in his opinion it offered him more control of the process. The choice of a spinoff over licensing may have been due to a lack of knowledge of the spinoff process, rather than a deep knowledge of the issues associated with both paths.

We did start off thinking about licences, but we decided in the end the best route was the other route [spinoff] ... we had all kinds of promises from two companies... one of which went bust and then the guy we were working with in the other company left.

7.6.2 Access to VC funding
As no attempts were made during the ATRP to commercialise the project, no contact was made with an external funding sources. As such, there is no data to present on TCD3 under this heading.

7.6.3 Academic's knowledge and entrepreneurial skills
This section presents the data gathered from the interviews with the various parties relating to the PIs' commercial knowledge and entrepreneurial skills.

7.6.3.1 Academic's knowledge of the ATRP
Given the unique usage of the ATRP programme as a proof of concept it could be argued that TCD PI3 had a very good knowledge of the ATRP, as he was the only
PI amongst those funded between 2001 and 2003 who has successfully used it as a precursor for a second CFTD.

The end point we intended to get to was to show that using animal systems mostly that this idea was viable.

The alternative view was that he did not heed the rules of the ATRP, and that he simply applied in the hope of receiving funding. This is probably untrue as TCD PI3 had obviously done some research on the ATRP; he knew that Enterprise Ireland was interested in patents from the ATRP, and he included the filing of a patent as one of the key deliverables from the project. He did not mention anything about the commercialisation of the patent which was what the scheme hoped to achieved. So in the sense that he delivered on the objectives of his contract, he adhered precisely to the terms of the programme.

They wanted us to get to see whether they could get a patent at the end of it, which is what we did...we've applied for an international patent after that [ATRP] grant and we're actually about a month from getting a second one.

7.6.3.2 Presence of an entrepreneur and social links
TCD PI3 was by his own admission a lifelong academic who had no commercial knowledge, and relied on others for commercial advice.

I know nothing about commercialisation at all. We take all our advice from Enterprise Ireland and from TCD T1 in Innovation [Services]...I'm 31 years as an academic.

TCD PI3’s main interest was in his research, and he thought that the steps needed to prove the technology could be commercialised were boring and uninteresting. However, the fact that he knew that these boring steps were necessary showed that he had some level of commercial knowledge.

There are also other aspects to this which are a bit boring but unfortunately have to be done for commercialisation. One is that you have to have a method of producing effective and clinical quality [products] by a good manufacturing practice.

When asked what motivated the second CFTD project, TCD PI3 said he would like to see the fruits of his research be of use to society. He said he was motivated by his own sense of legacy, as he was coming towards the end of his career, and he wanted to see the fruits of his career used somewhere, other than in a text book.
I've only got 5 to 7 years left before I retire and what I wanted to do was finish off maybe with something that was a commercial product. And also if you're spending many years doing academic research... you want some kind of result come from it which not just be pure knowledge.

7.6.4 Unique superior idea
It was hard to determine whether a unique superior idea was evident in this project. The PI said he developed the idea from a gap he found in the academic literature. While this might suggest an avenue worth exploring, this was not the same as confirming a market opportunity.

7.6.5 Process related data
Even though the TTO were proactive in meeting teams who received funding under the CFTD, TCD PI3 was fairly negative in his view of the TTO. Although he recognised that the TTO were severely under staffed at the time of his ATRP, he said the level of service he received was unacceptably poor. He gave the example of an EU project he was involved in where the agreement necessary to commence the project was not signed by the TTO until a year after the project was completed.

We had an EU grant at the same time and I asked for the contract we needed...for the grant. The contract for the grant arrived [from the TTO] a year after the grant finished.

TCD PI3 did accept that the levels of support from the TTO had changed, and that the TTO were taking a more proactive role by coming to regular meetings with the research team.

In fairness to them, they were very much understaffed, but now they’ve got a lot more staff and they give a very good service, but then it was abysmal.

As no attempt was made during the ATRP to find a licensee or to set up a spinoff company, no process of commercialisation was evident. However, a number of points are worth exploring to highlight some issues.

The idea for the project came from a review of the literature where TCD PI3 thought he saw a gap in the technology that could be exploited commercially.

I suppose through reading the scientific literature...we thought we could develop a superior technology based on a different principle...it was just opportunism, we saw the opportunity.
When asked if he spoke to clinicians or surgeons to understand better what the needs of the market were, he said he was told by the TTO not to as that could be construed as disclosure, which could negate the possibility of a patent.

...we were told to keep it absolutely quiet.

This shows that the academic had little knowledge of the commercialisation process at the time, and was reliant on the TTO for instructions on what he could and could not do. This advice (as taken) was inaccurate, but it is not possible to determine if TCD PI3 misinterpreted it, or was given it inaccurately by the TTO.

### 7.6.6 Summary of Case TCD 3

This case was unique in that the initial grant was used as a Proof of Concept. The PI never intended to attempt to commercialise its outcomes; instead he planned to apply for further funding under the CFTD to commercialise the outcomes of the original ATRP.

TCD PI3 was motivated by the sense of his own legacy, and had no commercial skills or experience. As a result he had to reply completely on the TTO to advise him. While the ATRP was successful in developing a patent, at the time of the interview, there was no indication to show that the technology would be commercialised.

### 7.7 Analysis of TCD3

The data above was analysed to look for evidence confirming / disconfirming the presence of a gap from the revised conceptual model, and the role the actors may have had in closing those gaps.

#### 7.7.1 Existence of gaps

- **Idea Uniqueness gap**
  
  According to the PI, he found a market gap via the scientific literature. However, he had no industrial or market feedback to confirm this. As a result, it was impossible to determine whether a market opportunity existed, and whether his idea was unique.

- **Funding gap**
  
  As with all the other projects, the funding gap existed as without the ATRP the project work carried out would not have been possible.

- **Knowledge gap**
Market and managerial knowledge gap existed as the PI admitted he had no market or commercial experience, as he had been an academic for over thirty years.

- Entrepreneurial gap
  While the PI discussed some industrial links he had in the past (which failed to result in licences), he displayed few industrial links. As such, the social links element of the gap may have existed. Given the unique use of the ATRP as a proof of concept, it is not possible to determine the level of commitment without also studying the subsequent CFTD.

7.7.2 Interventions by actors to close gaps

- Government
  As per the other projects, Government helped overcome the funding gap by making the ATRP funding available.

- Principal Investigator
  The PI made no attempts to commercialise this project. His intention was always to apply for another project under which to do it.

- Industry
  The PI had no contact with industry during this project.

- University
  The university failed to engage with the PI at any point during the original ATRP. They held quarterly meetings on the subsequent CFTD, but no evidence exists to show interaction between any office of the university and the PI in TCD3. It is important to note that the PI never sought any support, so while this suggests that the TTO was not pro-active, it does not prove that supports were not available if requested.

- Financial Institutions
  The financial institutions played no role in this project.

From the data presented above, Table 7.4 was developed to show the supports and interventions made by the various actors to close the gaps in TCD3.

Using these data, Figure 7.8 was developed to show what gaps existed and which actors played a role in their closure in TCD3. The size of these gaps was specific to the project, and varied at different times in the project. Again, the data from TCD3 has allowed the fading from the revised conceptual model to be removed, adding clarity to our knowledge of the phenomenon.
Table 7.4 Summary of TCD 3 case

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>ATRP &amp; CFTD funding via Enterprise Ireland</td>
<td></td>
<td>Applied for ATRP &amp; CFTD funding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td>Enterprise Ireland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td></td>
<td></td>
<td>Limited network</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The bidirectional arrows between the actors show the influence of interventions by an actor on all other actors, not just those adjacent to each other. Similarly, the bidirectional arrows between the gaps show how closing one gap impacts on the size of another gap, not just those it is adjacent to, as evident from the data.

Figure 7.8 Elements of conceptual model evident in TCD3

Figure 7.9 was also developed to show that the failure to close all four gaps meant the project resulted in no commercial outcome. The green boxes in the figure show those gaps that were overcome, while the red ones show those that were not closed sufficiently to generate a commercial outcome. Figure 7.9 shows that the entrepreneurial gap, the idea uniqueness gap and two thirds of the knowledge gap were not closed. As a consequence no commercial outcome emerged from the project.
As before the case data from TCD3 has provided a more in depth picture of the phenomenon than was available from the survey results. The combined case findings will be discussed in Chapters 8 and 9.

7.8 Conclusions
Using the research design outlined in Chapter 4, data was gathered on the six case studies via interviews with key personnel associated with each project. This chapter presented the data gathered on the three cases from TCD, and analysed each to highlight the existence of gaps, and the roles played by the various actors in closing them, summarised for the three projects in Table 7.5. As in chapter 6, we see that the lack of intervention by actors, or their inability to close all four gaps, resulted in the failure of all three projects to generate a commercial outcome within the time frame of this study.
Table 7.5 Summary of the gaps evident in the three TCD cases

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>TCD1,2 &amp; 3</td>
<td>ATRP, C+ or patent funding</td>
<td>TCD1,2&amp;3: Feedback on product</td>
<td>TCD1&amp;2: Feedback on product</td>
<td>PI persuaded to pursue a licence</td>
</tr>
<tr>
<td>Funding</td>
<td>TCD1,2 &amp; 3</td>
<td>ATRP, C+ or patent funding</td>
<td>TCD1,2&amp;3: Applied for ATRP / CFTD</td>
<td>TCD1&amp;2: Feedback on product</td>
<td>TCD1&amp;2: TTO provided marketing support &amp; access to training</td>
</tr>
<tr>
<td>Knowledge</td>
<td>TCD1: PM attended entrepreneurship training. Market support / reports from commercialisation specialists</td>
<td>TCD2: Networking support from commercialisation specialists</td>
<td>TCD2: Networking support from commercialisation specialists</td>
<td>TCD1: TTO network identified business mentor</td>
<td>Help identified market gap</td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>TCD1: Networking support from commercialisation specialists</td>
<td>TCD2: social network of PI via PAT</td>
<td>TCD2: Networking support from commercialisation specialists</td>
<td>TCD1: TTO network identified business mentor</td>
<td>Help identified market gap</td>
</tr>
</tbody>
</table>

The next chapter in this thesis presents the cross case analysis of the data presented in Chapters 6 and 7 in an attempt to answer the research questions posed by this study.
CHAPTER 8 : ANALYSIS OF THE CASE DATA

8.1 Introduction
This chapter presents the cross case analysis of the six individual cases presented in the previous two chapters. The chapter is set out in four parts; the first presents the university related cross case analysis, while the second presents the gaps with respect to four different scenarios (pre- and post-spinoff, and pre- and post-licensing). The third compares and contrasts these different scenarios, while the fourth presents and discusses the emergent model developed from the four scenarios.

8.2 Cross case analysis
In Chapter 5 I described how the cases were selected, while Chapters 6 and 7 presented and analysed the individual case data. The next section of this chapter focuses on the cross case analysis of these data, as per the case study methodology shown in Figure 8.1 (Yin, 2003).

Figure 8.1 Case study method (Yin, 2003)

8.3 Analysis of the data
Chapters 6 and 7 presented the data and an analysis on each of the six cases. In line with the analysis strategy shown in Figure 8.1, this chapter uses these within case findings to conduct the cross case analysis. This involved comparing and contrasting the findings of the individual cases to determine if patterns exist in the data.
In the presentation of the *within case* analysis, the university related data was presented separately to avoid duplication across the cases. The same is done for the *cross case* analysis as dealing with them on a case by case basis would mean serial duplication of the analysis, and would also make it more difficult to identify patterns in the behaviours of the actors.

### 8.4 Institutional level data

The data on the university are presented using two headings: *role of the university* and the *role of the TTO*. These heading were used based on the findings of the survey and the factors the literature suggested influence commercialisation.

### 8.5 Role of the university

To help analyse the data on the universities I grouped the variables relating to the universities' policies in Table 8.1 using a three-point scale to categorise each. This classification comes from the coding template described in Section 4.6.4 and included as appendix 3 to this thesis. The addition of labels to the codes is used to make the discussion simpler.

This scale classifies policies as *aligned*, *uncertain* and *misaligned*. Aligned refers to those policies that are well defined and communicated, and which encourage commercialisation. Misaligned refers to ill defined policies that are not communicated and which do not support commercialisation efforts. Uncertain refers to those that fall between the other two, e.g. a definite strategy that is not communicated and has neutral support for commercialisation efforts.

<table>
<thead>
<tr>
<th>Variable Categorisation</th>
<th>Aligned</th>
<th>Uncertain</th>
<th>Misaligned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment of actions and policies</td>
<td>Well defined strategy and well communicated across institution, supports commercialisation of research</td>
<td>Defined strategy but not well communicated across institution, neutral support for commercialisation</td>
<td>Ill defined, or no strategy and not communicated across institution, does not support commercialisation of research</td>
</tr>
<tr>
<td>University policies impact on choice of route to commercialisation</td>
<td>Encourages licensing over spinoffs</td>
<td>Encourages spinoffs over licensing</td>
<td>Does not encourage one route over another</td>
</tr>
</tbody>
</table>

Using these categories Table 8.2 was constructed to show where evidence existed in each of the six cases relevant to a categorisation. The data showed that both UL and Trinity were rated as misaligned by the academics. However, the TCD TTO staff rated themselves as aligned.
Table 8.2 Categorisation of policies by project

<table>
<thead>
<tr>
<th>Project / Categorisation</th>
<th>Aligned</th>
<th>Uncertain</th>
<th>Misaligned</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1</td>
<td></td>
<td></td>
<td>Policies ill defined and not supportive of commercialisation Policies did not favour one route over the other (spinoff versus licence)</td>
</tr>
<tr>
<td>UL 2</td>
<td></td>
<td></td>
<td>Policies ill defined and not supportive of commercialisation Policies did not favour one route over the other (spinoff versus licence)</td>
</tr>
<tr>
<td>UL 3</td>
<td></td>
<td></td>
<td>Policies ill defined and not supportive of commercialisation Policies did not favour one route over the other (spinoff versus licence)</td>
</tr>
<tr>
<td>TCD 1</td>
<td>Policies well defined and supportive of commercialisation</td>
<td>Policies did not favour one route over the other (spinoff versus licence)</td>
<td></td>
</tr>
<tr>
<td>TCD 2</td>
<td>Policies favour licence over spinoff</td>
<td>Policies ill defined and not supportive of commercialisation</td>
<td></td>
</tr>
<tr>
<td>TCD 3</td>
<td></td>
<td></td>
<td>Policies did not favour one route over the other (spinoff versus licence)</td>
</tr>
</tbody>
</table>

To examine these findings in more depth I looked at the individual case data under two headings, alignment of actions and policies, and influence of policies. An occurrence of a code was counted each time a comment was made by an interviewee relating to that code. Those occurrences were then grouped to compare and contrast the evidence from the six cases.

8.5.1 Alignment of actions and policies

Table 8.3 presents the number of times the different codes related to alignment of actions and policies occurred in the data. There were twenty different occurrences in the data of the misaligned codes, compared to eleven for aligned. The twenty occurrences of the misaligned codes were attributed to the academics or surrogate entrepreneurs, while the eleven aligned codes were attributed to staff from the TTO.

Table 8.3 Number of times university policy codes appear in interview data

<table>
<thead>
<tr>
<th>Factor / Categorisation</th>
<th>Aligned</th>
<th>Uncertain</th>
<th>Misaligned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alignment of policies</td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>University policies</td>
<td>11</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>impact on choice of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>route to commercialisation</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The frequencies of occurrence showed two obvious and distinct clusters, the first was amongst the academics who believed the actions of their university did not encourage them to commercialise their research. The second cluster was amongst the TTO staff who believed the university’s actions encouraged the academics.

The data from project UL1 showed that the only interactions they had with the TTO were the formal contractual negotiations to licence the technology. These interactions were very frustrating according to UL SEI, and did not support the creation of a spinoff. In particular, UL forced the spinoff to leave the campus as soon as it was established, whilst it also refused to offer an exclusive licence to the spinoff, as to do so would have resulted in the loss of research funding to the university (as other projects funded by Enterprise Ireland would have to be terminated).

UL PI2 said the policies on reward and recognition did not encourage academics to commercialise their work, as successful commercialisation was not a criterion for promotion in UL. In Trinity, TCD PI2 said his previous experiences of the policies clearly showed they did not support commercialisation.

Both universities offered leave of absence to members of staff who wished to take a defined leave from the university which was beneficial to UL PI1. However this policy was implemented by Human Resources for the benefit of any staff member, and was not specifically aimed at those commercialising their research. As implemented, the policy was best described as bureaucratic.

8.5.2 Influence of policies on spinoff or licence

The codes relating to the impact of the universities’ policies on the academics’ choice of route to commercialisation occurred twenty five times in the data (see Table 8.3). On four occasions the codes suggested the policies encouraged the academic to opt for a licence over spinoff, three times to favour a spinoff over a licence, and on eighteen occasions suggested the policies had no influence.

Three of the four occurrences of the codes suggesting the policies encouraged the academic to favour a licence were from TCD PI2, who opted for the licence route as a direct impact of the policies of the university. TCD PI2 said that his previous attempts to create a spinoff left him with negative views of the university’s policies. This was why he opted for what he called ‘the easier route to commercialisation’, a licence agreement.

UL1 accounted for eight occurrences of the eighteen did not influence codes: seven were from the interviews with the PI and surrogate entrepreneur who both thought
the policies had no influence on their decision to pursue a spinoff. The final occurrence was from UL TTD who suggested that the experience the university gained from this project would encourage the university to favour licences over spinoffs in the future. This was because he felt most academics were not skilled enough to overcome the managerial knowledge gaps necessary to start a new company, and that a licence agreement was therefore a more sensible option.

The remaining projects all decided on a spinoff or licence before starting their projects, and said the universities’ policies did not affect their decisions.

8.5.2.1 Discussion on the influence of policies on spinoff or licence

The two clusters evident in the data can be thought of as the users and owners of the policies, with the data showing a clear contrast between their views. This conflict raises an interesting question as to whether the TTO were acting as bureaucrats who rigidly implemented policies, or entrepreneurs that encouraged academics to spinoff their research. From the data it would appear that the academics certainly believed the TTO were bureaucratic. These results support the survey findings that indicated that the academic knowledge of their university’s policies, and how the TTO implemented them was related to their decision to opt for a licence or a spinoff or licence. This observation will be developed further in Section 8.6.

The level of support provided to all six academics was low, and both TTOs said they were prepared to let anyone who showed an interest to commercialise their research, regardless of the merit in the proposal. This was evidence of the low-selective-low-support model described in Section 2.4.3.3. The problem with implementing this in UL and TCD was that the model was only appropriate where industry actively pursued universities for research they could commercialise. This was not the case with either UL or TCD, so they were running an inappropriate model as defined by (DeGroof and Roberts, 2004).

8.5.3 Summary

Both UL and TCD claimed they supported commercialisation, but both ran models associated with highly entrepreneurial environments, when the environment demanded more supportive models. This was evidence of how their actions were misaligned with their policies. As a result, the academics pursuing spinoffs and licences did not get the levels of support they needed. The universities both left it to the academics to find their own funding and supports, and in the case of UL1 to get their own legal advice, and to find their own offices.
8.6 Role of the TTO

The second section of this analysis deals with the variables grouped under the heading role of the TTO. As in the previous section, each variable making up the factor was categorised on a scale of one to three in Table 8.4 (developed from the coding template). The labels are added once more for ease of discussion.

Adequate refers to those TTOs that had the necessary resources and skills to aid the academics in their commercial activities. Limited refers to those who could offer some supports, but not always those required. Inadequate refers to those where the necessary resources or skills were not available to the academics.

Table 8.4 Categorisation of the role of the TTO

<table>
<thead>
<tr>
<th>Variable / Categorisation</th>
<th>Adequate</th>
<th>Limited</th>
<th>Inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTO size</td>
<td>Adequate by the size of the research funding and investment from the university</td>
<td>Growing the staff levels but relying still on outside sources of finance to do so</td>
<td>Low staff levels and run on overheads from research</td>
</tr>
<tr>
<td>TTO Experience (marketing)</td>
<td>TTO staff are experienced (years on the job, or number of cycles completed)</td>
<td>TTO has limited experience or experience in different area</td>
<td>TTO does not have relevant experience (years on the job, or number of cycles completed)</td>
</tr>
<tr>
<td>TTO Experience (technology and patenting)</td>
<td>TTO staff are experienced (years on the job, or number of cycles completed)</td>
<td>TTO has limited experience or experience in different area</td>
<td>TTO does not have relevant experience (years on the job, or number of cycles completed)</td>
</tr>
<tr>
<td>TTO Structure</td>
<td>Department of University</td>
<td>For Profit company</td>
<td>Not for profit company</td>
</tr>
</tbody>
</table>

Using these categories, Table 8.5 was constructed to show where evidence existed in each of the six cases relevant to a categorisation. UL was rated as inadequate. However, TCD was rated as adequate by TCD2 and TCD3 and inadequate by TCD1. Examining the data in more detail it appears that TCD1 had more interaction with the TTO than the other projects, so the data from this project was given more weight in the analysis.

The data placed both TTOs in the lowest category in Table 8.5. As such, the issue that needed to be examined was whether the TTOs acted as bureaucrats or entrepreneurs, and if this influenced the commercialisation of a project or not. Certainly the categorisation of both TTOs using the case data suggested that both were bureaucratic. The following sections discuss each of the variables that made up the Role of the TTO factor.
Table 8.5 Categorisation of variables by project

<table>
<thead>
<tr>
<th>Project / Categorisation</th>
<th>Adequate</th>
<th>Limited</th>
<th>Inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1</td>
<td>TTO experience (technology and patenting) – good</td>
<td>TTO experience (marketing) – modest</td>
<td>TTO size – inadequate</td>
</tr>
<tr>
<td>UL 2</td>
<td>TTO experience (marketing) – good</td>
<td>TTO size – inadequate</td>
<td></td>
</tr>
<tr>
<td>UL 3</td>
<td>TTO experience (marketing) – modest</td>
<td>TTO experience (technology and patenting) – poor</td>
<td></td>
</tr>
<tr>
<td>TCD 1</td>
<td>TTO experience (marketing) – modest</td>
<td>TTO size – inadequate</td>
<td>TTO experience (technology and patenting) – poor</td>
</tr>
<tr>
<td>TCD 2</td>
<td>TTO experience (marketing) – good TTO experience (technology and patenting) – good</td>
<td></td>
<td>TTO size – inadequate</td>
</tr>
<tr>
<td>TCD 3</td>
<td>TTO experience (technology and patenting) – good</td>
<td>TTO Size - growing</td>
<td></td>
</tr>
</tbody>
</table>

8.6.1 TTO size

The number of times the different codes associated with the size of the TTO occurred in the interviews were recorded in Table 8.6. There were eighteen occurrences of the codes in total: thirteen which rated the TTO size as *inadequate* the remaining five rated it as *limited*.

Table 8.6 Number of Times Role of the TTO codes appear in interview data

<table>
<thead>
<tr>
<th>Factor</th>
<th>Adequate</th>
<th>Limited</th>
<th>Inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTO size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTO Experience (marketing)</td>
<td>3</td>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>TTO Experience (technology and patenting)</td>
<td>8</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>TTO Structure</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ten of the thirteen occurrences of the *inadequate* codes were shared between projects that attempted a spinoff *UL1* (three) and *TCD1* (seven). These data suggested that where the TTO was required to do more work to commercialise the project, it became apparent that the TTO were understaffed. The higher number of occurrences from *TCD1* may indicate that *TCD PI1* placed some of the blame for his failure to commercialise the project on the TTO, and its lack of resources.

8.6.1.1 Discussion on TTO size

From the data it was clear that all the interviewees (academics and TTO staff) believed the TTOs were under resourced and constrained with respect to
providing the supports required to realise a spinoff or licence. There was strong evidence that the TTOs were run along the low-selective-low-support model (DeGroof and Roberts, 2004), and that the lack of support from the TTOs prevented academics commercialising their research.

O'Shea, Allen et al. (2005) said it was the role of the TTO to help the academics overcome their own knowledge gaps by providing access to training, and introducing them to sources of finances. The patterns in the data support the earlier findings from the survey, discussed in section 5.4.2.4, that the size of the TTO impacted on its ability to provide the necessary supports. As there appeared to be bigger gaps (e.g. managerial) to overcome in starting a spinoff than generating a licence, the resource constraints of the TTO may have a greater negative impact on the academic trying to set up a spinoff than one pursuing a licence.

Given the lack of resources available within the TTOs, it would be natural to have assumed that the number of attempted licences would be greater than the number of attempted spinoffs, as the work required to overcome the gaps in the licensing situation was less than that required for a spinoff. This assumption also fitted the international norm where licensing was the more common route to commercialisation (Lockett, Siegel et al., 2005). However, the survey previously indicated that the size of the TTO was related to the choice of spinoff or licence by the academic, and in this research the number of attempted licences was lower than the number of spinoffs, both in the six cases and the whole population. This may suggest evidence of a low hanging fruit phenomenon given the short history of the ATRP.

In summary we saw that all the actors agreed the TTO were under resourced, and that this lack of resources meant that other actors had to intervene to compensate for the TTOs lack of resources. If they did not, a gap was unlikely to have been closed, resulting in no commercial outcome.

8.6.2 TTO experience: Marketing
In total there were ten occurrences of the codes associated with the TTO's marketing experience, three of which suggested the TTO had adequate experience, five which suggested the staff had limited experience, and two which suggested the staff had inadequate experience. However, there were no patterns in data to associate them with an institution or commercial outcome.

8.6.3 TTO experience: Patenting & technology
The number of times the codes associated with the TTO's patenting and technology experience occurred is shown in Table 8.6. There were fifteen occurrences of the
codes, eight of which suggested the TTO had *adequate* experience, one suggested the TTO had *limited* experience, and six suggested they had *inadequate* experience.

Looking for patterns in the case data I found that the two projects in the medical sector (*TCD1* and *UL3*) both rated the TTO’s experience as *inadequate*, while the other two unsuccessful projects (*TCD2* and *TCD3*) rated the TTO experience as *adequate*. The two projects in the medical sector were also different as they initially attempted to get investment for a spinoff, while the other two projects were focused on licensing.

These data suggested that while the TTOs were experienced in protecting IP (via patents) that they were not as experienced in certain technology areas, such as the medical sector. As a result, where the academics believed the TTO did not understand the nuances of starting a company in that industry, the academic opted for a licence instead.

### 8.6.3.1 Discussion on TTO experience

While universities were capable of generating IP, they typically lacked the resources and capabilities to commercialize that IP according to Wright, Vohora et al. (2004). The data from the cases concurs with this finding as it showed that the academics did not think the TTOs had the experience necessary to understand, or market their technology.

Cunningham and Harney (2006) found that universities typically appointed Technology Transfer Officers with strong industrial backgrounds. This was not the case in any of the Irish TTOs. In all cases, the TTO were originally staffed with personnel moved from other internal roles who had little or not previous technology transfer experience. This helps to confirm the academics’ views of the TTO staff.

Whether this lack of experience influenced the academics’ choice of spinoff or licence is open to debate. As we saw earlier, the academics appeared to choose their route to commercialisation before the projects started, so it was not possible to determine whether the experience of the TTO influenced their choices.

The analysis showed that it was plausible that the lack of TTO marketing experience may have had a negative influence on their ability to generate a licence, something that was suggested by the survey results. If this were the case, we would have expected to see that the academics had to rely on their own social networks, which was the case. As we saw from the interview with *UL PM2,*
the TTO provided no assistance in attracting potential licensees to view the technology. That work was done by the surrogate entrepreneur who used his contacts with local industry to set up meetings, 54 in total.

Similarly, the literature suggested that when the TTO had patenting experience they opted for the licensing route, as it was the easier route to commercialisation. However, strong patents were also necessary for technology based spinoffs. So in this respect, the lack of experience by the TTO may have had a detrimental affect on the realisation of both spinoffs and licences.

8.6.4 TTO Structure

UL and TCD both operated TTOs that were offices within a larger department, while neither showed evidence of an internal organisation structure. As a result I could not compare them to the internal organisation structures Cunningham and Harney (2006) found in the US universities they studied.

It is reasonable to assume that the structures of the TTO will adapt and mature over time, as they did in the US. So an analysis of the structures by future research may provide more insight into the influence the TTO structure has on commercialisation from Irish universities.

8.6.5 Supports from the TTO

The number of times the different codes associated with the supports from the TTO occurred is shown in Table 8.7. There were fifty occurrences of the relevant codes, which in itself demonstrates the importance of support from the TTO. Twenty one occurrences of the codes suggested the TTO provided adequate supports, twenty of which suggest the supports had a positive influence on commercialisation, while the other suggested they were negative.

Table 8.7 Adequacy of TTO Support

<table>
<thead>
<tr>
<th>Factor</th>
<th>Adequate</th>
<th>Limited</th>
<th>Inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academics availing of supports from incubator</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Academic's understanding of process of commercialisation</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Support on offer from TTO</td>
<td>21</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td>TTO communicates policies</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Avails of external supports</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Role of Enterprise Ireland</td>
<td>21</td>
<td>9</td>
<td>13</td>
</tr>
</tbody>
</table>
There were a further twenty three occurrences of the *limited* codes, two of which suggested a negative impact on commercialisation. The other twenty one suggest the supports had a positive influence. Finally, there were eight occurrences of the *inadequate* codes, only one of which suggested this had a positive impact on the commercialisation of research.

Ten occurrences of the *adequate* codes were from the TTO staff (seven from TCD and three from UL). As such, half of the occurrences of the codes came from the TTO the other half came from the project team members. Although both sets of actors had similar views of the supports from the TTO, this did not imply that the TTO always provided adequate supports to the academics.

Four of the eight occurrences of the *inadequate* codes were from UL1. Only two of the nine codes associated with UL1 suggested the TTO offered adequate support. The remaining three occurrences suggested the TTO offered limited supports.

On the other hand, TCD1 accounted for eleven of the *adequate* supports, three of the *limited* supports and only one of the *inadequate supports*. Eight of these codes were from comments made by the TTO staff, seven of which suggested they offered adequate supports.

Taking these data at face value, the frequency of occurrences suggests that the TTO at the two institutions offered adequate supports to academics wishing to commercialise their research. However, the academics that successfully commercialised their research thought that the supports on offer were limited, and when available were at the basic end of the scale.

### 8.6.5.1 Discussion on supports on offer from the TTO

The results of the survey, discussed in section 5.4.3, indicated that the level of supports on offer from the TTO influenced the creation of a spinoff or licences. However, the analysis of the case data found that it was possible to commercialise research without support from the TTO, although it was much more frustrating and difficult for the entrepreneur to do so.

There was a growing recognition in the literature that the TTO could help to prepare the spinoff for future investment by providing training to the academic to overcome the knowledge and entrepreneurial gaps, and early stage finance to overcome the financial gap (Jensen and Thursby, 2001). The TTO could also help expand the academics' social network by introducing them to other suppliers of non financial supports.
As we saw earlier, the TTOs in TCD and UL operated low-selective-low-support models. However, it was hard to tell whether this strategy was purposeful, or if it is because of the lack of resources available to the TTO. To understand which of these explanations was accurate, I looked at the sources of funding in both TTOs. From the data collected in the interviews with the TTO staff, and the documentary data available on each TTO, I found that both were primarily funded from external overheads (from SFI and Enterprise Ireland). As such the low-selective-low-support model was forced upon the TTO (by university funding priorities) rather than being part of their predefined strategy.

Since 2007 Enterprise Ireland provided the €35million TTSI fund (2007-2011) to improve the capabilities of the TTOs in all third level institutions. However, this money (provided over a five year period) did not require matching funding from the institution. As a result it did nothing to change the internal funding strategies of the universities with respect to commercialisation, as it did not force the senior management of the university to consider whether they wanted to invest in commercialisation in order to receive funding from Enterprise Ireland.

The analysis of the data also showed that the teams from UL generated the spinoff and licence without support from the TTO. In both cases the only interactions they had with the TTO were to agree the terms of the licence.

By contrast the TTO director in UL believed he provided excellent support to both teams. This data showed a clear conflict of opinions between the promoters and the TTO. This suggested the promoters thought the TTO were bureaucratic and inflexible, while the TTO believed they were proactive and flexible.

8.6.6 TTO communication and academic awareness of policies

There were ten occurrences of the codes associated with academics’ knowledge of universities’ policies on commercialisation (see Table 8.7); two suggested the academics had an adequate knowledge of the universities’ policies, three suggested the academic had a limited knowledge, while the remaining five all suggested the academic had an inadequate understanding of the universities’ commercialisation policies.

Two of the occurrences of the limited codes were from UL PI1 who successful set up the spinoff company. Similarly, four of the five occurrences of the inadequate code were from UL PI2 and UL PM1 who generated the successful licence from UL. This showed that the PI did not need to know about the policies to commercialise their
research. All six of these occurrences also suggested a negative impact on commercialisation.

8.6.6.1 Discussion on TTO communication & academic awareness of policies

As UL1 and UL2 were commercialised with the help of surrogate entrepreneurs, the patterns in the data suggest that the academics' lack of knowledge did not have a negative influence on the commercialisation of research, or the choice of route to commercialisation.

The survey results presented in section 5.4.1.2 indicated that both the academic's awareness of, and the manner in which the TTO communicated its policies, influenced the decision to pursue a spinoff or licence. As there were no occurrences of the codes in the data from the interviews I needed to find an alternative source of data in the cases to investigate if the survey finding could be supported. As we saw in the last section, the academics who commercialised their research had a poor or limited knowledge of the universities' policies on commercialisation. I used this finding and extrapolated it to investigate how effective the TTO were at communicating their policies. From this analysis I had to conclude that they were not effective, and that the policies were not being communicated to the academics.

From the analysis of the data we also saw that the awareness of the TTO policies, and by extension the effectiveness by which the TTO promoted them, had no influence on commercialisation. The data showed that the promoters of UL1 and UL2 (both surrogate entrepreneurs and academics) had no knowledge of their institution's policies on commercialisation at the start of their respective projects. Neither did they learn about these policies during the project, as all said they still had very little knowledge of the policies at the end of their projects.

One explanation for this was that the surrogate entrepreneurs chose to ignore the university's policies, or used the absence of certain policies to their own benefit. It was evident that both surrogate entrepreneurs knew what they wanted to do in terms of commercialisation, and engaged with the university only when they had to. In that sense they may have manipulated the lack of policies to their advantage.

Of course, this lack of engagement between the promoters and the TTO staff could also be attributed to the lack of resources. In the case of the spinoff there were too many instances where the interaction with the TTO frustrated the
surrogate entrepreneur and delayed the project. *UL SE1* found that once he identified an investor, the TTO did not share his sense of urgency in agreeing the licence deal, which nearly killed the project.

In a similar manner, *UL PM2* did the commercial work in *UL2* and only went to the TTO to ensure they were happy with the terms he was proposing to the licensee. This suited the TTO, as they did not have to do any work negotiating the licence.

The second possible explanation was that the universities did not have well defined or well communicated policies on commercialisation. This was difficult to accept as in each institution there were other PIs who claimed to have a good knowledge of their universities' policies. Although, this knowledge did not appear to help to commercialise their research.

This shows that it was not necessary to have an awareness of the universities' policies to commercialise research. Knowledge of the policies did not help to overcome the gaps in the process; rather it was the level of support that the policies provided that influenced the closing of the gaps.

### 8.7 Presence of unexpected phenomena

When coding the data from the interviews it became clear that two other phenomena relating to the commercialisation process were mentioned consistently by the interviewees. The first was whether the academic availed of any external supports. The second was the role played by Enterprise Ireland in the process of commercialisation.

#### 8.7.1 Availing of external supports

This variable was used to describe the levels of external support the academics availed of in attempting to commercialise their research. The variable was categorised on a three point scale shown in Table 8.8, using the coding template as before.

<table>
<thead>
<tr>
<th>Variable / Categorisation</th>
<th>Proactive</th>
<th>Neutral</th>
<th>Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availing of external supports</td>
<td>Avails of the supports externally</td>
<td>Avails of some supports</td>
<td>Not availing of supports from the incubator</td>
</tr>
<tr>
<td>View of Enterprise Ireland / government policies</td>
<td>Positive</td>
<td>Neutral</td>
<td>Negative</td>
</tr>
</tbody>
</table>
Categorising the data then in Table 8.9, I found that UL PI3 regularly availed of external support in an attempt to commercialise his project. UL1, TCD2 and TCD1 availed of some external supports, while the remaining two projects (UL2 and TCD3) did not avail of any external supports. This suggested that in an attempt to commercialise their research, the academics looked outside the university when they were unable to get the necessary support internally. It also implied the existence of a skills gap within the university that could only be overcome with external support. This highlighted the importance of strong social links to access the necessary resources.

<table>
<thead>
<tr>
<th>Variable / Categorisation</th>
<th>Proactive</th>
<th>Neutral</th>
<th>Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availing of external supports</td>
<td>UL3</td>
<td>UL1, TCD1, TCD2</td>
<td>UL2, TCD3</td>
</tr>
<tr>
<td>View of Enterprise Ireland / government policies</td>
<td>Positive</td>
<td>Neutral</td>
<td>Negative</td>
</tr>
<tr>
<td></td>
<td>UL3, TCD1, TCD2</td>
<td>UL2, TCD3</td>
<td>UL1</td>
</tr>
</tbody>
</table>

There were nine occurrences of the codes associated with the academic availing of supports external to their institution, six of which were seen to have a positive impact on commercialisation. Typically these supports were from external consultants who were hired on an as needs basis to fill skill gaps in the team.

Six of the codes were linked with projects that failed to commercialise their research; however, the other three were linked with UL1. This suggests that although not a prerequisite for success, the availability of external supports could help close the gaps.

8.7.1.1 Discussion on availing of external supports

Di Gergorio and Shane (2003) and Clarysse and Moray (2004) found that the availability of external resources played a significant role in encouraging or preventing academic entrepreneurial activity according to. The implication from this was that the TTO staff could aid the academics’ attempts to commercialise their research by sourcing external supports, and more importantly paying for them.

The survey data did not support this finding. However, from the case data, I found that UL1 did avail of external supports, but not in the manner alluded to by the literature. The spinoff had to employ their own legal agents to negotiate the licence deal with the TTO, and the investment from the VC. This was advice that they also paid for from their own funds, something the literature did not recognise.
On the other hand, the TTO staff in Trinity said that they recommended external supports to a number of academics, and where necessary paid for that advice (this is debateable as the C+ funds were provided for this purpose). However, when the academics' technology was not sufficiently well developed to ensure it was commercialised, the presence, or absence, of external support was not a distinguishing factor in their failure to commercialise their research. So regardless of how much external support was available, if the technology was not market ready there was little external support could do to overcome this.

8.7.2 Emerging role of Enterprise Ireland

The academics' view of Enterprise Ireland presented me with information on what the academics thought of the supports received from Enterprise Ireland. It was also a valuable surrogate for the academics' views of government policies. The academics' views were also categorised on a three point scale shown in Table 8.9.

Enterprise Ireland played two roles in the commercialisation of applied research, as both a source of funds and the implementer of government policy. There were twenty one occurrences of the codes associated with the role of Enterprise Ireland being seen as positive, nine where the role was seen as neutral (three of which had a negative impact on commercialisation), and thirteen where the role of was seen as a negative.

Nine of the fourteen negative occurrences were from UL1 which suggested that dealing with Enterprise Ireland was not a good experience. Six of these nine data points came from UL SE1 whose task it was to get agreement with UL, and by extension approval from Enterprise Ireland. The other three were from UL TTD who dealt with Enterprise Ireland on the university's behalf. These data show that both thought the Enterprise Ireland approval process put barriers in front of the team trying to commercialise their research.

Three other occurrences of the negative codes were linked to TCD PM1, who thought that the people from Enterprise Ireland who were appointed to help him did not have the necessary experience, as they had never commercialised a research project themselves.

Seventeen of the positive codes were linked to the financial supports on offer, specifically the additional financing provided via the C+. The other three reflected the personal support the team received from the Enterprise Ireland Commercialisation Specialists based in their institutions.
The patterns in these data suggested that the financial supports from Enterprise Ireland were an important factor in the process of commercialisation. However, the other role played by Enterprise Ireland, as implementer of government policy, was seen as restrictive. The promoters of UL1 thought the policies and procedures implemented by Enterprise Ireland hindered their commercial efforts, and impacted negatively on their ability to attract VC investment.

The members of UL2 thought the role of Enterprise Ireland had a neutral affect on their attempts to commercialise, as did TCD PI3 who did not attempt any commercialisation activities. The remaining three projects that generated no commercial outcome had a positive view of the role played by Enterprise Ireland.

**8.7.2.1 Discussion on the emerging role of Enterprise Ireland**

The survey had not predicted that Enterprise Ireland played a key role in the process. However, the analysis of the case data showed that the various actors interviewed had positive views of the C+ funding provided by Enterprise Ireland, as it gave the projects additional funding to fill the financial gap between the end of the ATRP and either receiving VC investment, or doing the licence deal.

As the C+ was a top up fund, and was contracted between the university and Enterprise Ireland, the money could not be used to fund any company specific activities, as that would have been direct (100%) state aid to the company, which was prohibited under EU legislation. UL SE1 thought the rules of the C+ were too restrictive and thought that Enterprise Ireland was too bureaucratic in the operation of the C+. He would rather have complete flexibility in how the money was spent.

Enterprise Ireland also provided non-financial supports to the projects, which included access to market reports and market data via the Client Knowledge Services department, or specialist advice from the local Commercialisation Specialist. UL PM1 was very complementary of the non-financial assistance they received. Similarly, the TCD TTO were complementary of the marketing and other non-financial supports, but TCD PM1 was highly critical of the support from Enterprise Ireland.

TCD PM1 said none of the Enterprise Ireland staff he met had commercialised a project themselves, and as such their titles of Commercialisation Specialists / Managers were misleading. This may have been true but it was more likely that he was attempting to apportion some of the blame for the project failure on Enterprise Ireland. As shown earlier, he lacked basic business skills and did not
always take advice when it was offered. As a result it may have been easier from him to blame someone else than to admit the project was unsuccessful because he and the other team members had not the necessary skills to succeed.

8.7.3 Summary
The analysis of the data on the institutional level factors confirmed the presence of the gaps, and showed how the university in particular could help to overcome them. It helped confirm the findings of the survey, while adding clarity to areas of the model where the survey was silent. It showed that while the university could help overcome gaps in the process that others actors could (and did) take on this role in the absence of support from the university.

The next section of this chapter continues the cross case analysis by comparing and contrasting the findings of the individual cases. However, before doing this it is necessary to discuss the boundaries used in the analysis first.

8.8 Four scenarios of commercialisation
To explain the analytical boundaries used in this next section, I use Figure 8.2 through to Figure 8.7 explain the time lines associated with the six projects. As the unit of analysis in this study was the ATRP / CFTD project, it was plausible to consider that the time frame to be analysed was simply the period during which a project was funded through the scheme. However, to narrow the analysis to this time frame would be to ignore the important events that happened outside this period.

Prior to the funding of the project, the PI first had to make a successful application to Enterprise Ireland in which he/she articulated a unique superior idea with commercial potential. If the proposal failed to articulate a unique idea, or could not demonstrate a market opportunity, then it was not funded. Therefore, the early identification of a market opportunity was a necessary step in the commercialisation process.

Similarly, the date at which the approved project funding ceased may not have been the date when the spinoff was ready to be incorporated, or the licence signed. Enterprise Ireland recognised this issue, and introduced a top up fund called the C+ that was made available (by invitation only) to those projects that Enterprise Ireland thought additional short term funding would help overcome the final barriers to commercialisation. The following figures show the time lines for each of the six projects.

Project UL1 was funded by the ATRP in 2002 for a three year period. Upon completion of the project, the team received additional funding via the C+ to allow them to
pursue a spinoff. The spinoff was incorporated at the end of the C+ in 2006, (see Figure 8.2).

Figure 8.2 Timeline of UL1

Project UL2 was funded by the CFTD in 2003 for a two and a half year period. It did not receive any additional funding once the project the completed. The licence agreement was signed shortly after the completion of the project, (see Figure 8.3).

Figure 8.3 Timeline of UL2

Project UL3 was also funded by the CFTD in 2003 for two years. The PI received C+ funding upon completion of the CFTD; however, twelve months after the completion of the C+, no commercial outcome had been achieved, (see Figure 8.4).
Project TCD1 was funded by the ATRP in 2002 for three years. The promoters received C+ funding on completion of the CFTD; however, twelve months after the C+ ended the project had generated no commercial outcome, (see Figure 8.5).

Project TCD2 was funded by the CFTD in 2003 for two years. No additional funding was provided after the CFTD funding ended, and twelve months after the completion of the CFTD the project had generated no commercial outcome, (see Figure 8.6).
Project TCD3 was funded under the ATRP in 2001 for three years, and again by the CFTD in 2005. As the initial ATRP was used as a Proof of Concept, it generated no commercial outcome. At the time this research was conducted, the CFTD had not generated a commercial outcome either, (see Figure 8.7).

8.8.1 Differences between the four scenarios

In my conceptual model, I proposed the existence of four scenarios (as shown in Figure 8.8) where the gaps that needed to be overcome differed. The existence of the different scenarios was borne out by the survey results that showed differences between the gaps in generating a spinoff or licence. The analysis of the six cases in Chapters 6 and 7 also highlighted differences pre- and post- the realisation of a spinoff or licence. So to aid the cross cases analysis, I use these four scenarios to compare and contrast the findings from the six individual case reports.
The arrows in Figure 8.8 represent how the gaps change and differ between the pre and post scenarios, and also between the spinoff and licence scenario. Each scenario is discussed in turn in the next section. The six cases are included in Figure 8.8 according to the scenario they were associated with.

Figure 8.8 Four scenarios of commercialisation

SPINOFF

Scenario A
UL1, TCD1, UL3

Scenario C
UL1

Scenario D
UL2, TCD2, TCD3

Licence

The cross analysis takes place in two parts. The first looks at the four individual scenarios, while the second compares and contrasts projects between the different scenarios as shown by the arrows in Figure 8.8.

8.8.2 Scenario A: Pre-spinoff

Projects UL1, UL3 and TCD1 each attempted to generate a spinoff so they were used as the source of data for this scenario. In the individual case reports, Tables 6.3, 6.5 and 7.2 summarised the interventions taken by the actors in each project. It was evident from Table 6.3 that the various actors in UL1 provided adequate support to overcome the four gaps, and as a result the project generated a spinoff.

The PI and SE used their contacts with industry, and feedback from the VCs to overcome the idea uniqueness gap. Government provided the initial funding and top up funding via the ATRP & C+. The promoters then invested their own money while waiting for the VCs to provide the initial seed investment. All five actors provided assistance in closing the knowledge gap, while the presence of the SE overcame the entrepreneurial gap.

In contrast, looking at UL3 (Table 6.5) and TCD1 (Table 7.2) we saw that many of the gaps were not addressed, or only partially addressed by the actors. In TCD1 the idea uniqueness gap was not addressed by any of the actors (including the PI), while in UL3 the VCs did not consider the technology unique, and were not prepared to invest in a spinoff to close the funding gap. As a result of the failure to close some of the gaps, UL3 and TCD1 generated no commercial outcome.
8.8.2.1 Actor interventions: pre-spinoff

Table 8.10 was constructed to present a generic set of actor-gap interventions that when present in the project could overcome the gaps in the pre-spinoff scenario.

Table 8.10 shows that to overcome the idea uniqueness gap, industry and the financial institutions had to provide feedback to the promoters on market opportunities, and the uniqueness of their technology. However, to gather this data, the PI had to engage with industry and or the financial institutions.

Table 8.10 Actor interventions to close gaps: pre-spinoff

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>ATRP type programme: €400k + top up 3 years + extension Conditions: attempt commercialisation Patent support</td>
<td>Customer Feedback</td>
<td>Engage with market</td>
<td>Training</td>
<td>Feedback focuses idea</td>
</tr>
<tr>
<td>Funding</td>
<td>Enterprise Ireland supports: marketing, training commercialisation specialists</td>
<td>Market pull, Surrogate entrepreneur</td>
<td>Previous commercial experience</td>
<td>TTO supports: Training, marketing, consultancy</td>
<td>Feedback on market</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Enterprise Ireland supports overseas and regional offices, commercialisation specialists</td>
<td>Personal commitment, Social capital</td>
<td>TTOs external network</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To overcome the initial funding gap, Government had to provide significant funding to the PIs, but not all of this needed to be up front. The money could be provided in phases depending on the progress towards commercialisation demonstrated by the PI, and whether further funding from the financial institutions had been secured. Government funding was provided with explicit conditions on how it could be used, the first being that the PI attempted to commercialise their technology. The financial institutions also set conditions on the use of their funds, typically based on achieving sales targets.

The various elements of the knowledge gap were closed by the different actors. The TTO had to provide marketing and managerial training where appropriate, while government needed to provide funding to ensure that the TTO were capable of providing these supports. Where the PI did not have the necessary commercial skills, then the TTO or an SE had to provide the required knowledge.
Government could also help overcome the knowledge gap through the supports offered via individuals such as the Enterprise Ireland Commercialisation Specialists.

Finally, the PI needed to be committed to the creation of the spinoff throughout the commercialisation process. They had to demonstrate this commitment frequently to ensure the other actors engaged with them, and they used their social links (also called social capital) to establish links with the other actors. Where the PI did not have the skills to realise a spinoff, they used their social capital to build a team that did. This often included taking on an SE to act as CEO of the spinoff.

8.8.2.2 Modelling the pre-spinoff scenario

Figure 8.9 was developed using the findings from each of the three projects presented in Figure 6.2, Figure 6.8 and Figure 7.2, which show that four potential gaps existed in the pre-spinoff scenario: 1) funding, 2) knowledge, 3) entrepreneurial and 4) idea uniqueness. Figure 8.9 also shows that five actors influenced the process of generating a spinoff: 1) government, 2) financial institutions, 3) industry, 4) the university and 5) the principal investigator. The actors' roles were to help overcome the gaps that existed pre-spinoff.
The outer blue boxes show the five actors whose interventions helped close the four gaps, represented by the inner green boxes. These gaps were made up of different elements as shown by the smaller internal boxes. The large box that contains the gaps represents the projects in which the gaps materialise. The arrows from the actors to the large box represent the interventions by the actors to close the gaps. The bidirectional arrows between the actors show that the intervention of one actor could have an impact on all other actors, not just those adjacent to them. The bidirectional arrows between the gaps also show that the closing of one gap had a potential impact on all the others, not just those adjacent to it.

For example, where VC funding was not forthcoming, a funding gap grew that Enterprise Ireland could close via the C+. Similarly, when the university did not have the expertise to provide the necessary support, a knowledge gap existed that was closed by an external consultant hired via the C+. This interaction between actors was consistent with the assertion that in the Triple Helix actors played different roles at different times, and in certain circumstances assumed different roles (Etzkowitz, 2003).

Figure 8.10 was created by combining Figure 6.3, Figure 6.8 and Figure 7.3. Figure 8.10 shows that the degree to which the gaps were closed determined whether a spinoff was realised or not. If any of the four gaps were not sufficiently closed, then a spinoff was not realised.

Figure 8.10 Degree of closure influences spinoff creation
Figure 8.10 identified that 1) the absence of an idea that displayed market opportunity or, 2) the lack of funding to support the commercialisation of a research project or, 3) insufficient knowledge within the university or research team or, 4) the absence of an entrepreneur, impacted (both individually and collectively) upon commercialisation. Also the degree to which the gaps were closed influenced which commercial outcome occurred, i.e. spinoff or licence.

8.8.3 Scenario B: Pre-licensing

As in the previous scenario, the two cases (UL2 and TCD2) who attempted to generate spinoffs were used to understand the pre-licensing scenario. The analyses of the two cases were presented in Table 6.4 and Table 7.3 to summarise how the actors helped overcome the individual gaps in each project.

Table 6.4 showed that the various actors in UL2 provided adequate support to overcome the four gaps, and as a result the project was successful in generating a licence. The PM used his contacts and various meetings with industry to overcome the idea uniqueness gap. As in the pre-spinoff case, government provided funding via the ATRP / CFTD. Government and the TTO provided assistance is closing the knowledge gap, while the presence of the PM acting as an SE overcame the entrepreneurial gap.

Table 7.3 also showed that in project TCD2 the PI used feedback from industry to overcome the idea uniqueness gap. As in the other cases, government provided the initial investment to overcome the funding gap. The PI used his social capital to overcome the knowledge gap, rather than relying on the TTO. The use of his social capital also helped to close the entrepreneurial gap. However, as described in the individual case report, an error in the filing of the patent led to delays of over a year in the negotiation of the licence, so the company lost patience and pulled out of the deal.

8.8.3.1 Actor interventions: pre-licensing

Table 8.11 was constructed to present a generic set of actor-gap interventions that when present in the project could overcome the gaps in the pre-licensing scenario.

Table 8.11 shows that as in the pre-spinoff scenario, to overcome the idea uniqueness gap, industry had to provide feedback to the promoters on market opportunities and the uniqueness of their technology. However, to gather this data the PI had to engage with industry first.
Table 8.11 Actor interventions: pre-licensing

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>ATRP type programme: €400k + top up 3 years + extension Conditions: attempt commercialisation Patent support</td>
<td>Customer Feedback</td>
<td>Engage with market</td>
<td>Applied for ATRP / CFTD funding</td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Enterprise Ireland supports: marketing, training commercialisation specialists</td>
<td>Market pull Surrogate Entrepreneur</td>
<td>Previous commercial experience</td>
<td>TTO supports: Training, marketing, consultants</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Enterprise Ireland networks Overseas and regional offices, commercialisation specialists</td>
<td>Personal commitment Social capital</td>
<td>TTOs external network</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To overcome the funding gap, Government had to provide significant funding to the PIs, but not all of this needed to be up front. The money could be provided in phases depending on the progress towards commercialisation demonstrated by the PI. These funds were provided under the same conditions as in the pre-spinoff scenarios.

The various elements of the knowledge gap were closed by the different actors. The TTO had to provide marketing and managerial training where appropriate, while government had to provide funding to ensure that the TTO were capable of providing these supports. Government agencies also provided support via their own staff, e.g. the commercialisation specialists who provided expertise and guidance to the PIs.

Finally, the PI had to be committed to seeking a licensee for their technology. They needed to use their social capital to establish links with companies who were interested in licensing the technology. Where the PI did not have social capital to achieve this, then the TTO and Commercialisation Specialists provided support, and introduced the PI to local companies.

As in the pre-spinoff scenario, these findings confirm the propositions from the conceptual model that four gaps existed, and that they were overcome by the intervention of five actors. It also confirmed that to realise a licence the gaps had to be closed to a certain extent.
8.8.3.2 Modelling the pre-licensing scenario

Figure 6.5 and Figure 7.5 were amalgamated to develop Figure 8.11. This shows that many of the same gaps existed pre-licensing as did pre-spinoff, and that the same actors had a role to play in closing those gaps. The bidirectional arrows between the gaps and actors show that the interventions taken by the actors in closing of gaps influenced other actors and gaps. Figure 8.11 also shows that the observed gaps evident in the commercialisation process existed under the same four headings that described the pre-spinoff gaps: idea uniqueness, funding, knowledge and entrepreneurship. The degree to which the gaps were closed had an influence on the outcome of the commercialisation process. As mentioned in Section 8.8.2, the same underlying propositions exist.

Figure 8.11 Gaps pre-licensing

The outer box representing the Financial Institutions is missing from this figure as they made no interventions to help close any of the gaps in the pre-licensing cases investigated. The boxes and arrows represent the same actors, gaps and interventions described in Section 8.8.2.2.

As in the first scenarios, Figure 6.6 and Figure 7.6 were combined to create Figure 8.12, which shows that the degree to which the gaps were closed determines whether a licence was generated or not.
The underlying propositions in Figure 8.12 were the same as those in the pre-spinoff scenario.

8.8.4 Scenario C: Post-spinoff

As UL1 was the only project to generate a spinoff, it was the only project to provide data for this scenario. Summarising the post-spinoff data from UL1 in Table 8.12, we see that the all four gaps were successfully addressed, and the company had, at the time of writing, secured over $20 million in external investment, had more than thirty staff, and offices in Ireland, US and Taiwan.

Table 8.12 Summary of UL 1 case

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Company</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea uniqueness</td>
<td></td>
<td>Market feedback</td>
<td>Engage with market</td>
<td></td>
<td>Market feedback</td>
</tr>
<tr>
<td>Funding</td>
<td>Fund of funds to VCs</td>
<td></td>
<td></td>
<td></td>
<td>Second round funding</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-technological</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-managerial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-social links</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-commitment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To overcome the idea uniqueness gap in UL1, industry and the financial institutions provided market feedback to the company to ensure that their
technology remained market focused, thus ensuring the idea uniqueness gap was overcome.

Government continued to provide funding, but in this scenario, the money was channelled via the financial institutions in the form of a fund-of-funds. 4LV provided a loan note as an initial investment, before a significantly higher investment in two subsequent funding rounds.

In helping to close the knowledge gap, Enterprise Ireland assigned a Development Advisor (DA) to work to the company, as well as providing support via the High Potential Start Up (HPSU) department. The university continued to provide access to technology (from which the company took a second licence), while the VC funds were used to hire a sales director.

Finally, the team continued to show the commitment necessary to drive the company forward, and closed the social links element of the entrepreneurial gap.

8.8.4.1 Actor interventions: post-spinoff

Table 8.13 was constructed to present a generic set of actor-gap interventions that when present in the project could overcome the gaps in the post-spinoff scenario.

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Company</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>See funding via fund of fund type schemes</td>
<td>Customer feedback</td>
<td>Engage with market</td>
<td>Feedback focuses idea</td>
<td>VC: seed funding</td>
</tr>
<tr>
<td>Funding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Enterprise Ireland supports : marketing, training, DA assigned</td>
<td>Market pull surrogate entrepreneur</td>
<td>Staff knowledge and experience</td>
<td>Access to technology</td>
<td>Potential to take seat on the board</td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>EI networks, overseas and regional offices, DA assigned</td>
<td>Market feedback</td>
<td>Commitment and building social capital</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.13 shows that to overcome the idea uniqueness gap, industry (potential customer) and the financial institutions needed to provide feedback to the company on what the market would purchase from them.

While the role of Government as the primary funding provider changed post-spinoff, government still had to continue to invest in fund-of-funds schemes to ensure that the VCs invest.
Once again, the various elements of the knowledge gap were closed by the different actors. Government provided support and expertise via Enterprise Ireland staff, while the university provided access to technology. While not evident from the UL1 case, the VCs often asked for a seat on the board which provided access to another source of knowledge.

Finally, the team had to continue to show commitment to the spinoff, and continue to build their social capital to help overcome gaps that might exist in the future. Government agencies such as Enterprise Ireland could help the company to do this by providing access their network of regional and overseas offices.

These findings help to confirm the propositions from the conceptual model that four gaps existed in the post spinoff scenario that were overcome by the interventions of five actors.

8.8.4.2 Modelling the post-spinoff scenario

Figure 8.13 was developed using the findings from UL1. It shows that many of the gaps that existed pre-spinoff also exist post-spinoff. The bidirectional arrows between the gaps and actors show that the interventions taken by the actors in closing of gaps influenced other actors and gaps. As before, there were five actors who influenced the closing of the gap. The PI was not specifically included on realisation of the spinoff, as they were typically no longer involved if they remained in the university, or their role changed from academic to business person if they joined the spinoff. As such, they were replaced by the spinoff company as an actor. The same underlying propositions existed as in the previous two scenarios.

The boxes and arrows represent the same actors, gaps and interventions described in Section 8.8.2.2. As the spinoff had now been generated, the degree of closure diagram was not relevant in the post-spinoff scenario.
8.8.5 Scenario D: Post-licence

As *UL2* was the only project to generate a licence, only the data from that project was used in this scenario. Table 8.14 shows how the five actors helped to overcome the gaps in project *UL2*. From Table 8.14 we see how the four gaps were addressed and that the technology was successfully integrated into the licensee's product. Anecdotal evidence collected after the data collection period showed the product was a market success for the company.

Table 8.14 Summary of UL 2 case

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry</th>
<th>Principal Investigator</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>Market Feedback</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>(match funding was available but not sought)</td>
<td>€50k project with UL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Market knowledge provided product specification</td>
<td>Technological know-how to integrate technology</td>
<td>Technological know-how to integrate technology</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Commitment of owner to drive licence and subsequent project</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post licence, the company provided the information on the *market-need* to overcome the idea uniqueness gap. The company also provided the funding to carry out the
integration project in the university. Government funds were available to support this work, but the company decided not to avail of them.

The various elements of the knowledge gap were closed by the company, PI and university, while the entrepreneurial gap was closed by the company.

8.8.5.1 Actor interventions: post-licensing

Table 8.15 was constructed to present a generic set of actor-gap interventions which when present in the project could overcome the gaps in the post-licensing scenario.

<table>
<thead>
<tr>
<th>Gap / Actor</th>
<th>Government</th>
<th>Industry / licensee</th>
<th>Principal Investigator</th>
<th>University</th>
<th>Financial Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea Uniqueness</td>
<td>Company support schemes: Innovation Partnership, Innovation Voucher</td>
<td>Market feedback</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Funding</td>
<td>Company support schemes: Innovation Partnership, Innovation Voucher</td>
<td>R&amp;D investment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>Enterprise Ireland supports: marketing, training, Development Advisor</td>
<td>Market pull</td>
<td>Access to technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entrepreneurial</td>
<td>Enterprise Ireland networks, overseas and regional offices, Development Advisor</td>
<td>Market feedback</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.15 shows that to overcome the idea uniqueness gap, the licensee had to provide the market opportunity. No other actor played a part in the closing of this gap (unless government legislation provided a new market opportunity).

To close the funding gap the company needed to invest in their internal R&D department. Government could provide access to matched funding via the state agencies to encourage industry to engage with universities. The conditions of the various funding schemes differed according to the level of funding provided. Similarly, the financial institutions could provide funding in the form of loans.

The university had to provide access to the technology to help overcome the knowledge gap. Similarly, Enterprise Ireland provided access to the network of staff and offices to help overcome the knowledge and entrepreneurial gaps, while the company provided expertise via its own staff to close both these gaps.
These findings help to confirm the propositions from the conceptual model that four gaps exist, and that these were overcome by the intervention of five actors.

### 8.8.5.2 Modelling the post-licensing scenario

Figure 8.14 was developed from the data on UL2. It shows that many of the same gaps that existed post-spinoff, also existed post licensing. The circular arrows between the gaps and actors show that the interventions taken by the actors in closing of gaps influenced other actors and gaps. As before there were a number of actors that influenced the closing of the gap. The same five underlying propositions also exist in this scenario.

The outer box representing the Financial Institutions is again missing from this figure as they made no interventions to help close any of the gaps post-licensing. The boxes and arrows represent the same actors, gaps and interventions described in Section 8.8.2.2.

Figure 8.14 Gaps post-licensing

As the licence had now being generated, the degree of closure diagram was not relevant in the post-licensing scenario.
8.8.6 Conclusions

Figure 8.9, Figure 8.11, Figure 8.13, and Figure 8.14 were developed from the analysis of the case data, and show that four gaps existed in the process of commercialisation. They also show that five actors influenced the closing of those gaps.

The survey and case confirmed that four different scenarios existed, while the data showed that the four gaps materialised differently in each scenario. As a result, the interventions by the actors in closing these gaps differed according to the scenario involved. The degrees to which the actors helped close these gaps corresponded with which commercial outcome was generated from the project.

The next section compares the gaps and actor-gap interventions between the four scenarios to identify if patterns and/or differences existed between the different scenarios that impacted on the roles played by the various actors.

8.9 Comparison of the four commercialisation scenarios

The discussion in the preceding section showed that the gaps in the process of commercialisation were different in the four scenarios. It also showed that different actors-gap interventions influenced the closing of the gaps in each scenario. The actors’ ability to influence the gaps varied depending on the scenario. This section discusses how the gaps differed between the four scenarios, and how this impacted on the roles played by the actors in bridging the various gaps.

8.9.1 Scenarios A&B: Pre-spinoff versus pre-licence

The data from all six cases was used to explore the differences between the pre-spinoff and pre-licence scenarios.

8.9.1.1 Differences in the gaps

There were a number of key differences in the gaps pre-spinoff and pre-licence as shown in Figure 8.9 and Figure 8.11. How these differences were evident in the data is discussed below.

- Idea Uniqueness gap. Pre-spinoff and pre-licensing there were no differences as the unique superior idea was shown to be driven by a market opportunity in both. The promoters of the spinoff developed the idea in the pre-spinoff scenario, while the company provided the idea in the pre-licensing scenario.
- Funding gap. Pre-spinoff, the funding requirement was much greater to finance the development of the technology and pay for staff and other related costs. However pre-licensing, the need for additional funding from
financial institutions over and above the funding from the ATRP / CFTD fund was unnecessary. Pre-spinoff, the funding gap was larger than it was pre-licence, so the degree of closure necessary was greater to generate a spinoff in comparison to a licence.

- Knowledge gap. Pre-spinoff, interaction with industry was necessary to identify a market opportunity, whereas pre-licensing the PI had to find a company to licence the technology. The promoters of the spinoff also had to acquire new managerial skills, while the PI who licensed their technology did not.
- Entrepreneurial gap. The promoters of the spinoff had to display enough commitment to set up a company and deal with the gaps as they emerged. The promoters also had to have or develop a network to give themselves access to funding and the market. In the pre-licensing scenario, the entrepreneurial gap was different, and did not call for the same level of commitment from the PI / PM to close it.

8.9.1.2 Difference in actor-gap interventions

Similarly, there were differences in the generic actor-gap interventions required to generate a commercial outcome, as shown in the differences between Table 8.10 and Table 8.11. This section describes the differences in the interventions required by the various actors in the pre-spinoff and pre-licensing scenarios.

- Government. Government funded projects in both scenarios to overcome the funding gap via the ATRP / CFTD. In the pre-spinoff scenario C+ funding was made available where required. Government also encouraged the VCs to invest in potential spinoffs by investing in fund-of-funds.
- Financial Institutions. The financial institutions that helped bridge the gap pre-spinoff had no role to play in funding technology development pre-licence; this was done through the ATRP / CFTD.
- Industry. Industry had a greater role to play in the pre-licensing scenario. Pre-spinoff, industry provided an indication of the competitive environment the actual spinoff would encounter, whereas pre-licensing, industry provided the route to commercialisation by licensing the technology.
- University. The university has more work to do to aid the PI pre-spinoff, than pre-licensing. Pre-licensing, the university provided marketing support to help the PIs attract potential licensees. Pre-spinoff, the TTO worked with the promoters to set up the company, and negotiate a deal with the university to gain access to the technology.
- Principal Investigator. The PI had a greater role to play in the creation of a spinoff than in the generation of a licence. Pre-spinoff, the PI had to show
the commitment necessary to run the business in order to attract external investment. This was not necessary pre-licensing, as industry helped overcome the knowledge gap. The PI also had to overcome the knowledge gap pre-spinoff, or use their social links to attract a surrogate entrepreneur to do so.

8.9.2 Scenarios A & C: Pre spinoff versus post spinoff

There were a number of key differences in the gaps that existed in the pre-spinoff and post-spinoff scenarios, as shown in Figure 8.9 and Figure 8.13. As UL1 was the only project to generate a spinoff the findings in this section were based on the data from that project. How they existed is discussed below. The pre-spinoff data was from the three projects, UL1, TCD1 and UL3.

8.9.2.1 Differences in gaps

The differences in the gaps are discussed under the headings of the four gaps.

- Idea Uniqueness gap. In the pre-spinoff and post-spinoff scenarios the idea uniqueness gap was present and materialised in the same way, i.e. the need for a product that satisfied a market opportunity.

- Funding gap. The funding gap changed significantly post-spinoff, as money was required to run the business, pay staff and other bills so that the business could survive and grow. Pre-spinoff, the UL1 spent well under $1 million over a four year period. Post spinoff, it has secured $20 million in external funding over two and a half years.

- Knowledge gap. The knowledge gaps post-spinoff placed more emphasis on the managerial and management capability, whereas pre-spinoff the emphasis was on the technological and marketing gaps. Post-spinoff, the promoters needed the skills to run the company on a day to day basis, whilst demonstrating marketing knowledge to attract customers.

- Entrepreneurial gap. The need for a social network remained the same pre-spinoff and post-spinoff; however, post-spinoff, the promoters' network was used to generate sales, not just to attract investment.

8.9.2.2 Difference in actor-gap interventions

There were also differences in the generic actor-gap interventions required to generate a commercial outcome, as shown in Table 8.10 and Table 8.13. This section describes the differences in the interventions required by the various actors.
- **Government.** The role of government pre-spinoff was in the promotion and funding of research. Post-spinoff, government's role became more focused on business regulation. In both situations government provided funding to the company, although at different funding rates. Pre-spinoff, the funding was via the ATRP / CFTD and C+, while post-spinoff funding was via programmes such as the Innovation Partnership.

- **Financial Institutions.** The financial institutions were responsible for helping to bridge the funding gap pre-spinoff and post-spinoff. The levels of funding provided differed considerably: €400,000 pre-spinoff versus $20,000,000 post spinoff. The criteria set by the VCs for investing in spinoffs was much more rigorous post-spinoff, as the sums of money were far greater.

- **Industry.** In both scenarios the role of industry was to provide information on the market, to allow the spinoff to develop a product to match the market opportunity. Post-spinoff, industry was also a competitor, so the promoters had to be more aware when marketing their technology to potential customers. Pre-spinoff, the promoters were seen as a group of academics, post-spinoff they were seen as competitors.

- **University.** Post-spinoff, the role of the university in supporting the spinoff and closing the gaps was diminished. Pre-spinoff, the university provided support (generally non-financial) to the promoters, and office space for them to develop their business plan. Post-spinoff, the company had to move off campus, and the same supports were not available from the university. Access to technology was the main link between the spinoff and university post-spinoff.

- **Principal Investigator.** Post-spinoff, the PI typically left the university for the company, and as a result changed role. Their main role was still in helping to overcome the technological gaps. However, due to the small number of staff in the spinoff, they usually carried out other roles that would not have been part of their remit in the university.

**8.9.3 Scenarios B&D: Pre-licence versus post-licence**

There were a number of key differences in the gaps pre-licence and post-licence, as shown in Figure 8.11 and Figure 8.14. As only UL2 generated a licence, the findings in this section were primarily based on the data from this project and how they existed is discussed below.

**8.9.3.1 Differences in gaps**

The differences in the gaps are discussed under the headings of the four gaps.
• Idea Uniqueness gap. Post-licensing, the company licensing the technology played the greater role in determining what unique superior idea was developed from the technology. However pre-licensing, the PI suggested a unique superior idea to the company in the hope of attracting a licence. Whether that idea was founded in a market opportunity was not relevant, as long as the company was interested in licensing the technology. Post-licence it was critical to the company that the idea focused on a market opportunity.

• Funding gap. Pre-licence, the development work was totally funded by the ATRP / CFTD, which was provided by the government. Post-licence, the gap related to the development of the technology into a product, and to the marketing of the new product and other related activities. At this point, the funding came from the company.

• Knowledge gap. The technological knowledge gap was large in both scenarios, although it manifested itself in two distinct fashions. Pre-licence, the gap was in the project team trying to develop the technology. Post-licence, the gap existed in the company who had to transfer the knowledge associated with the technology from the university to their staff. Managerial gaps existed in the company post-spinoff with respect to the means by which the technology transfer took place. This gap did not exist pre-licence.

• Entrepreneurial gap. The entrepreneurial gap was different pre-licence and post-licence in that the social links element of the gap was not present post-licence. Pre-licence, the social links gap existed because the PI has to use their network to attract potential licensees. Post-spinoff this was no longer necessary, so the gap was not present.

8.9.3.2 Difference in actor-gap interventions

There were differences in the generic actor-gap interventions required to generate a commercial outcome, as shown in Table 8.11 and Table 8.15. This section describes the differences in the interventions required by the various actors.

• Government. Government funded the projects pre-licence, and could also fund further development of the technology post-licence via the Innovation Partnership scheme. However, the levels of funding were different (100% pre versus 50-80% post) between the two scenarios due to EU state aid rules.

• Financial Institutions. The financial institutions played no role in either scenario, and only had an input if the company required investment to develop the technology further.
• Industry. Pre-licence the company needed to know enough about the technology to decide whether they could develop a product from it that would fit within their product portfolio. Post-licensing, the company required much greater technological knowledge to allow them to transfer the technology into their company. The licensee also had to overcome the marketing gap to exploit a market opportunity, and had to have the necessary managerial skills to deploy the resources to carry out these actions.

• University. The university helped overcome the marketing gaps pre-licensing and negotiated the terms of the licence, thereby filling the managerial gap. Post-licensing, the role of the university was to ensure the company had access to the know-how after the licence was signed, so that they could effectively transfer the technology and know-how into the company.

• Principal Investigator. The PI was responsible for bridging the technological gap pre-licence and post-licence. However, pre-licence the gap existed in the university. Post-licence it resided in the company. The PI also helped overcome the marketing gap pre-licence.

8.9.4 Scenarios C & D: Post-spinoff versus post-licence

There were a number of differences in the post-spinoff and post-licence scenarios, as shown in Figure 8.13 and Figure 8.14. The data from the successful spinoff (UL1) and licence (UL2) are used to explore these gaps, and how they exist is discussed below.

8.9.4.1 Differences in gaps

The differences in the gaps are discussed under the headings of the four gaps; unique superior idea, funding, knowledge and entrepreneurship.

• Idea Uniqueness gap. Post commercialisation both the spinoff and the licensee had to transform the technology into a unique superior idea. In that respect the gap was similar between the two scenarios.

• Funding gap. Once the spinoff was created, it had a much greater need for investment than the company licensing the technology. As seen in UL1 the company quickly spent the €500,000 invested by the promoters and a local VC. Twelve months after its creation the company was negotiating a second round VC investment worth €10 million. Post-licensing, the licensee spent €50,000 to integrate the technology into his company; this highlights the difference in scales.

• Knowledge gap. As the spinoff came from a university, it usually had the necessary technological expertise, but lacked the marketing skills. The SE provided the managerial skills, but this was not always the case. Post-
licensing, the licensee had the managerial and marketing skills, but it lacked the technological knowledge.

- Entrepreneurial gap. In both cases the PI already displayed commitment, by starting the company or licensing the technology. The promoters of the spinoff had to continue to show this commitment to attract further investment, while the owner of the licensee had to act as a champion to integrate the technology into their product portfolio. The spinoff also had to develop a customer base, which the licensee normally had, so their social links were more important.

8.9.4.2 Difference in actor-gap interventions

There were differences in the actor-gap interventions required to generate a commercial outcome, as shown in Table 8.13 and Table 8.15. This section describes these differences in the interventions required by the various actors.

- Government. Post-spinoff, the spinoff became a client company of Enterprise Ireland, and was then eligible for the same supports as the licensee. However, as the spinoff also sought further VC investment, government had an indirect influence through the financial support it provided via fund-of-funds.
- Financial Institutions. The financial institutions had a key role to play in the continued funding of the spinoff, while they had no input into the licensee unless the company looked for a loan (or debt equity) to expand based on the technology.
- Industry. In both scenarios industry provided market knowledge to the companies, so that they could develop unique superior products from their ideas. For the spinoff, industry also became a competitor for the first time, which meant the spinoff had to be more careful about what they told potential customers.
- University. Post-spinoff, the university provided the spinoff with access to technology so that post-spinoff they had an on-going role with the company. However, post-licensing the university had to ensure the effective transfer of the technology (and associated know-how) to the company as part of the licensing agreement.
- Principal Investigator. Post-spinoff, the PI usually joined the company and became part of the team responsible for running the company. Post-licensing, the PI remained in the university and provided technological knowledge to the company to ensure effective technology transfer.
8.10 An emergent model for the commercialisation of applied research

The previous section has shown how the four gaps materialised in each of the four scenarios, and how the five actors contributed to their closure. The comparisons of the different scenarios showed how the gaps changed depending on the scenario involved, and how this then influenced the role of the actors in closing the gaps. The size of the gaps was shown to change depending on the scenario. As a result, the degree of closure necessary to realise a spinoff, licence, or no commercial outcome was shown to differ, as proposed by Figure 8.10.

This information is now used to further refine the conceptual model first presented in Chapter 3, and then refined using the survey findings in Figure 5.2. Using the generic actor-gap models developed from each of the four scenarios, this section updates that conceptual model to present an emergent model for the commercialisation of applied research.

8.10.1 Propositions associated with the earlier conceptual model

In Chapter 3, I developed a number of propositions associated with my conceptual model summarised in the list below. This section takes each of these propositions in turn, and discusses what the analysis of the data in the research tells us about them, and how they contribute to the development of the emergent model.

- There are three possible process outcomes: a spinoff, a licence, or no commercial outcome.
- There are four scenarios, and the gaps that need to be overcome to deliver a commercial outcome differ according to the scenario involved.
- Interventions by actors help to close these gaps based on the willingness of industry to engage with the university and a supportive government.
- The higher the skill level with which the actors intervenes, the greater the impact on the closing of the gaps (and vice versa).
- There are different degrees of closure associated with the three different outcomes of the process.
- There is a market knowledge gap and an idea uniqueness gap.

8.10.1.1 Proposition 1

My first proposition was that there were three different outcomes possible from the process of commercialisation: spinoff, licence and no commercial outcome. The data from the survey and the cases demonstrated that each of these three outcomes were possible, and provided instances of each.
8.10.1.2 Proposition 2
My second proposition was that there were four scenarios in the process of commercialisation: pre-spinoff, pre-licence, post-spinoff and post-licence, and that the gaps in the process differed according to the scenario.

The discussion in Section 8.9 shows that for each of the four scenarios, the gaps were different, both in scale and how they materialised. However, the discussion also showed that each of the four gaps existed in each scenario, and that they had to be overcome to generate a commercial outcome.

8.10.1.3 Proposition 3
My third proposition was that interventions by actors could help close the gaps. The discussion in Sections 8.4 and 8.9 identified how each of the five actors in the conceptual model had a role to play in closing those gaps, in particular industry had to be willing to engage with the universities and government had to be supportive. If any of these elements were missing, then the process was unlikely to generate a commercial outcome. The discussion in Section 8.9 also showed that the interventions taken by the actors changed according to the scenario involved, because the gaps were different in each scenario.

8.10.1.4 Proposition 4
My fourth proposition was that where an actor intervened, and the skill with which they intervened was high, the greater the influence on the commercial outcome (and vice versa).

The data from the survey indicated that for certain factors there was evidence to show that the presence of and skill level of interventions were associated with the commercialisation of a project outcomes. The analysis of the cases using the four scenarios then showed that the presence of an intervention and the skill level of the required intervention changed according to the scenario involved. For example, higher levels of funding and managerial skills were required in the spinoff scenario compared to the licensing scenario.

As such, the presence of and skill level of the interventions became part of the emergent model, in which the presence of interventions and skill level of the intervention are represented by the degree of closure provided by the actor.

8.10.1.5 Proposition 5
My fifth proposition was that there was a different degree of closure associated with each of the three possible process outcomes. The data from the cases
clearly showed that the gaps in the pre spinoff scenarios were different from those in the pre licensing scenario: funding being the most obvious example.

To overcome these gaps required a different level of interaction by the actor, e.g. higher level of investment. This clearly shows that the degree of closure of the gaps was different between the scenarios, and this is represented by the degree of closure element of the emergent model.

8.10.1.6 Proposition 6
My sixth and final proposition was that two additional gaps existed as predicted by the NPD literature. They were a market knowledge gap and an idea uniqueness gap. The data from the cases demonstrated that knowledge of the market was a key differentiator between projects that realised a commercial outcome, and those that did not.

The data from the survey clearly showed that the presence of a unique superior idea influenced whether a project was commercialised or not. This was fully supported by the findings of the case studies which showed that the absence of a unique idea led to no commercial outcome. As such, both gaps are included in the emergent model.

8.10.2 Presentation of an emergent model for the commercialisation of applied research
The basic premise underlying this thesis was that the process of commercialising applied research involved the closing of a number of gaps by a variety of actors. From the analysis presented above, this research identified four gaps that hindered the commercialisation of research. These were: 1) an idea uniqueness gap, 2) a funding gap, 3) a knowledge gap made up of three elements, technological, managerial and marketing, and 4) an entrepreneurial gap made up of two elements, commitment and social links.

The five actors who influenced the closing of these four gaps were identified as: 1) government, 2) financial institutions, 3) industry, 4) the university, and 5) the principal investigator. This research also identified that four scenarios existed and that the gaps and actor-gap interventions changed according to which of the following four scenarios was involved: 1) pre-spinoff, 2) pre-licence, 3) post-spinoff, and 4) post-licence.

The emergent model is now presented in Figure 8.15 and Figure 8.16 by combining the generic models identified for each case. Figure 8.15 is developed by combining the
findings for the four scenarios in Figure 8.9, Figure 8.11, Figure 8.13 and Figure 8.14. It shows that there are four gaps and five actors that help to close the gaps. The bidirectional arrows between the actors show the influence of interventions by one actor on all others, not just those adjacent to them in the figure. Similarly, the bidirectional arrows between the gaps show how closing one gap could impact on the size of another gap, not just those it is adjacent to, as evident from the data.

Figure 8.15 Emergent model of commercialisation of applied research

While Figure 8.16 is a combination of Figure 8.10 and Figure 8.12 that shows that the degree to which the gaps are closed influences which of the following three outcomes occurs: 1) a spinoff, 2) a licence, or 3) no commercial outcome.
8.11 Description of emergent model

The following sections describe in more detail the emergent model to help the reader understand the premises behind it, and the assumptions inherent in it.

8.11.1 Presence of and interaction between gaps

There are four gaps in the model: a unique superior idea, funding, knowledge and entrepreneurship. This section presents the four gaps and discusses the elements of each. It also shows that the gaps are interrelated, and that a failure to close one gap, can influence the ability to close others.

8.11.1.1 Idea Uniqueness gap

The idea uniqueness gap refers to the presence of an idea that targets a market opportunity and can be transformed into a unique superior product. The presence of which Cooper (1979) found distinguished between successful and unsuccessful NPD projects.

The presence of unique superior idea is strongly linked to the market knowledge the academic possesses. This research found that without knowledge of the market, the academic was unlikely to have a technology that could be differentiated from the competition, and as a result was unlikely to be commercialised.

8.11.1.2 Funding gap

The funding gap defines the need for money at different points in the project. It exists from the initial idea phase, where finance is needed to develop the technology, all the way through to the creation of a spinoff company. The size of the gap varies depending on the technology, e.g. life science projects require higher levels of investment to carry out clinical trials, and the market it addresses, e.g. a local or global product launch.
The funding gap is inextricably linked to the other gaps, as in all cases money is required to overcome the gaps. For instance, where a management of technology knowledge gap exists, money is required to hire staff with the required skills, or to pay for part-time consultancy.

8.11.1.3 Knowledge gap
The knowledge gap is made up of three elements; *market, managerial and technological*. The *technological* gap refers to the academics' ability to overcome the technical challenges required to bring the product / process to the market. It is usually the easiest to overcome for the academics as they are generally experts in their areas of technology. The *market* knowledge gap refers to the promoters' knowledge of the market place, and relates to their ability to see an opportunity for a product or process based on a market gap. In this respect it is closely linked to the *idea uniqueness* gap.

The *managerial* gap is evidence of the academics' ability to bring the necessary resources together to overcome all the gaps, and to manage the interventions of the other actors in a timely manner. As stated above, the managerial gap is directly linked to the funding gap, as the academics must be able to gather the appropriate resources when required to deliver the project objectives. There is also a degree of overlap between the managerial gap and the entrepreneurial gap. To find the resources necessary, the manager will often rely on their *social links* external to the project and university. If and when the necessary resources are not available, then the manager has to remain *committed* to the project, and find alternative ways to overcome the gaps.

8.11.1.4 Entrepreneurial gap
The *entrepreneurial* gap is made up of two elements, the *social links* (or social capital) of the academics, and the *commitment* they show to the commercialisation process. *Social links* are required to marshal the resources necessary to commercialise the project. As the anecdote suggests, it is often *not what you know, but who you know* that makes the difference between success and failure. As evident, in project *UL1*, it was the PI's acquaintance with *UL SE1* that led to him joining the team, and ultimately becoming the main driver of the commercialisation effort. Subsequently, it was his *social capital* that gave them the links to potential customers, who in turn provided the market that attracted the VC investment.

As the process of commercialisation is also time consuming and stressful, the academic needs to display constant drive and *commitment* to the final objectives in order to keep the other actors involved. *TCD1* showed that the PIs decision not to be the CEO discouraged the VCs from pursuing the project any further.
8.11.2 Role of and interaction between actors

There are five actors included in the model: government, the financial institutions, industry, the host university, and the principal investigator. This section presents the five actors and discusses how each intervenes to close the gaps presented above. It also shows that the actor interventions can be interrelated in so far as the actions taken (or not) by one actor to close a gap, can influence the ability of the other actors to close other gaps.

8.11.2.1 Government

The role of government is two fold. It provides finance via Enterprise Ireland to fund schemes such as the ATRP (now called the Commercialisation Fund), the TTSI, and the VC Fund of Funds. Government also sets the rules by which the process of commercialisation happens, i.e. the university has ownership of the foreground IF from projects funded by the ATRP / CFTD.

In this respect, government is the most important actor in the process. Without the money, and the appropriate rules to encourage academic industry interaction, schemes to encourage commercialisation would not exist, and we would be in the same situation as pre 2001, when commercialisation from Irish universities was a fortuitous outcome of university led research.

So the interventions by government stimulate the remainder of the eco-system, and both encourage and facilitate the other actors to close the remaining gaps.

8.11.2.2 Financial Institutions

The financial institutions are generally the VCs. However, in some circumstances banks or other institutions act as a source of finance. The role of the financial institutions depends on the route to commercialisation pursued by the PI. Where a spinoff is the intended outcome, then the VCs, angel investors, and other sources will be required to invest in the company to help overcome the funding gap. The most common source of large investment is the VCs, who may also take a seat on the board, and provide business expertise.

In the licensing scenario, VC investment is usually not required and the Financial Institutions have no role to play, unless the licensee requires investment to grow its business (which may come from a bank in the form of an extended overdraft).

As seen from UL3 a failure to secure VC funding can have knock on effects on the closing of other gaps. In UL3, the lack of funding meant a clinical trial to prove the competitive advantage of the project was impossible, so the idea uniqueness gap was
not closed. Similarly, in *TCD1*, the VC identified a managerial gap that they wanted filled before they would consider investing in a proposed spinoff.

**8.11.2.3 Industry**

The term industry is used collectively to describe the companies interested in a given project. The roles of industry are several-fold in the process of commercialisation. *First*, potential customers give feedback to the PI on the technology, which can provide information to close the idea uniqueness gap and the market element of the knowledge gap.

*Second*, potential customers can provide the market opportunity that the VCs are looking for before they will invest. *Third*, when licensing a technology, the PI needs to find a company who is willing to pay for the technology. Without, an interest in the technology from potential customers or licensees, then it is unlikely that it will be commercialised. The exception to this is where the technology is a discontinuous innovation, where industry becomes the competition to the new spinoff.

These situations show that the interventions provided by industry all have an impact on the other actors, and that a failure by industry to engage with a project, can discourage other actors from intervening to close the gaps.

**8.11.2.4 University**

The university also has many roles to play in the process, as is represented by different personae in different situations.

To start, the university governing authorities set policies, rules and regulations for commercialisation that either encourage, or discourage academics from engaging in the process. The university authorities are also responsible for the setting up of a TTO, for the level of funding it receives, and by extension the strategy on commercialisation it pursues.

The TTO is the entity that represents the university in the model most frequently. Its role is to offer support, advice, and facilities to the PIs (dependent on the resources it has available). The PI must also agree the terms and conditions of a spinoff, including the licensing of the core technology, with the TTO. Similarly, the third party licensing a technology must negotiate with the TTO.

Finally, the HR department sets policies and procedures for reward and recognition of commercial efforts that can either encourage or discourage the PIs. These include financial gain from licence deals, and leave of absence to join a spinoff.
As the university has many roles to play, it has an influence on the other actors. If the university does not encourage, or value commercialisation, then it is unlikely the PI will try to commercialise their research. Similarly, if the TTO favours spinoffs over licences, or vice versa, then the PI, financial institutions, and industry are all affected. For example, if the TTO runs a low selective – low supportive model, then the PIs become more reliant on external actors to provide funding, and guidance.

8.11.2.5 Principal Investigator
The PI is the ultimate actor in the process, as his/her decision to commercialise the technology is the starting point in the process. In the first instance he/she must secure funding from Enterprise Ireland by demonstrating the existence of a market opportunity for their technology. Subsequently how the PI interacts with the other actors, determines whether the PI can gather the necessary resources to create a spinoff, or find a company to licence the technology.

The choices taken by the PI can also influence which actors have a role to play in the process. For example, if the PI pursues a spinoff, then more funding will be necessary and the VCs have a role to play. However, if the PI pursues a licence, then the VC probably have no role to play, and a company has a much greater role to play. Similarly, if the PI decides not to be part of the spinoff full time, or does not have the skills to be the CEO, then he/she is reliant on finding someone in industry to fill that role.

8.11.3 Degree of closure
Figure 8.16 shows the three potential outcomes from the process of commercialisation: spinoff, licence or no commercial outcome. The proposition highlighted in this part of the model is that the level of intervention required differs according to the desired outcome, and that a sufficient level of intervention is required to close all four gaps. Otherwise, the result will be no commercial outcome.

While the gaps are typically larger in the spinoff compared to the licence (e.g. funding), there is insufficient evidence to suggest that a lower degree of closure in an attempted spinoff would result in a licence, or vice versa.

8.11.4 Demonstrating the emergent model: the Case of NUI Maynooth
To demonstrate the applicability of the emergent model I use NUI Maynooth as a simple case. Evidence from the survey data shows there were only three projects funded in NUI Maynooth between 2001 and 2003, none of which resulted in a commercial outcome, and at that time there was no TTO. However, due to the changes made in the last five years, described below, NUI Maynooth is now an
example of how the emergent model can contribute to improved levels of commercialisation.

At a recent Intel research conference the director of the TTO at NUI Maynooth presented the work of his office over the last few years. Using funding from the TTSI, a TTO has been set up and three Technology Transfer Officers have been hired, each with relevant industrial experience. The presence of an adequately staffed office now allows the TTO to work with the PIs to commercialise their research. As a consequence, in 2008, two of the three Enterprise Ireland directorates awarded their 'Best in Class' commercialisation awards to PIs from NUI Maynooth.

The TTO has also proactively engaged with the other actors in the emergent model. In its interactions with local industry it has developed over 30 new relationships in the past two years that has helped the individual PIs to develop their social links, and has improved the interactions between the two actors.

Similarly, the TTO developed a very positive relationship with Enterprise Ireland and sees them as a key partner in the commercialisation of their research, both as an actor who helps to overcome the funding gap, and a partner in overcoming the knowledge and entrepreneurial gaps. In fact, the TTO director said he modelled the activities of his department on advice received from Enterprise Ireland.

Since 2007, the TTO has filed 23 patents, completed twelve licence deals, and generated one spinoff. In 2009 they expect to realise another two spinoffs, and they have a further thirteen in the pipeline (2010-2012).

The director attributes the success of NUI Maynooth to a number of factors. The first is a change in the culture of the university where commercialisation is actively promoted, and reward and recognition policies are in place to encourage academics to commercialise their research, thus helping to close the entrepreneurial gap. To facilitate this change in culture, the TTO runs a Commercialisation Skills programme, a Student Enterprise Award, and have an Annual Commercial Award.

Second, the TTO staff have the necessary skills and experience to overcome the knowledge gap and are seen as flexible rather than bureaucratic. Third, the activities of the TTO are aligned with the mission of the university, and finally interaction with industry is valued and promoted (overcoming the social links element of the gap).

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8.11.5 Summary
The emergent model presented in Figure 8.15 and Figure 8.16 shows that four gaps exist in the process of commercialisation, and that five actors have a role to play in overcoming these gaps. How the gaps materialise, and are closed is project dependent. Similarly, the interventions taken by actors in closing gaps can influence the size of the other gaps, as well as the interventions necessary from the other actors.

In closing the gaps, the model proposes that there is a threshold called the degree of closure that must be overcome to realise a spinoff or licence. The degree of closure refers to the size of the gaps, and infers that no commercial outcome will result if the gaps are not closed sufficiently.

8.12 Conclusions
This chapter presented the cross case analysis of the case data presented in Chapters 6 and 7. It used the four scenarios shown in Figure 8.8 as the basis on which to compare and contrast the findings of the six individual cases, the results of which were presented in two parts. The first was a combination of Figure 8.9, Figure 8.11, Figure 8.13 and Figure 8.14, to create Figure 8.15 which shows the gaps and actors involved the process of commercialisation. The second was the combination of Figure 8.10 and Figure 8.12 to develop Figure 8.16, which shows that a degree of closure is necessary to realise a particular outcome. The final section of the chapter described these various elements of the model, and how the model operates.

The next chapter discusses the theoretical contribution made by these findings to the literature presented in Chapter 2.
CHAPTER 9: THEORETICAL CONTRIBUTION MADE BY THIS STUDY

9.1 Introduction
This chapter takes the findings from Chapter 8 and reviews them with respect to the literature presented in Chapter 2 to identify the contribution to the literature made by this study. The following list outlines the main theoretical contribution made by this study:

- A dynamic view of the commercialisation model.
- The differentiation of the model in the case of spinoff versus licensing.
- The identification of three key variables that influence the model of commercialisation:
  - The presence of a unique superior idea.
  - The role of the Principal Investigator.
  - The role of marketing knowledge.

The discussion around these points is set out in five sections. The first highlights the patterns evident in the emergent model, while the second discusses the mutual adjustments made by the various actors in closing the gaps. The third section positions the emergent model with respect to Verganti and Landoni (2005) to show how the findings of my research compare with their original model. The fourth positions my findings to the literature review by Djokovic and Souitaris (2008) presented in Chapter 2 to see how my findings add to the general literature. While fifth and final section discusses how this study relates to the Triple Helix.

9.2 A dynamic view of the commercialisation model
As the study in which the Verganti and Landoni (2005) model was developed concentrated on the role of local government in closing the initial funding gap, there was little description of the roles played by the other actors in closing the gaps, and no mention of the interaction between actors as dictated by the Triple Helix. According to Leydesdorff (2003) in the Triple Helix, the model of 'university-industry-government relations encompasses the recursive dynamics within each of the helices along their respective time axes'. As a result, the role played by one actor moderates on the interaction between the other two.

The Verganti and Landoni model was static as it simply listed the actors and gaps in the process of generating an academic spinoff. A Triple Helix by its very construction is not expected to be stable (Etzkowitz and Leydesdorff, 2000). So when using the Triple Helix as a frame for this study, I needed to include a dynamic element in the emergent model to reflect the variations introduced by the behaviour of the actors in
closing the gaps, and the impact that had on the actions required of the other actors. The earlier static model did not account for such influence. Yet, the phase of the project at which the support was provided could influence the support the other actors had to provide. For example, if the academic had not closed the unique superior idea gap to the satisfaction of the VCs, then another actor had to continue to fund the project until the gap was closed.

The *dynamic* view recognised that in providing support to a project, the actions of one actor influenced the need for, and timing of, support from another. This view was exemplified by the initial funding provided by government via the ATRP / CFTD which eliminated the need for funding to be provided to the academic by their university.

The next section discusses in more detail the dynamic element of the process by identifying patterns in the processes of commercialisation evident in each of the cases, and shows how interventions by the various actors affected each other. The patterns referred to here were the routines in the behaviours of the actors identified in the data.

### 9.3 Patterns in the commercialisation of applied research

In Figure 8., the emergent model recognised that the closing of one gap by an actor could have an influence on the closing of other gaps, and on the supports necessary from the other actors. For example, when the funding gap was closed by a government sponsored research grant, the monies received by the PI were used to hire staff or pay for training. This had a positive effect as it also helped to close the knowledge gap (Chiesa and Piccaluga, 2000; Debackere, 2000; Di Gergorio and Shane, 2003; Jacob, Lundqvist et al., 2003; Lockett, Siegel et al., 2005 and Lockett and Wright, 2005).

In much the same way, the closing of the remaining gaps were found to influence each other. Closing the *market knowledge gap* directly influenced the closing of the *idea uniqueness gap*, by identifying the market opportunity which the product had to address. Similarly, having technological knowledge helped close the idea uniqueness gap by linking the technology to the market opportunity. Finally, a strong social network, and a commitment by the PI, helped secure funding from the VCs thus closing the funding gap (Druilhe and Garnsey, 2004).

From these findings we see that there were mutual dependencies between the actions of the actors in relation to the gaps, and that some gaps could not be closed without closing some or all of another gap. Hence, there was a dynamic element in the model.
developed from this study which extended the model proposed by Verganti and Landoni (2005).

9.3.1 Identification of patterns in the closing of gaps
In the same way that the closing of one gap influenced other gaps, the actions of one actor also influenced the actions of others. The dynamic element of the emergent model highlights that there were mutual adjustments made by the different actors in response to the actions of other actors. To better understand the dynamic nature of the model, the patterns evident in each of the four scenarios are discussed below.

9.3.1.1 Patterns pre-spinoff
This section presents the patterns evident from the case data in the pre-spinoff scenario. The common starting point of each project was the receipt of ATRP / CFTD funding from Enterprise Ireland which closed the initial funding gap. The patterns in how this funding was used helped to determine whether the promoters commercialised their research or not.

The successful spinoffs carried out their technology and commercial development concurrently. While the majority of the grant was normally used to close the technological knowledge gap, the PIs who commercialised their research also used the funding to close the project and market knowledge gaps (Shane, 2001), simultaneously with the technology gap. These PIs also used the time during which they were funded (by Enterprise Ireland) to expand their social links along with their technological development activities. In particular, the PIs met potential customers, and other industry contacts, to overcome their market knowledge gap. Where necessary, they used their social links to enhance the team's managerial skills, and in cases where the team did not have adequate commercial experience, to involve a surrogate entrepreneur (Vohora, Wright et al., 2004; Lockett, Siegel et al., 2005; O'Shea, Allen et al., 2005 and Price and Monsen, 2005).

In comparison, the PIs who did not commercialise their research, tended to focus on the technology gap and spent little or no time (or money) overcoming their market knowledge gap. They closed the gaps sequentially rather than concurrently, and in many cases failed to identify a product with market potential (and bridge the idea uniqueness gap), even though they had an innovative technology.

As mentioned earlier, the TTOs operated the low support low selective spinoff approach outlined by DeGroof and Roberts (2004). This meant that the TTOs did
not engage with the PIs until late in the process. Training or other non financial supports were often too late at this point as the team had already purchased them, or they had filled the gap using their own network. Often, the policies and procedures implemented by the TTO (at this point) hindered the progress of the spinoff.

In many ways the approaches taken by the TTO pre-spinoff were analogous to the attention managers give NPD projects according to Hayes, Wheelwright et al. (1988). In Figure 9.1 we see that in the early project stages, where their ability to influence is high, managers pay little attention to a development project. It is only when the project nears launch that managers feel it important to give a project their attention; however, at this point any changes they propose become much more costly. In the post launch phase, any defects that arise then require management attention.

![Figure 9.1 Management attention versus ability to influence NPD projects](image)

In much the same way, where the TTO ignored the ATRP / CFTD projects in their early years, it was because they saw this as the technology development phase where commercialisation activities did not happen. In others it was due to resource constraints. In both situations the outcome was similar, in that the PI did not get access to support from the TTO.

To show how the TTO influence manifested itself in the ATRP / CFTD projects I developed Figure 9.2 to show the overlap between the time line of the ATRP / CFTFD projects and Figure 9.1.
It was only when the PIs neared the creation of the spinoff (and the PI had to negotiate a licence from the university), that the TTO gave the spinoff their attention. As we saw in the UL1 case, the policies implemented by the TTO nearly killed the spinoff at this point. While in the TCD1 case, the lack of assistance at the early concept development phase meant the team failed to engage with customers, and were left with a product nobody would pay for. So in many respects, the patterns in commercialisation were the same as those in successful NPD projects.

9.3.1.2 Patterns pre-licence
As in the case of the pre spinoff scenario, I found similar patterns in how the PIs generated licences. The PIs who attracted a licensee used the ATRP / CFTD funding to close many gaps at once. It was only when the PI decided to pursue a licence, rather than a spinoff, that licence specific gaps materialised, and the supports required from other actors differed. I found that the choice of spinoff versus licence was determined by the personal choice of the academic. This challenged (Drulhe and Garnsey, 2004) belief that the level of supports provided by the university determined the choice of spinoff over licence.

Enterprise Ireland provided the initial funding to the PI in the same manner as before, and the PI typically spent this money to close the technology gap. When the PI decided to pursue a licence, rather than a spinoff, the need to close the managerial and funding gaps was reduced significantly. Instead, the PI used his/her links with industry to determine where a market opportunity existed, and which companies might be interested in a product or process that addressed that opportunity. The entrepreneurial gap now became one of selling the technology rather than trying to set up a company.
The PIs who successfully generated a licence used their social network, and the contacts provided by the university and Enterprise Ireland to approach a number of potential licensees. Where they did not have the social network or skills to do this then my research found that they relied on a surrogate entrepreneur.

Once again, the TTO only became involved at the point where the licensee was identified, and the TTO were needed to negotiate a deal to licence the technology (as in the UL2 case). While this was in line with Baldini, Grimaldi et al. (2004) findings that the TTO acted 'to facilitate, and regulate the transactions between parties who already knew each other', it shows that the TTOs failed to market their IP as suggested by Gordon (2004), Markman, Phan et al. (2005) and O'Shea, Allen et al. (2005).

This also demonstrated the TTO provided support late in the process. In the case of TCD2, this was a partial cause in the deal collapsing due to the incorrect patent application. Similarly, those PIs who relied on external parties to market their technology, failed to generate a licence.

I also found that the PIs who did not commercialise their research were unable or unwilling to explore the market to identify where their technology could be useful. Without a market focus, the PIs often failed to close the idea uniqueness gap, as they did not understand where their technology was applicable in the market place. This lack of networking and the inability to demonstrate where their technology was useful contributed to their failure to licence the technology.

9.3.1.3 Patterns post-spinoff

On realisation of the spinoff similar gaps existed as in the pre-spinoff stage. However, the sequence in which these gaps were closed differed from the pre-spinoff scenario, which meant the roles of the actors also differed.

As in the pre-spinoff scenario, the funding gap was generally closed (by the VC investment) to an extent from the outset. The new company used these funds to pay the salaries of the technical, marketing and managerial staff, and to cover other operating expenses. In circumstances where specific skills were not available within the team, they acquired them by hiring new staff or paying consultants to perform the work. I found that the spinoffs used their social networks to find these people, which agreed with the findings of Grandi and Grimaldi (2003) and Lofsten and Lindelof (2005), who suggested that networking capability of the company (post spinoff) influenced their growth.
When the PI left the university, he/she usually maintained his/her links to their former departments, and the spinoff licensed complementary technologies from the university. I found that this was an important factor in the ongoing success of the spinoff which concurred with Siegel, Waldman et al. (2003b). They found that most technologies, when licensed, were little better than at the proof of concept stage and required significant future development. I found that the continued participation of the academic was critical in providing the technical knowledge to bring the project to its completion which agreed with Siegel, Waldman et al. (2003a), Siegel, Waldman et al. (2003b) and Markman, Gianiodis et al. (2005).

The initial investment from the VC was generally short term, so the spinoff had a need to secure further investment if it was to grow and establish itself in the market. The level of the investment was again dependent on the technology and market sector the company was targeting. The timing of the first sale also varied widely according to the type of technology and the industrial sector involved. In the FMCG market the first sale could be made in the first year, while in the life sciences it could take more than five years to make the first sale. According to these two issues, the scale of the second round of VC funding differed widely.

9.3.1.4 Patterns post-licence
Upon licensing of the technology, the gaps that existed depended very much on the technology and the ability of the company to absorb the new technology (and associated knowledge). To help the company improve its absorptive capacity, Enterprise Ireland offered a number of financial (and non financial) supports such as the Innovation Partnership and R&D Fund. The Innovation Partnership scheme specifically targeted university-industry collaboration, so it was an ideal mechanism for the company to continue to engage with the PI to integrate the technology into a product.

9.3.1.5 Summary of the patterns evident in the data
This section showed that a number of patterns existed in each of the four scenarios in how the five actors help to close the four gaps. How the patterns were realised depended on the timing and level of the interventions made by the actors. Where one actor only partially closed a gap (e.g. funding), then another had to intervene to close the remainder of the gap. This showed that that emergent model had a dynamic element as predicted by Etzkowitz and Leydesdorff (2000).
9.4 Contribution with respect to Verganti and Landoni (2005)

Verganti and Landoni (2005) identified three gaps (funding, entrepreneurship and knowledge) to be closed to create an academic spinoff company. Their model involved at least four actors (government, financial institutions, industry and the university) in the closing of these gaps. The model was based on the Technology Transfer literature and incorporated the findings of a number of key papers in this area (Radosevich, 1995; Carayannis and Alexander, 1999; Vohora, Wright et al., 2004; Steffensen, Rogers et al., 2000; Clarysse, Wright et al., 2005 and Moray and Clarysse, 2005). In terms of the four analytical scenarios presented earlier, Verganti’s model was located firmly in, and limited only to the spinoff scenario.

How the actors influenced the closing of the gaps was not presented by Verganti and Landoni. The next section describes how the emergent model from this research confirms and builds on the gaps identified by Verganti and Landoni, and on the roles played by the individual actors.

9.4.1 Idea Uniqueness gap

Verganti and Landoni, O’Shea, Chugh et al. (2008) and Djokovic and Souitaris (2008) presented reviews of the literature that highlighted a set of consistent gaps, and actors who could help to overcome these gaps. Investigating the individual papers they reviewed in more detail it was evident that there was little or no mention given to the concept of an idea uniqueness gap.

Markman, Phan et al. (2005) and O’Shea, Allen et al. (2005) agreed that marketing was important to commercialise the research, but neither referred to the product that was used to fill the gap in the market. Chapter 8 highlighted the presence of a unique superior product as a success factor in the NPD arena. However, there was no equivalent in the literature on the commercialisation of research.

My research found that the presence of a unique superior idea that could be transformed into a new superior product was a contributor to commercialisation. In the pre-spinoff scenario, the VCs wanted to see evidence of a product that satisfied a market need. While in the pre-licensing scenario, the licensee wanted to see a technology that could form part of a new process or product.

As such my research extended the current literature by identifying the presence of an idea uniqueness gap, defined as a unique superior idea that could be matched to a market need, to deliver a competitive advantage to the owner, or licensee or the technology.
9.4.2 Principal Investigator as an actor

According to the Verganti and Landoni model, once the academic made the personal choice to pursue a spinoff, his/her role was largely complete with respect to the spinoff. My research contradicted this assumption, as I found that the academic had to remain committed and driven by the desire to start a spinoff if the company was to be successful. Hence the personal choice element of the Verganti and Landoni model became part of a commitment element in the entrepreneurial gap.

My research extended Verganti's view of the PI as I identified the PI as having a key role to play in closing of the four gaps in the emergent model, in all four scenarios. For example, the PI acted as an entrepreneur and used his/her social links to get funding from VCs, or to set up links with potential licensees.

Verganti and Landoni identified four actors in their model, but accepted that other actors could influence the closing of the gaps. The identification of the PI as a key actor is an important contribution as it showed the importance of the role the PI plays if the research is to be commercialised. The absence of the PI from the Verganti and Landoni model suggested that the other actors could close the gaps without the involvement of the PI. However, this study has shown that the PI had to provide considerable input if the project was to be commercialised. My research confirmed the findings of Siegel, Waldman et al. (2003a), Siegel, Waldman et al. (2003b) and Markman, Gianiodis et al. (2004) who thought that without the input of the PI it was extremely unlikely that a technology would be commercialised.

9.4.3 Funding gap

Verganti and Landoni found that funding was a problem shared between all new companies, but was more acute for academic spinoffs as they tended to lack links with potential investors, they had incomplete business models, and had technology that still needed research efforts or patenting and prototyping activities. On such a basis Clayman and Holbrook (2003) argued that the likelihood of generating a successful spinoff increased if the academic had access to more financial resources.

This study confirmed the existence of a pre-spinoff funding gap. This gap was primarily overcome by government funding at the outset, and VC funding at a later stage in the creation of a new spinoff. This was consistent with the findings of Siegel, Waldman et al. (2003a), Siegel, Waldman et al. (2003b), Vohora, Wright et al. (2004) and Lockett, Siegel et al. (2005), as it showed that access to funding was critical to successful realisation of a spinoff.
However, this study extended the previous studies listed above by identifying a funding gap that also existed in the pre-licensing scenario. While the gap may not be as large as in the pre-spinoff scenario, the lack of funding represented a gap in the pre-licensing scenario (typically closed by government).

9.4.4 Knowledge gap
The knowledge gap referred to by Verganti and Landoni had two elements, managerial and technological. In particular, Wright, Vohora et al. (2004) highlighted the lack of managerial expertise (the skills necessary to acquire resources and develop capabilities) as a factor that affected the spinoff's ability to acquire the other resources necessary to exploit the potential of their IP. The knowledge gap is not to be confused with the academics' ignorance of the universities' policies or procedures.

This study assumed that the PIs could overcome the technical gap (by nature of their academic qualifications), so this research concentrated on, and confirmed the presence of a managerial knowledge gap. This gap was evident in the lack of commercial skills and experience amongst the PIs. Examples of where it materialised were in the PIs' inability to secure external investment, to ensure the technology satisfied a market need, or to mobilise resources when necessary. This gap was closed either by the PI or by the addition of a surrogate entrepreneur. The use of a surrogate entrepreneur was consistent with the findings of Vohora, Wright et al. (2004), O'Shea, Allen et al. (2005) and Price and Monsen (2005) who suggested that the surrogate should not only understand the technology, but must be able to run the business, e.g. carry out financial and operational planning and deal with human resource issues.

This research also found evidence of a marketing knowledge gap that was not included in the Verganti and Landoni model. Although the Verganti and Landoni model did not specifically include a marketing gap, many authors have discussed a marketing deficit (the ability to attract interested parties who may licence the technology) in the process of commercialisation. However, this deficit was generally viewed with respect to the TTO, not the PI. The addition of the marketing element to the emergent model recognised the need for the PIs to have a clear knowledge of the market, so that they could identify a suitable market opportunity for their technology. Market knowledge was also important in helping to identify potential customers or licensees depending on the route to commercialisation chosen.

9.4.5 Entrepreneurial gap
At the onset of the commercialisation process Verganti and Landoni believed there existed a pool of potential entrepreneurs who were prevented from realising a spinoff
due to the presence of three gaps; knowledge, funding and entrepreneurship. However, according to Verganti and Landoni these gaps only materialised if the academic made the choice to pursue a spinoff. They defined this element of the entrepreneurial gap as the personal choice of the academic to become involved in the spinoff. Djokovic and Souitaris (2008) also found evidence in the literature to show that the way in which the academic chose to remain involved with the spinoff influenced its success.

This research challenged the breadth of this contention as it found that, for the project to be commercialised, the academic entrepreneur (or surrogate) needed to exercise personal choice to stay involved over the complete lifetime of the process. This element of the gap was therefore re-titled as commitment to show the breadth of that choice.

The second element of the Verganti and Landoni entrepreneurial gap was the social links, or network of the academic. Spinoffs were usually formed by a team, but a single entrepreneur was required to mobilize the resources necessary to deliver value and capture returns according to Landry, Amara et al. (2006). This was most commonly achieved by using their social networks. Luthje and Franke (2003) and Druilhe and Garnsey (2004) said that the academics who had direct and indirect relationships with the VCs were most likely to receive venture funding, and were less likely to fail. Similarly, Clarysse and Moray (2004) found that in the case where links between the academic community and industry were weakest, there was no commercialisation.

My research confirmed these findings; I found that the presence of an entrepreneur (or surrogate) was a key factor in determining whether a project would be commercialised or not. My research showed that it was the strong external links of the academic / surrogate that helped ensure a commercial outcome.

While this was commonly accepted as the case for the realisation of a spinoff, my research extended the literature as I found that the presence of an entrepreneur was also critical in the generation of a licence, as the social links possessed by the entrepreneur were critical in attracting a licensee.

9.4.6 Degree of closure

Verganti and Landoni made no reference to how well each gap had to be overcome, and if there was a threshold that had to be overcome in each gap to realise a commercial outcome. My research found that such a threshold existed, and described it as the degree of closure.
This implied that the gaps in the pre-spinoff scenario were by nature, generally larger than those in the pre-licensing scenario. As such, a failure to close the gap sufficiently in the pre-spinoff scenario led to a failure to spinoff a new company. However, the level of closure may have been sufficient to generate a licence. Where the threshold for a licence was not achieved, no commercial outcome resulted.

9.4.7 Summary of contribution with respect to Verganti and Landoni

The analysis of the data gathered by this study confirmed the existence of the same three gaps identified by Verganti and Landoni. It also extended Verganti and Landoni by identifying a fourth gap described here as the idea uniqueness gap. This study also explicitly confirmed the existence of the same four actors and identified the PI as the fifth actor in the process of commercialising applied research.

The knowledge gap was shown by this study to include three elements, technological, managerial and marketing, rather than the two described by Verganti and Landoni, technology and management. The addition of the marketing element recognised the need for the academics to have a clear knowledge of the market so that they could identify a suitable market opportunity for their technology. Market knowledge was also important in helping to identify potential customers or licensees, depending on the route to commercialisation chosen.

The entrepreneurial gap was extended by including the personal choice element from Verganti and Landoni and Djokovic and Souitaris (2008) as part of the commitment element. As discussed earlier, the academic needed to display their commitment to the commercialisation of the project through out the project, not just at the start.

Finally, the Verganti and Landoni model was static and concentrated on the pre-spinoff scenario. It did not recognise the dynamic element of the model, or take account of licensing as an alternative route to commercialisation. Therefore, the findings of this study extended the Verganti and Landoni model by demonstrating how the interventions taken by actors could add variation to the model that required different responses by the other actors. The findings also extend the Verganti and Landoni model by identifying and listing the gaps that existed in the pre-licensing, post-licensing and post spinoff scenarios.

9.5 Contribution with respect to Djokovic and Souitaris (2008)

In their review, Djokovic and Souitaris (2008) grouped the literature into three categories; macro, messo and micro. The macro level papers concentrated on government and industry, the messo papers concentrated on the university and TTOs, while the micro papers focused on the firm and individuals involved in setting up the
This section presents the contribution made by this study with respect to each of these categories.

9.5.1 Macro factors

Djokovic and Souitaris included government in the macro category and reviewed the papers which examined the policies and incentives used by government, such as tax incentives. Bozeman (2000), Shane (2002a) and Lockett, Siegel et al. (2005) found that government policy and industry-university interaction could stimulate spinoff activity. According to the Triple Helix, government acted as a public entrepreneur and venture capitalist in addition to its traditional regulatory role in setting the rules of the game, while universities became regional sources of economic development (Etzkowitz and Leydesdorff, 2000 and Etzkowitz, 2003).

9.5.1.1 Government's role

My research confirmed the Triple Helix's characterisation of government and found that, through the ATRP / CFTD and the associated C+ schemes, Enterprise Ireland (acting on behalf of the government) fulfilled the role of venture capitalist. Enterprise Ireland also funded the TTO, funded education and training for TTO staff and potential entrepreneurs, as recommended by Chiesa and Piccaluga (2000), Debackere (2000), Di Gergorio and Shane (2003), Jacob, Lundqvist et al. (2003), Lockett, Siegel et al. (2005) and Lockett and Wright (2005).

Enterprise Ireland contributed to a fund-of-funds scheme to support the VCs investment in potential spinoffs. The Irish government was forced to do this due to the very small number of VCs who operated in Ireland. By comparison with the US and UK, the VC community in Ireland was very small (less than ten VCs), and they acted more like banks than risk financers. This made securing investments more difficult for the spinoffs.

In terms of Government acting as a legislator, there were no equivalents to the regional governments studied by Verganti and Landoni (2005) and Nilsson (2006) in Ireland. As such, the innovation policy differences identified by (Nilsson, 2006) did not exist in Ireland, and government policies were consistent across all universities (unlike in Sweden and Italy where regional governments' policies were adapted to their regional context).

9.5.1.2 Industry's role

Djokovic and Souitaris also included industry in the macro category. The papers that focused on how industry (and the market) influenced the creation of spinoffs
attempted to show how the type of technology, characteristics of the market, and the effectiveness of patents determined the type of spinoff created (Shane, 2001). In particular DeGroof and Roberts (2004) said that ‘a strong entrepreneurial community (such as Boston or Silicon Valley) had the capability to select the best entrepreneurial projects and allocate resources to them’.

As the cases used in this research were from two regions (UL being rural and TCD being metropolitan), there was an opportunity to determine whether there were differences between the local industrial communities. This study showed that there were no differences between the local communities, and that both UL and TCD operated in a push environment, where the TTO had to market their technologies in the hope of attracting interest from industry (DeGroof and Roberts, 2004). My research found that industry in Ireland was not proactive in approaching the universities as a source of technology.

9.5.2 Messo factors
The messo-level category was used by Djokovic and Souitaris to group the literature that considered the roles played by the university and the TTOs. The papers grouped in this category tried to identify the support mechanisms that were employed by the academic institutions to incentivise spinout creation, as well as to explore the effectiveness of spinning out as a university technology transfer mechanism (Di Gergorio and Shane, 2003; Siegel, Waldman et al., 2003b; Powers and McDougall, 2005).

9.5.2.1 TTO
The studies listed above found that the size and experience of the TTO had a positive influence on spinoff activity, while the royalty regimes of the university were positively associated with spinoff creation (Lockett and Wright, 2005).

The findings of my research confirmed that the size and levels of experience of the TTO staff were important factors in the commercialisation of research. Where the TTO offices were understaffed it was difficult for the academics to get time to interact with them. Similarly, where the TTO staff members were inexperienced in commercialisation, they were unable to bridge the gaps in the academics skills and knowledge. In some cases it was possible to buy in this expertise, but this was not always the case.

As the structures of the TTOs were all similar in Ireland there was no evidence to show that the structure of the TTO had an influence on the level of
commercialisation. This could be due to the maturity of the process in Ireland and would be worthy of further research in the future.

9.5.2.2 University policies
Chiesa and Piccaluga (2000) believed that the main goal of the TTO was to guide the research group in picking the right exploitation strategy. To do this the TTO had to have a commercialisation strategy set by the university, and be able to provide the managerial competencies that were absent in the potential spinoff. My research found that the alignment of the universities actions with its policies was an important factor in commercialisation, and that where the actions of the TTO were not consistent with their mission (to commercialise), then it was more difficult (although not impossible) for the academic to commercialise their research.

While Druilhe and Garnsey (2004) showed that by improving the academics' knowledge of resources and opportunities, their choice of route to commercialisation could be shifted from licensing to spinoff creation; there was no evidence in my data to support this. I found no evidence to show that royalty rates were linked to spinoff creation either. My research found that it was the personal choice of the academic which governed the choice of spinoff, not the level of resources made available by the TTO.

9.5.3 Micro factors
Djokovic and Souitaris included the academic in their micro categorisation and discussed how the personal choice of the academic to become involved in the spinoff influenced commercialisation. They found evidence in the literature to show that the way in which the academic chose to remain involved with the spinoff influenced its success (Roberts and Hauptman, 1986 and Clarysse and Moray, 2004).

9.5.3.1 Commitment
As a result, Djokovic and Souitaris implied that the entrepreneur gap defined by the literature could be overcome by the personal choice of the academic. My research challenged this definition as I found that for the project to be commercialised, that the academic entrepreneur (or surrogate) needed to stay involved over the lifetime of the process. This element of the gap was therefore re-titled as commitment to show that it was an ongoing process.

9.5.3.2 Social links
Djokovic and Souitaris identified a number of papers which found that successful spinoffs were usually formed by a team. However, a single entrepreneur was
required to mobilize the resources necessary to deliver value and capture returns, according to Landry, Amara et al. (2006). This was most commonly achieved by using their social networks.

Luthje and Franke (2003) and Druilhe and Garnsey (2004) found academics who had direct and indirect relationships with the VCs were most likely to receive venture funding and were less likely to fail. Similarly, Clarysse and Moray (2004) found that in the case where links between the academic community and industry were weakest, there was no commercialisation.

My research confirmed these findings as I found that the presence of an entrepreneur (or surrogate) was a key factor in determining whether a project was commercialised or not. My research shows that it was the strong external links of the academic / surrogate that helped ensure a successful commercial outcome. This was consistent with Druilhe and Garnsey (2004) who found that entrepreneurs needed to have developed strong external ties to mobilize the resources they required.

While this was commonly accepted as the case for the realisation of a spinoff, my research extended the literature as I also found that the presence of an entrepreneur was critical in the generation of a licence, as the social links possessed by the entrepreneur were critical in attracting a licensee.

9.5.4 Summary of contribution with respect to Djokovic & Souitaris

The findings of my research confirmed the government's dual role in the Triple Helix, and that it had a role to play as both a legislator and regulator. I found that industry in Ireland was not proactive in approaching universities, and that the commercialisation of research therefore took place in a push environment.

In terms of the size and levels of experience of the TTO staff, my research confirmed that both were important factors in the commercialisation of research. However, I found no evidence to show that royalty rates are linked to spinoff creation. Instead my research found that it was the personal choice of the academic that governed the choice of spinoff, not the level of resources made available by the TTO.

Djokovic and Souitaris implied that the entrepreneurial gap defined by the literature could be overcome by the personal choice of the academic. My research challenged this definition as I found that for the project to be commercialised, that the academic entrepreneur (or surrogate) needed to stay involved over the complete life of the process.
Finally, my research confirmed that the presence of an entrepreneur (or surrogate) was a key factor in determining whether a project would be commercialised or not. My research showed that it was also the strong external links of the academic / surrogate that helped ensure a commercial outcome.

9.6 Contribution to the Triple Helix of Innovation

While the model proposed by Verganti and Landoni (2005) included the university, industry and government as actors in the process of commercialisation, they did not discuss the relationship between the actors. My research found that, as defined by Etzkowitz and Leydesdorff (2000), the Triple Helix of university-industry-government relations was dynamic, and that the actions of one actor had a moderating effect on the interactions between the other two. This confirmed and extended the usefulness of the Triple Helix as the frame in which to consider the commercialisation of applied research.

How those actions and interventions influenced the closing of gaps, and what patterns existed are now presented and discussed.

9.6.1 Impact of mutual adjustments

As highlighted above, the closing of gaps happened in many ways, by different actors and at unpredictable times. My research has shown that the actions of one actor could influence the actions of others. This was evidence of how one actor moderated the actions of the other two, as suggested by the Triple Helix. This notion of mutual adjustment between actors was discussed in many literatures. While I do not intend to provide a detailed description on the topic of mutual adjustment here, I will refer briefly to the organisational literature to provide some background to the mutual adjustments that were evident in my research.

According to Mintzberg (1979), mutual adjustment achieves the coordination of work by the simple process of informal communication. Under mutual adjustment, control of the work rests in the hands of the doers. Siggelkow and Rivkin (2005) argued that under mutual adjustment, decisions rest with the individual decision makers. In the context of the commercialisation of research the decision makers were the actors who helped close the gaps.

The previous section discussed the patterns evident in the closing of the gaps by the actors in the four analytical scenarios. However, in doing so it assumed that the actors provided their supports at the same point in each project and each scenario. While there may be patterns in the sequence of events shown above, the supports provided by the actors do not always come at the same time, or even at the most
advantageous time for the project. The following section discusses how the point in
the project where the actors provided their supports influenced the level of support
required (more or less) from the other actors.

9.6.1.1 Adjustments pre commercialisation
The Verganti and Landoni (2005) model suggested that the PI started the process
when they made the personal choice to pursue a spinoff. This was consistent
with the findings of Djokovic and Souitaris (2008). However, my research shows
that the process starts earlier than this, as illustrated when the PI had an idea
and applied to Enterprise Ireland to close the initial funding gap. If this funding
was not provided by Enterprise Ireland, then it was unlikely that any of the other
actors would provide the same level of funding to the same number of PIs. Hence
the other actors adjusted their behaviour based on Enterprise Ireland’s funding.
Here we see how government moderated the interaction between the university
and industry as dictated by the Triple Helix. We also see how the Triple Helix was
unstable in nature, as it assumed that the interactions were not predictable, and
that the moderation of one actor on the others was dynamic.

In certain circumstances where the university attracted industrial investment, it
may have been possible to fund a small number of projects to a point where the
VCs invested in them (using the high-support-high-selectivity model proposed by
DeGroof and Roberts (2004)). However, prior to the introduction of the ATRP in
2001 this was not the case, and commercialisation was a fortuitous outcome of
research rather than the planned outcome it is now. The lack of government
funding may have encouraged the VCs to invest in a lower number of projects,
as only a few would have been in the position to close the technological and
market barriers without government funding.

Returning to the personal choice of the academic, if the PI did not demonstrate
the commitment to start a company, then the only option for commercialisation
was via a licence. Given the difference in the gaps and roles of the actors
between the pre-spinoff and pre-licence scenarios, it was obvious how the
actions of the PI impacted on the other actors.

Similarly, if the PI was not committed to generating a licence or a spinoff, then it
was left to the university to attempt to commercialise the technology with the
assistance of Enterprise Ireland. However, as Jensen and Thursby (2001)
showed, it is much more difficult to commercialise a technology without the
involvement of the academic inventor.

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Where support (financial and non-financial) was not available from the university to help close the knowledge gaps, then the PI was forced to spend money received from government (via the ATRP) to purchase training, staff or market knowledge. As my research found, the marketing skills levels and experience of the TTO were poor, which forced the PIs into a situation where they had to close the knowledge gaps using alternative routes.

In this case the PIs were more reliant on industry and/or the VCs to identify the gaps in their knowledge (this could then adversely affect any investment or licence negotiations). Where the PI had not budgeted for the expenses incurred in purchasing these additional supports, then this reduced the budget they had for the technological and market activities needed to commercialise their project. In such cases, government or industry were forced to provide additional funding to ensure the project did not fail before getting an opportunity to win VC investment, or attract a licensee. Again, this was evidence of one actor moderating the interaction between the other two, as proposed by the Triple Helix.

The funding gap existent in the pre spinoff scenario did not exist to the same level in the licensing scenario, so the VC only had a role to play in the creation of a spinoff. Here the role of the VC was to provide the funding necessary to start the company, and to get it to a point where it was self sustaining. The levels of investment, and the payback periods, varied widely according to the technology and industrial sector involved (life sciences versus FMCG). Where the VC was unwilling to invest in the potential spinoff once the ATRP/CFTD funding was spent, then it fell on the other actors to bridge the funding gap. The PI could invest their own money, but typically relied on government for additional investment, as the universities did not have the money to invest. This meant that government became a seed capital investor when it may not have been their intention to do so.

As the actions required to successfully commercialise a technology varied so much between projects, the opportunity for the different actors to influence the process grew, and made it much harder for other actors to predict what support they would have to provide, and when. This uncertainty added to the difficulties the PI faced in commercialising their research, but it showed how the mutual adjustments made by the actors influenced the process outcomes, as suggested by Mintzberg (979).
9.6.2 Adjustments post commercialisation

With the exception of the life-sciences market (which had much longer times to market), the need to generate sales was often a pre-requisite from the VCs before they would invest in a company. The VCs placed conditions on the number and value of sales the company had to achieve in a certain time frame before they provided funds. If in this time the company did not achieve its targets, and had spent the initial investment, then it had to look to the other actors in order to survive.

In many cases government, via Enterprise Ireland, was the only actor in a position to fund the company. Industry was generally unwilling to invest if the technology was not mature enough or not market ready. In certain circumstances (R&D projects and job creation grants) Enterprise Ireland could invest up to €400,000 in a new company for an equity stake, but this was dependent on a level of matching funding (60% to Enterprise Ireland’s 40%) from the company. As in the pre-commercialisation case, Enterprise Ireland was forced to expand its role in the Triple Helix (Etzkowitz and Leydesdorff, 2000 and Etzkowitz, 2003) to act as a VC to prevent a short term funding gap closing the company.

If on the other hand, the investment from the VCs was too large the promoters could easily lose their focus on the market and revert into the laboratory spending too much time and money fine tuning their technology.

In the post licensing scenario, there was a general need for the PI to continue to work with the company to allow them to absorb the technology (Siegel, Waldman et al., 2003a; Siegel, Waldman et al., 2003b; Markman, Gianiodis et al., 2005). The amount of time the PI needed to spend on this depended on the absorptive capacity of the company (Whangthomkum, Igel et al., 2006). However, if the PI was not available, or was not prepared to work with the company, then the company had to find an alternative way to absorb the technology, or suffer a delay in bringing their product to market. In the worse case, the company had to pull out of the licence deal leaving the university to find another industrial partner.

9.6.3 Limitations of the Triple Helix

The Triple Helix considered the university as a single homogenous entity. It did not recognise that at certain times that the role of the university was undertaken by three different actors: the university as a legal entity, the TTO, and the PI. Neither the PI, nor the TTO were seen as actors in the Triple Helix. Their role was subsumed into the
university. While this may work to describe high level interactions with the other actors in the Triple Helix, it did not allow a mechanism to describe how the TTO and PI needed to act when they represented the university as an actor in the process of commercialisation.

While accepting the limitations of the Triple Helix outlined by O'Malley, McOuat et al. (2002), this research has shown that the Triple Helix is a useful model in which to consider the commercialisation of applied research. However, it did not help define what initiatives or policies should be used by the actors to help close gaps.

The results of this research recognised the different role of the TTO and the PI, and the emergent model specifically included the PI as a separate actor to the university. The emergent model also provided a means for recommending what initiatives and policies should be implemented by the actors (these are presented and discussed in Chapter 10).

9.6.4 Summary of contribution to Triple Helix

The patterns in the closing of the gaps in each of the four scenarios provided evidence to show how each actor moderated the interaction between the others in the Triple Helix. This confirmed the use of the Triple Helix as an appropriate frame in which to consider university-industry interaction.

However, this research has also shown that the Triple Helix model was limited in scope. The Triple Helix was deficient in its consideration of the various personae that it represented under the banner of the university. As highlighted a number of times in this thesis, the PI, TTO and university are three separate and distinct personae that are not homogeneous. While it was convenient at times to present them as a single actor, at other times they must be treated separately.

9.7 Opportunities for future research

The analysis of the data in this study confirmed the findings of the literature presented in Chapter 2, and contributed to the literature by adding a fourth gap and fifth actor to the model for commercialisation. This research also identified four scenarios in which the gaps and roles of the actors change. However, the discussion of the survey data in Chapter 5, and the case data in Chapters 6, 7 and 8 highlighted a number of topics that require further research so that we can understand how they impact on the process of commercialisation. These opportunities are presented below.
9.7.1 University policies

The analysis of the data in this study showed no evidence to support a hypothesis that the alignment of the universities' missions and policies on commercialisation influenced the commercialisation of research. Further analysis of the successful outcomes when they were split into two subgroups (spinoffs and licences) also failed to support the hypothesis.

To understand why the data gathered in this study did not support the findings of the literature, we have to consider the maturity level of the policies used by the Irish universities. It may be that to date the TTO have not had the opportunity to develop their skills and to optimize their policies to show that the university mission alignment factor has an influence on the commercialisation of research. In that respect, a longitudinal study of the TTO performance would provide more data to determine whether the hypothesis posed is true or not.

9.7.2 TTO Structures

When analysing the data on the structures of the TTO it became clear that there was insufficient evidence to confirm or reject the hypotheses associated with the structures of the TTO. One reason for this is that the TTOs are not mature enough and that the TTO staff have not completed enough cycles through the commercialisation process to develop a mature process. Again, a longitudinal study of the TTOs, their structures and policies is necessary to determine whether the hypotheses developed from the literature are true with respect to Irish universities.

9.7.3 Process of commercialisation

The analysis of the data on the processes used to commercialise research in each of the universities showed that when the commercial outcomes were split into two subgroups (spinoffs and licences), that the variables availing of supports from the incubator and the academics' understanding of royalty and equity rates influenced the commercialisation of research.

However, the process of commercialisation as a factor was not found to influence the commercialisation of research. This may also be due to the low maturity levels of the processes and the number of commercialisation projects the universities had tried to commercialise. It may be the number was too low to provide adequate opportunity for the universities to learn from their successes and failures. The processes may only become effective (and then show evidence of an influence on the commercialisation of research) over time. This is something that should also be included in a future longitudinal study.
9.7.4 Presence of surrogate entrepreneurs

Four of the PIs who replied to the survey commercialised their research even though they did not display characteristics of an academic entrepreneur. One of these, UL P12, relied on the efforts of the PM to commercialise the technology, while he concentrated on the technical issues. This suggests that the surrogate entrepreneur has a significant role to play in the process.

Whether the skills of the entrepreneur can be taught and how this could be implemented in an Irish context is also an area worthy of future research.

9.7.5 Patterns in the closing of gaps

This study highlighted the patterns in the closing of the gaps, and the patterns in the supports offered by the various actors in each of the four scenarios. In highlighting these patterns I was also able to show how the timing and type of support provided by an actor influenced the closing of the gaps and the roles of the other actors. The presence or absence of other patterns is an issue for future research.

9.7.6 The Triple Helix

This research has also shown that the Triple Helix model is not all encompassing. The Triple Helix is deficient in its consideration of the various actors that it represents under the banner of the university. As highlighted a number of times in this thesis, the PI, TTO and university are three separate and distinct personae that are not homogeneous. While it is convenient at times to present them as a single entity, at other times they must be treated separately. Future research needs to consider whether the various actors in the university should be considered separate, and whether a Quadruple Helix would better explain the process of interactions between the actors involved in the process of commercialisation.

9.7.7 The choice of route to commercialisation

Licensing is seen as the most popular route to commercialisation, in part because the TTO see it as an easier option. As such, I would have expected to see a higher number of licences than spinoffs generated from projects studies in this research. Instead, the number of spinoffs in the population surveyed was roughly double the number of licences, which suggests some other relationship existed between the process of commercialisation and the academics decision to choose the licence or spinoff route. An explanation for this may be that the spinoffs generated to date were the low hanging fruit that were generated by early successes, and that once these had been accounted for, the number would decrease to lower levels. A long term study is required to investigate this in more detail.
9.7.8 The case of NUI Maynooth

The previous seven headings have made suggestions on areas for future research that could add to our knowledge on the commercialisation research. To support the need for this research I presented the story of the TTO at NUI Maynooth in Section 8.11.4 and how it has developed over the past five years.

A research study into the differences between NUI Maynooth and the other Irish universities would be interesting to investigate if Maynooth's success is attributable to the different approach it appears to have taken, where commercialisation is valued and actively encouraged. It would also be interesting to see if Maynooth generate more spinoffs than the other institutions in the long term. The size of their spinoff pipeline is larger then any other I am aware of at any other institution, and given the much smaller number of ATRP / CFTD projects funded at NUI Maynooth, suggests a much higher rate of conversion from research project to spinoff.

In summary, NUI Maynooth appears to run a process that corresponds remarkably closely with the emergent model presented above. Hence a longitudinal study at NUI Maynooth may offer further support for this emergent model of commercialisation from Irish universities.

9.8 Conclusions

The outcomes of this study were compared primarily with the model developed by Verganti and Landoni (2005) in their study of Italian academic spinoffs. While their model was static, and identified four gaps and four actors who influenced the closing of those gaps, this study showed that a related model was dynamic, and that the behaviour of the actors influenced the other actors. This research also demonstrated the degree to which the gaps were closed had an influence on the process outcome, e.g. spinoff, licence or no commercial outcome.

The Verganti and Landoni model related only to the spinoff scenario, while this study extended the model to identify the gaps and actors associated with licensing.

Most gaps Verganti and Landoni identified were confirmed by this study although the personal choice gap was incorporated into the entrepreneurial gap. This study further expanded on the Verganti and Landoni model by adding the concept of an idea uniqueness gap. Similarly, this study confirmed the role of the four actors identified by Verganti and Landoni, whilst also demonstrating the role played by the PI as a fifth actor in the process.
Finally, this study highlighted the patterns in the closing of the gaps, and the patterns in the supports offered by the various actors in each of the four scenarios. In highlighting these patterns, the emergent model showed how the timing and type of support provided by an actor influenced the closing of the gaps and the roles of the other actors. The presence or absence of other patterns was an issue for future research.
CHAPTER 10: POLICY IMPLICATIONS FROM THIS RESEARCH STUDY

10.1 Introduction
The final chapter of this thesis is in two parts: the first summarises the answers to the research questions posed at the onset of this study. The second discusses the policy implications for the actors in the Triple Helix based on the findings of this research.

10.2 Answering the research questions
Through Chapters 1, 2 and 3 of this thesis I developed and refined a number of research questions that sought to expand our understanding of the commercialisation of applied research from Irish universities. Those questions were:

- What gaps need to be overcome by Irish universities in the process of commercialisation to generate spinoffs and licences?
- Who are the actors that influence the closing of these gaps?
- Are there patterns in the way in which these actors intervene in the process, and is there a link to the commercialisation outcome (spinoff or licence)?
- What policy implications are there for the further development of the Triple Helix of university-industry-government relations?

The first section of this chapter summarises the findings of this research with respect to these questions.

10.2.1 What gaps need to be overcome?
Using the literature as a basis, a conceptual model was developed in Chapter 3 which identified three gaps that hindered the commercialisation of a project outcome: a financial gap, a knowledge gap and an entrepreneurial gap. The survey and case studies carried out in this study supported the presence of these gaps, refined them, and added a fourth, an idea uniqueness gap.

In summary, this study showed that four gaps need to be closed in the commercialisation of applied research. They are: 1) a finance gap, 2) a knowledge gap consisting of managerial, marketing and technical gaps, 3) an entrepreneurial gap consisting of commitment and social links, and 4) an idea uniqueness gap.

10.2.2 Who are the actors who can overcome these gaps?
This research found the following five actors influenced the commercialisation of applied research; 1) government, 2) the financial institutions, 3) a receptive industry, 4) the university, and 5) the Principal Investigator. The roles they play vary according to the commercial outcome sought (licence or spinoff), and the timing of their
Are there patterns in how these actors intervene?

The analysis of the case study data confirms that four scenarios exist in commercialising applied research, and that the interventions required by the five actors to close the four gaps differ according to these scenarios. This highlights a number of patterns in the closing of the gaps as discussed in Section 9.3. This research also confirms that the degree to which the gaps are closed influences the outcome of the process, as indicated by Figure 10.2.

The case studies also highlight two different types of pattern, static and dynamic as discussed in Section 9.3. The static patterns relate to the closing of gaps as presented by Verganti and Landoni (2005). The dynamic patterns refer to the emergent and interactive behaviour of the actors in closing these gaps.

The dynamic patterns show how the closing (or not) of one gap can have an influence on the closing of another. This dynamic view also considers how the behaviour of the actors influences the closing of the gaps, and how the actors make mutual adjustments in response to the actions of each other. It reflects the influence the
behaviour of an actor has on the closing of the gaps, and on the actions of the other actors, consistent with the Triple Helix.

Figure 10.2 Degree of closure influences outcome

![Diagram showing the influence of closure on outcomes](image)

10.2.4 Summary

This research found that there are four gaps that need to be closed in the process of commercialisation of applied research. It also identifies five actors who have a role to play in closing those gaps. The patterns in how the actors intervene to close these gaps depend on which of four scenarios is involved. There are static and dynamic elements evident in the patterns that show how the actions of one actor can influence the actions of another. Finally, the degree to which the gaps are closed influences the outcome of the process.

This thesis research started in 2004 when the commercialisation of applied research was not a topic for popular debate. With the current economic situation, the commercialisation of applied research is recognised to be more important to the universities in a number of ways. First, there are potential financial gains via licence agreements. Second, the projects funded under the commercialisation schemes offer researchers the opportunity to gain masters and doctoral level qualifications which help the universities meet the government's targets of doubling (over 2006 base) the number of science and engineering PhDs by 2013 (Irish Government, 2006). Third, the projects undertaken also provide the opportunity to publish research outcomes, increasing the profile of individual academics and the university. Finally, the funding available from government to carry out the research is an important income stream. The associated overheads (30% of cost excluding capital) also provide a means to support the administrative offices of the universities, such as Human Resources and Finance, not just those involved in the process of Technology Transfer.
10.3 Implications for actors in the Triple Helix

The discussion in Section 9.3 on this thesis demonstrated that changes were necessary in how each of the actors operated if the process was to be successful. This has policy implications for the actors in the Triple Helix. This section now presents those policy implications for these actors.

10.3.1 Implications for government

The identification of an emergent model for the commercialisation of applied research has implications for national governments who wish to stimulate economic growth based on the transfer of knowledge from universities to industry. It has particular relevance for the Irish government and the state agencies it uses to implement its policies.

10.3.1.1 Funding for commercialisation of research

The literature has shown that the commercialisation of research is something that only bears fruit in the long term. The Commercialisation Fund has only been in existence since 2001, and as most projects were funded for three years (and it took at least another year to sign a licence or to realise a spinoff after completion of the project), there has been insufficient time for a critical mass of projects to have been completed to determine the success (or otherwise) of the fund to date.

In the current economic downturn it would be easy to use the number of licences or spinoffs as an indicator of the programme success, (see Figure 10.3 and Figure 10.4 for the national totals). However, evidence from the individual universities appears to show that the more recent introduction of the TTSI has had a positive impact on the levels of commercially focused activities in the universities, and suggests evidence of a culture shift towards third pillar activities. Figure 10.5 shows that the trend in disclosures and patents in DCU is upwards since the introduction of the TTSI, and importantly the literature recognises a relationship between the number of patents and the number of commercial outcomes.

In light of this increase, the government should continue to invest in research focused on university industry interaction.
The recent report by the Special Group on Public Service Numbers and Expenditure Programmes (2009), suggested that the various bodies that provide
funding to the HE sector should be rationalised into one agency with responsibility for all HE sector funding. This could be a positive step if the levels of funding are maintained, as one body would have the ability to take a more holistic view of basic and applied research and ensure the balance between the two is appropriate.

Brian Lenihan, TD (Minister for Finance) announced in the recent budget\(^8\) that one department would be given responsibility for all HE funding. This would overcome the funding issue that arose earlier in 2009 where individuals departments simultaneously reduced spending on the HE sector without discussion with each other, thus undermining the closure of the funding gap by government. Under the new proposal, all government departments that fund research (e.g. Education, Enterprise Trade and Employment, and Agriculture) in the HE sector would give their budgets to the nominated department who would then fund projects based on requests from the individual departments. While the same projects would still get funded, the unplanned reduction in funding that happened in 2009 would not reoccur. This model has been operating successfully in Norway for a number of years.

10.3.1.2 Encouraging academics to engage in spinoff activity

This research found that commercialisation was unlikely to happen without the involvement of the PI. As a consequence, government needs to encourage academics to become *academic entrepreneurs* and to get involved in commercialisation activities. Government can do three things to promote this: 1) encourage academics to view the creation of a spinoff as the favoured commercial option (this has to be done in tandem with the universities), 2) facilitate surrogate entrepreneurs to engage with the academics, and 3) encourage the universities to view *academic entrepreneurship* as a valid academic pursuit.

Governments are also asking PIs to do something for which they have not prior skills and/or experience, so training and other supports are essential to encourage the PIs to become academic entrepreneurs. Such supports should be given to the incubators so that they can offer these training courses and other supports to ensure the PIs have the necessary skills to commercialise their research.

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10.3.1.3 Encouraging universities to interact with industry
At an institutional level, universities should be encouraged to engage with industry and to become more flexible in their approach to commercialisation. While individual collaboration between PIs and industry can be achieved through funding schemes targeting individual projects, collaboration at an institutional level depends on the university adopting commercialisation as its Third Pillar. Government can use legislation and regulations to provide a win-win situation for both parties.

An IP policy that gives ownership of the IP to the university and ensures that the PI receives a financial reward (if and when the IP is commercialised) is necessary to encourage university engagement. Such a policy should not have a detrimental impact on the other actors, as it provides industry and the financial institutions with an engagement mechanism that is common across all institutions. Government must also encourage universities to value the commercialisation of research as a valid academic pursuit. To do this, the government (via its own policies) must encourage universities to offer career paths for researchers that provide realistic and meaningful opportunities for advancement.

10.3.1.4 Encouraging industry to interact with academia
Just as the university and PI need to be encouraged to engage in the process, government must also consider policies and supports that encourage industry to engage with academia. Through Enterprise Ireland, the government offers a continuum of supports to encourage industry to engage with academia. These supports are discussed later under the implications for Industry.

10.3.1.5 Legislation to encourage commercialisation
In Ireland, the Celtic Tiger produced a culture of investing in property (in Ireland and abroad). As the economic downturn has taken effect, the large returns from the property and construction sectors are no longer available to investors or to government. As they look for opportunities to invest elsewhere, the government should be encouraging investors to look to Intellectual Property instead. There are a number of ways this might be achieved.

The first method is to encourage more Venture Capital funds to set up in Ireland. At present there are too few VCs in Ireland, and those that are here act more like banks who expect a return on every investment. To increase the number of VC funds that specifically target seed funding of academic spinoffs, the government could copy the Venture Capital Trust schemes that exist in the UK.
Under the Venture Capital Trusts investors receive a substantial tax rebate on their investment the day of their investment. In this way, the investors would have an immediate 41% return on their investment (based on highest rate of tax) which reduces the risk. The VC Trusts are then charged with investing only in academic spinoffs. (Enterprise Ireland announced a new €500 million VC fund-of-fund in December 2008 in an attempt to encourage more VC activity in academic spinoffs).

The second method is to continue to extend the Seed Capital Scheme (SCS) and BES to allow start ups to raise greater levels of initial funding, so that they are not so reliant on the VC community. Under the SCS and BES owners of companies can claim back up to five years of their PAYE tax from the revenue commissioners, which they then invest in their company. In most spinoffs, it is the SCS and BES monies that promoters use to leverage matching funding from Enterprise Ireland to invest in their business.

10.3.1.6 Encouraging Surrogate Entrepreneurs (SE)

The presence of an SE is shown by this research to be an important factor in closing the managerial gap, idea uniqueness gap, finance gap and potentially the funding gap. Where the PI does not have the skills, or inclination, to drive a spinoff, the presence of an SE can overcome this gap. Governments have a role to play in encouraging SEs to become involved in the process, and by extension help close the gaps. This can be achieved by offering financial supports to projects wishing to engage an SE (via funds like the C+), or by offering financial support directly to potential SEs.

A key challenge faced by potential surrogate entrepreneurs is gaining access to information to understand what projects have spinoff potential. This can be achieved very simply by allowing the SE access to the IP portfolio held by the university, or through discussion with the TTO on projects that may have potential. Once again, government should be encouraging the universities to interact with SEs. This can be achieved by financial supports targeted at both the university and SE, so that a funding gap is not used as an excuse to avoid this interaction.

In Ireland, Enterprise Ireland is running a pilot scheme where potential SEs are invited to join the programme with a view to setting up a spinoff company. Called the Business Partners9 scheme, the programme placed ads in the National

9 https://www.enterprise-ireland.com/businesspartners
Press in December 2008 to attract applicants. Over 180 applications were received, and currently around twenty SEs have been selected to take part in the first phase of the scheme.

Under the scheme, the SEs are given access to the technology to understand what spinoff opportunities exist. Enterprise Ireland also gives them access to their regional and overseas networks to help them engage with potential customers and investors. The role of the SE is to develop a business plan for a spinoff, and where possible to secure investment to close the funding gap. They are also expected to use their previous commercial and managerial experiences to overcome the knowledge gap, and their drive and social links to close the entrepreneurial gap. The Business Partners are paid up to twenty thousand euro for six months to work with the PIs.

The success of the scheme will be judged by the number of spinoff opportunities generated by the Business Partners.

10.3.1.7 Access to infrastructure
The case of the spinoff company in UL1 highlighted the importance of access to incubation space. To ensure the transition from academia to industry is as smooth as possible more high quality incubation space is required, with the associated financial and non financial supports to help the PIs overcome the gaps in their projects.

10.3.1.8 Improving TTO skills and resources
The literature proposed that the skills and resources available to the TTO were important factors in commercialising research. The emergent model shows how the skills and resources available to the TTO help close the knowledge and idea uniqueness gaps in particular. As a consequence, the government should ensure that the necessary funds and training are available to the TTOs. In this regard, Enterprise Ireland has provided financial support to the third level sector via the Technology Transfer Strengthening Initiative (TTSI) since 2007. The TTSI provides the finance for the TTOs to expand their staffing levels, to ensure the necessary skills and resources are available in each institution.

The five years of the TTSI are one hundred per cent funded by Enterprise Ireland, with no contribution from the relevant institutions. When the contracts come up for renewal in 2011, the universities should be asked to provide some small level of matching funding (e.g. 10%) to demonstrate their ongoing commitment to commercialisation activities. In most universities, the TTO is
often seen as providing an ancillary service to the university community, so it is low on the list of priorities when the university sets its budgets. This has a knock on effect in the wider sense as it demonstrates a lack of interest by the university in the commercialisation of research, which in turn discourages the academics from engaging in it. Similarly, all TTO staff are on short term contracts funded by SFI overheads, or the TTSI. This does not reflect a long term commitment by the universities to commercialisation.

10.3.1.9 Summary of implications for government

In summary we see that national and regional governments have many roles to play in promoting technology transfer. As regulator, government should provide the financial and non financial supports necessary to encourage greater university–industry interaction. In Ireland, this includes the continued funding of the Commercialisation Fund, and an improved focus on skills training for both the PIs and the TTO staff.

Government can also encourage universities to value the commercialisation of research, and provide meaningful career recognition for those academics involved in the commercialisation of research. In Ireland, government also needs to introduce new financial schemes to encourage investors to consider technology as an attractive alternative to property. A summary of recommendations for government are included in Figure 10.1.

Table 10.1 Recommendations for government as an actor

<table>
<thead>
<tr>
<th>Area of interest</th>
<th>Recommendation for government</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercialisation Fund and Patent Fund</td>
<td>Continue to support both schemes by prioritising them in the annual budget to help overcome funding gap. This in turn helps to overcome other gaps</td>
</tr>
</tbody>
</table>
| Encouraging academic entrepreneurship   | 1) Prioritise spinoff over licensing  
2) Facilitate SE to engage with academic to overcome entrepreneurial gap  
3) Promote academic entrepreneurship as valid academic pursuit |
| Encouraging university – industry interaction | Review Innovation Voucher scheme to increase industry interaction  
Continue to fund Innovation Partnerships, ILRP and Competence Centres to encourage university industry interaction |
| Legislation                             | Enact legislation to encourage investment in Intellectual Property to close the funding gap |
| Encourage Surrogate Entrepreneurs       | Roll out Business Partners scheme to help close the knowledge and entrepreneurial gaps |
| Improve Infrastructure                  | Modify TTSI to require a small level of matched funds from the university  
Encourage university to avail of incubation fund |
| Improve TTO skills and resource         | Improve funding via TTSI by requiring match funding |
10.3.2 Implications for the universities

In light of the findings of my research there are a number of implications for the universities interested in the commercialisation of research as the Third Pillar of their mission. These relate to how the university enacts its role in the Triple Helix, and specifically relates to their policies on commercialisation and the supports (financial and non financial) offered to academics.

It also involves resourcing the TTO with skilled and experienced staff, and where appropriate, financing this from the universities' own resources. The following section outlines a series of recommendations for the university based on the findings of my research. Key to these recommendations is the recognition that the university, TTO and PI are different personae with, at times, different needs.

10.3.2.1 University policies

To maximise the commercial potential from the research carried out in their various faculties, the universities must have a vision that is pro commercialisation. They must put in place the necessary policies and supports to help the PIs overcome the gaps that exist in the various scenarios. To show how this can be successfully achieved I provide the example of Durham University in the UK which is ranked 5th on the UK university league table10.

With a reputation for academic excellence, Durham is also quickly developing a reputation amongst industry as a university it can engage with. The university's mission is:

"To ensure the knowledge and expertise we generate is used to contribute effectively to economic and social development through a culture of knowledge transfer, enterprise and entrepreneurship which permeates all University activities"

To deliver this mission, the university appointed a Dean of Knowledge Transfer who is at the highest management level in the university. In this way, the importance of this role to the university is clear for all to see. The TTO reports to this Dean, who is also responsible for the Office of Regional Development as well as a number of other functions. The current Dean sells the TTO on the basis of collaboration with industry and the positive impact that has on research income.

10 Complete University Guide in association with the Independent newspaper, 2009
He does not focus on the income from spinoffs or licences, although the income is welcomed.

In this situation, the TTO is seen as part of a bigger entity, whose role it is to grow the local economy, and in doing so the TTO is allowed to take financial risks. The only thing they cannot risk is the university's reputation. All members of the TTO staff have experience in the relevant areas, and the size of the TTO is sufficient to allow close interaction with all their clients (PIs).

Using Durham University as a template, or copying aspects of the approach taken by NUI Maynooth (see Section 8.11.4) would be a good starting point for the remainder of the Irish universities. The remainder of this section looks at some of the key policies issues in more detail.

10.3.2.1.1 Reward and recognition policies
The first change the universities should consider is a review of their promotion policies for PIs. As discussed earlier, academics are promoted based on the number of papers they publish in peer reviewed journals. There are no metrics for patenting, licensing or generating a spinoff used in promotion. If the universities wish to increase the number of academics involved in applied research, then they must implement policies that recognise and reward entrepreneurship, by offering a career path based on successful interaction with industry. They must also remember that 'what gets measured gets done', so their metrics must be well thought out.

10.3.2.1.2 Human resources policies
It is unlikely that experienced academics on permanent contracts will leave a secure pensionable position for a risky new venture. It is more likely that recent post doctorate researchers would consider starting a spinoff. In Ireland, this cohort is more likely to be a contract employee, who the universities actively discourage from applying for CF funding. The universities fear that continued funding under a CF project would entitle the researcher to a contract of indefinite duration (CID) which has financial implications (redundancy payments) for the university. So they avoid giving researchers CIDs at all costs, and by extension have policies that prohibit these researchers applying for funding in their own name.

Instead of seeing these researchers as a threat, the university should view them as an opportunity, and use them as a cohort to focus on
commercialisation. Instead, the universities continue to rely on permanent staff to start spinoffs, even though they recognise that those PIs are not as interested as contract staff.

10.3.2.2 TTO resources

This research has confirmed the findings of many other studies in that the TTO has a key role to play in the commercialisation of applied research (Di Gergorio and Shane, 2003; Siegel, Waldman et al., 2003b; Lockett and Wright, 2005 and Powers and McDougall, 2005). The factors relating to the TTO include the level of experience of the TTO staff, the marketing they carry out, and the financial or non-financial supports they offer to the PIs.

The data from the cases showed many of the universities reassigned administrators from other departments to staff their TTOs. This is an example of where the universities have failed to show commitment to the process of commercialisation. The universities should be leveraging TTSI funds to increase access to training for the TTO staff, and where possible hiring experienced staff from other universities (e.g. UK).

10.3.2.2.1 Training

The data from the cases showed that both the TTO staff and PIs had low levels of managerial, technical and marketing knowledge. The cases also highlighted a shortage of academic entrepreneurs. All these issues can be overcome by the provision of specific training in the relevant areas.

Evidence from MIT has shown that by providing targeted training that the levels of entrepreneurship in academia can be increased (Chell and Allman, 2003 and Luthje and Franke, 2003). As a result of these findings, the universities should consider including courses in entrepreneurship on their undergraduate curricula to encourage more students to become interested in starting their own businesses. They should also provide similar training to faculty members and encourage them to become academic entrepreneurs.

10.3.2.2 Use of incubators

While the literature showed that the presence of an incubator was linked to successful commercialisation (Colyvas, Crow et al., 2002), this research found that there was not sufficient evidence from Irish universities to support or contradict this finding. However, the UL1 case showed the difficulties created by the lack of an incubator in UL. To encourage academics to commercialise their research, the universities should set up incubation units
consistent with the space required by the number of spinoffs created per annum. These incubators should include training and knowledge supports to close the key gaps, not just physical space.

If managed correctly incubators can attract spin-in companies as well as encouraging spinoffs, which would help to create a critical mass and encourage more academics to spinoff their research. As highlighted earlier, success breeds success (Di Gergorio and Shane, 2003).

10.3.2.3 University engagement with industry
There are many ways for the university to engage with industry, including simple events like breakfast meetings or networking evenings where companies are encouraged to attend to meet PIs who may be working in their areas of interest.

Given the low levels of interaction between industry and academia in Ireland, a recent report by Forfás recommended that the Higher Education Institutions (HEI) and industry must make concerted efforts to understand the needs of the other, and open a dialogue that explores their individual and combined needs. Entitled 'Promoting Enterprise-Higher Education Relationships' (Forfás, 2007) the report said the third level sector needed to explicitly declare their intentions to interact with industry.

Each HEI needs to develop clear policy statements on the role of enterprise collaboration in its research strategy, facilitating a change in culture with respect to working with enterprise. This is a fundamental starting point for the development of an effective university-industry collaboration system.

The Forfás (2007) report also recommended that each institution (in receipt of state funding to encourage university-industry interface) should be required to 'define the role of enterprise research partnerships in their overall research strategy'. In doing so the institutions should ensure that the message filters down to individual academics.

10.3.2.4 Summary of implications for universities
The findings of this research have implications for the third level sector if they wish to engage in Third Pillar activities. This section highlighted four key areas on which the universities should concentrate. The first is on the adoption of new policies and the revision of existing policies to encourage, and support, the commercialisation of applied research as a valid academic pursuit. The second and third were to allocate the necessary funding to provide specific
commercialisation related training, for both the TTO staff and academics, and to set up incubator facilities. The final recommendation is for the universities to engage more vigorously with local industry to encourage more university-industry collaboration. A summary of recommendations for the university are included in Table 10.2.

Table 10.2 Recommendations for the university

<table>
<thead>
<tr>
<th>Area of interest</th>
<th>Recommendation for the university</th>
</tr>
</thead>
<tbody>
<tr>
<td>University Policies</td>
<td>Have a vision that is pro-commercialisation and advertise this to the academic community. Reward and recognition - Include commercialisation as a criteria for promotion. Human resources - Encourage and allow post doctoral researchers to apply for commercialisation funding as they are more likely to consider starting up a company than a tenured academic.</td>
</tr>
<tr>
<td>TTO Resources</td>
<td>Leverage TTSI funding to appoint experienced staff with the necessary skills and experience. Provide training for both TTO staff and PIs. Set up / use incubators to encourage spinoffs.</td>
</tr>
<tr>
<td>Engage with industry</td>
<td>Develop clear statement of the role of enterprise collaboration in its research strategy.</td>
</tr>
</tbody>
</table>

10.3.3 Implications for industry

The emergent model shows how industry has a role in closing the gaps. However, to achieve this, companies needs to increase their levels of interaction with the university sector. This section discusses some of the implications this has for the role of industry.

10.3.3.1 Access to technology and improved absorptive capacity

The first benefit to be gained by industry through its interaction with the universities is a more in depth knowledge of the capability of the third level sector, and the technologies that the universities have.

In the current economic climate, access to new technology is vital for companies to help them differentiate themselves from the competition. This can be achieved either by technological differentiation (via access to new technology), or price differentiation (via process improvement), both of which can be achieved through collaboration with the university and individual PIs.

When companies engage with the third level institutions they should also be aware that the researchers involved in the project become a source of knowledge that can be transferred to the company via the movement of the researchers. Rogers, Takegami et al. (2001) found that the movement of people with the technology is the most effective form of technology transfer. This
movement of people can also help companies to overcome the absorptive capacity issues faced by most SMEs. As a consequence, companies should consider hiring the contract researchers at the end of a project to ensure they gain maximum benefit from their interaction with the university. This can help to overcome the knowledge gap that exists post-licence.

10.3.3.2 Availing of state supports to encourage interaction
Post-licensing and post-spinoff, a funding gap was found to exist. This can be closed by a number of actors including government. Companies should be aware of the role government can play in helping them to overcome this gap, and they should educate themselves on the supports available to them from their national and regional governments.

In Ireland, Enterprise Ireland has targets to increase the number of Irish companies investing €100k in R&D to 1050, and to increase the number of companies investing over €2M to 100 (Enterprise Ireland, 2005) by 2013. These targets will effectively double the number of companies engaging in R&D from the 2005 base. To encourage this increase in investment by industry, Enterprise Ireland offers a number of different financial support measures. However, to help achieve these targets, industry must decide to engage with Enterprise Ireland and to make use of the supports on offer.

Enterprise Ireland offers Innovation Vouchers worth €5,000 to help companies engage with the third level sector. However, less than 5% of companies have used their vouchers, which is a very low number given that companies are allowed group their vouchers allowing them to engage in more substantial projects. Individual companies and networks must make more use of this scheme to increase their levels of communication with the third level sector.

Enterprise Ireland also offers the Innovation Partnership scheme which funds up to 80% of the cost of a collaborative research project. 179 companies engaged in Innovation Partnerships over the last three years; however, as the scheme is open to all companies in Ireland (both Enterprise Ireland and IDA clients) this represents less than a 5% uptake. In 2007-2008, the average cost of a project involving an indigenous company was €211,000 with funding of €131,000 from Enterprise Ireland. Again, companies should be encouraged to made more use of this scheme to engage with academia.
10.3.3.3 Industry Led Research Programmes in Ireland

The Irish government is committed to investing over €53million on industry led research over the next five years. The Competence Centres offer €1million per annum for up to five years as an initial state investment. The member companies are expected to contribute both cash and personnel to carry out the research, and the long term sustainability of the centre is based on an incremental level of industrial investment.

Industry must take advantage of these schemes if only to unsure its own survival. The opportunity to dictate the research agenda for such a large scale programme is a first for Irish industry. As such, it is an opportunity that industry should not miss, particularly as it will allow companies to foster new dynamic relationships with the actors in the academic community.

10.3.3.4 Opportunity for growth

This study highlighted that, in comparison with the entrepreneurial nature of industry in Boston and Silicon Valley (DeGroof and Roberts, 2004), where industry provides a pull on the technology from the third level sector, Irish industry has technology pushed on it by the universities. Higher levels of interaction with the universities can help overcome this issue and as a result, offer industry an avenue for higher returns via investment in new technology.

Over the last decade the majority of capital invested in Ireland has been in the property and construction sectors. Very little has been invested in Intellectual Property (even the owners of companies chose to invest in property over technology). Given the downturn in this sector recently, industrial investors should be encouraged by government to look towards academia as a home for their investment.

10.3.3.5 Summary of implications for industry

There are many benefits available to those companies who choose to engage with the third level sector. Amongst those benefits are access to technology, know-how, and personnel that would not otherwise be available to the company. Industry should be encouraged to make use of the financial supports available from the government to set up collaborations with industry, as it is a low risk means to help them increase their bottom line.

Enterprise Ireland offers a host of schemes (consistent with the emergent model) that help overcome the financial burden of this interaction, (see Table 10.3). It is in industry's best interest to make maximum use of these schemes.
Table 10.3 Recommendations for industry

<table>
<thead>
<tr>
<th>Area of interest</th>
<th>Recommendation for industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to technology and skilled personnel</td>
<td>Engage with the universities to understand what technologies are available and to recruit skilled staff</td>
</tr>
<tr>
<td>Funding to engage with universities to carry out research</td>
<td>Utilise state funding mechanisms such as the Innovation Partnership scheme or via the Competence Centres</td>
</tr>
</tbody>
</table>

10.4 Summary of implications for actors in the Triple Helix

National and regional governments need to encourage universities to value the commercialisation of research, and to provide meaningful career recognition for those involved in the commercialisation of research. In Ireland, the government particularly needs to introduce new financial schemes to encourage investors to consider technology as an attractive alternative to property.

The universities should concentrate on a number of aspects. The first is on the adoption of new policies and the revision of existing policies to encourage and support the commercialisation of applied research. They should also allocate funding to provide specific commercialisation related training.

Industry can benefit from access to technology, know how and personnel that would not otherwise be available to the company. Companies should also be encouraged to make use of the financial supports available from the government.

All three actors in the Triple Helix need to play their part in the relationship to ensure that levels of university-industry interaction increase in Ireland, as this interaction will be a key factor in the economy’s ability to recover from the current global economic crisis.

10.5 Closing Statement

The opening paragraph of this thesis highlighted that trends in globalisation, the current global economic crisis, and the rise of the knowledge economy had contributed to increased calls by national and regional governments for universities to contribute to the development of their economies (Etzkowitz and Chunyan, 2008).

The aim of this research was to investigate the process of knowledge transfer between universities and industry to bring clarity to the actors so that they would better understand their own role in the process of commercialisation, and also have a better appreciation of who the other actors were, and what their individual and collective roles were in the process.
This thesis achieved that by providing an emergent model that describes the gaps that need to be overcome in the process, and by identifying the actors who help to overcome these gaps. In particular, this thesis identified four commercialisation scenarios and showed that the gaps, and actor interactions required to overcome them, differ depending on the particulars of a scenario.

In doing so, this thesis has made a theoretical contribution and a number of policy recommendations to the actors in the emergent model. As the economic climate has changed dramatically since calls for the universities to contribute to economic development became popular at the turn of the century, the importance of this theoretical contribution has significantly increased. As such, each of the five actors included in the emergent model have a role to play to ensure the economic potential from the commercialisation of research in Irish universities is realised and maximised.
References:


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Appendix 1: Survey Protocol

1.1 Introduction
This protocol describes the field procedures followed by the pilot survey which formed the first phase of my research. It considered the following questions:

- Who collected the data?
- How they collected the data?
- From whom they collected the data?
- When they collected the data?
- How they recorded the data?

1.2 Aim of the survey
The intention of the survey was to collect empirical data on the various dimensions of the conceptual model developed in Chapter 3. The questions were based on the operationalisation of the factors presented in the next section. The questions were developed to determine whether a factor influenced commercialisation or not. Questions on the context, process of commercialisation, and outputs of the process were also included to gather data on all elements of the model. I used multiple questions to investigate variables to allow for triangulation of the data, see Table A.0.1 for the list of questions relating to each variable.

Given the unit of analysis was the ATRP / CFTD project, I assumed government were supportive, therefore I did not interview a representative of government. Similarly, industry representatives were not interviewed as they were assumed to be receptive to technologies developed by the academics if there was a market need.

1.3 Sources of data
As the unit of analysis was projects funded by the ATRP / CFTD, the appropriate source of data was the PI. To gather data on the policies of the university and the role of the TTO, the TTOs were also interviewed to get their answers to questions on policies etc. The answers to these questions were useful in comparing the replies from the PIs.
Table A.0.1 Question to variable links

<table>
<thead>
<tr>
<th>Presence of variable</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>University</strong></td>
<td></td>
</tr>
<tr>
<td>University Mission Statement and policies</td>
<td>7, 8, 9, 10, 11, 12 &amp; 32</td>
</tr>
<tr>
<td>Distribution of royalty rates</td>
<td>13</td>
</tr>
<tr>
<td>TTO Structure and size</td>
<td>5, 6, 16, 17, 21, 22 &amp; 23</td>
</tr>
<tr>
<td>Use of an incubator</td>
<td>26, 27 &amp; 28</td>
</tr>
<tr>
<td>Use of internal VC funds</td>
<td>29 &amp; 30</td>
</tr>
<tr>
<td>Previous marketing experience of TTO staff</td>
<td>16</td>
</tr>
<tr>
<td>Patenting, licensing or technical expertise of TTO</td>
<td></td>
</tr>
<tr>
<td>Policies on IP</td>
<td>33, 34, 35 &amp; 36</td>
</tr>
<tr>
<td>Incentives (financial) for TTO</td>
<td>See TTO questionnaires</td>
</tr>
<tr>
<td>Inventor acting as entrepreneur</td>
<td>2, 3, 15, 17, 37, 38, 40, 44, 49, 50, 51 &amp; 52</td>
</tr>
<tr>
<td>Unique Superior Idea</td>
<td>4</td>
</tr>
<tr>
<td>Presence of a medical school</td>
<td>24</td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td></td>
</tr>
<tr>
<td>Network academic has with industry</td>
<td>2, 3, 25 &amp; 42</td>
</tr>
<tr>
<td>Prior business experience of academic</td>
<td>41</td>
</tr>
<tr>
<td><strong>Associated skill level</strong></td>
<td></td>
</tr>
<tr>
<td><strong>University</strong></td>
<td></td>
</tr>
<tr>
<td>University Mission Statement and policies</td>
<td>7, 8, 9, 10, 11, 12 &amp; 32</td>
</tr>
<tr>
<td>Use of an incubator</td>
<td>26, 27 &amp; 28</td>
</tr>
<tr>
<td>Use of internal venture capital funds</td>
<td>29, 30 &amp; 31</td>
</tr>
<tr>
<td>TTO Structure</td>
<td>6, 14, 16, 22 &amp; 23</td>
</tr>
<tr>
<td>Incubational model employed</td>
<td>See TTO questionnaire</td>
</tr>
<tr>
<td>TTO experience and size</td>
<td>16, 18, 29, 20 &amp; 21</td>
</tr>
<tr>
<td>Previous marketing experience of TTO staff</td>
<td>16</td>
</tr>
<tr>
<td>Expertise in patenting, licensing or technical expertise of TTO staff</td>
<td>16</td>
</tr>
<tr>
<td>Academic as an entrepreneur</td>
<td>37, 38, 44, 50, 51 &amp; 52</td>
</tr>
<tr>
<td>Research profile of academic</td>
<td>43, 44, 45, 46 &amp; 47</td>
</tr>
<tr>
<td>Familiarity of Academic with policies etc</td>
<td></td>
</tr>
<tr>
<td><strong>Industry</strong></td>
<td></td>
</tr>
<tr>
<td>Strength of network academic has with industry</td>
<td>2, 3, 25 &amp; 42</td>
</tr>
<tr>
<td>Prior business experience of academic</td>
<td>2 &amp; 41</td>
</tr>
</tbody>
</table>
Where an academic had more than one project funded they receive two (or three) copies of Section 2 to complete for each project. They only completed the other sections once.

1.4 Data collection methods
I was the sole collector of all data in this study. I used a combination of face to face interviews and a mail survey to collect the data. Where I had access to the PIs (in UL and TCD) I used a face to face interview to administer the surveys. All questions were asked in the order they appeared on the survey, and all responses are recorded. For the other universities, I posted the survey with a letter of introduction and a stamped address envelope to encourage the academic to fill out and return the survey.

Due to the smaller population of TTO directors I interviewed each of the TTO directors using a face to face interview.

1.5 Question development
As shown in Table A.0.1, I used multiple questions to probe individual variables. How those questions were developed is now discussed.

In Chapter 3, I developed a contextual model using the literature discussed in Chapter 2. Table 3.1 shows the variables that made up each construct, and the sources of the literature from which they are taken. In order to develop a set of questions to probe each variable, it was necessary to operationalise this list of variables.

To do this, I returned again to the literature and to the specific papers listed in Table 3.1. Where a list of measures was available to describe how the original authors investigated the variables, I copied those for use in my research. Where they were not evident in the literature, I developed my own measures using whatever information was available from the literature. Table A.0.2 presents an operationalisation of the variables.
Table A.0.2 Operationalisation of the variables

<table>
<thead>
<tr>
<th>Construct</th>
<th>Source</th>
<th>Variable</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge gap</td>
<td>(Di Gergorio and Shane, 2003; Vohora, Wright et al., 2004)</td>
<td>Commercial skills of academics</td>
<td>Previously worked in industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical knowledge of academic</td>
<td>Strength of network with industry, frequency of contact</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Management skills of academic</td>
<td>Prior business experience in spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prior experience of licence issuance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Publication record</td>
</tr>
<tr>
<td>Funding</td>
<td>(Siegel, Waldman et al., 2003b); (Di Gergorio and Shane, 2003; Jacob, Lundqvist et al., 2003)</td>
<td>Lack of funds</td>
<td>Lack of funds</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>(Vohora, Wright et al., 2004)</td>
<td>Commercial skills of academics</td>
<td>Unique Superior Idea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social Links</td>
<td>Inventor acting as entrepreneur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commitment of academic</td>
<td>Strength of network academic has with industry</td>
</tr>
<tr>
<td>Role of University</td>
<td>(Di Gergorio and Shane, 2003); (Markman, Phan et al., 2005); (Clarysse, Wright et al., 2005); (Siegel, Waldman et al., 2003a; Markman, Phan et al., 2005)</td>
<td>Policies that provide incentives for entrepreneurial activity</td>
<td>TTO size and experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTO structures and licensing strategies</td>
<td>Presence of a university holding company</td>
</tr>
<tr>
<td></td>
<td></td>
<td>University incubation strategy</td>
<td>Traditional university structure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motivation of TTO staff</td>
<td>Previous marketing expertise of TTO staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reward and recognition</td>
<td>Expertise in patent law and licensing or technical expertise of TTO staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structure of the TTO</td>
<td>Incentives on offer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Strength of marketing skills</td>
<td></td>
</tr>
<tr>
<td>Role of government</td>
<td>(Bozeman, 2000; Shane and Stuart, 2002; DeGroof and Roberts, 2004; Djokovic and Souitaris, 2008; O'Shea, Chugh et al., 2008)</td>
<td>Support programmes</td>
<td>Support programmes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Source of funding</td>
<td>Levels of funding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Policies and regulations on commercialisation</td>
<td>Policies governing commercialisation</td>
</tr>
<tr>
<td>Role of industry</td>
<td>(Chiesa and Piccaluga, 2000; Cesaroni, Contri et al., 2005; Lockett, Siegel et al., 2005; O'Shea, Allen et al., 2005)</td>
<td>Receptive industry</td>
<td>Level of interaction</td>
</tr>
<tr>
<td>Role of the Principal Investigator</td>
<td>(Jensen and Thursby, 2001; Luthje and Franke, 2003; Clarysse and Moray, 2004; Dru Ih and Garnsey, 2004; Gordon, 2004; Gübeli and Doloreux, 2005; Lockett, Siegel et al., 2005; Landry, Amara et al., 2006; Wright, Lockett et al., 2006; O'Shea, Chugh et al., 2008)</td>
<td>Source funding</td>
<td>Funding history</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical knowledge</td>
<td>Publication record</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial knowledge</td>
<td>Prior licensing, spinoff history</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commitment</td>
<td>Ownership of previous spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social links</td>
<td>Patenting history</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Frequency of links to industry</td>
</tr>
<tr>
<td>Role of Financial Institutions</td>
<td>(Calantone and di Benedetto, 1988; Luthje and Franke, 2003; Dru Ih and Garnsey, 2004; Landry, Amara et al., 2006; (Di Gergorio and Shane, 2003)</td>
<td>Source of funding</td>
<td>Presence of local VC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Business advice</td>
<td>Size of funds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number of spinoffs supported</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Take seat on board of spinoff</td>
</tr>
</tbody>
</table>
1.6 Pilot study
I piloted the PI and TTO questionnaires in UL where I had best access to the relevant individuals. I used a project I had worked on as I knew if the data collected via the survey was an accurate reflection of the project. Similarly, I piloted the TTO questionnaire in UL. Where appropriate, changes were made to the questionnaires before they were rolled out to the entire population.

1.7 Time frame for data collection
Both pilot surveys were carried out in May 2006. Modifications to the questionnaires were made in time to send out the PI questionnaires in June 2006. Follow up telephone calls and emails were made four and six weeks after the posting of the original survey.

The TTO surveys were carried out during June and July 2006 according to the availability of the TTO directors. Interviews were scheduled in advance via personal telephone calls.

1.8 Non-respondents
Where replies were not received within four weeks of the original posting of the survey, I emailed a copy of the survey to the Principal Investigator and followed up with a telephone call to encourage the academic to reply. I did the same six weeks after the original posting where responses were not received. I also asked my colleagues in the various universities to encourage the academics to reply to the survey.

1.9 Methods of data analysis
I used the latest version of the Statistical Package for the Social Sciences (SPSSv.13) to analysis the data according to the following plan in Figure A.1.

The first analysis technique used was the Chi Squared test. This was used to investigate if a relationship existed between the construct and the project outcome. The Chi Squared test was based on the Null Hypothesis that assumed that each of the expected outcomes was equally likely.
The second step in the analysis was to carry out a *Correlation* test using the appropriate parametric and non-parametric tests. The correlation test indicated whether two variables were correlated, and indicated the strength and the direction of the relationship between the pair of variables under test. The third analysis step was to examine if I could say there was a *difference in the means* between the two variables with 95% confidence.

To identify factors that allowed an outcome to be predicted, I used a *Regression* test. Regression testing was appropriate as the dependent variable in this study was categorical and binary (whether project outcome was commercialised or not). I chose the *Logistical Regression* model that was specifically used to deal with such data (Montgomery, Peck and Vining, 2001).

The analysis considered the data with respect to the following questions:

1. Was there a relationship between the constructs in the model and the project outcomes?
2. If so, what was the strength of the relationship between them?
3. What confidence (in terms of statistical significance) could I have in the presence and strength of these relationships?
4. What areas were there for further investigation via the case studies?
1.10 Questionnaires
As there were slight variations in the nature of the questions to be posed to the academics and the TTO staff, I used two similar questionnaires, one focused on the academics, the other on the TTO staff. These questionnaires are included below.
Letter of Introduction

June 2006

Dear <first name>,

As a student in the School of Business Studies, Trinity College, Dublin I am carrying out a PhD study with Prof. Paul Coughlan into the manner in which universities approach the commercialization of their research. My study focuses on projects funded by Enterprise Ireland under the Advanced Technology Research Programme (ATRP) and the Commercialisation Fund: Technology Development (CFTD) in the calls for proposals from 2001 to 2003. The aim of my study is to develop an understanding of how the commercialization of research is conducted in Irish Third Level Institutes and to determine if there are common practices that can be associated with projects that exploit their findings commercially.

This research is particularly timely as universities in Ireland face an increasing financial challenge. Eighty percent of university income is derived from direct state funding however, the actual levels of funding have, until recently, been frozen since 2002 with potentially damaging consequences for the universities as they attempt to contribute to the development of Ireland as a knowledge based society. As such, universities must find other sources of income if they are to make this contribution. Here, the commercialisation of research is relevant. The Intellectual Property (IP) developed as a natural outcome of their research activities represents a key source of potential income for the universities. However, there are many barriers to the successful exploitation by universities of this IP. This study aims to highlight the conditions that are necessary to commercially exploit applied research in Ireland.

As a recipient of funding under the < programme > in < year > for the project entitled < project name> I would appreciate an opportunity to include your project in my study. Including your project would involve completing the attached questionnaire that should take approximately fifteen to twenty minutes.

All data collected in this research will remain confidential and participating persons or projects will not be identified. Upon completion of this research I will make my findings available to all the participants.

Thank you for your co-operation.
Yours sincerely,

Mark Whelan
087 8595466
mwhelan8@tcd.ie
Conditions for the Commercialisation of Applied Research from Irish Universities:
A Triple Helix of University – Industry – Government Relations

This survey is a part of a research project being undertaken at the School of Business, Trinity
College Dublin, to explore the conditions and factors that affect the commercialisation of research
from Irish universities using the Advanced Technology Research Programme (2001) and the
Commercialisation Fund Technology Development programme (2002 and 2003) as the unit of
analysis.

Instructions for completion
Please complete all sections as they relate to your relevant ATRP or CFTD project. Where you
have received funding for more than one ATRP / CFTD during the years 2001 to 2003 please fill
out a separate Section 2 for each project on the additional sheets provided.

Please return completed questionnaires using the stamped address envelope attached to
Mark Whelan
Room ER1-027, Engineering Research Building
University of Limerick
National Technological Park
Limerick

For any questions, please contact Mark Whelan on 061 213358 or on mwhelan8@tcd.ie
Section 1: Personal Profile
Please provide the following details about yourself, your institution and the department you work in.

Name ___________________________ Title ___________________________
Phone: __________________________ Email: __________________________
Department __________________________
University __________________________

Section 2: Your Project Profile
This section examines the background to your ATRP / CFTD project(s). Please fill out this section for each project you have been awarded between 2001 and 2003.

1. Project Title: _________________________________________________________
   a) Start date: 
   b) Projected end date: 
   c) Level of funding received 
   d) Sector, please tick appropriate box
      □ Biotechnology
      □ ICT
      □ Industrial Technologies (Materials and Manufacturing)

2. Before starting your project, how did you establish the commercial requirements of the project?

   □ Interaction with potential customers or end users
   □ Market trials
   □ Customer visits
   □ Focus groups
   □ Other (please specify) ____________________________________________
   □ Not applicable as new to market product

3. Did either the technical or commercial objectives of your project changed over the lifetime of the project? □ Yes □ No (if no, skip now to question 4) 

   If they have changed what caused them to change? Tick all appropriate boxes
   a) Technical
      □ Not applicable
      □ Lack of technical resources to complete all project objectives
      □ Lack of equipment to complete all project objectives
      □ Lack of financial resources to complete project objectives
      □ Technical objectives not fully understood at project onset
      □ Objectives too optimistic for project time frame
      □ Other (please specify) ____________________________________________

   b) Commercial
      □ Not applicable
      □ Change in market during project
      □ Better understanding of market needs developed during project
      □ Commercial opportunities not fully understood at project onset
      □ Specific customer requests
      □ Other (please specify) ____________________________________________

   c) If, with changed, when did they change (in what month of the project approximately)

      □ Technical __________ □ Commercial __________
d) Who was most responsible for initiating these changes?

☐ The project team
☐ A customer
☐ External consultant
☐ Enterprise Ireland
☐ Other (please specify)

4. In your own opinion, did you have a product or process suitable for commercialisation upon completion of your project?

☐ Yes       ☐ No       ☐ Needed more development
**Section 3: Your Institution**

Please answer all questions in this section in relation to how they affect your ATRP or CFTD project described in Section 2. For the purpose of this document, the term ‘the commercialisation of research’ refers to the development of a spin off company or a licensing agreement.

5. Does your institution have a specific department or office responsible for helping academics to license their research outputs or create spin off companies that you are aware of?

   □ Yes □ No □ Don’t know (if no, skip to question 7)

6. Is this function the responsibility of a university office, department or a separate company?

   □ Office that is part of larger department
   □ Separate university department
   □ Company
   □ Other (please specify) ____________________________

   a) What is its name of this function? ____________________________

   b) If a separate company, is it run on a ‘for profit’ or ‘nonprofit’ basis?

   □ Profit □ Non Profit

7. Does your institution have a strategy for the commercialisation of research that you are aware of?

   □ Yes □ No □ Don’t know

8. In your opinion, which of the following are the universities policies on commercialisation specifically intended to encourage? Please tick the most appropriate.

   □ Licensing
   □ Start up
   □ Both
   □ Neither
   □ Collaborative Research
   □ Other (please specify) ____________________________

9. Does your university have written policies for the licensing of technology or the creation of spin off companies that you are aware of? □ Yes □ No □ Don’t know

10. Can you provide a brief description of these policies, as you understand them?

    ____________________________________________________________________________

    ____________________________________________________________________________

11. How would you describe the usefulness of the universities policies on licensing and spin-offs? Please tick the box you think is most appropriate.

   □ Don’t have any policies
   □ They hinder the process of licensing and setting up a spin off
   □ They don’t specifically help to develop a license of set up a spin off company
   □ They provide some assistance in developing a license of set up a spin off company
   □ They provide good strong guidance in developing a license of set up a spin off company
   □ They actively encourage the development of licenses of setting up a spin off company

Page 313
12. Did these policies encourage you to develop a licensing agreement or create a spin off company from your ATRP / CFTD, or did they discourage you? Please tick one.

□ Encourage  □ Discourage  □ Neither

a) If they discouraged you, which of the following describe why, please tick all relevant boxes.

□ Too bureaucratic
□ Not focused on needs of the project
□ All the work has to be done by the academic team, no support available
□ No financial help available
□ Other, please specify _______________________________

b) In general, considering other projects to that described in Section 2, would these policies encourage or discourage you (in general) for trying to develop a licensing agreement or creating a spin off company?

□ Encourage  □ Discourage  □ Neither

13. Does your institution have a policy on how licensing income is shared between the inventors and the institution?

□ Yes  □ No  □ Don’t know

a) Is it published? □ Yes  □ No  □ Don’t know

b)

c) If you have a policy, what is the share of the income between the different groups?

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
<th>Breakpoints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research office / central</td>
<td></td>
<td></td>
</tr>
<tr>
<td>university funds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Department of inventors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

c) Does it vary according to the level of monies involved? □ Yes  □ No  □ Don’t know
Section 4: Services offered by your Institution

This section looks at the services (including physical infrastructure) on offer from your institution to academic teams looking to commercialise their research outputs. For the purposes of this survey the term Technology Transfer Office is used to refer to the office responsible for helping academics commercialise their research.

4.1: Technology Transfer Office (TTO)

Please answer the questions in Section 4.1 only if your institution has a TTO, otherwise please skip to Section 4.2.

14. Were the TTO proactive in offering help to you / your project team in attempting to commercialise your research?
   □ Yes □ No (if 'no' please skip to question 15 now)

   a) If, yes, at what stage of the project did they offer help? Please indicate approximate month of first engagement. (month number ______ )

   b) Was this an ongoing / repetitive interaction?
      □ Ongoing □ Repetitive

      If repetitive, how frequent was the interaction? Please tick the most appropriate box.
      □ Daily □ Weekly □ Monthly □ Less than monthly □ Other, please specify_________________________________________

   c) Can you describe the interaction that took place? Please tick the appropriate boxes.
      □ Assistance with business planning
      □ Introductions to companies / potential licensees
      □ Introductions to venture capitalists
      □ Introductions to private investors
      □ Education programmes
      □ Marketing of project
      □ Other (please specify) ___________________________________

15. If the TTO were not proactive in approaching you, did you seek help from the TTO when trying to commercialise your research?
   □ Yes □ No (if 'no' please skip to question 16 now)

   a) If yes, at what stage of the project did you seek their help? Please tick the most appropriate box.
      □ Pre application □ Patenting Stage □ When incubation space was required □ When commercialisation activities started □ After project completion

   c) How frequent was the interaction between you and the TTO on your project? Please tick the most appropriate box.
      □ Once off □ Daily □ Weekly □ Monthly □ Less than monthly □ Other, please specify_________________________________________
d) Can you describe the interaction that took place? Please tick all the appropriate boxes.

- □ Assistance with business planning
- □ Assistance with patenting process
- □ Introductions to companies / potential licensees
- □ Introductions to venture capitalists
- □ Introductions to private investors
- □ Education programmes
- □ Marketing of project
- □ Other (please specify) _____________________________________

16. If you worked with the TTO on your ATRP / CFTD project, how would you rate the knowledge or experience of TTO Staff in terms of the following? Please tick the appropriate box for each area.

The ratings refer to the ability of the person to perform the tasks as expected of their role

<table>
<thead>
<tr>
<th>Universities policies on commercialisation</th>
<th>No awareness</th>
<th>Locally aware</th>
<th>Nationally Aware</th>
<th>Internationally aware</th>
<th>World Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patenting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to explain commercialisation options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous commercialisation experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketing of research outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of your industrial sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. What supports does the TTO offer? Please tick the appropriate boxes

<table>
<thead>
<tr>
<th>Supports Offered</th>
<th>Yes</th>
<th>No</th>
<th>Don't know</th>
<th>Which did you avail of?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low cost consultancy services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business plan development</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venture Capitalist introductions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private investor introductions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education programmes on starting a business</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Education programmes on licensing</td>
<td></td>
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<td></td>
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<tr>
<td>Chief Executive Officer search</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Staff search</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
18. How would you rate the Technology Transfer Office staff in terms of their helpfulness in commercialising your research?

☐ Not at all helpful
☐ Somewhat helpful
☐ As expected of them to conduct their job
☐ Very helpful
☐ More helpful than expected

19. Do you think the TTO has the appropriate skills to help academics commercialise their research?

☐ Yes  ☐ No  ☐ Not Applicable (if yes, please skip to question 21 now)

20. If not, what skills are missing? Please tick appropriate boxes

<table>
<thead>
<tr>
<th>Knowledge of the university's policies on commercialisation</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of Patenting process and laws</td>
<td></td>
</tr>
<tr>
<td>Ability to explain commercialisation options</td>
<td></td>
</tr>
<tr>
<td>Previous commercialisation experience</td>
<td></td>
</tr>
<tr>
<td>Business Planning</td>
<td></td>
</tr>
<tr>
<td>Marketing of research outcomes</td>
<td></td>
</tr>
<tr>
<td>Specific knowledge of your industrial sector</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Please specify</td>
<td></td>
</tr>
</tbody>
</table>

21. Do you think the TTO is adequately staffed?  ☐ Yes  ☐ No  ☐ Don’t know

22. Would you recommend working with the TTO to other staff interested in commercialising their research outputs?

☐ Yes  ☐ No  ☐ Don’t know

a) If no, why not?

☐ Too bureaucratic to work with
☐ TTO were not focused on needs of my project
☐ TTO did not have the required knowledge to help me
☐ TTO did not have the required business experiences to help me
☐ TTO office is under resourced
☐ TTO staff lack the contacts and networks to be useful to me
☐ Other, please specify ______________________________

23. Would you change anything about the TTO?  ☐ Yes  ☐ No  ☐ Not applicable

a) If yes, please explain what and why.

____________________________________________________________________

24. Did you seek, or receive assistance from any other university departments during your ATRP / CFTD project?

☐ Yes  ☐ No  ☐ Not applicable

a) If yes, what was the nature of this interaction?

____________________________________________________________________

____________________________________________________________________

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25. Did you seek, or receive assistance from any other source(s) in attempting to commercialise your research outcomes? If yes, please tick all appropriate departments / activities.

☐ No
☐ Other university office / department
☐ External consultancy
☐ Enterprise Ireland (Shannon Development or Urdaras na nGaeltacht)
☐ Enterprise Ireland staff based on campus
☐ County Enterprise Board
☐ Other, please specify

4.2: Incubators and Venture Capital

26. Does your institution offer incubation facilities to potential start up companies?

☐ Yes  ☐ No  ☐ Don’t know  ☐ In partnership with other agency / institution

(If 'no' please skip to Question 29 now)

27. If your institution has an incubator or access to one via a partner, under what conditions are these facilities offered to potential start ups? Please tick all appropriate boxes

☐ Maximum Time Period
☐ Turnover limit
☐ Staff size limit
☐ Don’t know
☐ Other (please specify)

28. Do you know what supports the incubators offer? Please tick the appropriate boxes

<table>
<thead>
<tr>
<th>Supports Offered</th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
<th>Dependent on being in incubator? Y/ N/ Don’t know</th>
<th>Did you avail of this service? Y / N / NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office spaces at reduced rents</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Wet lab facilities</td>
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<td></td>
<td></td>
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<tr>
<td>Low cost consultancy services</td>
<td></td>
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</tr>
<tr>
<td>Business plan development</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Venture introductions</td>
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<tr>
<td>Capitalist introductions</td>
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<tr>
<td>Private investor introductions</td>
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<tr>
<td>Education programmes on starting a business</td>
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<tr>
<td>Education programmes on licensing</td>
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<tr>
<td>CEO search</td>
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<tr>
<td>Staff search</td>
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<tr>
<td>Other (please specify)</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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29. Does your institution have a venture capital fund(s)?
   □ Yes  □ No  □ Don't know

   (If you answer no, please fill out the next question (a) and then skip to question 32)
   a) If not, does it have a relationship with any specific Venture Capital Fund provider
      □ Yes , name of fund ___________________________  □ No □ Don't know

30. If your institution has a venture capital fund, how big are these funds and what size awards do they make?

<table>
<thead>
<tr>
<th>Number of awards per annum</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum value of award</td>
<td></td>
</tr>
<tr>
<td>Term of the award (i.e. period in which money must be spent)</td>
<td></td>
</tr>
</tbody>
</table>

31. What are the conditions under which these awards are made?

   ____________________________________________________________
   ____________________________________________________________

32. Does your institution take an equity stake in spin off companies established by university staff?
   □ Yes  □ No  □ Don't know
   a) If so, what percentage does it take? □  %
   And under what conditions?

<table>
<thead>
<tr>
<th>Term (time period)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum investment period</td>
<td></td>
</tr>
<tr>
<td>Maximum investment period</td>
<td></td>
</tr>
<tr>
<td>Undiluted share holding</td>
<td></td>
</tr>
<tr>
<td>Cash Investment</td>
<td></td>
</tr>
<tr>
<td>Permission to use intellectual property</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
</tbody>
</table>
Section 5: Protecting Intellectual Property

33. Does your institution have a published policy on patenting and licensing of technology?

☐ Yes  ☐ No  ☐ Don’t know

(if ‘no’ please skip to Question 36)

34. If yes, when did you become aware of this policy?

☐ Before applying for my ATRP / CTFD project
☐ During the lifetime of my ATRP / CFTD project
☐ When I wanted to file for a patent
☐ After the completion of the project
☐ Other, please specify ________________________________

35. Can you briefly describe your understanding of this policy?

_____________________________________________________________________

_____________________________________________________________________

36. In your opinion, which of the following do these university policies on Intellectual Property specifically encourage?

☐ Licensing of technologies
☐ Formation of new start up companies
☐ Both
☐ Neither
☐ Collaborative Research
☐ Other (please specify) ________________________________
Section 6: Your Choice of ATRP or Commercialisation Fund

37. How did you become aware of the ATRP or Commercialisation Fund that funded your project? Please tick the relevant box(es).

☐ The university research office
☐ Enterprise Ireland staff based in your institution
☐ Enterprise Ireland / Shannon Development / Udaras na nGaelacht
☐ A colleague
☐ Other (please specify) ___________________________________________________________________

38. Can you briefly describe your understanding of the aims of the ATRP / CFTD in funding your project?

________________________________________________________________________
________________________________________________________________________

39. Why did you choose the ATRP / CFTD as a source of funds? Please tick all the appropriate boxes.

☐ Successful in receiving ATRP / CFTD grant in the past
☐ Successful in receiving other grant from Enterprise Ireland in the past
☐ Wanted to commercialise my research outputs
☐ Easier source of finance that SFI
☐ Recommendation of a colleague
☐ Recommendation of TTO staff
☐ Recommendation of Enterprise Ireland
☐ Other (please specify) ___________________________________________________________________

40. In your opinion, did the ATRP / CFTD encourage you to do any of the following? Please tick the appropriate box.

☐ Licensing of technologies
☐ Formation of new start up companies
☐ Both
☐ Neither
☐ Collaborative Research
☐ Other (please specify) ___________________________________________________________________
Section 7: Your Academic and Industrial background

41. Have you ever worked in industry? □ Yes □ No
   a) If yes, in what role?

   b) For how long (and when) did you work in industry?
   Number of Years  When (e.g. 1995-1999)

42. How would you describe your current links with industry? Please tick one
   □ Weekly interaction
   □ Monthly interaction
   □ Less than monthly interaction
   □ No interaction with industry in last 12 months

43. Please indicate the sources of research funding you have received over the last five years

<table>
<thead>
<tr>
<th>Sources of Funding</th>
<th>Within the last 5 years</th>
<th>Prior to the last 5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Applications</td>
<td>Received</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Foundation Ireland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enterprise Ireland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other State Agency (Please specify)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>European Union Please specify programme</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
44. Why did you, or what would make you apply to the following funding sources? Please tick all appropriate boxes

<table>
<thead>
<tr>
<th>Source</th>
<th>Easy to apply</th>
<th>High Probability of funding success</th>
<th>Reporting requirements are not stringent</th>
<th>Good for my academic profile</th>
<th>Funded aimed at my area of interest</th>
<th>Other (please specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal University funds</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science Foundation Ireland</td>
<td></td>
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<td></td>
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<tr>
<td>Enterprise Ireland</td>
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<td></td>
</tr>
<tr>
<td>Other State Agency (Please specify)</td>
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<td></td>
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<tr>
<td>European Union</td>
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<tr>
<td>Please specify programme</td>
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<tr>
<td>Industry</td>
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<tr>
<td>Other (Please specify)</td>
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</tbody>
</table>

45. What is the number of peer reviewed papers you have published in the last five years?
   Number of Journal Articles / Papers

46. What is the number of peer reviewed conference papers you have presented in the last five years?
   Number of Conference Papers
   a) What percentage of these became journal articles, book chapters etc.

47. In what year did you receive your PhD (if appropriate) e.g. 1999

48. Have you ever applied for, or received a patent? □ Yes □ No

49. Have you, or do you intend to apply for a patent based on the results of your ATRP / CFTD project?
   □ Yes  □ No  □ Don't know yet
a) If no, what would stop you from applying for a patent? Please tick all appropriate boxes.

- [ ] I have no interest in getting a patent
- [ ] There isn't the required level of novelty in my research to gain a patent
- [ ] I don't understand the process of applying for a patent
- [ ] It is too long and drawn out to apply, I don't have the time to spend on it
- [ ] Too expensive, I don't have access to funding to apply
- [ ] No help available from university to apply
- [ ] I'm too busy to apply for a patent
- [ ] Other (please specify)

50. Have you ever been involved in a university spin off company?  □ Yes □ No

   a) If so, did (or do) you own shares in this spin off?  □ Yes □ No

   b) What role did (or do) you hold in this company?

   c) What percent of the company did (or do) you own?  __________ %

51. Have you, or do you intend to set up a spin off company based on the outcomes of your ATRP / CFTD project?

   □ Yes □ No □ Don't know yet

a) If no, what would stop you?

- [ ] I have no interest in setting up a company
- [ ] I don't have the time to spend on setting up a company
- [ ] I don't understand the process of setting up a company
- [ ] I want to continue with my research
- [ ] Too expensive, I don't have access to the necessary funding
- [ ] No help available from university to start a company
- [ ] Other (please specify)

52. On a scale of 1-5 how would you rate yourself in terms of your interest in commercialising the outcomes of your current research? Please tick one

- [ ] Not at all interested in commercialising my research
- [ ] Would be interested if somebody else wanted to help me
- [ ] Somewhat interested
- [ ] Keen to commercialise my research
- [ ] Actively pursuing commercialisation of my research
Thank you for taking the time and effort to fill out this questionnaire.

I will be glad to share the findings of my research with you once it has been completed.

Please return completed questionnaires using the stamped address envelope attached to

Mark Whelan
Room ER1-027, Engineering Research Building
University of Limerick
National Technological Park
Limerick

For any questions, please contact Mark Whelan on 061 213358 or on mwhelan8@tcd.ie
Section 1: University Profile
Please provide the following details about yourself, your institution and the department you work in.

University ________________________________ TTO / Incubator ________________________________

Interviewee Name ___________________________ Phone: ___________________________
Email: ___________________________ Function / Role ___________________________

Section 2: Technology Transfer Organization (TTO) Profile
(for the purpose of this document, the term Technology Transfer Office (TTO) refers to the department or office responsible for the commercialisation of the university's research)

1. In what year was the TTO in your institution first established?

   Year of foundation ______________

2. Please complete the following table giving details of the staffing levels in your department

<table>
<thead>
<tr>
<th>Number of Personnel</th>
<th>At foundation</th>
<th>2006</th>
<th>Average length of service</th>
<th>years</th>
</tr>
</thead>
</table>

3. What was the mission of the TTO when it was first established?

   _________________________________________________________

4. Has this mission changed since the TTO was set up? □ Yes □ No

   a) If so, when did it change and how? Year of change ______________

      How it changed _____________________________________________

   b) In your opinion, what factors influenced this change? Please tick appropriate boxes

      Economic factors □
      Internal University Factors □
      Government Policies □
      Industry □
      Other (please specify) □ ______________________________________

5. What is the ownership structure of the TTO?

   PRO's department □
   External but wholly owned □
   External □

   a) If the TTO is a separate company, is it owned by the university? □ Yes □ No

      How is it run? For profit □ Not for profit □
Section 3: TTO Staff Profile

The intention of this section is to examine the experience levels of the TTO staff

6. Does TTO staff receive on the job training? □ Yes □ No
   a) What type of training do they receive and how often? Please include the regularity of training next to each box in the following table

<table>
<thead>
<tr>
<th>Type of Training Received</th>
<th>Regularity of Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universities policies on commercialisation</td>
<td></td>
</tr>
<tr>
<td>Patenting</td>
<td></td>
</tr>
<tr>
<td>Ability to explain commercialisation options</td>
<td></td>
</tr>
<tr>
<td>Previous commercialisation experience</td>
<td></td>
</tr>
<tr>
<td>Business Planning</td>
<td></td>
</tr>
<tr>
<td>Specific knowledge of your industrial sector</td>
<td></td>
</tr>
</tbody>
</table>

Examples of training:
- On the job
  - Formal course presented by internal staff member
  - Formal course presented by external trainer

7. Do TTO staff have a written job description? □ Yes □ No
   a) If yes, does the staff member have an input into it creation? Tick appropriate

   Yes □
   No □
   Standard Job description used □

   b) If no, do they have a verbally agreed one? □ Yes □ No
8. How would you rate the knowledge / experience of TTO Staff in terms of the following? Please place a cross in the relevant box against each area.

The ratings refer to the ability of the person to perform the tasks as expected of their role

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>Less than expected</th>
<th>As expected</th>
<th>More than expected</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Knowledge of university organisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universities policies on commercialisation</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Patenting</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ability to explain commercialisation options</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Previous commercialisation experience</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Business Planning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketing of research outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific knowledge of your industrial sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. What are the average salaries of the TTO staff?

   a) Less than €30,000 □
   b) €30,000 - €45,000 □
   c) €45,000 - €60,000 □
   d) more than €60,000 □

10. Are TTO staff offered incentives based on their performance? □ Yes □ No

   a) If yes, are these awards for teams or individuals?

   Teams □
   Individuals □
Section 4: Policies of the TTO
This sections examines the day to day procedures used by the TTO staff if helping to create spin offs or develop license agreements

11. Do you have written policies for the licensing of technology or the creation of spin off companies?
   □ Yes □ No
   a) If yes, can you summarise them here?

   ________________________________________________________________
   ________________________________________________________________

   b) Are these policies policed? □ Yes □ No

   c) If yes, please describe how they are policed and by whom

   ________________________________________________________________
   ________________________________________________________________

   d) If no, why not?

   ________________________________________________________________
   ________________________________________________________________

12. Which of the following Are these policies specifically intended to encourage? Please tick one

   Licensing □
   Start up □
   Both □
   Neither □
   Other □ please specify _______________________________________

13. When were these policies first developed?

   Year of Development □

   a) How have they evolved since then? □ Yes □ No

   b) When did these changes occur?

   Year of Change □

   c) What factors do you think influenced the evolution of these policies?

   Economic factors □
   Internal University Factors □
   Government Policies □
   Industry □
   Other (please specify) □ please specify ______________________________
14. Does your institution have a policy on how licensing income is shared between the academics / development team and the institution? □ Yes □ No
d) Is it published? □ Yes □ No
e) If you have a policy, what is the breakdown between the different groups?

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic team</td>
<td></td>
</tr>
<tr>
<td>Research office / central university funds</td>
<td></td>
</tr>
<tr>
<td>Department of research team</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
</tbody>
</table>

14. How would you describe the usefulness of the universities policies on licensing and spin-offs? Please tick one

□ They hinder the process of licensing and setting up a spin off
□ They don't specifically help to develop a license of set up a spin off company
□ They provide some assistance in developing a license of set up a spin off company
□ They provide good strong guidance in developing a license of set up a spin off company
□ They actively encourage the development of licenses of setting up a spin off company

Section 5: Services offered by the TTO
This section looks at the services (including physical infrastructure) on offer from the TTO to academic teams looking to commercialise their research outputs

16. Does your institution offer incubation facilities to potential start up companies? □ Yes □ No

17. Under what conditions are these facilities offered to potential start ups? Please tick appropriate boxes

Maximum Time Period □
Turnover limit □
Staff size limit □
Other (please specify) □ ________________________________

18. What supports does the incubators offer? Please tick the appropriate boxes

<table>
<thead>
<tr>
<th>Supports Offered</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office spaces at reduced rents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wet lab facilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low cost consultancy services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free consultancy services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business plan development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Venture Capitalist introductions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private investor introductions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEO search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff search</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
19. Does your institution have a venture capital fund(s)? □ Yes □ No

b) If not, does it have a relationship with any specific Venture Capital Fund provider
□ Yes □ No

c) If yes, what is the name of this VC Fund? Name of fund ___________________

20. If your institution has a venture capital fund, how big are these funds and what size awards do they make?

<table>
<thead>
<tr>
<th>Number of awards per annum</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum value of award</td>
<td></td>
</tr>
<tr>
<td>Term of the award (i.e. period in which money must be spent)</td>
<td></td>
</tr>
</tbody>
</table>

21. What are the conditions under which these awards are made?

________________________________________________________________________
________________________________________________________________________

22. How are staff from the TTO assigned to work on commercialisation projects? Please tick appropriate boxes

- Ad hoc basis □
- On a rota basis □
- By industrial experience □
- By portfolio (specify type) □
- By academic background □
- By geographic market □
- Other (please specify) □

23. In terms of interaction with the academic team who wish to commercialise their research, at what point in the project do the TTO usually become involved? Please tick the most appropriate box

- Pre application □
- Within first six months of project □
- After six months and before last six months (please indicate approximate month) □
- Within last six months of project □
- After project completion □

24. Typically, how often to the TTO staff interact with the academic team to help commercialise their research.

- Daily □
- Weekly □
- Monthly □
- Less than monthly □
- Other, please specify ____________________________
25. Can you describe the types interaction that take place? Please tick the appropriate boxes

- [ ] Assistance with business planning
- [ ] Introductions to companies / potential licensees
- [ ] Introductions to venture capitalists
- [ ] Introductions to private investors
- [ ] Education programmes
- [ ] Marketing of project
- [ ] Other (please specify) ___________________

26. Do the TTO staff member(s) become integrated members of the project team?  
- [ ] Yes
- [ ] No

27. Do you think academics are proactive in asking for help from the TTO in attempting to commercialise their research?  
- [ ] Yes
- [ ] No

a) If not, what do you think might stop them?
- [ ] They consider the TTO staff too bureaucratic
- [ ] They thought the TTO staff were not focused on needs of project
- [ ] They thought the TTO staff did not have the required knowledge to help
- [ ] They thought the TTO staff did not have the required business experiences to help
- [ ] Other, please specify ___________________

28. In your opinion, do academics proactively try to avoid involving the TTO in attempting to commercialise their research?  
- [ ] Yes
- [ ] No

a) If your answer is yes, why do you think this happens?
- [ ] They consider the TTO staff too bureaucratic
- [ ] They thought the TTO staff were not focused on needs of project
- [ ] They thought the TTO staff did not have the required knowledge to help
- [ ] They thought the TTO staff did not have the required business experiences to help
- [ ] Other, please specify ___________________

29. How would you rate the knowledge or experience of the academics you work with in terms of the following? Please place a cross in the relevant box against each area.

*The ratings refer to the ability of the person to perform the tasks as expected of their role*

<table>
<thead>
<tr>
<th>Poor</th>
<th>Less than expected</th>
<th>As expected</th>
<th>More than expected</th>
<th>Expert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Knowledge of university organisation</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Universities policies on commercialisation</td>
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<tr>
<td>Patenting</td>
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</tr>
<tr>
<td>Ability to explain commercialisation options</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Previous commercialisation experience</td>
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<tr>
<td>Business Planning</td>
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<td></td>
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</tr>
<tr>
<td>Marketing of research outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific knowledge of their industrial sector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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30. Do you think the TTO has the appropriate skills to help academics commercialise their research?
□ Yes □ No

a) If not, what skills are missing? Please tick the appropriate boxes.
- Knowledge of the university's policies on commercialisation
- Knowledge of Patenting process and laws
- Ability to explain commercialisation options
- Previous commercialisation experience
- Business Planning
- Marketing of research outcomes
- Specific knowledge of your industrial sector
- Other (please specify) ________________________________

31. How would you rate the Technology Transfer Office staff in your institution in terms of their interest in commercialising the research outputs of the university? Please tick one.

- Not at all interested in commercialising research □
- Would be interested if academic were leading processs □
- Somewhat interested □
- Keen to commercialise research □
- Actively pursuing commercialisation of research □

32. Do you think the TTO is adequately staffed? □ Yes □ No

33. Would you change anything about the TTO? □ Yes □ No

If yes, please explain what and why?
_________________________________________________
_________________________________________________
_________________________________________________
Section 6: Intellectual Property Protection

34. Does your institution have a published policy on patenting and licensing of technology?
- □ Yes □ No

35. Does your institution take an equity stake in spin off companies established by university staff?
- □ Yes □ No
  a) If so, what percentage does it take?  %

And under what conditions?

<table>
<thead>
<tr>
<th>Term (time period)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum investment period</td>
</tr>
<tr>
<td>Maximum investment period</td>
</tr>
<tr>
<td>Undiluted share holding</td>
</tr>
<tr>
<td>Cash Investment</td>
</tr>
<tr>
<td>Permission to use intellectual property</td>
</tr>
<tr>
<td>Other (please specify)</td>
</tr>
</tbody>
</table>

36. Since its inception, how many licenses and start up companies has the TTO helped create?

<table>
<thead>
<tr>
<th>Number of licenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of spin offs</td>
</tr>
<tr>
<td>Number of those (spin offs) still trading</td>
</tr>
</tbody>
</table>

37. In your opinion, how successful have these license agreements and spin offs been?

- i. Not at all successful □
- ii. Somewhat successful □
- iii. Met expectations set at start up □
- iv. Very successful □
- v. Exceeded expectations at start up □
Appendix 2: Case Study Protocol

2.1 Introduction
This protocol describes the field procedures followed for the case study phase of my research. It discusses the pre-visit preparation, data collection and analysis techniques, as well as presenting the questions that were used in the interviews. It also considers the following questions.

- Who collected the data?
- How they collected the data?
- From whom they collected the data?
- When they collected the data?
- How they recorded the data?

2.2 Process flow chart for case study research
Figure B.1 shows the activities involved in carrying out this research study, and the flow of those activities. The action plan was sequential and was set out to ensure the study was robust and repeatable.

Figure B.1 Case study method (Yin, 2003)

[Diagram showing process flow chart]

The first step in the action plan was to develop the theory for investigation via the cases. In this study the theory was developed from the literature and then refined via a survey. The second step was to select the cases that were used to gather the data. The choice of data was critical as it dictated the researcher's ability to explore
and examine their research questions. If the cases did not provide data on the phenomena under consideration then they were useless to the study. The next section explains in detail the issues for consideration in choosing the cases (Voss, 2009) and the criteria used by this study.

2.3 Choice of cases
The first step in choosing the case studies was to decide which members of the population were eligible for inclusion in the research. As the literature and findings of the survey suggested a number of factors influenced the outcome of the commercialisation process, the choice of cases had to ensure each of these factors could be explored in detail. Similarly, to avoid collecting irrelevant data, the choice of cases was restricted to PIs who replied to the survey. Therefore the criteria for case selection were as follows:

- The PI must have responded to the questionnaire.
- The cases had to allow for the collection of relevant data to help investigate the conceptual model.
- The cases had to include at least one project who attempted a spinoff, one who attempted a licence, and one project that was not commercialised.
- The cases had to come from more than one institution to allow for inter-institutional differences to be considered.

On this basis I chose six cases, three from UL and three from TCD that displayed characteristics of interest related to the phenomenon under investigation. The individual cases were chosen to represent attempts made at each institution to generate a spinoff and a licence.

2.4 On-site data collection
The initial interviews were conducted with the PIs as they were the people I assumed would have the most knowledge of the project. However, if this was not the case then they were asked to nominate a second interviewee. More than one person per project was interviewed to overcome issues of post project rationalisation and to provide points for triangulation.

2.4.1 Sources of data
The primary data source was the interviews with the project team and the TTO staff. Where supporting documentary data from the TTO website or other similar sources were available I also used it. During the interviews the interviewees were asked if any supporting documents were available and how I could access it.
At a minimum, I intended to interview the PI and the TTO staff member responsible for each project. Where a commercialisation manager, or equivalent, worked on a project I also interviewed them. If the interviewees recommended other individuals as a source of data, where possible, I interviewed that person as well. Table 2.1 shows the predetermined list of interviewees at the start of the data collection.

Table B.0.1 Initial predetermined list of interviewees

<table>
<thead>
<tr>
<th>University of Limerick</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL PI1</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>UL SE1</td>
<td>Business Manager</td>
</tr>
<tr>
<td>UL PI2</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>UL PM2</td>
<td>Commercialisation Manager</td>
</tr>
<tr>
<td>UL PI3</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>UL TTD</td>
<td>Director TTO</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trinity College</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCD PI1</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>TCD PM1</td>
<td>Business Manager</td>
</tr>
<tr>
<td>TCD PI2</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>TCD PI3</td>
<td>Principal Investigator</td>
</tr>
<tr>
<td>TCD TTD</td>
<td>TTO manager</td>
</tr>
</tbody>
</table>

2.4.2 Pilot study
To ensure that the questions helped to gather the necessary data to explore the phenomenon under investigation, I used project UL1 as a pilot and interviewed UL PI1, UL SE1 and UL TTD. I then analysed the data from this project to ensure that the questions were focused on the factors identified by the survey.

2.4.3 Time frame for data collection
To ensure end of semester exams and holidays did not interfere with the data collection I conducted the interviews in April / May 2007.

2.5 Method of data collection
The data were collected using a semi-structured interview based on the questions included at the end of this protocol. The questions were asked in order (where practical) and all responses were recorded using a dictaphone. This allowed me to pursue interesting answers in more detail. Where questions were skipped due to the interviewee providing additional unexpected data, I returned to these questions when appropriate to ensure the flow of the interview was maintained.

The audio recordings of the interviews were transcribed and sent to the interviewees to ensure they were an accurate reflection of the interview. As this was research for
my PhD. I was the only recorder of data. I transcribed all the interviews personally to ensure the transcripts were an accurate reflection of the interviews.

2.5.1 Informant selection
As discussed in the previous section, my plan was to interview a predefined group as shown in Table B.0.1. This included the PIs and relevant Project Managers as my key project informants. Where other team members were identified by the PIs as having played a key part in the successful commercialisation of the project outcomes, I asked to interview these individuals. Similarly, where an external individual, such as a surrogate entrepreneur, was involved in the commercialisation process I invited them to take part in the research to discover their role in the project. This selection logic used is shown in Figure B.2, as all the individuals I intend to interview were predetermined, they were included in the purposeful section of the diagram. The ovals represent those individuals, while the double oval indicates that I started, where possible, with the PI.

I also intended to interview the TTO staff member who was responsible for each project and used my own knowledge of the projects to provide additional sources of data. This use of multiple informants offered an opportunity to triangulate the data to ensure individual biases or post-rationalisation did not affect the outcomes of the research (Voss, Tsikriktsis et al., 2002).

Figure B.2 Informant Selection Logic (adapted from Sanjek, 1990)

In total, I planned to interview twelve people across the six projects; these included the six PIs, three TTO staff, two project managers and the CEO of the successful
spinoff. The interviews were recorded using a dictaphone to allow me to concentrate on the answers, so that unexpected responses could be pursued.

2.6 Method of data analysis
The transcripts were analysed using a predetermined list of codes developed from the list of factors under investigation. This list of codes is included as appendix 3.

To start the analysis I analysed each of the individual cases to create within case analyses. I then used this data to draw cross case conclusions from which I modified the theory where appropriate.

2.6.1 Operationalisation of the variables
To help collect the data on the relevant factors, I operationalised the data according to the scheme used for the survey (see Table B.0.2).
Table B.0.2 Operationalisation of the variables

<table>
<thead>
<tr>
<th>Construct</th>
<th>Source</th>
<th>Variable</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge gap</td>
<td>(Di Gergorio and Shane, 2003) (Vohora, Wright et al., 2004)</td>
<td>Commercial skills of academics</td>
<td>Previously worked in industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technical knowledge of academic</td>
<td>Strength of network with industry</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Management skills of academic</td>
<td>Frequency of contact</td>
</tr>
<tr>
<td>Funding</td>
<td>(Siegel, Waldman et al., 2003b) (Di Gergorio and Shane, 2003) (Jacob, Lundqvist et al., 2003)</td>
<td>Lack of funds</td>
<td>Prior business experience in spinoff</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prior experience of licence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Publication record</td>
</tr>
<tr>
<td>Entrepreneurship</td>
<td>(Vohora, Wright et al., 2004)</td>
<td>Commercial skills of academics</td>
<td>Unique Superior Idea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social Links</td>
<td>Inventor acting as entrepreneur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commitment of academic</td>
<td>Strength of network academic has with industry</td>
</tr>
<tr>
<td>Role of University</td>
<td>(Di Gergorio and Shane, 2003) (Markman, Phan et al., 2005) (Clarysse, Wright et al., 2005) (Markman, Phan et al., 2005) (Siegel, Waldman et al., 2003a)</td>
<td>Policies that provide incentives for entrepreneurs</td>
<td>TTO size and experience</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TTO structures and licensing strategies</td>
<td>Presence of a university holding company</td>
</tr>
<tr>
<td></td>
<td></td>
<td>University incubation strategy</td>
<td>Traditional university structure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motivation of TTO staff</td>
<td>Previous marketing experience of TTO staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reward and recognition</td>
<td>Expertise in patent law and licensing or technical expertise of TTO staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Structure of the TTO</td>
<td>Incentives on offer</td>
</tr>
<tr>
<td>Role of government</td>
<td>(Bozeman, 2000; Shane and Stuart, 2002; DeGroof and Roberts, 2004; Djokovic and Souitaris, 2008; O'Shea, Chugh et al., 2008)</td>
<td>Support programmes</td>
<td>Support programmes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Policies and regulations on commercialisation</td>
<td>Levels of funding</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Policies governing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>commercialisation</td>
</tr>
<tr>
<td>Role of industry</td>
<td>(Chiesa and Piccaluga, 2000; Cesaroni, Conti et al., 2005; Siegel et al., 2005; O'Shea, Allen et al., 2005)</td>
<td>Receptive industry</td>
<td>Level of interaction</td>
</tr>
<tr>
<td>Role of the</td>
<td>(Jensen and Thursby, 2001; Luthje and Franke, 2003; Clarysse and Moray, 2004; Druilhe and Garnsey, 2004; Gordon, 2004; Gübeli and Doloreux, 2005; Lockett, Siegel et al., 2005; Landry, Amara et al., 2006; Wright, Lockett et al., 2006; O'Shea, Chugh et al., 2008)</td>
<td>Source funding</td>
<td>Funding history</td>
</tr>
<tr>
<td>Principal Investigator</td>
<td></td>
<td>Technical knowledge</td>
<td>Publication record</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commercial knowledge</td>
<td>Prior licensing, spinoff history</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commitment</td>
<td>Ownership of previous spinoff</td>
</tr>
<tr>
<td></td>
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<td>Frequency of links to industry</td>
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<td></td>
<td></td>
<td>Number of spinoffs supported</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Take seat on board of spinoff</td>
</tr>
</tbody>
</table>
2.7 Questions for inclusion in the interviews.

Based on the operationalisation of the data, the questions were developed to probe the measures listed above. As the phrasing of the questions differed depending on the interviewee, I used three separate lists of questions. The first was for the PIs, the second for the Project Manager / Commercialisation Manager and the third for the TTO staff. The list of questions was as follows:

2.8 Principal Investigator questions

Project description and opportunity identification
1. Why did you apply to the Commercialisation Fund for funding?
2. What would you describe as the goal of the Commercialisation Fund?
3. What was the output of your project?
4. When did you recognise there was commercial potential in this output?
5. How did you recognise there was commercial potential in this output?
6. Had you ever been involved in an effort to commercialise the outcome of a research project before?
7. Is so, what was your role and what did you learn from this involvement?

Motivation of the PI – choice of spinoff / licence
8. What motivated you to commercialise the outcome of your project?
9. Why did you chose a spinoff or licence as the route to commercialisation?
10. Where you the main driver of the commercialisation of the project outcomes or was anyone else involved in this process of commercialisation?
11. If someone else was involved, who where they and what input did they have on the decision making process?
12. How did this person become involved with your project?

Process of commercialisation used (if appropriate)
13. How did you go about commercialising your project outcomes, what process did you use?
14. Did you receive support from your institution in attempting to commercialise your research outcomes?
15. From whom did you receive this support, and what did this support entail?
16. How competent would you say these people you worked with were in terms of helping in the process of commercialising your research?
17. Where you aware if your institution had policies on commercialisation before you started to commercialise your research outcomes?
18. Did these policies influence your decisions on how to commercialise your research in any way, if so how?
19. Did you know prior to your attempts to commercialise your project what assistance was available to you from your institution?
20. How and when did you become aware of the help that was available to you?
21. Did you make use of any of these supports? Which ones and why? If you did not make use of them, why did you not?
22. Did you receive support from any external sources? If so, what was did this entail, who initiated the contact, when and why?
23. Where you successful in your attempts to commercial your project? What was the outcome of the process of commercialisation?
24. If you were not successful, why do you think you were unsuccessful?
25. Would you do anything different the next time you were involved in the commercialisation of a research project?
26. Any other points you’d like to raise with me about your efforts to commercialise your project outcomes?

2.9 Commercialisation Manager questions

**Project description and opportunity identification**

1. When did you become involved in this project?
2. At whose request did you become involved?
3. What was your role in the project?
4. What is your own background?
5. How and when did you recognise there was commercial potential in the idea?
6. Had you ever been involved in a spinoff or licence agreement from the outcome of a research project before?
7. What was your role in this other project?

**Motivation of the PI – choice of spinoff / licence**

8. Would you say you where the main driver of the commercialisation of the project outcomes?
9. What factors influenced the decision to chose a spinoff / licence as the route to commercialisation?
10. Where you aware of the institutions policies on commercialisation prior to your involvement in this project?
11. If not, how and when did you become aware of these policies?
12. Did these policies influence the decisions on how to commercialise the project outcomes in any way, if so how?
Process of commercialisation used (if appropriate)

13. How did you go about commercialising the project outcomes? What process did you follow?
14. Did you receive support from the institution in attempting to commercialise the research project outcomes?
15. From whom did you receive this support, and what did this support entail?
16. How competent would you say the people how supplied this support were in terms of helping in the process of commercialising your research?
17. Did you know prior to your attempts to commercialise the project what assistance was available to you from your institution?
18. How and when did you become aware of the help that was available to you?
19. Did you make use of any of these supports? Which ones and why? If you did not make use of them, why did you not?
20. Did you receive support from any external sources? If so, what was did this entail, who initiated the contact, when and why?
21. Where the team successful in your attempts to commercial your project?
22. If not, why do you think the group were unsuccessful?
23. Would you do anything different the next time you were involved in the commercialisation of a research project?
24. Any other points you’d like to raise with me about your efforts to commercialise your project outcomes?

2.10 Technology Transfer Officer questions

Background to TTO involvement

1. Had you ever been involved in a spinoff or licence agreement from the outcome of a research project before working on this project?
2. If so, how many other projects were you involved with and what where the outcomes of these project, spinoffs or licences?
3. Where these efforts successful and if so what would you say were the main reason they were successful.
4. If they were not successful, what was the main reason they were not successful.

Evaluation of the opportunity

5. When did you become involved in this project?
6. At whose request did you become involved?
7. Where the team already committed to a route to commercialisation when you became involved, if so, what was it?
8. Did this change during your involvement with the project? If so, why do you think the route changed?

**Motivation of the PI – choice of spinoff / licence**

9. Who would you say was the main driver in the project team behind the commercialisation of the project?

10. How would you describe the group’s knowledge of the commercialisation process when you first started to work with the team?

11. How would you describe the group’s knowledge of the commercialisation process at the end of your involvement with the process?

12. Where the team aware of your institutions policies on commercialisation when you first got involved with their project?

13. If not, did you make them aware of the policies? And if so, why and when did you do this?

14. Do you think the academic’s knowledge of the policies influenced their decision on how to commercialise the project outcomes in any way, if so how do you think it influenced their decision-making?

**Process of commercialisation used (if appropriate)**

15. Can you describe briefly your institutions’ process for commercialisation?

16. Where the team aware of this process before starting to work with you?

17. Did this project follow this process? If not, why not and what deviations from the process were made from the process? What drove these changes?

18. Where the team aware of the supports offered by the institution to aid them in their commercialisation efforts?

19. If so, what level of awareness had they?

20. Did the project team make use of the supports from the institution? Which supports and why? If you did not make use of them, why do you think this was?

21. Did the team receive support from any external sources? What were these supports, who offered them and when in the process were they offered?

22. Where the team successful in the attempt to commercial the project outcomes?

23. If not, why do you think they were unsuccessful?

24. Would you do anything different on the next project you work on as a result of what happened on this project?

25. Any other points you’d like to raise with me about your efforts to commercialise your project outcomes?
### Appendix 3 ATRP Forms

#### 3.1 ATRP Application Form

Advanced Technology Research Programme 2001
Proposal Submission form

For Office Use
Only / /2001

Administrative Form F1

**TO BE COMPLETED BY THE INSTITUTION SUBMITTING A SINGLE-INSTITUTION PROPOSAL OR THE INSTITUTION CO-ORDINATING THE PROJECT IN THE CASE OF A COLLABORATIVE PROPOSAL.**

<table>
<thead>
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<td>Co-ordinating Institution</td>
<td>Department</td>
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<tr>
<td>Address</td>
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<tr>
<td>E-mail</td>
<td>Tel</td>
</tr>
<tr>
<td></td>
<td>Fax:</td>
</tr>
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</table>

**Collaborating Institution(s):**

1
2
3
4
5

| Signature of Principal Investigator | Date: / / |
| Signature of person authorised to endorse the participation of the Institution in the project | Date: / / |
| Position | |

Page 345
Project Abstract (max 100 words)

Project Details

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<th>Start Date</th>
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Total Capital

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<td>Travel (overseas)</td>
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<td>Sub-total other non-pay</td>
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Total project cost (IR£):
**Administrative Form F2** To be completed by each collaborating Institution in a collaborative project.

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<tr>
<td>Contact Person</td>
<td></td>
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<td>E-mail</td>
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**Brief summary of the Institution’s role in the project:**

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Project cost (IR£) attached to the collaborating Institution:

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**Sub-total:**

**Total Capital**

- Current non-pay
- Consumables/materials
- Subcontract/consultancy
- Travel (domestic)
- Travel (overseas)
- Other non-pay

**Sub-total of collaborating Institution (IR£):**

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<tr>
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<td>/ /</td>
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F3: Project Description

F3.1 Objectives of the project

F3.2 Project summary

F3.3 Project Background, technical description and rationale

F3.4 Project plan and management

Major Project Deliverables

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Major Milestones

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F3.5 Track record

F3.6 Commercial potential and economic importance
3.2 ATRP Technical Assessment Form

Advanced Technologies Research Programme 2001
Technical Evaluation Report Form

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<tr>
<th>Institution</th>
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Meaning of marks: 20 = poor, 40 = fair, 60 = good, 80 = very good, 100 = excellent
Proposals must achieve an overall mark of at least 75 out of the possible 100 and at least 60 in each of the sub-criteria to go forward to stage 2 of the evaluation process.

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<tr>
<th>Sub-criterion</th>
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<td>Technical objective, feasibility and likely outputs</td>
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<tr>
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Overall mark out of 100 (average of the marks awarded above):

General Comments:

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### 3.3 ATRP Commercial Evaluation Form

**ATRP 2001 - Commercial Evaluation Report Form**

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<th>Potential start-up co.?</th>
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<tr>
<td>Commercial interest to existing industries?</td>
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<tr>
<td>Sectoral opportunity or threat?</td>
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<table>
<thead>
<tr>
<th>Sub-criterion</th>
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<td>Potential for exploitation, and credibility of plan</td>
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Page 351
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<td>Ill defined, or no strategy and not communicated across institution, doesn't support commercialisation of research</td>
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<p>| 3.3.1.2 | Academic's knowledge and entrepreneurial skills | Academic acting as an entrepreneur | Positive | Academic displays strong entrepreneurial skills or surrogate entrepreneur was present |
| 3.3.1.1 | Academic's knowledge and entrepreneurial skills | Academic acting as an entrepreneur | Negative | Academic displays strong entrepreneurial skills or surrogate entrepreneur was present |
| 3.3.2.2 | Academic's knowledge and entrepreneurial skills | Academic acting as an entrepreneur | Positive | Academic shows signs of entrepreneurship |
| 3.3.2.1 | Academic's knowledge and entrepreneurial skills | Academic acting as an entrepreneur | Negative | Academic shows signs of entrepreneurship |
| 3.3.3.2 | Academic's knowledge and entrepreneurial skills | Academic acting as an entrepreneur | Negative | Academic shows no signs of entrepreneurship and is more interested in research |
| 3.3.3.1 | Academic's knowledge and entrepreneurial skills | Academic acting as an entrepreneur | Negative | Academic shows no signs of entrepreneurship and is more interested in research |
| 3.4.1.2 | Academic's knowledge and entrepreneurial skills | Strength of industrial network | Positive | Strong regular contact with industry |
| 3.4.1.1 | Academic's knowledge and entrepreneurial skills | Strength of industrial network | Negative | Strong regular contact with industry |
| 3.4.2.2 | Academic's knowledge and entrepreneurial skills | Strength of industrial network | Positive | Irregular contact with industry |
| 3.4.2.1 | Academic's knowledge and entrepreneurial skills | Strength of industrial network | Negative | Irregular contact with industry |
| 3.4.3.2 | Academic's knowledge and entrepreneurial skills | Strength of industrial network | Positive | No contact with industry |
| 3.4.3.1 | Academic's knowledge and entrepreneurial skills | Strength of industrial network | Negative | No contact with industry |
| 3.5.1.2 | Academic's knowledge and entrepreneurial skills | Prior business experience of academic | Positive | Previous spinoff or licence experience |
| 3.5.1.1 | Academic's knowledge and entrepreneurial skills | Prior business experience of academic | Negative | Previous spinoff or licence experience |
| 3.5.2.2 | Academic's knowledge and entrepreneurial skills | Prior business experience of academic | Positive | Some industrial experience |
| 3.5.2.1 | Academic's knowledge and entrepreneurial skills | Prior business experience of academic | Negative | Some industrial experience |
| 3.5.3.2 | Academic's knowledge and entrepreneurial skills | Prior business experience of academic | Positive | No industrial experience |
| 3.5.3.1 | Academic's knowledge and entrepreneurial skills | Prior business experience of academic | Negative | No industrial experience |</p>
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<td>Understanding of policies</td>
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