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UNIVERSITY OF DUBLIN, TRINITY COLLEGE

THE INFLUENCE OF INTER-COMPANY LINKAGES ON COMPANY PERFORMANCE: THE CASE OF THE IRISH SOFTWARE INDUSTRY

A DISSERTATION SUBMITTED TO THE FACULTY OF BUSINESS, ECONOMIC AND SOCIAL STUDIES IN CANDIDACY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

SCHOOL OF BUSINESS STUDIES

By

Vladimir Shugurov

AUGUST 2001

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DECLARATION

I declare that this thesis has not been submitted as an exercise for a degree at any other university. I declare that this thesis is comprised entirely of my own work. I agree that the Library may lend or copy this thesis upon request.

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Vladimir Shugurov

August 2001

SUMMARY

This study was undertaken to examine the following research question: *How and why do inter-company linkages influence company performance?*

Many studies (e.g. Teece, 1997; Gemser, 1996; Hagedoorn, 1990) have contributed conceptually to our understanding of inter-company linkages. However, none of them provides a completely appropriate answer to the research question. In the light of this, a new model has been developed, building primarily on dynamic models outlined in the literature review. This model attempts to explain the influence of inter-company linkages on company performance. Within this theoretical framework, linkages are understood to be joint R&D, production and marketing activities of two companies that require the combination of different resources in order to produce innovation for the use of either or both partners.

The model processes two inputs, namely information about the types of inter-company linkages that companies have and the stage of development of the industry in which these companies operate into a single output - appropriateness of inter-company linkages. Appropriateness of inter-company linkages refers to factors that govern partaking companies' ability to capture the profits generated by innovation which is created as a result of linkage activities. These factors represent the linkages' potential to generate innovation and absorb resources, which are in demand at any given stage of industry development.

The information inputs are transformed into 'Linkage Appropriateness' measures following a three stages procedure. The first stage deals with the information about linkages. Each type of linkages is assigned a potential to produce innovation and utilize resources depending on the performed activities (e.g. R&D, production, marketing).

The second stage deals with the information about industry. The industry demands for innovation (induced by both competitors and clients) and resources (induced by

competitors) are defined and calibrated for each stage of the industry development (defined in life-cycle terms: emergence, growth, maturity, decline).

And finally, appropriateness of inter-company linkages is calculated. A linkage gets points depending on its potential to produce certain innovation and utilise certain resources, and the size of industry demand for these innovation and resources. As a result of this procedure, the model produces a discrete numeric output - 'Appropriateness of Inter-company Linkages'. The study's hypothesis states that companies that have linkages with higher appropriateness are likely to have better performance.

In order to test the hypothesis as well as the model's operation, a postal survey was carried out among nine hundred and four Irish software companies. One hundred and twenty three of these companies submitted valid responses. The statistical analysis of these data showed that the hypothesis was true for large companies (those employ 50-500 people) but not for smaller companies.

It is suggested that the model's failure to find interdependence between linkage appropriateness and different types of linkages in the case of small and medium companies may be caused by the aspects of the research methodology rather than by the absence of such interdependency. These aspects are discussed and suggestions for further research are formulated.

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CHAPTER 1

INTRODUCTION

A phenomenon which has grown dramatically in recent years, and which has attracted a great deal of attention is that of collaboration between companies. This phenomenon has been approached from a number of different perspectives such as economic, sociological, geographic, planning, public policy and even psychology.

The object of this investigation was not in direct correlation with any single disciplinary perspective and was primarily determined by the nature of a research question, which are as follows:

How and why do inter-company linkages influence company performance?

Business, economic and sociological perspectives were chosen as most appropriate for considering these questions.

Linkages in the Irish software industry were used as an empirical base for considering the research question, therefore the literature review included both the appropriate studies on inter-company linkages in general and inter-company linkages in the Irish software industry.

1.1 LITERATURE REVIEW

All general studies on inter-company linkages, although very different and done from different disciplinary perspectives, can be divided into two approaches, static and dynamic.

1) Static Approach

In the first more popular approach inter-firm linkages are considered rather static in nature. Academics persuading this approach (i.e., Hobday, 1994, Rothwell and Dodgson, 1993, Marceau, 1994, Porter, 1990, Autio, 1994 and others) devote very little attention to the change that happens with inter-company linkages over time. Their studies to date focus mainly on antecedent conditions of inter-organisational linkages or the structural

properties of networks in comparison with other types of organisations. (Gemser et al., 1996, p. 442).

In this work, these studies were classified into three approaches according to the emphasis that their authors place on the importance of diversity of institutions that establish linkages and the effect of complementarities among them (i.e., Co-ordination). These approaches are *company-company linkages* and *chains of production, networks, clusters, complexes* and *science parks*.

In the literature on *company-company linkages*, the authors restrict their analysis to the linkages established by two companies, without considering a wider context of a network. In the studies which are considered in the literature review chapter, the focus has tended to be on inter-organisational dependence (Hagedoorn, 1990), 'complimentarities' of large-small companies (Rothwell and Dodgson, 1993) and underlying motives of cooperation (Narula and Hagedoorn, 1999).

Chains of production, networks, clusters, complexes and science parks approaches to the analysis of collaboration are concerned in a wider context of a network; mapping networks of relationships between innovators, users, suppliers of finance, materials and components, public research laboratories and state bodies involved in innovation and technology policy making (see Marceau, 1994, Porter, 1990, Autio, 1994 and others). Although these approaches do not only deal with alliances between business companies, but also inter-organisational linkages of all kinds, the focus nevertheless still tends to be primarily on companies.

2) Dynamic Approach

In the second *dynamic approach* inter-organisational linkages are treated as developing over time. The intensity of the collaboration is determined by environmental factors such as efficiency of intellectual property protection, nature of innovative product/technology and availability of specialised assets (those used while producing innovation). These environmental factors are changing while industry/technology develops and this

influences the occurrence and intensity of inter-institutional collaboration. Studies done in this tradition were classified into two approaches - *industry development preconditioned* and *product/technology development preconditioned.*

Within the *industry life-cycle preconditioned framework* (Teece, 1997, Robertson and Langlois, 1995, Gemser, 1996) the creation and evolution of inter-company linkages is linked with phases of industry development.

In the *technology and product life cycle preconditioned approaches* (Hobday, 1994, Abernathy and Utterbach, 1978) the importance of product/technology, rather than industry development, is stressed while assessing the evolution of inter-company linkages.

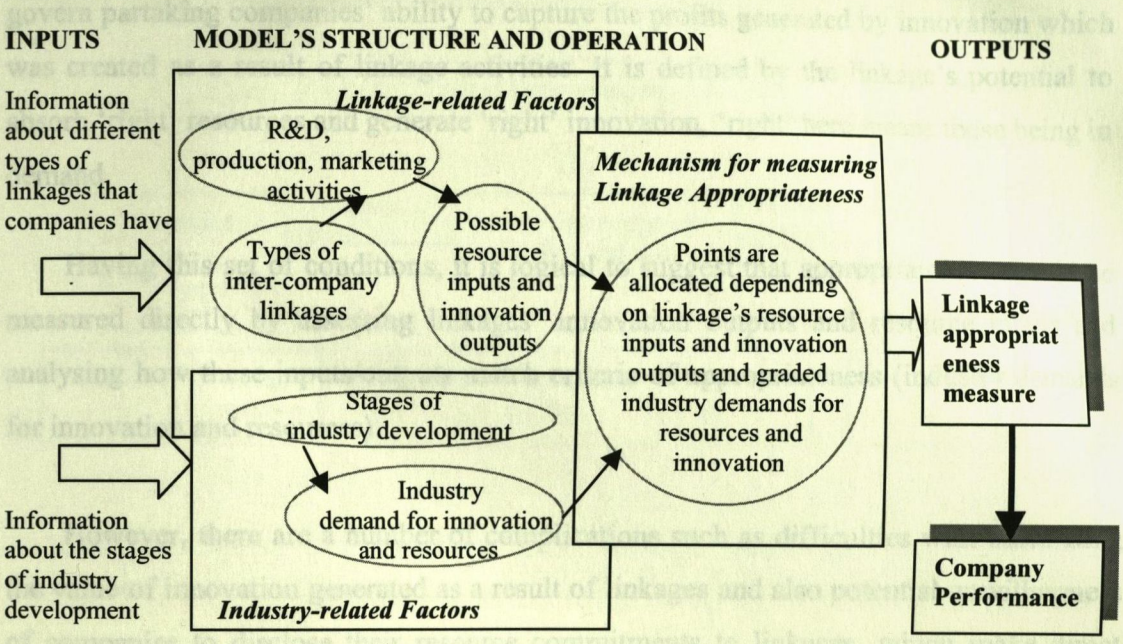
3) Studies on Inter-company Linkages in the Irish Software Industry

This study focuses on inter-company linkages in the Irish software industry. Therefore the literature review includes studies on inter-company linkages in Ireland (O'Riain, 1997, O'Gorman, O'Malley and Mooney, 1997) as well as a description of the Irish software sector indicators which shape the industrial environment within which the linkages are established and sustained.

1.2 THE RESEARCH MODEL

Existing studies as summarised above have conceptually contributed to our understanding of inter-company linkages. However, none of them was completely appropriate for answering the above research questions. In the light of this problem, a new model has been developed, primarily adapting dynamic models, which are outlined in the literature review chapter. In the suggested classification, the new model is dynamic, industry development preconditioned (for more details see Chapter 2). This means that linkages are treated as developing over time and their evolution is associated with the industry lifecycle.

Figure 1.1: Elements of the Research Model



As shown in Figure 1.1 above the model has two inputs, namely information about the ***types of linkages that companies have*** and information about ***the stages of industry development***. Based on these inputs, it produces a single output – ***Linkage Appropriateness.***

The remaining part of the introduction gives more details on three blocks contributing to the research model, namely linkage-related factors, industry-related factors and the mechanism for measuring linkage appropriateness.

1) Linkage-related Factors

This section deals with the linkage-related factors which *identify the linkages' potential to absorb resources and produce innovation.* In this model linkages are understood as the joint R&D, production and marketing activities of two companies that require the combination of different resources in order to produce primary and/or incremental innovation for use of either or both partners.

At the same time, similar to other dynamic models, this one emphasises the importance of appropriateness, while explaining and appraising development of inter-

company linkages. The *appropriateness of inter-company linkages* refers to factors that govern partaking companies' ability to capture the profits generated by innovation which was created as a result of linkage activities. It is defined by the linkage's potential to absorb 'right' resources and generate 'right' innovation, 'right' here means those being in demand.

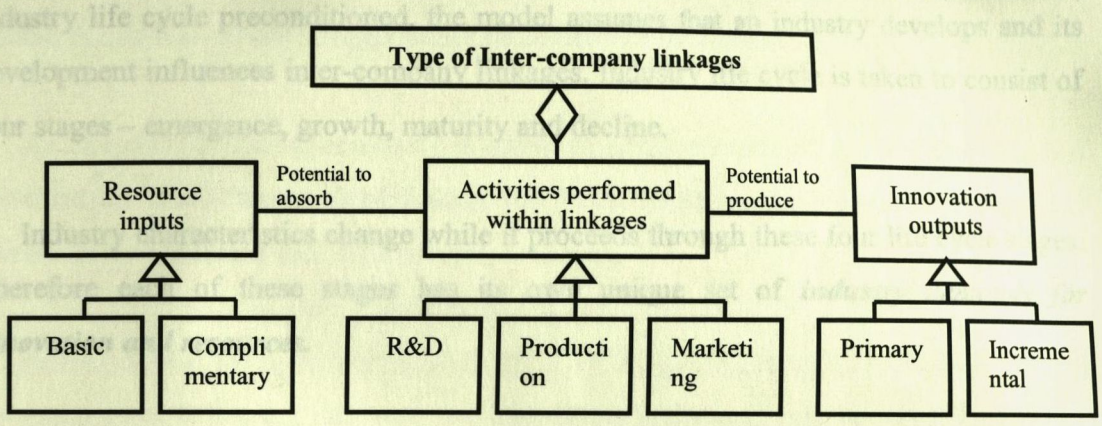
Having this set of conditions, it is logical to suggest that appropriateness should be measured directly by assessing linkages' innovation outputs and resource inputs and analysing how these inputs/outputs match criteria of appropriateness (industry demands for innovation and resources).

However, there are a number of complications such as difficulties with calculating the value of innovation generated as a result of linkages and also potential unwillingness of companies to disclose their resource commitments to linkages, which make direct assessment of the contents of linkages difficult.

To avoid these complications, the inputs/outputs of inter-company linkages are measured indirectly by analysing characteristics of linkages, which indicate the linkage potential to generate innovation and absorb resources. A metaphoric example of this would be measuring the yolk and white contents of an egg, not directly by destroying it, but through examining its weight, shape, colour and other appropriate characteristics that reflect the contents with a certain level of probability.

The characteristic '***types of inter-company linkage***' is used to designate linkages' potential to produce primary and incremental innovation outputs and absorb basic and complementary resource inputs. This characteristic indicates which of three activities, namely ***R&D, production and marketing*** are performed within each given linkage (see Figure 1.2).

Figure 1.2 Assessing Resource Inputs and Innovation Outputs of Different Types of Linkages (Linkage-related Factors)



R&D, production and marketing were assessed with regard to their resource requirements and innovation outputs. In this study we use the Schumpeterian approach to innovation. In this approach, primary innovation is understood as the commercial or industrial application of something radically new - a new product, process, or method of production; a new market or source of supply; a new form of commercial, business or financial organisations. Incremental innovation is understood as commercial or industrial application of a novel recombination of old ideas.

The assessment showed that R&D requires basic resources (i.e. qualified personnel, machines and equipment, technology, etc.) and may result in generating either primary or incremental innovations. Production also requires input of basic resources, but may produce only incremental innovation. Marketing absorbs complementary resources (i.e. developed trademarks, customer-support networks, channels of distribution, etc.) and incremental innovation only can be produced as a result of marketing activities.

In this model, each linkage is assigned with possible resource inputs and innovation outputs, depending on which activities are performed within this types of linkage and inputs and outputs of these activities.

2) Industry-related Factors

Industry-related factors determine demands for innovation and resources. Being dynamic industry life cycle preconditioned, the model assumes that an industry develops and its development influences inter-company linkages. Industry life cycle is taken to consist of four stages – emergence, growth, maturity and decline.

Industry characteristics change while it proceeds through these four life cycle stages. Therefore each of these stages has its own unique set of ***industry demands for innovation and resources.***

It was assumed that each of the demands have a range of five values starting with very low and going up to very high. These demands are graded - demands for innovation and resources are allocated a certain number of points (e.g. 0.2 - for very low, 0.6 - for low, 1 - for medium, 1.4 - for high and 1.8 - for very high: for more details on calibrating industry demands see Section 3.2).

3) Mechanism for Measuring Linkage Appropriateness

The third stage of the model sets out a mechanism for measuring the appropriateness of inter-company linkages. Scores indicating the Linkage Appropriateness are allocated depending on:

a) Linkage potential to absorb certain resource inputs and generate certain innovation outputs;
b) The size of graded industry demands for these innovations and resources.

For example, the 'contract-out software development' types of inter-company linkage, which is common in the Irish software industry, is assumed to have R&D and production activities performed within it.

R&D is recognised as a type of activity that requires an input of basic resources and may produce both primary and incremental innovation. Production also absorbs basic resources and it is capable of producing incremental innovation.

As already mentioned, contract-out software developments often combine these two activities therefore this types of linkage has the potential to produce both primary and incremental innovation and absorb basic resources.

Assuming that the Irish software industry is at the growth stage of its development, it determines the following demands for innovation and resources: demand for primary innovation – high (1.4 points), demand for incremental innovation – high (1.4 points), demand for basic resources – very high (1.8 points) and demand for complementary resources – high (1.4 points).

With the above potential for innovation and resources and industry demands for these inputs /outputs, the appropriateness of 'contract-out product development' is as follows:

Appropriateness = (points scored for producing primary innovation + points scored for producing incremental innovation + points scored for absorbing basic resources + points scored for absorbing complementary resources);

So in this case this equation is:

Appropriateness = 1.4 + 1.4 + 1.8 + 0 = 4.6

Please note that if a linkage does not have potential to have one or two out of four inputs/outputs (complementary resource input for "contract-out product development") it does not get points for these missing components no matter how high demand is.

It should be made clear that all linkages considered in this model have potential to produce at least one innovation output and absorb one resource input.

Because demands for innovation and resources change while an industry develops, the same type of linkage may be allocated with different number of points of appropriateness at different stages of industry development (e.g. the appropriateness "Contract-out product development" is 3.8 at the emergence, 4.6 at the growth, 3 at the maturity and 2.6 at the decline stages of industry development).

The hypothesis, adopted in this study, states that companies that established more appropriate linkages are likely to have better performance. Checking this hypothesis is the main objective for this research.

1.3 DEFINITIONS

The next section contains definitions of terms which are frequently used in this study. For ease of referencing, the definitions are organised in alphabetic order.

Appropriateness of inter-company linkages refers to factors that govern a company's ability to capture the profits generated by innovation which was created as a result of linkage activities. It is defined by the linkages' potential to generate innovation and absorb resources, which satisfy criteria of appropriateness or in other words there is industry demand for them. The more criteria a linkage satisfies (the more 'right' innovation and resources it has potential to produce) and the more important these criteria are (the higher the demands are) the more appropriate this linkage is. The hypothesis adopted in this study states that firms with appropriate linkages are likely to have better performance.

Basic resources are directly involved in production and R&D. They include qualified personnel, finance, specialised premises, machines and equipment, technology, products and specialised know-how.

Business partnerships are understood to be joint R&D, production and marketing activities performed by two companies that require putting together different resources. Business partnerships with the potential to produce innovation are inter-company linkages.

Complementary resources are those that are not directly used in the production and R&D process. They include resources used in marketing and after-sale support such as qualified personnel, channels of distribution, developed trademarks, customer-support networks and knowledge of the market.

Criteria of appropriateness are used as measuring tools for assessing inter-company linkages. They are defined by an industry and change while it develops. In this model, industry demands for primary and incremental innovation as well as basic and complementary resources are chosen as criteria of appropriateness.

Duration of inter-company linkages is one of five inter-company linkage characteristics which are considered in the model. Inter-company linkages, like any form of organisation, undergo a cycle of creation, institutionalisation and, with high probability, termination. In this model all linkages are divided into two groups – short- and long-term.

Incremental innovation is the commercial or industrial application of a novel recombination of old ideas.

Inter-company linkages are understood to be joint R&D, production and marketing activities of two companies that require putting together different resources in order to produce innovation for use of either or both partners.

Level of inter-company linkages is one of five characteristics of inter-company linkages, which shows if linkages are established by companies operating either at the

same level of value chain – horizontal linkages or different levels of value chain – vertical linkages.

Marketing activities that accelerate the movement of goods and services from the manufacturer to the customer, including everything connected with advertising, distribution, merchandising, product planning, promotion, publicity, sales, transportation and warehousing of goods or services.

Participation in inter-company linkages is one of five characteristics of inter-company linkages that indicates if inter-company linkages are established either by only domestic companies - Irish-Irish linkages or by both domestic and overseas companies – mixed linkages.

Primary innovation is the commercial or industrial application of something new – a new product, process, or method of production; a new market or source of supply; a new form of commercial, business, or financial organisations; a new form of the movement of goods and services from the manufacturer to the customer.

Production is any form of activity that adds value to goods and services, including creation, transportation, and warehousing until used.

Research and Development (R&D) is applying the findings of science and technology in creating a firm's products and services.

Scope of inter-company linkages is one of five linkage characteristics which reveals if linkages are formed by two companies from the same (software) industry – mono-industrial linkages or by companies operating in different industries – hetero-industrial linkages.

Types of inter-company linkage is the major characteristic of inter-company linkages. In this model it has been recognised as the only characteristic that clearly

indicates which activities (R&D, production or marketing) are performed within linkages. Fifteen different types of inter-company linkages were considered in this study. These are as follow: joint venture, contract-out software development, joint software development pact, contract-out design/multimedia, contract-out product adaptation, contract-out translation/localisation, contract-out software testing, contract-out after-sale support, agent agreement, reciprocal agent agreement, venture nurturing, sponsored spinouts, contract-out R&D staff, contract-out production staff and contract-out marketing staff. The choice of these linkages would be explained later in Section 3.1.5.

1.4 STRUCTURE OF THE THESIS

This thesis consists of six chapters including introduction. The chapters are followed by references and appendices (see Table 1.1 for brief summary on each of these chapters).

Table 1.1: Structure of the Thesis

1. Introduction	An explanation of what the research is about and why it is important and interesting, the research questions and hypotheses are also stated.
2. Literature Review	An analysis of what other researchers have said on the subject and where this project fits in.
3. Methodology	An explanation of why certain data were collected, what data were collected, from where they were collected, how they were collected and how they were analysed.
4. Research Model	A description of the research model and an explanation of how it works.
5. Results	A presentation of the research results
6. Analysis, Discussion and Conclusions	An analysis of the results showing the contribution to knowledge and pointing out any weaknesses and limitations. A description of the main lessons which were learnt from this study and what future research should be conducted
References	An alphabetical list of the sources from which information has been obtained and which have been cited in the text.
Appendices	Detailed data referred to but not shown elsewhere.

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

This literature review chapter consists of two sections. The first section **'Studies on Inter-organisational Linkages'** analyses what other researchers have said on the subject. All studies have been classified into two traditions – static approach (the linkages are analysed at some given moment of time) and dynamic approach (the linkages analysed while they are developing).

The second section **'Studies on Inter-company Linkages in the Irish Software Industry'** provides information about the Irish software industry and linkages in Ireland with particular emphasis on the linkages in the Irish software industry.

Both the design of the chapter and the choice of particular studies, which are analysed in it, were greatly influenced by the requirements of the model, which was developed in order to explore the influence of the inter-company linkages in the Irish software industry on company performance (for more details on the model see Chapter 4).

2.1 TWO TRADITIONS IN THEORIES ON INTER-ORGANISATIONAL COLLABORATION

There is a wide variety of theoretical explanation for why firms collaborate. They include those which examine changing industrial structures and systems of production, and those focusing more particularly on the role technology and innovation play in this change. Others focus on economic explanations and the competitive relationships between firms, while others focus on qualitative issues such as organisational learning (Dodgson, 1994, p. 286).

Although collaboration occurs in many different forms, and may by established for many different reasons, Dodgson (1994, p. 286) suggests that three generalizable assumptions underpin them. These assumptions are as follow:

1) Positive sum gains;
2) Environmental uncertainty;
3) Flexibility and efficiencies.

Getting positive sum gains from collaboration means that firms participating in collaboration can together obtain mutual benefits, which they could not achieve independently. These benefits are increased scale and scope of activities, shared costs and risk and improved ability to deal with complexity.

It is believed that it easier for firms to deal with *environmental uncertainty,* such as increasingly sophisticated demand, growing competition, internationalisation and rapidly changing technologies, in collaboration than in isolation (Dodgson, 1994, p. 286).

Collaboration is also stated as offering more *flexibility and efficiencies* compared to its alternatives. For instance, collaboration may be an attractive alternative to direct foreign investment and mergers and acquisitions because it is more easily amended once entered into, and allows firms to monitor and possibly gain from external technological developments without having to invest heavily. Other potential benefits of collaboration such as increased scale and scope may positively influence partaking companies' performance.

In this literature review theoretical studies on inter-institutional collaboration were classified into two traditions - static and dynamic (see Figure 2.1 below).

Figure 2.1: Two Traditions in Theories on Inter-organisational Collaboration

Studies on Inter- institutional Collaboration		
Static Tradition		***Dynamic tradition***
Company-company Linkages Chains of production Networks Clusters Complexes Science Parks	Level of co-ordination ↓	Industry Development Preconditioned Models Technology Development Preconditioned Models

In the first more common static approach (i.e. Hagedoorn, 1990; Rothwell and Dodgson, 1993) inter-institutional collaboration is considered rather static in nature. Academics pusuing this approach devote very little attention to changing network structure over time. Their studies focus mainly on the particular characteristics of inter-company collaboration as well as the structural properties of wider networks of linkages including companies, universities, research institutions and state regulatory agencies.

In the second, dynamic approach, academics (i.e. Teece, 1997; Robertson and Langlois, 1995) consider inter-organisational collaboration as dynamic in nature. Their studies focus on how and why the intensity of inter-organisational collaboration changes over time. At the core of most of these studies is the idea that inter-organisational collaboration is aimed at producing innovation and this collaboration evolves from the evolution of the collaborative relationship itself and the associated learning as well as changes in the environment of the collaborative relationship (e.g. efficiency of copy-right regime and availability of assets).

2.1.1 Inter-organisational Linkages: Static Tradition

In the static tradition different types of inter-institutional collaborations are analysed at one given moment of time and their past or possible development is not taken into consideration.

Figure 2.2: Static Tradition in Theories on Linkages

Studies on Inter- institutional Collaboration	
Static Tradition	***Dynamic tradition***
Company-company Linkages Chains of production Networks Clusters Complexes Science Parks	Industry Development Preconditioned Models Technology Development Preconditioned Models

Level of co-ordination ↓

As shown in Figure 2.2 (highlighted area), all static models were classified into two groups according to the level of co-ordination. Co-ordination here is understood as a combined or co-ordinated action aimed at producing innovation. These two groups are as follows:

1) *Company-company linkages*. This group involves models covering forms of inter-institutional collaboration with lower level of co-ordination - linkages established and sustained by two companies, without considering other participants of innovation process.
2) *Chains of production, networks, cluster, complexes and science parks*. All these approaches to inter-institutional collaboration allow a higher level of co-ordination. A wider network of linkages between companies as well as other institutions such as universities, research institutes and different state agencies are taken into account while analysing different aspects of collaboration.

2.1.1.1 Company-company Linkages

Hagedoorn (1990) points out that there are a number of models classifying different types of inter-firm linkages. Auster (1987) classifies 'inter-corporate linkages into technology transfer and exchanges, R&D arrangements and joint ventures. Chesnais (1988, p. 515) introduces a model in which government involvement, technological characteristic, capital requirements and industry structure shape existing forms of inter – organisational linkages. Harrigan (1985, p. 4) offers categorisation based on the degree of ownership and control. Contractor and Lorange (1988, p. 6) propose a classification of different types of inter – organisational linkages leading from more extensive to intensive forms of co-operation between companies.

1) Classification Based on the Extent of Inter-organisational Dependence

Hagedoorn (1990) himself suggests the tentative classification of modes of co-operation in terms of the extent of inter-organisational dependence. He proposes classification summarised in Table 2.1.

Table 2.1: Classification modes of Co-operative Agreements and their Organisational Interdependence

Mode of co-operation	Organisational interdependence
Joint ventures and research corporations	Large
Joint R&D, such as research pacts and joint development agreements	
Technology exchange agreements (mutual), technology sharing, cross-licensing, mutual second-sourcing	Medium
Direct investment, minority and cross holding	
Customer-supplier relations, R&D contract, co-production, co-makership	
One-directional technology flow, second-sourcing, licensing	Small

Source: Hagedoorn, 1990, p. 18

The following sub-sections contain more information on which of this modes of co-operation.

i) Joint Ventures and Research Corporations

Joint ventures and research corporations are combinations of the economic interests of at least two companies in a new separate company. Profits and losses of this company are shared according to equity investment. Joint ventures have shared R&D alongside with other activities such as production, marketing, sales, past-sale services etc. Potential advantages of joint ventures include spreading of risks, sharing of fixed costs, economies of scale, access to new markets, competitive repositioning and sharing of research efforts. There are also some problems in sustaining joint ventures originating from the risks involved in sharing of research results and know-how, the desire for control by individual partners, co-ordination of different planning approaches and time horizons, disagreement on design specifications and loosing flexibility in market response and decision making.

Because of these difficulties R&D joint ventures are mostly not concerned with the core of research activities and strategic activities of their parent companies. Harrigan

(1985, p.326) points out that the higher a product line or area of technology was in strategic importance, the more reluctant firms were to use co-operative strategies to leverage their competitive positions. Joint ventures were formed to supplement some existing strengths; but other forms of co-operation were used in those areas that constituted firms' strategic cores.

Hagedoorn (1990, p.22) made similar findings:

> Many companies consider joint ventures and research corporations as relevant forms of organisation of joint research in new areas of research, in particular after a first phase of joint experimenting with technology exchange agreements. If the R&D involved is more crucial to one company, we can expect this partner to attempt to achieve a majority stake or misappropriate influence in the joint venture's management.

For the purpose of this study it should be stressed that a number of research by Hladik (1985, 1988) and Harrigan (1988) show that successful co-operation in joint ventures is positively affected by similarity in size and different types of resources of participating parents companies.

ii) Joint R&D and Technology Exchange Agreements

Hagedoorn (1990, p.22) points out that joint R&D and technology exchange agreements regulate technology transfer and R&D sharing and/or transfer between two or more companies. Large companies tend to apply joint R&D and technology exchange agreements as pilot projects to analyse the possible benefits of collaboration before entering more interdependent forms of collaboration such as joint ventures and research corporations. (Contractor & Lorange, 1988)

Joint R&D agreements include:

(i) joint research pacts which establish joint undertaking of research projects with shared resources;

(ii) joint development agreements.

Joint R&D agreements in their nature and objectives are similar to joint ventures and research corporations. At the same time, they need less partner interdependence. Companies establish and sustain joint R&D agreements in order to minimise risk and cost and achieve Co-ordination effect. These types of agreements were especially popular in recent years (Hagedoorn, 1990, p.22).

Technology exchange agreements cover:

i) technology sharing agreements;
ii) cross-licensing;
iii) mutual second-sourcing.

Within the first type of technology exchange agreements mentioned above companies negotiate the distribution of established knowledge and artefacts either by one partner or collective efforts. The other two forms of technology exchange agreements such as cross-licensing and mutual second-sourcing were developed from single-source technology transfer mechanisms. Standard licensing is a contract that regulates a transfer of technology from one company that has proprietary rights to other company in exchange for payments. Single licensing often concerns transfer of somewhat older technology and products (Killing, 1983, pp. 88-89; Bonin, 1986, p. 76). Cross-licensing, as Hagedoorn (1990, p. 23) understands it, includes licensing for reciprocity and cross licensing. Licensing for reciprocity covers exchange of licences to supplement partner's own research with licensed technology or to avoid patent protection. Cross-licensing covers exchange of licences or packages of licences with calculated value (Telesio, 1979, pp. 60-64). Large companies use these agreements for exchanging packages of patents to avoid patent infringements, from which Hagedoorn (1990, p. 23) concludes that, compared with unilateral licensing; this bilateral form of technology transfer applies to more advanced technology transfer.

Mutual second-sourcing is the bilateral form of the second-sourcing agreement. Second-sourcing agreements involve a transfer of product technology, which allows one

firm to make an exact copy of another firm's product. By doing this a company which provides technology secures its ability to continuously supply its customers. Although second-sourcing will result in loss of market share for the originator of the product, it may compensate it as a result of market growth resulting from growth of demand for innovative product/service. For instance, companies are normally more inclined to upgrade one of the outsourced components if there are many suppliers offering this innovative component, compared to the situation where there a few or just one, because in this case if should they have some problems with the existing supplier, they can always switch to another one. (OECD, 1985). In other words, advantages of second-sourcing are found in overall growth and securing of supply for one side and secured demand for other. Mutual second-sourcing often results from efforts of companies to minimise the risk of opportunistic behaviour by its second-sourcing partner through a reciprocal arrangement.

iii) Direct Investment and Co-operation

Under certain conditions equity investment can be considered as a form of co-operation. Minority stakes, especially those held by a large company in a smaller innovative company may be seen as a case of co-operation, especially if that is combined with research contracts. This practice is wide spread in biotechnology (OECD, 1987). There a number of advantages in such equity investments, among them risk sharing, access under certain conditions to the results of R&D of a partner etc. However, because of limited participation, the access to exclusive rights and/or decision-making is normally small. In the case of cross-investment, the relation between two partners may be closer.

iv) Customer-Supplier Relations and One-directional Technology Flows

Hagedoorn (1990, p. 24) classifies customer-supplier relations into a number of forms of partnership:

1) Co-production contracts apply to the linkages between two or more companies when the 'leading' company supplies the technology and critical components,

and other company/companies manufacture less critical components and assemble final products.

2) Co-makership is long-term contracts between users and suppliers, with users out-sourcing some of their production process and technology, especially quality control, and also standards to suppliers of sub-assemblies.

2) Classification based on the Idea of 'Complementarities' of Large – Small Companies

Rothwell and Dodgson (1989, 1993) concentrate on benefits of large-small company collaboration. Large and small companies are seen by them as complementary to each other. Large firms often try to create and adopt the flexibility attributes of small firms. They claim that experience had shown that merging of a small firm with a large firm almost always leads to reducing of its flexibility and most of its other advantages. Therefore large companies often prefer being involved in collaboration with prospective small innovation firms rather then buying them. While describing different forms of inter-company linkages, many studies refer only to joint ventures and assume that other forms of collaboration have similar features. Nevertheless it should be clear that collaboration agreements differ with respect to both organisational and economic effect. Rothwell and Dogson (1993) offered a classification that identifies different types of linkages between small and large companies. They classify small – large company linkages into several different categories (Rothwell, 1989, pp. 275-291; Rothwell & Dodgson, 1993, p. 20; Hagedoorn, 1990, pp. 17-29). These categories as follow:

i) **Manufacturing subcontracting relationships:** Small firms supply components and sub-assembly to large companies. Large companies frequently transfer technological, manufacturing and quality control know-how to their small suppliers.

ii) **Producer-customer relationships:** Small firms supply their products to large companies. Sometimes large companies involved in producer-customer

relationships transfer technological know-how, export advice and supply suggestions in order to adjust small firms' products to their needs.

iii) **Licensing agreements:** Large firms provide licences for technologies to small firms that they themselves do not wish to exploit. In some cases it can involve technology which the large company will subsequently purchase in the form of equipment for in-house use. The transfer by large process companies of new process control technology to small instrument companies represents one example of this.

iv) **Contract-out R&D:** Large companies support appropriate R&D activities within small firms, which have the necessary expertise or small specialist consultancy companies. Examples of this include automobile companies funding R&D in specialist engine developers and pharmaceutical companies funding R&D in small biotechnology companies.

v) **Collaborative development:** Large and small companies develop a new product for the large company. For example, small software or design houses collaborate respectively with large computer and automobile manufacturers.

vi) **Large-small firm joint ventures:** Large and small firms collaborate in the development of an innovative new product containing technology new to the large partner. The large firm provides financial, manufacturing and marketing resources while the small firms contributes special expertise and entrepreneurial dynamism. Generally the new products are complementary to the large firms' product range.

vii) **Educational acquisitions:** Large companies acquire a small innovation firm in order to learn from its expertise or enter a new business area. Examples of this are quite common in the biotechnology field.

viii) **Sponsored spinouts:** The large company offers financial backing for entrepreneurial employees to form a new small firm to exploit technology

developed within the parent company which is considered unsuitable for in-house development and exploitation.

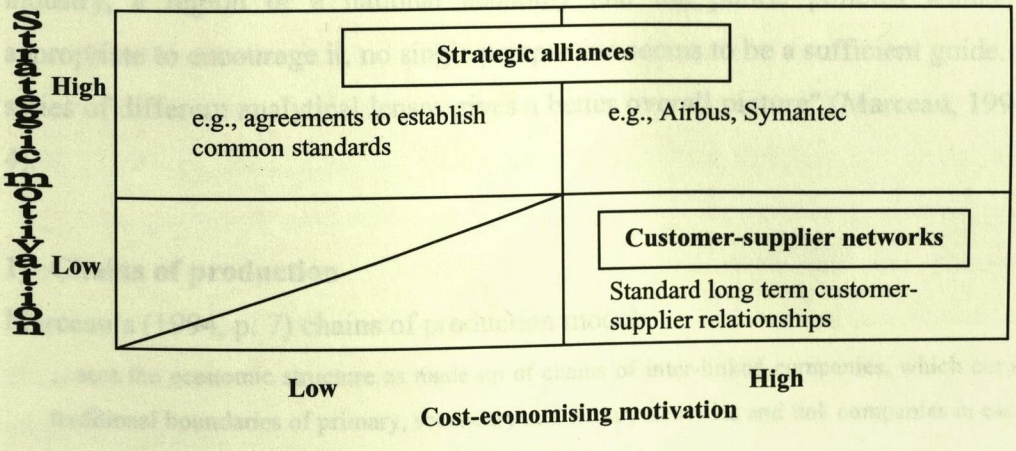
ix) **Venture nurturing:** The large company offers to small spin-out firm the wide range of support including financing, expertise in management, marketing and manufacturing, and, if appropriate the channels of distribution.

x) **Personnel secondment:** A number of large European companies have developed schemes to 'loan' experienced managers to assist new and existing small innovation firms.

3) Classification Based on Underlying Motive of the Cooperation

Depending on the underlying motive of the cooperation, Narula and Hagedoorn (1999) classified all the linkages into two groups namely cooperative agreements and strategic alliances. They suggested that most co-operative agreements have two possible motivations (see Figure 2.3).

Figure 2.3: Explaining the Underlining Differences between Strategic Alliances and Customer-supplier Networks



Source: Narula and Hagedoorn , 1999, p. 284

First, they suggest a cost-economising motivation, where either or both companies within the relationship have entered into it to minimise its net costs. They call these cooperative agreements or customer-supplier networks and argued that they included 'generally (but not always) customer-supplier agreements, or vertical relationships within a value-added chain and embody a short-term perspective' (Narula and Hagedoorn, 1999, p. 284).

The second 'strategic' motivation for collaboration is long-term profit optimisation. It is achieved through establishing particular types of collaboration that allow enhancing the value of the firm's assets. Examples of strategic alliances are joint R&D agreements to establish common standards.

2.1.1.2 Chains of Production, Networks, Clusters, Complexes and Science Parks

The phenomenon of collaboration in innovation is very wide and complicated because so many different players are involved in the innovation system such as national governments, large and small firms, universities, research and educational institutions, banks, venture capital funds etc. In order to analyse the system one should set up several approaches towards it. "In trying to evaluate the innovative potential of a firm, an industry, a region or a national economy and the public policies which may be appropriate to encourage it, no single perspective seems to be a sufficient guide. Rather a series of different analytical lenses gives a better overall picture" (Marceau, 1994, pp. 3-4).

1) Chains of production

Marceau's (1994, p. 7) chains of production model:

> ...sees the economic structure as made up of chains of inter-linked companies, which cut across the traditional boundaries of primary, secondary and tertiary activities and link companies in each of these areas together through their contribution to the final product.

Normally, large supplier firms lead the chains. These organisational forms are supposedly very effective in channelling innovation know-how and technologies between the firms. Marceau (1994, p. 8) noted that:

Once a series of companies in an industry changes to just-in-time or total quality management methods reciprocal change in supplier firms is very likely to follow and lead to the upgrading not only of the whole chain but also of at least parts of related chains to which key suppliers are linked through their other markets.

2) Networks

A number of legally independent firms are trying to create a competitive advantage by building and maintaining linkages with other organisations. Inter-organisational networks have a different nature. They may consist of the exchange of information; of resources and/or joint activities therefore it is very important to distinguish between different types of 'networks'. As Hobday (1994, p. 231) points out the term has been used often confusingly to describe virtually all intra- and inter-firm forms of collaboration.

The network concept has been applied to focus technological partnerships among large firms (Mody, 1989) and the close technological user-producer linkages analysed by Lundvall (1988). Apart from that, it has been used to analyse Japanese intra-firm *keiretsu* organisational structures (Aoki, 1988; Aoki, 1986, pp. 971-983). The term has been applied to the regional clusters of firms identified by Porter (1990). In addition, Gemser et al. (1996, p. 440) point out that inter-organisational linkages are often referred as 'networks'. However academics use the term 'network' to describe a wide range of inter-organisational linkages, often without paying attention to different characteristics, environmental conditions and nature of organisations taking part in various network structures. This leads to considerable theoretical confusion about precise content of the network concept.

In this work we will use Rosenfeld's (1995) definition of networks because it is very clear and applies mostly to inter-companies linkages that are at the centre of our analysis.

According to him the term network generally refers to a group of independent companies with restricted membership and specific, even contractual, business objectives likely to result in mutual gains. The members of networks freely choose partners and agree explicitly to co-operate in some way and to depend on each other to some extent. Networks easily develop within clusters.

3) Clusters

Dodgson and Bessant (1997, p. 27) note that clusters:

> Include the various circles created when innovative users work closely with innovative suppliers; the creation of finance and service industries with knowledge of local conditions; and labour markets in which there is mobility of personnel between firms, thereby transferring technological know-how, and in which the competition for key employees raises salaries and thus attracts highly skilled workers.

There are two major approaches to clusters - geography based and industry based. In the geography-based approach (Marshal, 1919; Piore and Sabel, 1982) clusters are considered as geographical propinquity of firms developing and using similar and related products and technologies to produce successful innovation. In the framework of this approach the importance of collaboration between firms rather than the competition is stressed. The regional agglomeration of high technology firms such as Route 128 in Boston, Silicon Valley in California, and Cambridge and the 'M4 Corridor' in England have led to the development of this approach. Firms in industrial districts are supported by government policies both at the infra-structural level (e.g. provision of excellent technical education in Denmark) and at the taxation level (e.g. provision of special tax incentives for artisans and firms with a specified number of workers, as in Italy) (Marceau, 1994).

A cluster in Rosenfeld's (1995, p. 5) 'geography' definition is a

> Geographically bounded concentration of similar, related or complementary businesses, with active channels for business transactions, communications and dialogue, that share specialised infrastructure, common opportunities and threats.

Clusters do not have formal membership requirements, and based on high-trust transactional relationships between firms, in the vertical and lateral dimensions. They involve implicit co-operation around a collective vision rather than common goals. (Cooke, 1996, p. 144) Clusters may be a single product range, such as knitwear or tiles or united across a product range such as electronics where skills and technologies rather than products link cluster members. Table 2.2 shows comparison of networks and geography clusters.

Table 2.2: Networks and Geography Clusters Summary Table

Networks	Geography clusters
Networks give access to specialised services at lower cost	Clusters attract specialised services to region
Networks have restricted membership	Clusters have open membership
Networks rely on informal or formal-contracted agreements	Clusters are based on shared norms of reciprocity
Networks facilitate more sophisticated business	Clusters facilitate firm-acquisition of wider competencies
Networks have common business goals	Clusters have shared vision

Source: (Cooke, 1996, p. 144)

The industry-based approach to clusters is wider than purely geographical. For Porter (1990) the clustering of industries connected by horizontal and vertical relationships, their construction and their competitive advantage define the competitive advantage of nations. He points out that there are several factors, which contribute to national competitive advantage:

1. Factor conditions: The presence of such factors as skilled labour, capital stock, knowledge resources and infrastructure.
2. Demand conditions: The presence of home demand for the innovative industry's products or services.
3. Related and supporting industries: The presence of suitable suppliers and related industries that are also internationally competitive.

4. Firm strategy, structure and rivalry: The conditions governing how companies are created, organised and managed and the nature (intensity) of domestic rivalry.

These factors act as a mutually reinforcing diamond, which underpins the competitive advantage of clusters. Two other variables influence this system: 'chance events' (pure inventions, breakthroughs in basic technologies, wars, external political developments, and major shifts in foreign market demand), and government action (including anti-trust policy, regulation, education and procurement). According to Porter, clusters stimulate competitiveness when all the elements of the 'diamond' are strong, mutually complementary and operating effectively.

4) Complexes

The complexes approach was developed by a group of academics from the small industrial countries of Europe such as the Netherlands, Denmark and Australia (van Tulder, 1988; Marceau, 1992). In the framework of this approach they stress the importance of a welfare element and public sector, rather than private sector R&D in these countries. The complex is described as a network of co-operation between:

1. Producers (firms);
2. Public sector research organisations;
3. Users (usually other firms);
4. Regulators (governments of all levels).

Marceau (Dodgson & Bessant, 1997, p. 30) points to the value of the complex lens in considering innovation systems:

1. It contains a specific role for government authorities, which may act directly to assist the complex rather than being reduced to providing general infrastructure or to targeting particular companies.
2. It indicates the central importance of public R&D facilities.

3. The approach allows the analyst to pinpoint weaknesses in the complex much more clearly and to devise policies for plugging gaps. These weaknesses may not lie in the 'obvious' industrial participants, but in public institutions and policies not usually considered in the overall framework of innovation support.

4. It can identify lead organisations - such as hospitals -, which, once encouraged towards innovation, can have the knock-on effect of further developing the complex.

5) Science Parks

During 1970's and 1980's different types of science parks have been the target of great expectations and hopes. Time has proven that many of these expectations have been unrealistic: small innovation companies which make up the core of science parks have not turned out to be the automatic generators of economic growth and new employment in the way that many policymakers expected (Autio, 1994, p. 259). Most science parks have failed to meet their goals with regard to the creation of new fast growth innovation companies (Massey et al., 1992). In fact, some studies have shown that most small innovated companies do not even want to grow because the experience has shown that there exists many niches for them in modern economies, most of which seem to be small and stable (Autio, 1994, pp. 259-260; Autio and Kauranen, 1992). The European science parks have not become financially and technologically successful as some people expected them to become (Autio, 1994; Quintas et al., 1990). The moneymaking potential of science parks seems to be smaller than expected. However we should avoid going to the other extreme and discard the potential benefits of science parks.

Scientific parks are essentially concentrations of know-how and technology. Science parks refine technology to achieve the best possible hold to satisfy various customers needs, they link sources and users of technology, forming complex but flexible innovation networks (Rothwell, 1991; Gelding, 1992). According to the traditional concept that is widespread in the USA and the Great Britain, a scientific park is

combination of laboratories, research groups of universities, research institutes, companies and individual researchers which are related to a university and focused on the successful development and commercialisation of innovation products and technologies. However, this definition is rather conditional, for example, in 1981 in the USA only 27 out of 80 science parks were closely linked with universities.

Significant distinctions in construction and principles of functioning of science parks occur depending on the place of their origin. All scientific parks can be classified into three different models (Rudakova, 1991):

1. The American model (USA, Great Britain);
2. The Japanese model (Japan);
3. The mixed model (France, Germany).

i) American Model

The American model includes three different groups of science parks such as traditional scientific parks, research parks and incubators (innovation centres).

A *traditional science park* is a complex of well-equipped laboratories and production facilities that have a strong connection with a university. Entrepreneurial researches, including ex- or even present employees of the university can develop an innovation idea up to a commercial product within the framework of a science park. Such types of scientific parks are very common in the USA and Great Britain. Stanford Scientific Park is a good example of a traditional science park. Apart from universities and research institutions it includes 80 inter-linked small and larger companies. The park specialises in electronics. Another example is Triangle Park in Northern California. This park includes three larger and a number of smaller universities and colleges, 40 research centres, different state institutions, numerous companies and individual entrepreneurs. In 1985, 20,000 people were employed in this park. The park specialises in the natural sciences, public health services and environmental protection technologies.

Research parks are very similar to the traditional science parks. They are also based around a university and include a wide range of different research institutions and companies. However within research parks innovations are developed only up to the prototype stage. They sell these prototypes to larger companies for further production and marketing. Illinois Technical Institute is one of the examples of research parks in the USA.

Incubators (USA) or *innovation centres* (Europe) have normally had a very strong link with universities and geographically located either on the university campuses, or very close to them. Within these centres small innovation companies and individual researchers wishing to commercialise their ideas can get low-rent access to the laboratories, research equipment, some production facilities and also necessary information and services. These kinds of science parks were very popular in Europe in the late 1980's. By 1987, thirty-eight innovation centres were in operation in different European countries fourteen of which were located in Great Britain (Rudakova, 1991, p.25).

ii) Japanese Model of Science Parks

The Japanese model of science parks is based on the idea of science cities-technopoles. Technopoles provide very comprehensive surrounding for innovation development incorporating science, research, production, marketing, finance, consultant and favourable psychosocial climate. The Japanese State normally plays a large role in creation and developing of these cities. They made a programme regulating the process of formation and allocation of technopoles. Under this programme 19 allocations were selected for future technopoles. All these places had to satisfy the following criteria:

1. They were to be located within a thirty minutes drive distance from the nearest large city with a population not less than two hundred thousands people and within a one day drive from Tokyo, Nagoya or Osaka;
2. They had to have a total coverage of not more than 500 square miles;

3. They had to have a balanced set of modern high-technology production, finance institutions, universities and research centres;
4. They were to be located in nice areas and to be built in harmony with local traditions and natural conditions.

Local authorities, by means of local taxes and stimulation of corporate investments were to finance the creation of the technopoles. The contribution of the central government included tax privileges, an accelerated depreciation of building and equipment allowances, and direct grants at the rate of up to thirty percent of investment projects. Besides that small companies could get 15-year loans on very favourable conditions with annual rate of less than 2.7 percent. (Tacuno, 1989, p. 20)

iii) Mixed Model of Science Parks

France and Germany have developed a mixed model of science parks. European science parks are supposed to combine the positive factors associated with American and Japanese concepts. As a result French and German technopoles are somewhat similar to Japanese ones, because they emphasise the importance of broad Co-ordination effect and psychosocial climate for successful innovation development. But at the same time they try to adapt the high entrepreneurial spirit and great risk taking behaviour that characterises the American model of science parks.

2.1.1.3 Summary

In this review, studies on inter-institutional collaboration are classified into two traditions: static and dynamic. Within the static tradition, properties of inter-organisational linkages are analysed at one particular moment of time and the dynamics of their development are not taken into account. Studies done in the static tradition were attributed into two groups according to the level of co-ordination between collaborating institutions. The co-ordination here is understood as a combined or co-ordinated action aimed at producing innovation.

The first (low co-ordination) group includes studies investigating different properties of company-company linkages, such as extent of inter-organisational dependence (Hagedoorn, 1990), complementarities of large and small firms (Rothwell and Dodgson, 1993) and underlying motive of the collaboration (Narula and Hagedoorn, 1999).

The second (higher co-ordination) group includes studies, which examine properties of wider networks of linkages formed by companies, universities, research institutions and different state agencies. Within this tradition, academics analyse different aspects of chains of production (Marceau, 1994), networks (Hobday, 1994; Moody, 1989; Cooke, 1996; Porter, 1990), complexes (van Tulder, 1988; Marceau, 1992) and science parks (Rudakova, 1989: Tacuno, 1989).

2.1.2 Inter-organisational Collaboration: Dynamic Approach

In the next part of the chapter we will analyse different studies that treat inter-organisational linkages as dynamic in nature. At the core of the most of these studies is the idea that the intensity of collaboration is determined by the environmental factors such as efficiency of intellectual property protection, nature of innovative product/technology and availability of specialised assets (those used while producing innovation). These environmental factors are changing while industry/technology develops and this influences the intensity of inter-institutional collaboration. Studies done in the dynamic approach were classified into two approaches as shown in Figure 2.4 (highlighted area).

Figure 2.4: Dynamic Approach in Theories on Linkages

Studies on Inter- institutional Collaboration	
Static Tradition	*Dynamic tradition*
Company-company Linkages ↓ Level of co-ordination Chains of production Networks Clusters Complexes Science Parks	Industry Development Preconditioned Models Technology Development Preconditioned Models

1) Industry development preconditioned models. These models are popular amongst researchers from continental Europe, especially Germany and Netherlands. The models are based on the idea that patterns of inter-company collaboration are linked to the life cycle development of an industry.
2) Technology and product development preconditioned models. These models are widespread mostly among American researchers. Product and technology life cycles rather than industry life cycle are believed to determine the development of occurrence and intensity of collaboration in this approach.

2.1.2.1 Industry Development Preconditioned Models

This section outlines three models. Firstly, there is a summary of very influentional model by Teece (1997) in which he introduced the concepts of 'appropriability regime' and 'complimentary assets'. Then there is a sub-section on the model by Robertson and Langlois (1995) in which they put an emphasis on the balance between appropriability of profits permitted by horizontal and vertical integration and specialisation. Finally, the influence of appropriability regime on vertical/horizontal linkages is outlined as prescribed by Gemser's (1996) model.

1) Teece's Model

Teece (1986, 1997) offered a framework that identifies the factors that determine who wins from innovation: the firm that is first to market, follower firms, or firms that have related capabilities that the innovator needs. It also explains the distribution of the profits from innovation between innovator, follower and suppliers. Finally the framework describes the occurrence and relevance of inter-firm collaboration.

This framework is founded on three fundamental building blocks:

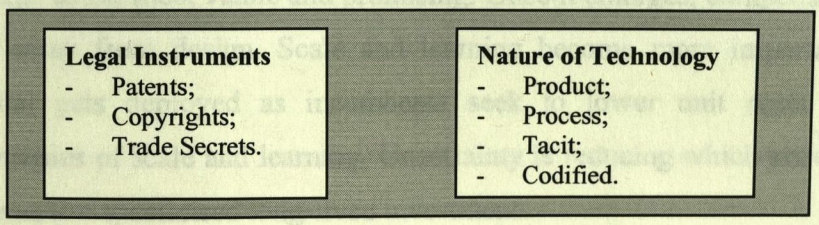
1) The appropriability regime;
2) The dominant design paradigm;
3) Complementary assets.

(i) Appropriability Regime

A regime of appropriability refers to environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovator. (Teece, 1992, p. 188)

Two dimensions of such a regime (see Figure 2.5) are the nature of technology and efficiency of legal mechanism of intellectual property protection.

Figure 2.5: The Dimensions of Appropriability Regime



Source: Teece, 1992, p. 189

Teece suggested that patents often provide little protection because the legal requirements for upholding their validity or proving their infringement are high. In some industries, particularly those with a high level of process innovation, trade secrets are stated as being a viable alternative to patents. The degree to which knowledge is tacit or codified affects the possibility of imitation. Codified knowledge is believed to be easier to pass and more exposed to industrial espionage.

The nature of technology and the efficiency of the legal protection define the property-rights environment within which a firm operates. Tecce had drawn a dictonomy between environments in which the appropriability regime is tight (technology is relatively easy to protect), for example Coca-Cola syrup, and weak (technology is almost impossible to protect), for instance, the Simplex algorithm in linear programming.

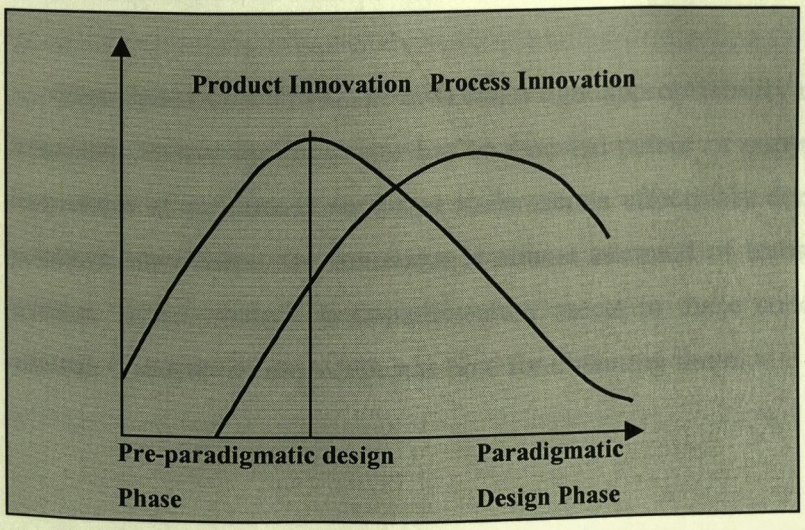
(ii) The Dominant Design Paradigm

Teece (1992) adopted Abernathy and Utterback's (1978) model, which explains the technological evolution of an industry as one of three major blocks of his own framework. According to this model, in the early 'pre-paradigmatic' stage of industry development, product designs are multiple, manufacturing processes are fluid and adaptively organised and generalised capital is used in production. Competition between firms manifested itself in competing among different designs.

After considerable trial and errors, one design or a narrow class of designs begins to emerge as the most viable and promising. Once it emerges, competition switches to price and away from design. Scale and learning become more important, and specialised capital gets deployed as incumbents seek to lower unit costs through exploiting economies of scale and learning. Uncertainty is reducing which provides an opportunity to amortize specialised long-lived investments.

Innovation is not necessarily halted once the dominant design emerges; but it becomes more process than product in its nature, as producers attempt to lower production costs for the new product (see Figure 2.6).

Figure 2.6: Innovation over the Product/Industry Life Cycle



Teece (1992, p. 190) points out that the Abernathy-Utterbach framework works better for mass markets where consumer tastes are relatively homogenous than for small–niche markets where the absence of scale and learning economies attaches much less of a penalty to multiple designs.

(iii) Complimentary assets

Teece (1992, p. 191) says that 'the successful commercialisation of an innovation requires that the know-how in question be utilised in conjunction with other capabilities or assets. Services such as marketing, competitive manufacturing, and after-sale support are almost always needed. These services are often obtained from complimentary assets that are specialised.'

Teece differentiates among complimentary assets that are generic, specialised and co-specialised. Generic assets are general-purpose in their nature and do not need to be tailored to the innovation in question. Specialised assets have unilateral dependence between the innovation and the complimentary assets. Co-specialised assets are those with bilateral dependence between the innovation and the complimentary assets.

(iv) Implications for Profitability and Vertical/Horizontal Integration

These three concepts were related in a way that determines the imitation process and the distribution of profits between innovator and follower.

Teece points out (1992, p. 193) that a tight appropriability regime exists in those few instances 'where the innovator has an ironclad patent or copyright protection or where the nature of product is such that trade secrets effectively deny imitators access to the relevant knowledge, the innovator is almost assumed of translating its innovation into market value.' Access to complimentary assets in these conditions is not necessarily critical, because the innovator has time for obtaining them.

Weak appropriability is much more common than tight appropriability. It occurs when imitation is easy (an innovator does not have solid patent or copyright protection and nature of the product is such that it cannot be a trade secret). In these conditions access to complimentary assets is critical if the innovator is to avoid handing over the large proportion of the profits to imitators.

Depending on the appropriability regime, a profit-seeking innovator should pursue different strategies: if appropriability is difficult, in other words, if imitation is easy, a firm should be more inclined to integrate vertically and/or horizontally. If appropriability is easy, a firm should be more inclined to specialisation. Teece links his complimentary asset concept to the product/technology life cycle by arguing that specialised complementary assets are relatively unimportant during the early (pre-paradigmatic), low-volume stages of an industry. Later on, while an industry is developing, output increases, the complimentary assets become of crucial importance to the competitive advantage of firms, and as a result horizontal and vertical linkages grow during the paradigmatic phases of the product life cycle.

2) Robertson and Langlois' Model

Robertson and Langlois (1995, pp. 543-562) have identified appropriability as an important determinant of changing network structure. In their point of view appropriability relates to a firm's ability to seize returns from its innovation. They point out that there is a trade–off between specialisation and appropriability of profits permitted by horizontal and vertical integration. The balance between specialisation and appropriability of profits from linkages is changing while industries are developing. The advantages of specialisation such as economies of scope for promoting innovation should lead to a low degree of integration. However, the ability of an innovator to receive profits from innovation may be constrained if the adoption and use of the innovation depend on the activities of other firms, either at the same or at different stages in the value chain. Similar to Teece (1992) Robertson and Langlois point out that inter-company collaboration becomes more intense in the paradigmatic phase of industry development.

3) Gemser's Model

Gemser et al (1996, pp. 439-466) extend the idea developed in the work of De Jong (1986), Abernathy and Utterback (1978, 1980) and provide a descriptive framework that reflects the idea that changing inter-firm networks are linked to patterns of industry development.

In this model one of the most important propositions relates to appropriability. If appropriability is difficult because the intellectual property rights (IPR) protection regime is weak, firms tend to establish formal and informal linkages. Following De Jong (1986, pp. 69-112) they divide an industry life-cycle into four phases. Each phase has its own characteristics that determine establishment or change of inter-firm linkages as shown in Table 2.3.

Table 2.3: Linking Changing Inter-firm Linkages to Industry Development

Industry life cycle	**The environmental conditions that increase or decrease the necessity to establish**	
	Horizontal linkages between competing firms	**Vertical linkages between firms and their suppliers**
Emergence	Establishment of linkages to pool resources, to create the necessary industry infrastructure and to enhance appropriability conditions.	Forging linkages to create the necessary infrastructure.
Growth	Decrease of linkages because of growth of the number of firms, specialisation and more effective IPR.	Increase of linkages because of specialisation.
Maturity	Decrease of linkages owing to take-overs and mergers which must enlarge resources and create economies of scale and scope	Decrease of linkages because firms integrate vertically
Decline or De-maturity	Increase of linkages in order to reduce competition, to rationalise (over-capacity) and to enhance appropriability conditions	Increase of linkages because firms focus on 'core capabilities' and/or enhance innovative capability.

Source: (Gemser et al, 1996, p. 442)

According to the model, in the first phase of the industry life cycle, the structure of the industry is rather monopolistic and follows a pattern of radical and rapid product innovations. The product life cycle of most innovations is very short, which reduces the

possibility to earn profits and makes a search for intellectual property rights (IPR) protection irrelevant. The uncertainty element for firms is much larger than in a more mature industry. Firms rarely possess all the necessary resources and competencies to create and deal with such an industry infrastructure so they create inter-firm linkages. The high expenditures on R&D, marketing and production and low appropriability of profits favour above all the establishment of horizontal inter-firm linkages in order to increase speed of R&D and reap economies of scale. Firms tend to establish reliable, preferably formal, vertical linkages with suppliers and distributors in the different levels of value chain.

In the second (growth) phase of the industry life cycle the number of firms is swiftly growing due to relatively low barriers to entry and high profit margins and difficult appropriability conditions for innovators. Firms start to specialise to gain competitive advantage over competitors, which leads to horizontal disintegration among the firms operating at the same level of the value chain, and to the establishment of new or consolidating of already exiting vertical linkages with complimentary firms.

In the third (maturity) phase of the industry development when the growth market slows down, barriers to entry and the level of industry concentration increase. Innovation is process and cost cutting in its nature because there are established technology and standards. Slow or stagnant growth of demand leads to over-capacity and to take-overs and mergers between rival and complementary firms in order to get economies of scale and scope.

In the fourth decline or de-maturity stage, firms try to avoid price competition, by focusing on product differentiation. Appropriability of profits is difficult because of expired patterns and/or because forms of product differentiation are difficult to protect legally. Firms sell 'peripheral' parts of their business, and enter to formal and informal linkages in order to rationalise over-capacity. The establishment of new linkages with firms from new adjacent industries could eventually 'rejuvenate' the industry's pattern of development.

2.1.2.2 Technology/Product Development Preconditioned Models

This sub-section contains two models which emphasise the importance of product/technology development while describing inter-company linkages. In the first model, Hobday analyses how complimentary assets influence user-producer linkages over the product life cycle. And finally there is a summary on Abernathy and Utterback's model, which was used as one of the foundation blocks in Teece's model.

1) Hobday's Model

The link between complementary assets and life cycle is further analysed by Hobday (1994, pp. 231-243; 1997) who focuses on product life cycles instead of industry life cycles. Based on Teece's framework, Hobday (1997, p. 158) puts forward a three – stage product life cycle scheme (see Table 2.4).

Table 2.4: Significant Characteristics in the Three Phases of Product Life Cycle

	Stage 1	**Stage 2**	**Stage 3**
Diffusion Stage	Selection Introduction Slow adoption Multiple niches	Imitation Rapid take-off Niche growth	Maturity Saturation Expansion Mass market
Investment Focus	Product innovation Pre-production	Capital goods Process technology Heavy investment	Incremental process/product Cost minimization Scale/scope economies
Complementary Assets	Least critical Technology based	Growing importance Financial Marketing Large firms High growth firms	Critical Global marketing and management
Organisational Form	Small Firms Networks Large firms	Large firms High growth firms	Very large firms (e.g. Keiretsu) Vertical/horizontal integration
Learning	Pre-investment Trial and error Uncertain	Imitative Cumulative	Predictable Incremental
User-producer Linkages	*Intense* *Changing* *Product design*	*Systematic* *Process focus* *Capital goods*	*Formalised* *Predictable* *Less critical*

Source: Hobday, 1997, p. 159

As it can be seen from the table, during the first stage of industry development, the inter-company linkages may offer advantages to suppliers and users. The network focuses on technology accumulation, collective learning, rapid skill development and risk sharing.

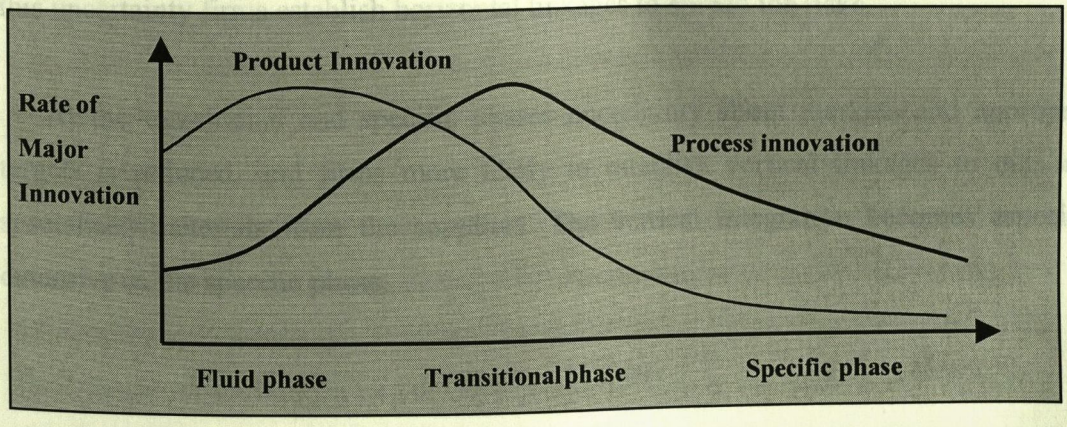
During the stage two there is a shift away from intense producer-user collaboration as suppliers organise production facilities to meet growing demand from customers.

During stage three, learning shifts away from user-producer interaction to traditional production learning curve. At this stage leading firms rely less on the network and small firms, incremental product and process innovations are carried out in house.

2) Abernathy and Utterback's Model

William Abernathy and James Utterback (1978) developed a model of the dynamics of innovation in industry. The model (see Figure 2.7) hypothesises that the rate of major product and process innovation follow a general pattern over time and share an important relationship. As it can be seen from the figure below, the rate of product innovation in an industry is highest during its early years.

Figure 2.7: The Dynamics of Innovation



Source: Utterback, 1994, p. xvii

The authors call this period the 'fluid phase'. During this phase a great deal of experimentation with product design and operational characteristics takes place. In the course of this phase of high product innovation, much less attention is given to the process by which products are made, so the rate of process innovation is much slower compared to the rate of product innovation.

According to the model, the period of fluidity is typically followed by 'transitional phase'. In this phase the rate of major product innovation slows down and the rate of major process innovation speeds up. At this point, standard designs that have either proven themselves in the marketplace as the best form for satisfying user needs, or designs that have been dictated by accepted standards, by legal or regulatory constraints substitute product variety.

And finally, there is a 'specific phase', where the rate of major innovation both product and process dwindles. The industries going through this phase become extremely focused on cost, volume and capacity; product and process innovation appears in small, incremental steps. Table 2.5 summarises significant characteristics in each of the phases.

In the initial fluid stage when market needs are ill defined and the relevant technologies are yet little explored there is a high level of uncertainty. Confronted with this uncertainty firms establish horizontal linkages to spread the risks.

At the transitional and specific phases uncertainty about markets and appropriate targets is reduced, and firms more likely to establish vertical linkages to outsource specialised materials from the suppliers. The vertical integration becomes especially extensive in the specific phase.

Table 2.5: Significant Characteristics in the Three Phases of Industrial Innovation

	Fluid Pattern	Transitional Pattern	Specific Pattern
Competitive emphasis	Functional product performance	Product variation	Cost reduction
Innovation stimulated by	Information on users' needs and users' technical inputs	Opportunities created by expanding internal technical capability	Pressure to reduce cost and improve quality
Predominant type of innovation	Frequent major charges in products	Major process charges required by rising volume	Incremental for product and process, with cumulative improvement in productivity and quality
Product line	Diverse, often including custom designs	Includes at least one product design stable enough to have significant production volume	Mostly undifferentiated standard products
Production processes	Flexible and inefficient; major changes easily accommodated	Becoming more rigid, with changes occurring in major steps	Efficient, capital-intensive, and rigid; cost of change is high
Equipment	General-purpose, requiring skilled labour	Some sub processes automated, creating 'islands of automation'	Special-purpose, mostly automatic, with labour tasks mainly monitoring and control
Materials	Inputs are limited to generally-available materials	Specialised materials may be demanded from some suppliers	Specialised materials will be demanded; if not available, vertical integration will be extensive
Plan	Small-scale, located near user or source of technology	General-purpose with specialised sections	Large-scale, highly specific to particular products
Organisational control is	Informal and entrepreneurial	Through liaison relationships, project and task groups	Through emphasis on structure, goals, and rules

Source: William Abernathy and James Utterback (1988, pp. 25-36)

Most technology-based innovation in this model in this model is understood as the part of a continuum of change. Each wave of innovation repeats the pattern of inter-linking product and process innovation and has its fluid, transitional, and specific phases. The overall number of firms participating in the second wave of innovation is lower compared to the number of the companies participating in the first wave. The reason for this drop-off in the number in later waves was related to the fact that markets are often well defined by the first wave of innovation and established firms develop the distribution channels and production facilities to serve these markets, limiting the

numbers of possible firms that can reform the industry even if they have a superior technology.

2.1.2.3 Summary

In this literature review, studies on inter-company collaboration are classified into two traditions – static and dynamic. In the dynamic tradition, the intensity of collaboration is understood to depend on the environmental factors such as efficiency of intellectual property rights protection regime, nature of innovative know-how (tacit or codified) and availability of complimentary assets (those used while producing innovative product/service). These external environmental factors are affected by the evolution of an industry or product/technology. Consequently, the intensity of collaboration is changing while the environment develops.

In this tradition inter-company collaboration is treated as a means of creating and profiting from innovation and the properties of particular types of linkages are not considered, the authors mostly refer to the likelihood and intensity of collaboration in general.

Studies done in the dynamic tradition were attributed to two approaches – 'industry development preconditioned' and 'technology/product preconditioned'. In the first approach, the authors (e.g. Teece, 1996; Robertson and Langlois, 1995; Gemser et al, 1996) link the likelihood and intensity of inter-company collaboration to industry development. In the second approach (e.g. Hobday, 1994; Abernathy and Utterback, 1978), the likelihood and intensity of collaboration is linked to the evolution of technology or product.

2.2 INTER-ORGANISATIONAL COLLABORATION IN THE IRISH SOFTWARE INDUSTRY

This section contains information on inter-company linkages in the Irish Software Industry. It consists of three sub-sections. The first two sub-sections, namely *'The Irish Software Industry Indicators'* and *'Studies on Inter-company Linkages in Ireland'* give a wide picture of both the Irish Software Industry and general studies on inter-company linkages in Ireland. The third sub-section - *'Studies on Inter-company Linkages in the Irish Software Industry'* - examines the up-to-date studies on the linkages between software companies in Ireland.

2.1.1 Irish Software Industry Indicators

In this section different characteristics of the Irish software industry, which shape the environment in which inter-company linkages are established and sustained are analysed. In the study we use the National Software Directorate definition of the software sector as illustrated in Table 2.6.

Table 2.6: Definition of the Software Sector

INCLUDED are companies:	**EXCLUDED** are:
1. Developing software products/systems for subsequent sale to end-users. 2. Developing systems software and/or software development tools for sale to hardware/software vendors. 3. Providing services directly related to the design and/or development of software systems. 4. Involved in localisation of either their own organisation's products or third-party products. 5. Involved in the development of programmes or systems for subsequent incorporation into dedicated hardware devices. 6. Providing technical training in the areas of systems analysis, design and programming. 7. Providing "hot-site/disaster recovery facilities.	1.Personnel of Irish companies who are based in overseas offices. 2. Companies providing data entry or processing or bureau services for either local or overseas organisations. 3. Companies providing training services for standard software packages. 4. The software development functions of in-house IT departments. 5. Companies involved in the sale of hardware and/or third-party software packages, except where they have a separate software development function.

Source: (O'Gorman, O'Malley and Mooney, 1997, p. 2)

The development of the software industry in Ireland is a relatively recent occurrence. A number of the longest-established firms started in the 1970s, but Coras Trachtala (1987) found that in 1986 there were only about 1,800 people employed in the industry (1,200 of these in indigenous firms and 600 in subsidiaries of foreign-owned companies). Since then, there has been sustained rapid expansion, as major overseas software companies brought their operations into Ireland sparking a quick growth in the indigenous industry. As a result in the last few years the Irish software industry has emerged as a world-class industry with strong overseas and indigenous sectors. The industry is ideally suited to Ireland. It is people rather than capital-intensive; it demands a highly skilled labour force; has no undesirable environmental effects; it is increasingly based on the English language and unlike capital-intense, low-skill industries, investment in it is not easily displaced. In other words it perfectly matches the Irish advantages listed above and as a result the industry has performed well over the past decade, now it accounts for 10% of Irish exports, and has very good potential for further development (NSD, 1992; NSD, 1997).

Table 2.7 shows the steady growth trend in revenue, employment and exports for both Irish and overseas companies observed in the software industry in Ireland (as defined in the table above) since 1991.

Table 2.7: Development of the Software Industry in Ireland from 1991 till 1997

		1991	1993	1995	1997	Growth 1991-97
Revenue (IR£m)	**Irish**	150	236	386	528	252%
	Overseas	1,580	1,756	2,611	3,933	149%
	Total	1,730	1,992	2,997	4,461	158%
Employment	**Irish**	3,801	4,495	5,773	9,200	142%
	Overseas	3,992	4,448	6,011	9,100	128%
	Total	7,793	8,943	11,784	18,300	135%
Exports (IR£m) [% of total revenue]	**Irish**	61.3[41]	116[49]	226[58]	365[69]	495%[68]
	Overseas	1,548[98]	1,726[98]	2,585[99]	3,854[98]	149%[0]
	Total	1,609	1,842	2,811	4,219	162%

Sources: (NSD, 1993; NSD, 1997, p. 3)

In 1997 the industry employed 18,300 people. This figure is expected to rise to 20,000 employees by the year 2000. What is more important is that the sector employs a very high proportion of graduates, with remuneration levels well above the average for other industries. The skill profile of the software industry is high and will continue to grow, providing many opportunities for graduates from a range of disciplines.

In the overseas sector, the Irish operations are being given responsibility for more business functions. The industry profile is changing from one of low-skill, low value-added manufacture and assembly, with profits being transferred to the parent country, to one of integrated businesses, including marketing, research and development, and sales functions. All the factors listed above have had the effect of investing more money in Ireland, and of rooting the software industry more securely here.

After the USA Ireland is the second largest exporter of software in the world with exports worth IR£4.219 billion in 1997. While overseas companies account for most of this export (IR£3.854 billion), Irish firms have improved significantly in recent years. In 1997, IR£365 million or 69% of the output of Irish firms was exported representing a rise by 495% over seven years (1991-97). The growth in exports was almost twice as high as growth in revenue and highlights that Irish firms are becoming increasingly export oriented. Irish firms exported an average of IR£57,552 per employee in 1997. According to estimates by the National Software Directorate (1992) growth in the industry will mostly come from exports. The industry can thus make an even more significant contribution to the Irish balance of trade. What is even more important is that the indigenous software products have very little imported content, their gross export value being equivalent to their net export value. The steady growth in revenues in both Irish and overseas companies over the last several years has provided a good basis for the further development of the firms.

Irish indigenous software industry has emerged as one of the most promising smaller industries in the global software industry. As O'Riain (1997, p. 9) points out the Irish software industry has better or comparable characteristics to other emerging successful

software industries such as in India and Israel. Table 2.8 indicates, that the Irish industry is in a similar size category to the industries in India and Israel. The Irish industry's export profile is similar to that of the Indian industry's one, consisting mainly of offshore development and international labour contracting. The Irish industry is closer to the Israeli and the US models in its focus on software products rather than services (NASSCOM, 1996).

Table 2.8: Sales and Exports in the Indigenous* Software Industry in India, Ireland and Israel 1993-1995

Year	Sales ($ million)			Exports ($ million)			Exports as % of total Sales		
	India	Ireland	Israel	India	Ireland	Israel	India	Ireland	Israel
1993	388	368	700	225	190	175	58%	52%	25%
1994	554	N/A	790	330	N/A	220	60%	N/A	28%
1995	823	610	N/A	485	357	N/A	59%	59%	N/A

Note: Figures may not be strictly comparable as survey coverage and methodologies are different.
* Figures for India include trans-national companies, figures for Ireland and Israel do not.

Source: (O'Riain, 1997, p. 9)

Some industry characteristics, which are useful for the purpose of this research which analyses inter-company linkages in the Irish software industry and their impact on the company performance, are outlined below.

2.2.1.1 Number of Companies

The number of Irish and overseas companies has grown rapidly between the years 1991-1997. Table 2.9 highlights that the number of Irish firms has increased by 96% from 1991 to 1997. At the same time the number of overseas companies operating in Ireland has increased by 46%. In 1997, 9.8% of all overseas companies in Ireland were operating in the software sector.

Table 2.9: Number of Companies Operating in the Software Industry in Ireland, 1991-1997

	1991	1993	1995	1997	Growth 1991-97
Irish Firms	291	336	390	571	96%
Overseas Firms	74	81	93	108	46%
Total	365	417	483	679	86%

Sources: (NSD, 1993: NSD, 1997, p.2)

2.2.1.2 Company Size and Employment

Table 2.10 shows that 5% of the largest Irish firms account for over 33% of the total employment and generated 37% of the total revenue in the indigenous sector. The lower end of the scale for Irish firms shows that the industry is highly fragmented: 46% of Irish firms employ fewer than six and account for 9% of total employment. 65% of Irish firms employ fewer than ten. In Europe as a whole, only 36% of software companies employ fewer than 10, while 56% employ twenty or less. This information might be useful for choosing a sample for the research.

Table 2.10: Size of Irish and Overseas Companies in the Software Industry

Firm Size	No. of Irish Firms (%)	No. Employed (%)	No. of Overseas Firms (%)	No. Employed (%)
200+	N/A	N/A	4 (5%)	1,824 (45%)
50-200	14 (5%)	1,259 (33%)	16 (22%)	1,275 (31%)
41-49	6 (2%)	262 (7%)	4 (5%)	170 (4%)
31-39	11 (4%)	362 (9.5%)	7 (9.5%)	226 (5.5%)
21-29	25 (8%)	579 (15%)	10 (13.5%)	250 (6.5%)
10-19	46 (16%)	588 (15.5%)	16 (22%)	222 (5.5%)
6-9	55 (19%)	395 (10%)	7 (9.5%)	51 (1.5%)
1-5	134 (46%)	356 (9%)	10 (13.5%)	34 (1%)
Total	291 (100%)	3,801 (100%)	74 (100%)	4,052 (100%)

Sources: (NSD, 1993; NSD, 1997, pp. 2-3)

Overseas companies are larger than their Irish counterparts. Table 2.10 shows that only 23% of overseas companies employ fewer than ten, and these smaller companies

account for just 2.5% of total employment in all overseas companies. At the same time, the top four overseas companies account for 45% of total employment.

The data from National Software Directorate (1993) mainly coincides with the data of research of a number of companies undertaken by Sean O'Riain in 1997. According to this study, overseas companies operating in Ireland are normally much larger than Irish firms (see Table 2.11).

Table 2.11: Distribution of Companies and Employees by Company Size*

Number of Employees	Irish		Overseas	
	% of Irish Firms	% of all Employees	% of Overseas Companies	% of all Employees
1-10	57	6	14	0.4
11-50	35	15	41	8
51-250	6	12	36	2
250+	1	7	9	27
Total	99**	40.5	100	59.5

* All employees-permanent and temporary, full-time and part-time.
** Total does not sum to 100 due to rounding.

Source: (O'Riain, 1997, p. 11)

The table above shows that most of the Irish firms fall into 1-10 and 11-50 categories. At the same time there are very few overseas companies with less than 10 employees and most of them employ more than 50 people. It is clear that despite the emergence of some larger Irish firms, the indigenous sector is still dominated by smaller firms.

The average size of Irish firms has been slowly increasing. In 1993, 64% of Irish firms employed less than 10 employees (compared to 57% in 1997) and 5% employed more than 50 employees in 1997 (up to 7%) (O'Riain, 1997, p. 11). Overseas companies have also been increasing in size but at a more rapid pace. In 1993, 32% of them had above 50 employees in 1993 and 21% under 10 employees compared with 45% and 14% now (O'Riain, p. 10). Table 2.12 shows the growth of number of both Irish and overseas companies employing more than 50 employees between 1991-1997.

Table 2.12: Companies Employing more than 50 People

	1991	1993	1995	1997	Growth 1991-97
Irish Firms	14	17	24	27	93%
Overseas Firms	20	17	29	51	155%
Total	34	34	53	78	129%

Sources: (NSD, 1993; NSD, 1997, p.3)

2.2.1.3 Ownership of Firms

Table 2.13 shows the ownership of companies in the Irish software industry. Independent Irish firms predominate with almost three-quarters of all firms and another 4.2% being either joint ventures or Irish firms, which have been acquired by foreign firms. Among overseas companies American ones predominate.

Table 2.13: Ownership of Firms by Nationality

Ownership	% of Firms
Independent Irish	73.2%
Joint Venture	1.3%
Acquisition of Irish Firm by Multinational	2.9%
Subsidiary of Multinational	22.6%

Source: (O'Riain, 1997, p.10)

2.2.1.4 Distribution of Companies by Sub-sector

The National Software Directorate (1997, p. 2) divides the software industry into 12 sub – sectors. Table 2.14 shows the distribution of companies both Irish and overseas by those sub-sectors. The best potential for linkages are amongst the Banking/Financial Systems, Telecommunication Software and Software Localisation sub-sectors (Interview with John Dixon, executive of NSD, Enterprise Ireland).

Table 2.14: Sub – sectoral Specialisation Among Irish and Overseas Firms

Sector	% of Firms
General Business Application Products	17
Banking/Finance Systems	8.5
Multimedia/CBT Systems	7
Telecommunication Software	8
Other Niche Product Development	21
Internet-Related Products and Services	5
Software Localisation	4
Firmware	0.5
Software Tools/Systems Software	6
Bespoke Development/Software Services	16
Customer Support	1
Other	6
Total	100

Source: (NSD, 1997, p. 2)

2.2.1.5 Geographic Distribution of Companies in Software Industry

The software industry in Ireland is basically concentrated around Dublin (Table 2.15). In 1993 71% of all Irish firms and 76% of overseas companies were located in or around Dublin. There was also a cluster in Cork City and the greater Cork region.

Table 2.15: Location of Irish and Overseas Companies in Ireland in 1993

Region	No. of Irish Firms	%	No. of Overseas Firms	%
Dublin	206	71	56	76
East	6	6	1	1.35
South East	30	10	7	9.4
Mid West	14	5	6	8
West	15	5	1	1.35
South West	7	2	2	2.7
North West	5	2	N/A	N/A
North East	5	2	N/A	N/A
Midlands	3	1	1	1.35
Total	291	100	74	100

Source: (NSD, 1992, p.2-2)

2.2.1.6 Exports

The overseas companies in the software industry in Ireland are mostly export-oriented, 71% of these obtaining over 90% of their revenues from exports. (O'Riain, 1997, p.11) The Irish firms have greater range of export orientation. (Table 2.16) There is a cluster of firms at the export (bottom) and domestic market (top) – oriented sectors of the table.

Table 2.16: Percentage of Revenues from Exports among Irish Companies in 1997

Export Revenue, %	% of Irish Firms
0	18.4
1-9	6.7
10-19	9.5
20-29	15.1
30-39	3.4
40-49	6.2
50-59	7.8
60-69	4.5
70-79	3.9
80-89	6.2
90-99	12.4
100	6.1

Source: (O'Riain, 1997, p. 11)

As can be seen Irish companies have become more export oriented as compared to 1990 as shown in table 2.17. In 1997, the percentage of companies focused mainly on the domestic market (export revenue less than 30%) has decreased by 6.3%, the percentage of companies that have no exports at all has decreased by 18.6%. Over the same period, the percentage of mostly export-oriented companies (export revenue more than 70%) has increased by 3.6%.

Table 2.17:Percentage of Revenues from Exports among Irish Companies in 1990

Export Revenue, %	% of Irish Firms
1	37
1-10	11
11-20	6
21-30	2
31-40	2
41-50	7
51-60	4
61-70	6
71-80	7
81-90	6
90+	12

Source: (NSD, 1992, p.2-2)

Export orientation among Irish firms correlates with a focus on software product development. Table 2.18 shows the distribution of Irish companies focused on product development (41% getting over 50% of their revenue from products) and providing services (37% of all firms) (O'Riain, 1997, p. 11). In its distribution of product and service oriented companies, the Irish software sector is close to the US one (47% and 35% respectively).

Table 2.18: Product and Service Orientation of Irish Software Companies

Percentage of Revenues from Products/Services	Revenue from Software Products			Revenue from Software Services		
	Exporting Firms (%)	Non Exporting Firms (%)	All Firms (%)	Exporting Firms (%)	Non Exporting Firms (%)	All Firms (%)
0-10	26.9	41.2	28.6	23.9	5.0	21.4
11-50	28.3	37.3	30.9	40.5	48.7	41.3
51-90	30.4	18.1	27.8	19.8	15.8	19.9
91-100	14.4	3.4	12.8	15	30.5	17.4
Number of Firms	148	31	184	148	31	184

Source: (O'Riain, 1997, p. 12)

There is a strong correlation between export orientation and product focus. Sean O' Riain (1997, p. 12) points out that:

> 45% of all exporting Irish firms earn over half of their revenues from product sales and a quarter earn over 80% from products. The average (mean) percentage of revenues from product sales is 30% for non-exporting firms and 46% for exporting firms. The mirror image of this is the heavy services focus among firms focussed almost solely on the Irish market.

Amongst the export markets for Irish software Europe (49%) and North America (43%) predominate. Besides that, these Irish companies export their software products and services to the Far East (1%), the Pacific Rim (3%) and other regions (4%). The biggest European market for Irish companies is the UK (21%). Irish companies have established offices overseas and the total number of these offices has been growing (in 1997 the number of offices Irish companies had was 100 – 41 in the UK, 10 in Europe, 31 in the USA and 4 in other countries). This represents a total growth of 18% since 1993. However, most still rely upon their ability to sell directly into overseas markets, or use agents or distributors (NSD, 1992, p. 2-2).

2.2.2 Studies on Inter-company Linkages in Ireland

There are several studies on inter-firm linkages in Ireland (Stewart, 1976; McAleese and McDonald, 1978; O'Farrell and O'Loughlin, 1980, 1981; O'Malley, 1995; O'Riain, 1997; Gorg and Ruane, 1998; O'Gorman, O'Malley and Mooney, 1997). These studies reflect the growing concern about importance of inter-firm linkages between Irish firms and overseas companies for the Irish economy.

Some studies argue that the continuing duality in performance between the overseas and Irish companies is often linked with the perception that overseas companies have relatively low linkages within the Irish economy. For example, in the early 1980's, NESC compiled the NESC Report No. 64, *A Review of Industrial Policy* (Telesis Report). The report proposed that overseas manufacturing companies in Ireland with few exemptions: (p. 22)

...do not embody the key competitive activities of the businesses in which they participate: do not employ significant numbers of skilled workers: and are not significantly integrated into traded and skilled sub-supply industries in Ireland

The more recent study by O'Malley (1995) supports this perception. According to his study expenditure on Irish materials accounts for 42.5 per cent of indigenous industry sales, comparing to 11.4 per cent of sales for overseas companies. However, O'Malley's most recent research (Cooke, 1996, p. 123) brings some qualifications to this view. In his research O'Malley focuses on quantifying the indirect employment in services associated with employment in industry. He found that the number of indirect jobs were greater for overseas manufacturing then for Irish manufacturing companies.

Two studies by Stewart (1976) and McAleese and McDonald (1978) had also shown that overseas companies have had lower linkages than Irish companies.

Stewart's (1976) analysis is based on data from a random sample of forty-three foreign and indigenous firms in the West of Ireland for the period 1964-70. He describes different types of linkages between Irish firms–suppliers and multinational and domestic buyers. The study contains information about the proportion of locally-sourced inputs relative to a firm's output, where inputs include raw materials; and manufacturing and services inputs. Also, he accepts interdependence between firms without analysing the issue of causality.

Studies done by McAleese and McDonald (1978) use data from a large survey of 269 manufacturing firms that were operating in Ireland in 1974 (see Mc Aleese, 1977). It analyses the determinants of backward linkages between Irish firms–suppliers and overseas companies operating in Ireland. O' Farrell and O'Loughin (1980, 1981) undertake similar analysis based on a selection of 360 firms out of 466 operating in Ireland in 1976.

These two studies highlight that:

1. Overseas companies in Ireland tend to have lower linkages than Irish firms, controlling for sectoral and size differences.
2. Older firms both Irish and multinational tend to have higher linkages than newer firms do.

However, it cannot be concluded from these studies that linkages at an individual firm level increase over time since the data looks only at different types of firms at a single point of time.

Gorg and Ruane (1998) attempt to clarify this issue using panel data from the electronics sector as having the largest potential for linkages (Crowley, 1996), rather than cross-sectional analysis. Their study is based on the Forfas Irish expenditure database and covers a more recent period from 1982 to 1995. Overall their sample included observations for 215 firms which were in existence in 1995, 150 of which were overseas. The sample includes 44 per cent of all foreign firms and 14 per cent of Irish firms operating within the electronics sector in 1995. The findings of their study are similar to results obtained by Stewart and McAleese and McDonald:

1. Both Irish and foreign firms seem to increase their linkages over time;
2. Foreign firms have lower linkages than Irish firms;
3. Large and expanding firms both Irish and foreign have lower linkages than other firms.

All these studies above are based on Hirschman's (1958) concept of inter sectoral linkages. There are several other studies (see, for example, O'Malley, 1989, Chapter 7; Kennedy, 1991 and Crowley, 1996) using econometric techniques to analyse the determinants of inter-firm linkages. Other studies of inter-firm linkages in Ireland (see, for example Angel (1994)) are mainly undertaken by authors associated with geography or regional planning departments. They are often based on concepts of economic geography.

2.2.3 Studies on Inter-company Linkages in the Irish Software Industry

The linkages between companies in the software industry have developed over time. The first linkages, which often involved Irish firms and overseas companies, were created in the early 1980s. These linkages were mostly in logistics, software-manual printing and packaging. Some of these linkages were very successful. For instance, the software-manual printing industry sub-supplying overseas companies grew rapidly from $9 million to $135 million in five years (IDA, no date; Jacobson & O'Sullivan, 1994, p. 5). In the late 1980s, alongside with linkages as described above, Irish firms started developing more sophisticated ones in the area of software development and production. These included localisation, translation and personal secondment for overseas companies operating in Ireland. Microsoft was especially active in employing Irish firms for these types of linkages.

Later on Irish firms started establishing linkages for providing customer support. For example, Compaq established some linkages with Irish firms for providing 24 hours support lines for Microsoft products. These services are mostly concentrated towards the US market. Now there is evidence that Irish firms are establishing linkages with high innovation content with overseas companies carrying out R&D operations in Ireland.

There are only two studies on inter-company linkages in Ireland. The first one entitled 'Innovation, Employment and Growth in the Irish Software Industry' was undertaken by Sean O'Riain from Department of Sociology at University of California, Berkley. The second one – 'The Irish Indigenous Software Industry: An Application of Porter's Cluster Analysis' was done by Colm O'Gorman, Eoin O'Malley and John Mooney of the National Economic and Social Council in Dublin. The following sub-sections outline the findings of these studies.

2.2.3.1 Innovation, Employment and Growth in the Irish Software Industry (O'Riain's Study)

O'Riain classifies all linkages between overseas and Irish companies into five different categories (see Table 2.19)

Table 2.19:Local and International Alliances between Companies in the Irish Software Industry

	No		Yes, with Irish Firms in Ireland		Yes, with multinationals		Yes, with firms outside of Ireland	
	IR	MN	IR	MN	IR	MN	IR	MN
Technology								
Co-development of New Technology	59	66	17	4*	5	4	28	34
Sharing Existing Technology	62	57	17	5*	4	7	23	39*
Creation of Technical Standards	86	91	7	0*	2	0	7	5
Business								
Co-marketing	50	71*	21	2*	4	5	29	21
Joint Ventures	66	73	18	2*	5	0	18	25
Labour Contracting								
Contracting Labour from Partner	70	61	18	21	2	2	15	18
Contracting Labour to Partner	61	82	25	5*	6	5	19	9
Contracting for Services								
Design and Multimedia	75	84	16	7	4	2	9	13
Location and /or Translation	85	75	7	13	4	11	6	7
Assembly and Logistics	94	88	4	4	1	5*	4	4
Programming and Coding	64	72	24	11*	6	2	14	18
Political								
Lobbying Government	92	91	7	7	1	5*	1	0

* Difference between Irish and multinational companies statistically significant at the .05 level

Source: O'Riain (1997, p. 52)

The analysis shows that most companies operating in Ireland have some alliances with other firms foreign or domestic. Only 14.1% of Irish firms and 17.2% of overseas companies have no linkages at all. However, the linkages between overseas companies and Irish firms are often concentrated on low-end activities such as contracting labour from Irish companies to provide overseas companies with flexibility in their staffing. Some overseas companies contract Irish firms for programming and coding rather than

contracting for labour directly. Overseas companies are playing a very strong role in developing the translation, localisation, logistics and assembly sub-supply sectors in the Irish software industry. O'Riain (1997) points out that 26% of overseas companies operating in Ireland are involved in contracting for localisation and/or translation and all of those are doing some translation and localisation work in house as well. At the same time, 31% of overseas companies are carrying out translation and localisation in house without contracting to Irish companies.

Apart from these linkages, there is little evidence of connection between the Irish and multinational sector. Both overseas companies operating in Ireland and Irish firms seem to avoid having linkages with overseas companies operating in Ireland. 82% of Irish firms and 75% of overseas companies having subsidiaries in Ireland having no alliance with other overseas companies in Ireland–even including those low-end activities. In other words only 18% of Irish firms have linkages with overseas companies operating in Ireland. The more advanced technological and business linkages pursued by overseas companies are mostly outside of Ireland.

There is a good level of contracting labour and programming services between Irish firms themselves. Beside this there is also co-operation in more advanced linkages such as co-development of technology, co-marketing and joint ventures. Even so, for Irish firms linkages with other firms outside Ireland are more common than local alliances in these 'advanced' business and technical areas (O'Riain, 1997).

It is necessary to stress that alliances with Irish firms and overseas companies operating in Ireland are largely exclusive. Among Irish firms only 10-15 of those with an alliance with an Irish firm or MNC in a particular area (e.g. co-marketing, contracting labour to partner, etc.) had alliances with both Irish firms and overseas companies. This trend was even more pronounced among multinational firms.

The most distinct area of coincidence is between technology/business linkages with overseas companies and contracting linkages with Irish firms. 34% of Irish firms and

33% of overseas companies involved in any alliance in those areas are involved in both. This also highlights the predominance of linkages with Irish firms for labour and services contracting and with overseas companies for technology and business based linkages.

O'Riain (1997) points out that Irish firms with big export records are more likely to establish international linkages, especially of the technology or business kind. Other important characteristics of firms are that product orientation, service orientation, the proportion of engineers in the workforce and nation of origin of multinationals have no impact on the linkages which firms entered. Correlation between technology/business international alliances and percent exports was $r = 0.38$.

There is evidence that the size of firms, both Irish and multinational had a positive influence on the likelihood of establishing linkages. The larger an overseas company is the more likely it is to have alliances of either kind with Irish firms: $r = 0.29$ and 0.27 between number of employees and number of technology/business networks and number of contracting linkages respectively. The larger Irish firms also have a larger number of links with the overseas companies operating in Ireland. The Irish firms with linkages with overseas companies in Ireland were more likely to establish linkages with overseas firms.

Summary of O'Riain's Study

Sean O'Riain's (1997) findings on the study of linkages between overseas and Irish companies in the software industry shows that these can be classified into three categories – general information about companies with linkages, general information about linkages and factors influencing linkages between companies:

(i) General information about companies with linkages:

1) Most Irish and overseas companies operating in Ireland have some linkages with other companies foreign or domestic. Only 14.1% of Irish companies and 17.2% of overseas companies have no linkages at all.

2) Larger companies, both Irish and overseas, have higher linkages than other companies.
3) Both overseas and Irish companies seem to avoid having linkages with the subsidiaries of overseas companies operating in Ireland. Only 18% of Irish and 25% of overseas companies have linkages with other overseas companies operating in Ireland.

(ii) General information about linkages

1) Linkages between overseas companies and Irish firms are mostly concentrated on low-end activities such as contracting labour from Irish companies to provide overseas companies with flexibility in their staffing. Some overseas companies contract Irish firms for programming and coding rather than contracting for labour directly. Overseas companies are playing a very strong role in developing translation, localisation, logistics and assembly sub-supply sectors in the Irish software industry.
2) The more advanced technological and business linkages pursued by both Irish and overseas companies are mostly outside of Ireland.
3) Linkages between Irish and overseas companies are largely exclusive. Among Irish companies only 10-15 of those with an alliance with an Irish company or overseas companies in a particular area (e.g. co-marketing, contracting labour to partner etc.) had alliances with both Irish companies and overseas companies. This trend was even more pronounced among multinational firms.

(iii)Factors influencing linkages between companies

1) Irish companies with big export records are more likely to establish international linkages especially of the technology or business kind.
2) Other important characteristics of the firms such as product orientation, service orientation, the proportion of engineers in the workforce and nation of origin of multinationals had no impact on the linkages which companies entered into.

3) Irish companies that already had linkages with overseas companies in Ireland were more likely to establish linkages with overseas firms outside of the country.

2.2.3.2 The Irish Indigenous Software Industry: An Application of Porter's Cluster Analysis (O'Gorman, O'Malley and Mooney Study)

Another study, which indirectly concerns linkages in the Irish software industry, was done by O'Gorman, O'Malley and Mooney (1997). The study was commissioned by the National Economic and Social Council to examine the importance of industrial clusters for industrial development, and the suitability of Porter's clustering model, in the context of the Irish software industry.

The case study was primarily intended to examine the extent of the influence of industry clusters and the applicability of Porter's approach. It profiled and assessed the performance of the industry and then applied the Diamond Model developed by Porter (1990) (for more details see Section 2.1.1.2), as a framework for analysing the determinants of competitive advantage and significance of clustering in the industry.

As regards to the role of Porter's four determinants of competitive advantage, the study found that *factor conditions* were important for competitiveness of the Irish software industry, particularly in the case of the labour force. *Domestic demand conditions* had less pervasive influence than factor conditions. As regards *related and supporting* industries they were not seen as of any great importance for the industry's competitive advantage. However the foreign MNE-dominated computer and telecommunications equipment sectors helped to develop the type of labour skills useful for the indigenous software industry and in this sense they were stated as important "related sectors". Finally, as regards the importance of *strategy, structure and rivalry,* it was said to be important for indigenous software companies to have a strategy of specialisation in market niches. It was also stated that most companies experienced strong competition in the Irish market from other firms located in Ireland, and most of

these believed that such competition had an effect in increasing companies' international competitiveness (O'Gorman, O'Malley and Mooney, 1997, pp. 45-47).

This section mainly concentrates on a section of this study which covers its findings on the related and supporting industries and clustering in the industry. Although this condition was not believed to be of very high significance for the industry's competitive advantage it describes the environment in which inter-company linkages are established and sustained, which makes it relevant for our study.

As already said, in Porter's framework, the third broad determinant of competitive advantage in a particular industry is the presence in the same country of supporting (supplier) and other related industries. These industries are likely to be a source of partners for software companies for establishing inter-company linkages.

The study also revealed that a large majority of indigenous software companies have had business partnerships (inter-company linkages) with foreign MNEs in Ireland, particularly MNEs specialising in computer hardware or software. At the same time only a fairly small minority of indigenous software companies considered these linkages as important for their competitiveness (O'Gorman, O'Malley and Mooney, 1997, p. 36). In addition, about half of the Irish companies that took part in the study had some kind of linkages with other indigenous software companies which were not direct competitors. A limited amount of sub-contracting was found between them (O'Gorman, O'Malley and Mooney, 1997, p. 50).

The study also analysed to what extent was there evidence of "clustering", in the sense used by Porter. For Porter, a key outcome of geographic clustering is the way in which it promotes interaction among competing companies (inter-company linkages).

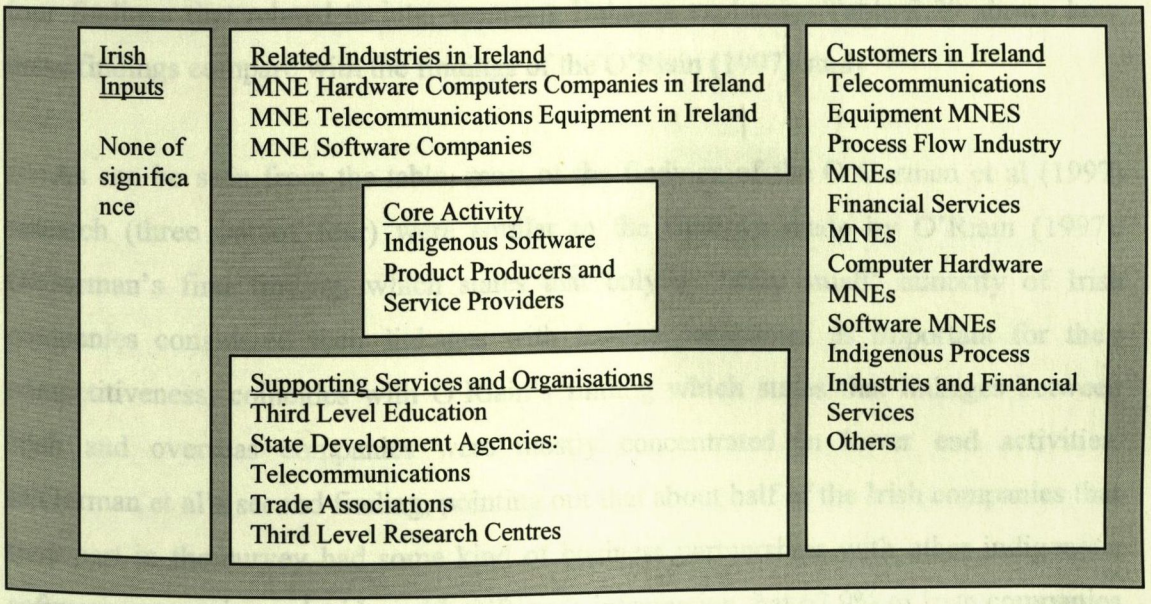
Porter's primary emphasis is on competitive rivalry, but he does admit the beneficial role of non-direct forms of collaborative arrangements, without providing any description

of networks in relation to his cluster concept and pays little attention to the manner in which relations actually operate (Nuys, 1995, p. 28).

A geographic concentration of indigenous software companies was found mainly in Dublin, but also in Cork, Limerick and Galway. Many companies, which participated in the study, said that the major reasons for locating there were access to skilled labour and access to international airports to facilitate travel between companies and their international customers.

There was little or no evidence that geographic concentration appeared because of a need for proximity to other software companies or supplier industries. The structure of related and supporting industries and organisations in the clusters found in the Irish software industry is illustrated in Figure 2.8.

Figure 2.8: The Structure of Related and Supporting Industries and Organisations in the Clusters in the Irish Software Industry



Source: O'Gorman, O'Malley and Mooney, 1997, p. 51

As it can be seen form the figure, there were no significant indigenous supplier industries for the Irish software industry cluster. At the same time the researchers discovered a number of customer sectors, both indigenous and foreign, and some were stated as relatively influential. These included MNEs in the process industries, software, computer hardware, telecommunications equipment and financial services, as well as Irish companies in the process industries and financial services.

Significant 'related' industries were also found. These were mostly overseas MNEs which helped to develop software labour skills and opportunities to engage in co-operation with Irish software companies. Finally it was reported that there was a wide range of supporting services and organisations.

2.2.3.3 Comparing the Findings of the O'Gorman et al and O'Riain Studies

The O'Gorman et al study (1997) is mostly concerned with the application of Porter's (1990) clustering model in the context of the Irish software industry and they made only four findings that related to inter-company linkages explicitly. Table 2.20 shows how these findings compare with the findings of the O'Riain (1997) study.

As can be seen from the table, most of the findings of the O'Gorman et al (1997) research (three out of four) were similar to the findings made by O'Riain (1997). O'Gorman's first finding, which states that only a 'fairly small' minority of Irish companies considered their linkages with foreign companies as important for their competitiveness, coincides with O'Riain's finding which states that linkages between Irish and overseas companies were mostly concentrated in lower end activities. O'Gorman et al's second finding, pointing out that about half of the Irish companies that took part in the survey had some kind of business partnerships with other indigenous software companies, coincides with O'Riain's information that 67.9% of Irish companies had linkages with other Irish companies. Then O'Gorman et al point out that a limited amount of sub-contracting was found between companies which is largely in line with O'Riain's observation that most often companies established labour contracting,

coding/programming and co-marketing types of linkages. And finally there is one finding made by O'Gorman et al (a large majority of indigenous software companies had business partnerships with foreign MNEs in Ireland) that contradicts those made by O'Riain (only 18 % of Irish companies had linkages with overseas companies operating in Ireland).

Table 2.20: Comparing the Findings of the O'Gorman et al and O'Riain Studies

O'Gorman's Findings	O'Riain's Findings
'Fairly small' minority of indigenous companies considered business partnerships with foreign MNEs as important for their competitiveness (**COINCIDES**).	Linkages between overseas companies and Irish firms were mostly concentrated on lower end activities such as labour contracting and coding/programming.
About half of the Irish companies that took part in the survey had some kind of business partnerships with other indigenous software companies which were not direct competitors (**COINCIDES**).	67.9% of Irish companies have had linkages with other Irish companies.
A limited amount of sub-contracting was found between companies (**COINCIDES**).	Most often companies established labour contracting, coding/programming and co-marketing types of linkages.
Large majority of indigenous software companies had business partnerships with foreign MNEs in Ireland (**CONTRADICTS**).	Most Irish and overseas companies operating in Ireland have had some linkages with other companies foreign or domestic. Only 14.1% of Irish companies and 17.2 % of overseas companies have had no linkages at all. Both overseas and Irish companies seem to avoid having linkages with the subsidiaries of overseas companies operating in Ireland. Only 18 % of Irish and 25% of overseas companies have linkages with other overseas companies operating in Ireland.

2.2.4 Summary

This section contains information on different aspects of collaboration in Ireland with emphasis on collaboration in the Irish software industry in particular. First of all, there is a sub-section which describes Irish software industry indicators such as number of companies, company size and employment, company distribution by sub-sectors etc. These indicators characterise the environment in which inter-company linkages are established and sustained. The findings of studies on inter-company collaboration in Ireland are also outlined. Two of these studies, by O'Riain (1997) and O'Gorman,

O'Malley and Mooney (1997) investigate different aspects of inter-company collaboration in the Irish software industry. These studies showed that more than half of companies in the Irish software industry had linkages.

CONCLUSIONS

In this literature review theoretical studies on inter-institutional collaboration are classified into two traditions - static and dynamic. In the static tradition inter-institutional linkages are considered at one particular moment of time. In the dynamic tradition inter-company collaboration is understood as evolving over time. The development and the pattern of this collaboration is linked to the industry or technology/product development.

Within the static tradition, authors analyse particular aspects of inter-institutional linkages such as inter-organisational dependence, complementarities of large and small companies, properties of wider networks of linkages, etc. Researchers working in the dynamic tradition normally focus on the likelihood of general collaboration at different stages of industry/technology development without exploring the details of this collaboration.

Table 2.21 below contains brief summaries of the reviewed studies. It shows that studies done in the static tradition were divided into six approaches, marked 1.1-1.6 in the table. These approaches are company-company linkages, chains of production, networks, clusters, complexes and science parks. Among them, studies on company-company linkages stand alone as regard to the level of co-ordination. Co-ordination here is understood as combined or co-ordinated action performed by two or more institutions and aimed at producing innovation. The company-company linkages (lower co-ordination) approach considers linkages between companies only. The remaining five approaches (chains of production, networks, clusters, complexes and science parks) consider wider networks of linkages including companies, universities, research institutes and state regulatory agencies.

Table 2.21: Studies on Inter-institutional Collaboration

Studies on Inter- institutional Collaboration	
1 Static Tradition	**2 Dynamic tradition**
1.1 Company-company Linkages	**2.1 Industry Development Preconditioned Models**
- Hagedoorn (1990) [Organisational interdependence]	- Teece (1997) [Depending on 'appropriability regime' which refers to environmental factors such as efficiency of copyright and nature of technology as well as availability of specialised complementary assets (subject to industry development) firms specialise or integrate.
- Rothwell and Dodgson (1993) [Benefits of large-small firms collaboration]	
- Narula and Hagedoorn (1999) [Underlying motive of collaboration]	
1.2 Chains of production	
- Marceau (1994) [Innovation and technology transfer through chains of inter-linked companies]	
1.3 Networks	
- Mody (1989) [Focused technological partnerships among large firms]	- Robertson and Langlois (1995) [Appropriability relates to a firm's ability to profit from innovation, the balance between specialisation and integration is changing while industries are developing]
- Lundvall (1988) [Close user-producer linkages]	
- Aoki (1988) [Japanese intra-firm keiretsu organisational structures]	
- Rosenfeld (1995) [Networks as groups of independent companies with restricted membership and specific business objectives likely to result in mutual gains]	- Gemser et al (1996) [Depending on appropriability which depends on intellectual property rights protection (subject to four stages of industry development) the inter-firm networks are changing while industry develops]
1.4 Clusters	
- Dodgson and Bessant (1997) [Various circles created by innovative users and suppliers with knowledge of local market that facilitate the transfer of personnel and technological know-how between firms]	**2.2 Technology/Product Development Preconditioned Models**
- Pior and Sabel (1982) [Geographical propinquity of collaborating firms developing similar and related products and technologies to produce successful innovation]	- Hobday (1994) [Depending on availability of complimentary assets (subject to three stages of product life cycle) firms integrate or specialise]
- Cooke (1996) [Implicit co-operation around a collective vision rather than common goals]	
- Porter (1990) [The clustering of industries connected by horizontal and vertical relationships and 'diamond' of factors contributing to their competitive advantage]	- Abernathy and Utterback (1978) [Rate of major product and process innovation follow a general three phases pattern over time which influence the horizontal and vertical linkages]
1.5 Complexes	
- Marceau (1992) [Co-operation between producers, public sector research organisations, users and state regulators with a specific role of government and public R&D facilities]	
1.6 Science Parks	
- Rothwell (1991) [Science parks link sources and users of technology, forming complex but flexible innovation networks]	

Studies in the dynamic tradition were classified into two approaches, industry development preconditioned models and product/technology preconditioned models (marked 2.1 and 2.2 in Table 2.21). In both approaches the evolution of inter-institutional collaboration is defined by either 'appropriability regime' (firm's ability to profit from innovation) or by availability of 'complimentary' assets (those used while producing

innovative product/service). These two factors ('appropriability regime' and availability of 'complimentary' assets) are understood to be a subject to either industry (industry development preconditioned models) or technology evolution (product/technology evolution preconditioned models).

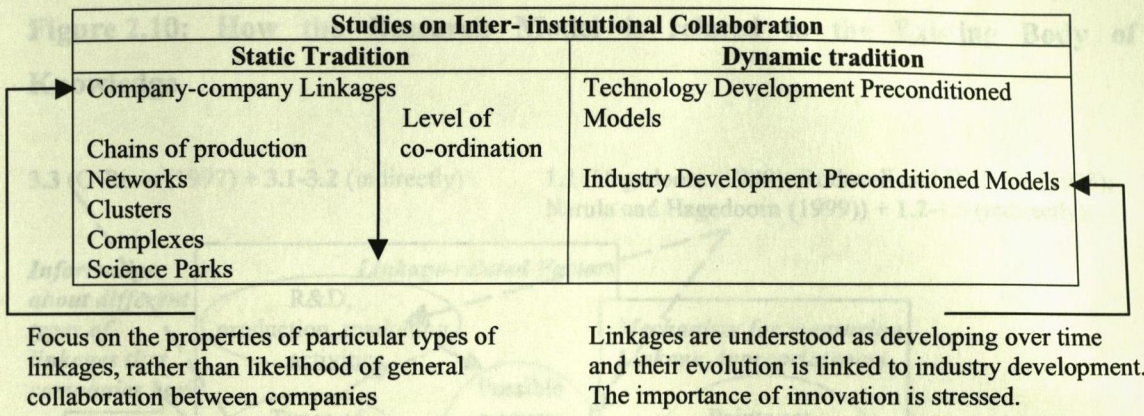
Apart from general theoretical study, the literature review includes a section on inter-organisational collaboration in Ireland as summarised in Table 2.22. It contains a review of Irish software industry indicators (marked 3.1 in the table) as well as studies on inter-institutional collaboration in Ireland (3.2) and studies on inter-institutional collaboration in the Irish software industry (3.3).

Table 2.22: Studies on Inter-institutional Collaboration in Ireland

3 Studies on Inter-institutional Linkages in Ireland
3.1 Irish Software Sector Indicators
- NSD (1997) [After the USA, Ireland is the largest exporter of software in the world]
3.2 Studies on Inter-company Linkages in Ireland
- O'Malley (1995) [Expenditure on Irish materials account for 42.5% of indigenous industry sales and 11.4% of sales for overseas companies; overseas companies were not significantly integrated into traded and skilled sub-supply industries in Ireland]
- Stewart (1976), McAleese and McDonald (1978) [Overseas companies in Ireland had lower linkages; older firms both Irish and international had higher linkages than newer firms did]
- Gorg and Ruane (1998) [Both Irish and foreign firms increased linkages over time; foreign firms had lower linkages than Irish firms; large and expanding firms both Irish and foreign had lower linkages than other firms]
3.3 Studies on Inter-company Linkages in the Irish Software Industry
- O'Riain (1997) [85.9% of Irish and 82.8 of foreign companies had 13 different types of inter-company linkages mostly concentrated on labour contracting and coding/programming; companies tended to have more advanced technological and business linkages abroad; larger companies had higher linkages; linkages between Irish and overseas companies were largely exclusive; companies with big export records had more international linkages]
- O'Gorman et al (1997) [Large majority of Irish software companies had linkages with foreign MNEs; 'fairly small' minority of Irish companies considered these linkages as important for their competitiveness; about half of Irish companies had linkages with other Irish companies; a limited amount of sub-contracting was found]

This study investigates how different types of inter-company linkages found in the Irish software industry affect a company's performance at different stages of industry development. Figure 2.9 shows how this study fits into the existing body of knowledge.

Figure 2.9: Where This Study Fits into Existing Body of Knowledge

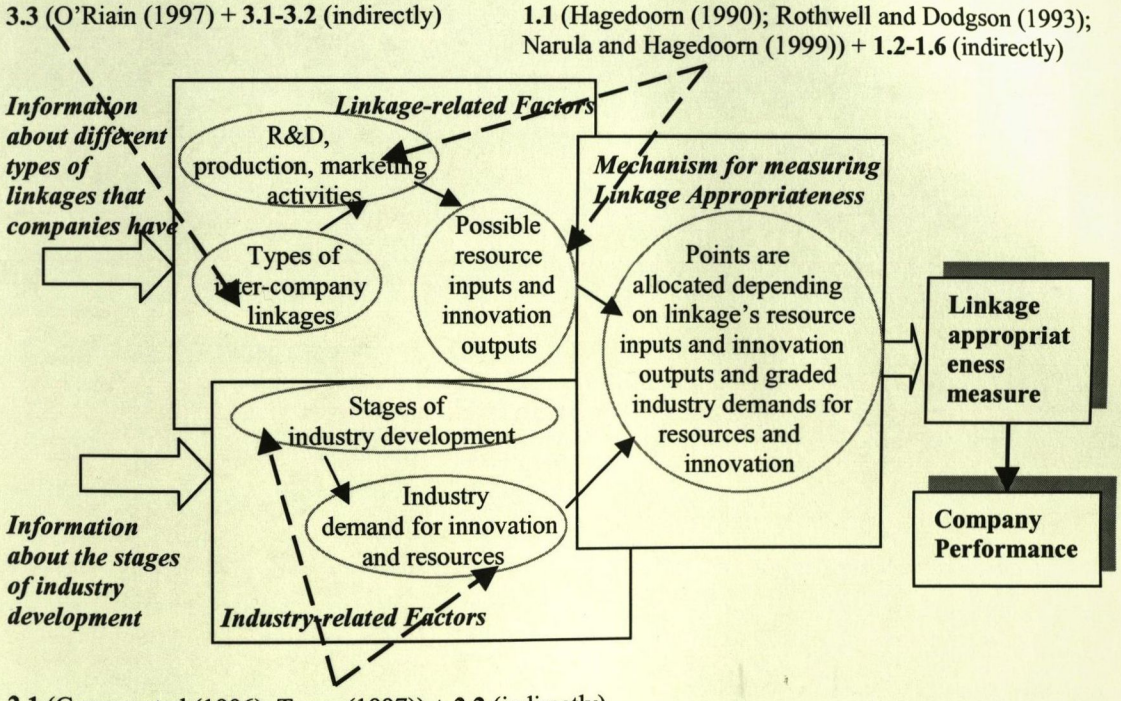


The research model developed for this study considers linkages established by companies only, wider networks of linkages including universities, research institutions and state regulatory bodies are not taken into consideration. From this point of view, this study fits into the 'company-company' approach in the static tradition. At the same time, inter-company linkages are treated as developing over time and their evolution is a subject to industry development. This makes this study similar to works done in industry development preconditioned models in the dynamic tradition. Summarising, the model used in this study is synthetic and combines the 'company-company' approach from the static tradition with the 'industry development preconditioned' approach in the dynamic tradition.

Figure 2.10 shows how different studies from the literature review contributed to the research model (for more details on the model see Chapter 3). As shown in this figure, the list of inter-company linkages used in the research was combined with a major contribution made by O'Riain (1997), in which he analyses different aspects of inter-organisational linkages in the Irish software industry (for a summary on his research see 3.3 in Table 2.22). Findings of research on inter-organisational collaboration (eg. Gorg and Ruane (1998); McAleese and McDonald (1978) - marked 3.2 in Table 2.22) and information on different indicators of the Irish software industry by NSD (1997) (marked

3.1 in Table 2.22) were also taken into consideration while researching what types of linkages existed in the Irish software industry.

Figure 2.10: How the Research Model is related to the Existing Body of Knowledge



Studies by Hagedoorn (1990); Rothwell and Dodgson (1993) and Narula and Hageedorn (1999) (marked 1.1 in Table 2.21) as well as (indirectly) findings of other studies made in 'chains of production', 'networks', 'clusters' and 'science park' approaches (marked 1.2-1.6 in Table 2.21) were used while identifying what kind of activities (e.g. R&D, production and marketing) are performed within different types of linkages as well as what kind of resources can be utilised by these linkages and what kind of innovation can be produced as result of linkage activities.

And finally, findings made by the researchers working in the dynamic tradition, namely Gemser et al (1996); Teece (1997) as well as (indirectly) Hobday (1994) and

Abernathy and Utterback (marked 2.1 and 2.2 in Table 2.21), contributed to defining the stages of industry development and industry demands for innovation and resources at different stages of industry life cycle.

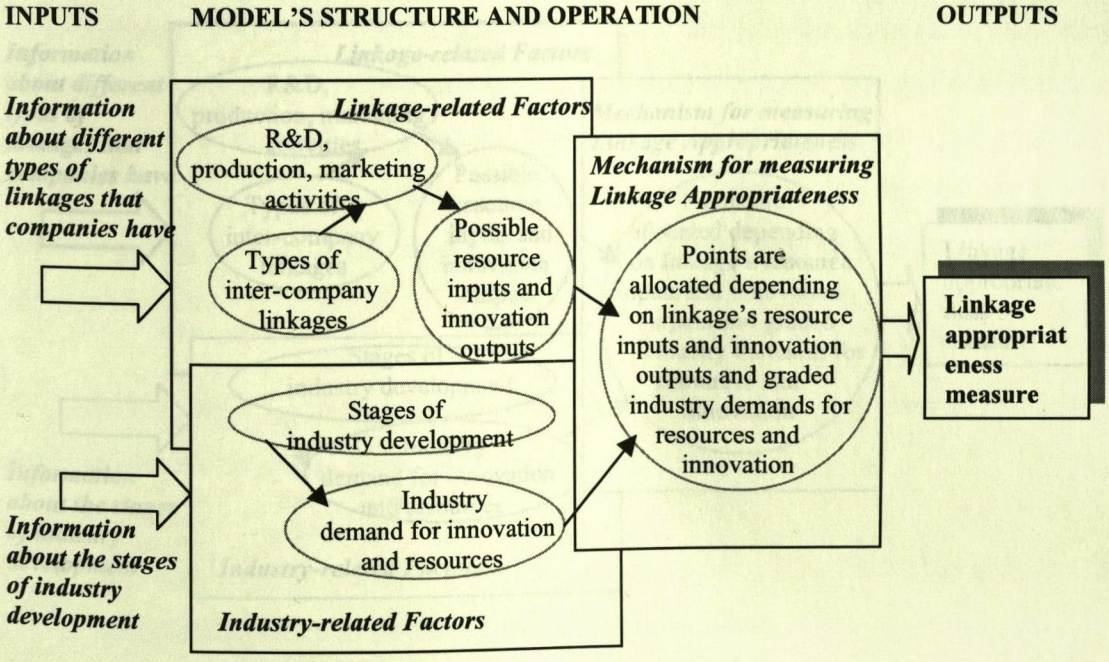
CHAPTER 3

RESEARCH MODEL

INTRODUCTION

Existing models (e.g. Teece, 1997; Gemser, 1996; Hagedoorn, 1990) have conceptually contributed to our understanding of inter-company linkages. However, none of them was completely appropriate for this research, which concerns the nature of linkages in the Irish software industry and their impact on companies' performance. In the light of this problem, a new model has been developed, primarily adapting dynamic models, which are outlined in the literature review chapter. In the suggested classification (see Section 2.1), the new model is dynamic, industry life cycle preconditioned. This means that linkages are treated as developing over time and their evolution is associated with the industry lifecycle.

Figure 3.1: Elements of the Research Model



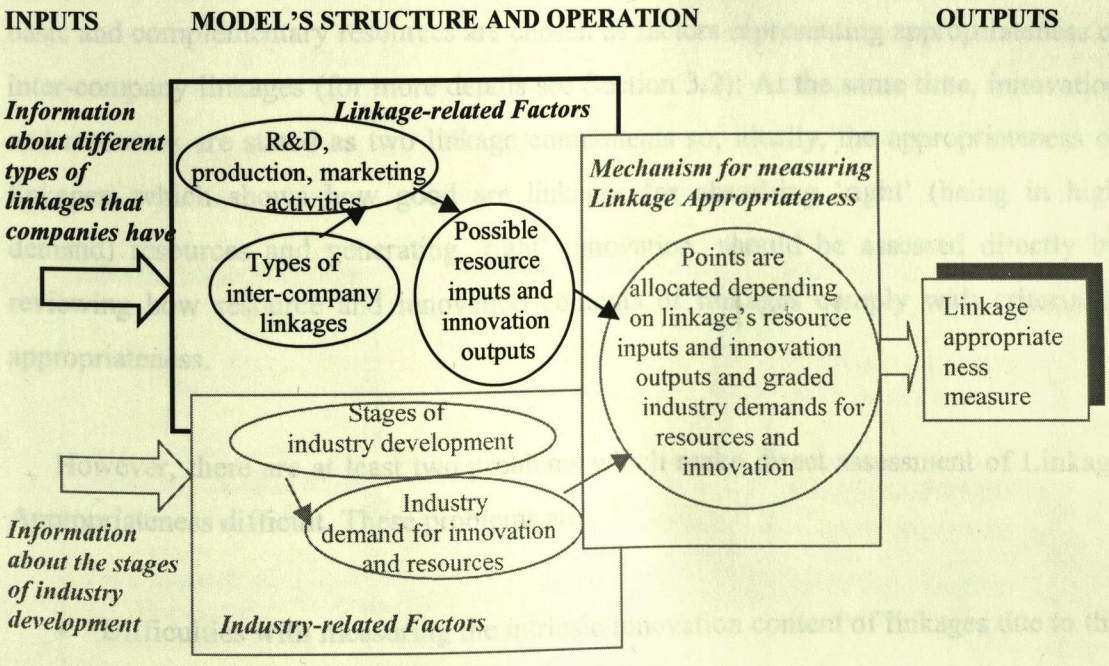
As shown in Figure 3.1 above the model has two inputs, namely information about the ***types of linkages that companies have*** and information about ***the stages of industry development***. Based on these inputs, it produces a single output – ***Linkage Appropriateness.***

This chapter consists of three sections namely 'Resource Inputs and Innovation outputs of Linkages', Industry Demands for Innovation and Resources' and Assessing Linkage Appropriateness'. These sections contain description of linkage- and industry - related factors as well as the mechanism for measuring linkage appropriateness.

3.1 RESOURCE INPUTS AND INNOVATION OUTPUTS OF LINKAGES (LINKAGES-RELATED FACTORS)

This section outlines a part of the research model which identifies the possible resource inputs and innovation outputs of inter-company linkages (highlighted area in Figure 3.2).

Figure 3.2: Elements of the Research Model (Linkage-related Factors)



This section consists of four sub-sections. The first two sub-sections examine the logic of choosing **'types of inter-company linkage'** (as referred to in Figure 3.2) as the only linkage characteristic which may reflect linkage potential to generate innovation and absorb resources.

The third subsection outlines the actual mechanism whereby the identification of **possible resource inputs and innovation outputs** of inter-company linkages are assumed to be dependent on the **activities (R&D, production and marketing)** performed within linkages.

And finally, the fourth sub-section outlines a new classification for inter-company linkages. This classification is based on linkages' resource inputs and innovation outputs, as described in sub-section three.

3.1.1 Five Characteristics that May Indicate Linkages Potential to Generate Innovation and absorb Resources

In this model, industry demands for primary and incremental innovation and also for basic and complementary resources are chosen as factors representing appropriateness of inter-company linkages (for more details see Section 3.2). At the same time, innovation and resources are stated as two linkage components so, ideally, the appropriateness of linkages, which shows how good are linkages for absorbing 'right' (being in high demand) resources and generating 'right' innovation, should be assessed directly by reviewing how resource and innovation contents of linkages comply with criteria of appropriateness.

However, there are at least two problems which make direct assessment of Linkage Appropriateness difficult. These problems are:

- Difficulties with measuring the intrinsic innovation content of linkages due to the complicated (hard to measure) nature of this construct;
- Complications with getting information on the innovation and resource contents of linkages because this information may be treated as confidential by partaking companies.

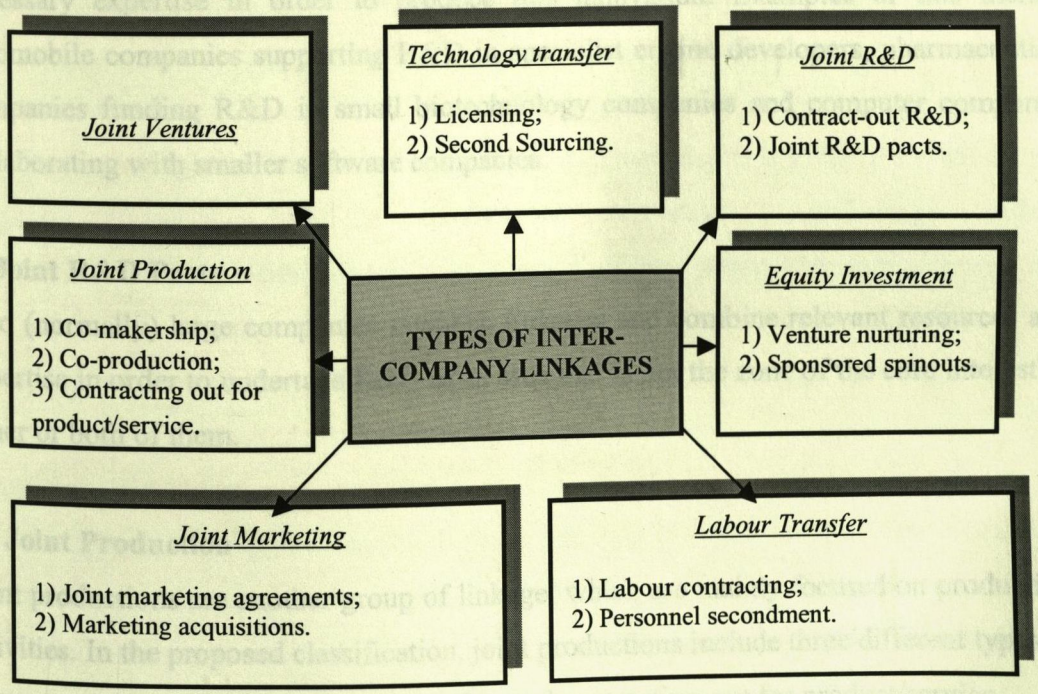
Because of these problems, linkage *potential* to generate innovation and absorb resources rather than 'real' innovation and resource contents is used in order to assess its appropriateness in this model.

Five characteristics, which describe different aspects of inter-company linkages, are analysed and discussed with regard to their ability to reflect linkage potential to generate innovation and absorb resources. These characteristics are type, extent, level, duration and participation. The following sub-section contains a description of these five characteristics.

3.1.1.1 Types of Linkages

Types of inter-company linkages are the most informative of five linkage characteristics. It gives an idea about the nature of linkage activities (for more details see Section 3.1.2). Figure 3.3 shows seven different groups of inter-company linkages.

Figure 3.3: Seven Groups of Inter-company Linkages



Information about different forms of linkages from each of the seven groups is summarised in the following part of this section (for more details see Section 2.1.1.1).

1) Joint Ventures

Joint ventures are normally established by two companies that combine their economic interests into a new separate company. Profits and losses of this company are shared according to equity investment. Joint ventures have shared business activities such as R&D, production and marketing.

2) Joint R&D

Joint R&D agreements in their nature and objectives are somewhat similar to joint ventures but they do not include production or marketing. Joint R&D agreements include:

i) Contract-out R&D

One (normally larger) company, which is looking for a particular innovation supports appropriate R&D activities within another (normally smaller) company, which has the necessary expertise in order to produce this innovation. Examples of this include automobile companies supporting R&D in specialist engine developers, pharmaceutical companies funding R&D in small biotechnology companies and computer companies collaborating with smaller software companies.

ii) Joint R&D Pacts

Two (normally) large companies establish linkages and combine relevant resources and expertise in order to undertake R&D in an area that is not the zone of the core interest of either or both of them.

3) Joint Production

Joint productions are another group of linkage, which are mainly focused on production activities. In the proposed classification, joint productions include three different types of linkages – co-makership and co-production and contracting-out for product/service.

i) Co-makership

Co-makership involves long-term contracts between users and suppliers, with users or companies that produce final products out-sourcing some of their production process and technology to suppliers of sub-assemblies.

ii) Co-production

Co-production contracts apply to the linkages between two companies when the 'leading' company supplies the technology and critical components, and the other company manufactures less critical components and assemble final products.

iii) Contracting for a product/service

This type of joint production normally applies to the linkages between large and small companies where small ones supply specially developed products to large companies. Large companies involved in producer-customer relationships transfer technological know-how, expert advice and supply suggestions in order to adjust small firms' products to their needs. These products do not directly contribute to large companies' final products, which differentiate them from co-makerships.

4) Joint Marketing

Joint marketing agreements are linkages that help companies to accelerate the movement of goods and services from the manufacturer to the customer, including everything connected with advertising, distribution, merchandising, product planning, promotion, publicity, sales, transportation and warehousing of goods and services. There are two forms of joint marketing:

i) Agency Agreement

Two independent companies establish these linkages in order to form new marketing channels. An agent company having this kind of linkages gains access to products, which are complementary to its own product range, and also new technological know-how. A supplying company gains a new marketing channel and knowledge of a new market.

ii) Collaborative Marketing

Companies that have these linkages perform bilateral sales of complementary products. The only difference between agency agreements and collaborative marketing is that not one but both companies with this linkage act as agents.

5) Technology Transfer

These linkages that involve technology transfer and exchanges have shared production activities and can be divided into two groups:

i) Licensing

This type of linkages is established to transfer technology from one company that has proprietary rights to another company in exchange for payments.

ii) Second-sourcing Agreement

Second-sourcing agreements involve a transfer of product technology, which allows one firm to make an exact copy of another firm's product. By doing this the firm, which provides the technology, secures its ability to supply its customers continuously. Although second-sourcing will result in loss of market share for the originator of the product, it may be compensated with market growth resulting from many suppliers.

6) Equity Investment

Stakes, especially those held by a large company in a small innovation company, may be seen as inter-company linkages, if a company-investor wants to gain access to the innovation produced as result of their joint activities, rather than using it just as a risk investment. These types of linkages have shared R&D activities. They can be classified into two groups:

i) Venture Nurturing

A large company acquires a stake in a small firm and offers to this firm a wide range of support including financing, expertise in management, marketing and manufacturing,

and, if appropriate, the channels of distribution. In exchange for its assistance, the large company acquires access to innovation, which is produced as a result of the small firm activities.

ii) Sponsored Spinouts

A large company offers financial backing for entrepreneurial employees to form a new small firm to further develop and possibly to exploit technology developed within the parent company which is considered unsuitable for in-house development and exploitation.

7) Labour Transfer

Labour transfer linkages are established for staffing of all kind of company activities (e.g. R&D, production and marketing). All labour transfer linkages can be attributed to two different groups:

i) Labour Contracting

Companies operating abroad often prefer to contract labour force from local companies to employing their own personnel. This practice allows them to be more flexible in their staffing policy and reduce management and transaction costs and also social payments.

ii) Personnel Secondment

A number of large European companies have developed schemes to 'loan' experienced managers to assist new and existing small innovation firms.

3.1.1.2 Scope of Linkages

Scope of inter-company linkages is another characteristic, which is recognised as describing an important aspect of linkages and potentially usable for estimating their innovation and resource contents. It refers to the industrial location of inter-company linkages. In this model all inter-company linkages are classified into two groups according to their extent:

1) Intra-industrial linkages

This group includes linkages between companies operating in the same industry. In the case of this study, it is the Irish software industry. Contracting of labour between overseas and Irish companies in the software industry is an example of this type of linkage.

2) Inter-industrial linkages

This covers linkages between companies operating in different industries. For instance, linkage between software and financial companies aimed at developing a piece of software for banking.

3.1.1.3 Level of Linkages

Level of linkages shows how broad is the spectrum of linkages along the value chain. Linkages can be attributed to two groups with regard to their extent. These groups are as follows:

1) Horizontal Linkages

Horizontal linkages are formed by companies from the same level of value chain. For instance, joint R&D type linkages between two fellow software companies aimed at developing new software tools.

2) Vertical Linkages

Vertical linkages occur between companies operating at different levels of the value chain. Co-makership linkages, when a company-user is out-sourcing some of its production process to a company-supplier, is an example of vertical linkages.

3.1.1.4 Participation in the Linkages

Another interesting aspect of inter-company linkages is nationality of partaking companies. This aspect is enlightened by a characteristic called participation in the inter-company linkages, which attributes linkages to two groups:

1) Linkages between Local Companies

These linkages are formed by two local companies, which combine appropriate resources and create innovation. Examples of this include an Irish design company collaborating with an Irish software company to develop a new web site.

2) Local-foreign Linkages

Local and foreign companies form linkages of this type. For instance, large multinational companies establish linkages with Irish companies for localisation.

3.1.1.5 Duration of Linkages

The last in the list of five characteristics is that of duration of inter-company linkages. This characteristic shows for how long linkages are sustained by companies. Inter-companies linkages, like any form of organisation, undergo a cycle of creation, institutionalisation and, with high probability, termination. In this model all linkages are divided into two groups – short and long-term.

1) Short-term Linkages

Short-term linkages refer to linkages that are sustained for less than two years. The dynamic character of the software industry with short life spans of the majority of products and intensive R&D make this term sufficient for developing at least one innovation project.

2) Long-term Linkages

Linkages with a duration of more than two years are hypothesised as long-term. This period in the software industry is normally long enough for developing more than one innovation project.

3.1.2 Types of inter-company linkage as the Only Characteristic that Reflects Linkages Potential to Generate Innovation and Absorb Resources

Five characteristics, which describe different aspects of inter-company linkages have been analysed with regard to their ability to reflect linkage potential to generate innovation and absorb resources.

As can be seen from Table 3.1, all five characteristics describe important areas of linkages. However, four of them, namely scope, level, participation and duration are focusing on very narrow and specific areas and if used separately do not give a comprehensive image of linkages activities, which makes it difficult to use them as indicators of the linkage potential to generate innovation and absorb resources.

Table 3.1: Linkage Characteristics and Aspects of Linkages They Describe

Linkages Characteristic	Described Aspect of Linkages
Scope of Linkages	Industrial spread of linkages
Level of linkages	Spectrum of linkages along the value chain
Participation in linkages	Nationality of partaking companies
Duration of linkages	Age of linkages
Types of linkage	Nature of activities performed within linkages

The fifth characteristic - types of linkage - shows the nature of linkage activities, which is a very broad and comprehensive area that can be used (as is shown in the next section) for estimating the linkage's possible innovation outcome as well as resource requirements.

That is why this characteristic was recognised by an author as reflecting linkage potential to produce primary and incremental innovation and absorb basic and

complementary resources and was chosen as the only characteristic that is used in order to assess the appropriateness of inter-company linkages.

3.1.3 Analysing Linkage Potential to Generate Innovation and Absorb Resources

Linkage potential to generate innovation and absorb resources is calculated based on the information about activities (R&D, Production and Marketing) performed within the linkages and resource inputs and innovation outputs of these activities.

Not all types of business partnerships outlined in the general classification as described in Section 3.2.1.1 meet the requirements for inter-company linkages set in this study. Four of them, namely licensing, contract-out coding/programming, contract-out disk duplication and contract-out package assembly was not believed by the researcher to have a potential to produce either primary or incremental innovation and was therefore excluded from the further analysis. The information about this business partnership was still collected in order to increase the descriptive value of the research findings.

3.1.3.1 Activities Performed within Different Types of Inter-company Linkage

In this model, inter-company linkages are understood as joint R&D, production and marketing activities performed by two companies which require resource inputs and produce innovation outputs for the use of either or both partaking companies.

Types of inter-company linkage was recognised as indicating which of these three activities are performed within each particular linkage as shown in Table 3.2. This assumption was based on the previous research (e.g. Hagedoorn (1990), Auster (1987), Contractor and Lorange (1988), for more details see Chapter 2). Please note that the reference to these studies is implicit rather than explicit and further research is required in order to validate this assumption.

The rows of this table contain the names of different types of linkage. The columns show three activities performed within linkages – R&D, production and marketing. In the case of a particular linkage having a particular activity performed, there is a "+" mark on the cross between a column representing this activity and a row representing this linkage.

It can be seen from the specimen table that most of the linkages have just one activity. However there is one type of linkage namely joint venture, which has all three activities performed within it.

Table 3.2: Activities Performed within Different Types of Inter-company Linkages

Types of Inter-company Linkages	**Activities performed**		
	R&D	**Production**	**Marketing**
Joint Venture	+	+	+
Joint R&D			
1. Contract-out R&D	+		
2. Joint R&D Pact	+		
Joint Production			
1. Co-makership		+	
2. Co-production		+	
3. Contracting for a Product/service		+	
Joint Marketing			
1. Agency Agreement			+
2. Collaborative Marketing			+
Technology Transfer			
1. Second-sourcing			+
Equity Investment			
1. Venture Nurturing	+		
2. Sponsored Spinouts	+		
Labour Transfer			
1. Contracting out Staff - Contracting out R&D Staff - Contracting out Production Staff - Contracting out Marketing Staff	+	+ 	 +
2. Personnel Secondment - R&D Personnel Secondment - Production Personnel Secondment - Marketing Personnel Secondment	+	+ 	 +

3.1.3.2 Resource Inputs and Innovation Outputs of R&D, Production and Marketing Activities

Each of three activities performed within inter-company linkages is assumed to require certain resource inputs and to have the potential to produce certain innovation output as shown in Table 3.3.

Table 3.3: Resource Inputs and Innovation Outputs of R&D, Production and Marketing Activities

Activity	Resource Inputs		Innovation Outputs	
	Basic	Complementary	Primary	Incremental
R&D	+		+	+
Production	+			+
Marketing		+		+

Research and Development (R&D) activities involve applying the findings of science and technology in creating a company's products and services. This activity is believed to require an input or basic resources (qualified personnel, finance, specialised premises, machines and equipment, technology, products and specialised know-how used in R&D and production) and may produce both primary (something new - a new product, process, or method of production; a new market or source of supply; a new form of commercial, business, or financial organisations) and incremental (the commercial or industrial application of a novel recombination of old ideas) innovations.

Production is any form of activity that adds value to goods and services, including creation, transportation, and warehousing, until used. This form of activity is understood as utilising basic resources and having potential to produce incremental innovation.

Marketing activities that accelerate the movement of goods and services from the manufacturer to the customer, including everything connected with advertising, distribution, merchandising, product planning, promotion, publicity, sales, transportation and warehousing of goods or services. These activities are regarded to absorb

complementary resources (those that are not directly used in the production process, including resources connected to marketing and after-sale support such as qualified personnel, channels of distribution, developed trademarks, customer-support networks and knowledge of the market) and to have potential to produce incremental innovation.

The assumptions about resource inputs and innovation outputs of R&D, production and marketing activities were based on the definition of these activities (see Cooper and Argyris (1999), Rosenberg (1993), and Johannsen and Page (1995)) as well as studies by Hagedoorn (1990), Rothwell and Dodgson (1993) and Narula and Hagedoorn (1999) (for more details see Section 2.1.1.1 and Table 2.10). However, further research is required to validate these assumptions.

3.1.3.3 Possible Resource Inputs and Innovation Outputs of Different Types of Inter-company Linkages

Having defined resource inputs and innovation outputs of R&D, production and marketing, as well as which of these activities are performed within different types of linkages (as described in Sections 3.1.3.1 and 3.1.3.2), one is able to define possible resource inputs and innovation outputs of different types of inter-company linkages as shown in Table 3.4.

The table has a similar structure to Table 3.2. The only difference is that it has five rather than three columns, representing activities performed within each particular types of inter-company linkage, and resource inputs and innovation outputs defined by these activities.

Table 3.4: Possible Resource Inputs and Innovation Outputs of Different Types of Inter-company Linkages

Types of Inter-company Linkages	Activities performed	Resource Inputs		Innovation Outputs	
		Basic	Complementary	Primary	Incremental
Joint Venture	R&D, Production, Marketing	+	+	+	+
Joint R&D					
1. Contract-out R&D	R&D	+		+	+
2. Joint R&D Pact	R&D	+		+	+
Joint Production					
1. Co-makership	Production	+			+
2. Co-production	Production	+			+
3. Contracting for a Prod./service	Production	+			+
Joint Marketing					
1. Agency Agreement	Marketing		+		+
2. Collaborative Marketing	Marketing		+		+
Technology Transfer					
1. Second-sourcing	Marketing		+		+
Equity Investment					
1. Venture Nurturing	R&D	+		+	+
2. Sponsored Spinouts	R&D	+		+	+
Labour Transfer					
1. Contracting out Staff					
- Contracting out R&D Staff	R&D	+		+	+
- Contracting out Production Staff	Production	+			+
- Contracting out Marketing Staff	Marketing		+		+
2. Personnel Secondment					
- R&D Personnel Secondment	R&D	+		+	+
- Production Personnel Secondment	Production	+			+
- Marketing Personnel Secondment	Marketing		+		+

3.1.4 Activities-based Classification of Inter-company Linkages

Having defined inter-company linkages as joint activities performed by two companies, it is logical to classify them into groups according to which of three activities are performed within them. Table 3.5 contains this classification.

Table 3.5: New Resource Inputs and Innovation Outputs based Classification of Inter-company Linkages

Types of Inter-company Linkages	Activities performed	Resource Inputs		Innovation Outputs	
		Basic	Complimentary	Primary	Incremental
R&D-oriented Linkages					
1. Contract-out R&D	R&D	+		+	+
2. Joint R&D Pact	R&D	+		+	+
3. Venture Nurturing	R&D	+		+	+
4. Sponsored Spinouts	R&D	+		+	+
5. Contracting out R&D Staff	R&D				
6. R&D Personnel Secondment	R&D				
Production-oriented Linkages					
1. Co-makership	Production	+			+
2. Co-production	Production	+			+
3. Contracting for a Prod./ service	Production	+			+
4. Contracting out Production Staff	Production				
5. Production Personnel Secondment	Production				
Marketing-oriented Linkages					
1. Agency Agreement	Marketing		+		+
2. Collaborative Marketing	Marketing		+		+
3. Second-sourcing	Marketing		+		+
4. Contracting out Marketing Staff	Marketing				
5. Marketing Personnel Secondment	Marketing				
Linkages involving various activities – Joint Ventures					
1. Joint Venture	R&D, Production, Marketing	+	+	+	+

As was already mentioned, most inter-company linkages have only one activity performed within them – R&D (R&D-oriented Linkages in a suggested classification), production (production-oriented linkages) or marketing (marketing-oriented linkages). The exception is joint venture, as noted earlier.

3.1.5 Inter-company Linkages in the Irish Software Industry

Inter-company linkages outlined in section 3.2.1 are very general and can be found in any industry in any country. However, the particular features of every individual industry, as well as the whole economy and even the cultural environment, may create the conditions for establishing industry-specific sub-types of inter-company linkages.

Table 3.6 contains illustrative linkages existing in the Irish software industry (column one) alongside with the general classification of inter-company linkages (column two). The general classification was as adopted from the study done by Hageddorn (1990). The list of linkages in the Irish software industry was developed based on the data from previous research (O'Riain, 1997) and the interviews conducted in the course of the pilot study (see Chapter 4 for more details).

Table 3.6: Linkages in The Irish Software Industry

Linkages in the Irish Software Industry	**General Classification**
Joint Venture	Joint Venture
Joint R&D	
Contract-out Software Development	Contract-out R&D
Joint Software Development Pact	Joint R&D Pact
Joint Production	
Contract-out Design/Multimedia, Contract-out Product Adaptation, Contract-out Translation/Localisation, Contract-out Software Testing Contract-out After-sale Support	Co-makership Co-production Contracting for a Product/Service
Joint Marketing	
Agent Agreement	Agent Agreement
Reciprocal Agent Agreement	Collaborative Marketing
Technology Transfer	
N/A	Second-sourcing
Equity Investment	
Venture Nurturing	Venture Nurturing
Sponsored Spinouts	Sponsored Spinouts
Labour Transfer	
Contract-out R&D staff, Contract-out Production Staff, Contract-out Marketing Staff	Labour Contracting
N/A	Personnel Secondment

One can see that most inter-company linkages from the general classification are present in the Irish software industry. These linkages are joint venture, contract-out software development (contract-out R&D), joint software development pact (joint R&D pact), agent agreement, collaborative marketing (reciprocal agent agreement), licensing, venture nurturing, sponsored spinouts, labour contracting (contract-out R&D Staff, contract-out production staff and contract-out marketing staff).

Sometimes the same type of linkage is labelled slightly differently, for example, 'joint R&D pact' and 'joint software development pact', but it is still the same type of linkage. The information about types of linkages found in the Irish software industry was extracted from the up to date studies (see Chapter 2) as well as interviews with industry representatives conducted during the pilot study.

Not all linkages from the general classification necessarily exist in all industries. For instance, there was no evidence about the existence of second sourcing and personnel secondment types of inter-company linkages in the Irish software industry. At the same time, a particular industry may have linkages that are not outlined in the general classification. However, if analysed, these linkages normally appear to be sub-types of linkages outlined in the general classification. For instance, contract-out software development, joint software development pact, contract-out design/multimedia, contract-out product adaptation, contract-out translation/localisation, contract-out software testing and contract-out after-sale support which were recognised as different forms of joint production.

Some forms of business partnerships that exist in the Irish software industry such as licensing, contract-out coding/programming, contract-out disk duplication and contract-out package assembly did not meet the linkage requirements set in this study. As can be seen from Table 3.7 these four forms of business partnerships were thought to lack a potential to produce innovation. Because joint activities and innovation output are two key elements of inter-company linkage (as understood in this study), all these forms of business partnership were not considered to be linkages for the purpose of this study.

Table 3.7: Business Partnerships Recognised as not Being Linkages

Business Partnership	Joint Activity Performed	Innovation Produced
Licensing	Production	None
Contract-out Coding/Programming	Production	None
Contract-out Disk Duplication	Production	None
Contract-out Package Assembly	Production	None

The assumption about these business partnerships as lacking potential to produce innovation is based (implicitly) on the existing research (Hageddorn (1990), Jacobson and O'Sullivan (1990) and O'Riain (1997)) as well as the information collected while carrying out the pilot study. However, the further research is required to validate it. The information about these business partnerships was still collected in order to enhance the descriptive value of this research, however they were not taken into account while calculating linkage appropriateness.

3.1.5.1 Resource Inputs and Innovation Outputs of Different Linkages in the Irish Software Industry

Table 3.8 shows performed activities as well as resource inputs and innovation outputs of inter-company linkages in the Irish software industry. This table summarises information from two previous tables (Table 3.6 and Table 3.7).

Table 3.8: Resource inputs and innovation outputs of Inter-company Linkages in the Irish Software Industry

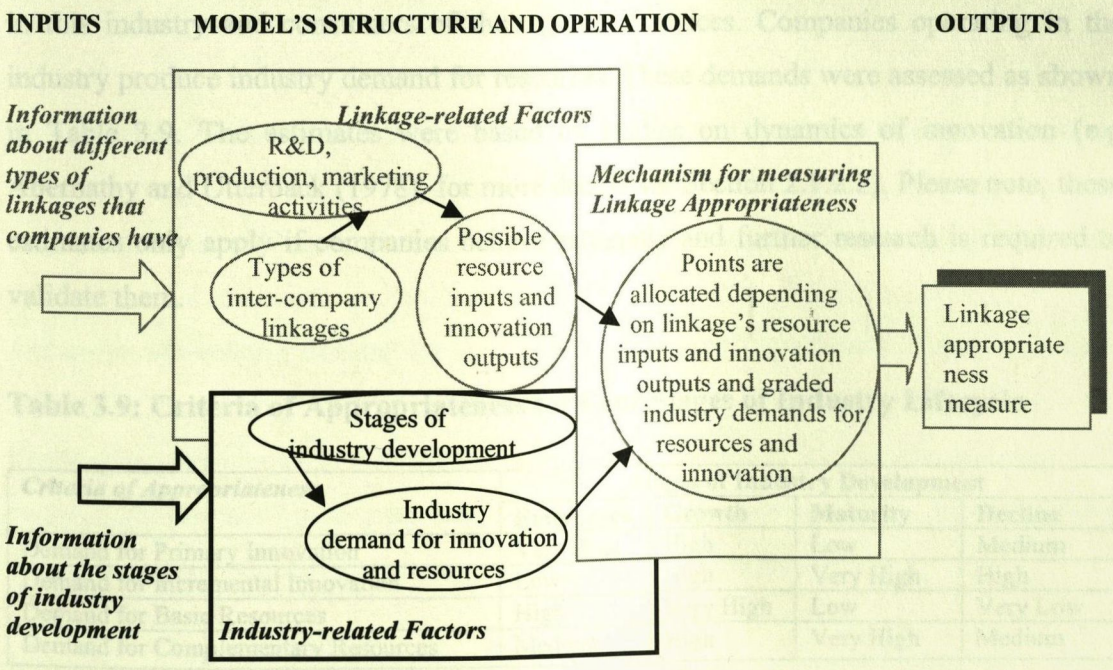
Types of Inter-company Linkages	*Activities performed*	*Resource Inputs*		*Innovation Outputs*	
		Basic	*Complementary*	*Primary*	*Incremental*
R&D-oriented Linkages					
1. Contract-out Software Development	R&D	+		+	+
2. Joint Software Development Pact	R&D	+		+	+
3. Contract-out R&D Staff	R&D	+		+	+
4. Sponsored Spinouts	R&D	+		+	+
5. Venture Nurturing	R&D	+		+	+
Production-oriented Linkages					
1. Contract-out Design/ Multimedia	Production	+			+
2. Contract-out Product Adaptation	Production	+			+
3. Contract-out Trans./ Localisation	Production	+			+
5. Contract-out Software Testing	Production	+			+
6. Contract-out after-sale Support	Production	+			+
7. Contract-out Production Staff	Production				
Marketing-oriented Linkages					
1. Agent Agreement	Marketing		+		+
2. Reciprocal Agent Agreement	Marketing		+		+
3. Contract-out Marketing Staff	Marketing		+		+
Linkages involving various activities – Joint Ventures					
1. Joint Venture	R&D, Production, Marketing	+	+	+	+

Linkages outlined in the table are classified into groups according to activities performed. The innovation outputs and resource inputs were assigned in accordance with the mechanism described in Sections 3.3.1-3.3.3.

3.2 INDUSTRY DEMANDS FOR INNOVATION AND RESOURCES (INDUSTRY-RELATED FACTORS)

In this section we provide an overview of industry-specific factors considered in this model, namely industry demands for innovation and resources which act as criteria of appropriateness (see Figure 3.4).

Figure 3.4: Elements of the Research Model (Industry-related Factors)



Criteria of appropriateness are used as measuring tools for assessing inter-company linkages. They are defined by an industry and change while it develops. In this model, industry demands for primary and incremental innovation as well as basic and complementary resources are chosen as criteria of appropriateness.

The section consists of three sub-sections. In the first sub-section industry demands for resources and innovation are identified for different stages of industry development. The second sub-section explains how and why industry demands for resources and innovation were graded (assigned with a certain number of points depending on their size). The third sub-section covers a number of practical issues connected with identifying the present stage of the Irish software industry development.

3.2.1 Industry Demands for Innovation and Resources

Following Teece (1997), Gemser (1996) and other researchers, whose studies are described in Chapter 1, the industry lifecycle is understood to consist of four phases. Each phase has its own characteristics that determine industry demands for innovation and resources. Industry demands for innovation is induced by both companies operating in this industry and consumers of their product/services. Companies operating in the industry produce industry demand for resources. These demands were assessed as shown in Table 3.9. The estimates were based on studies on dynamics of innovation (e.g Abernathy and Utterback (1978), for more details see Section 2.1.2.2). Please note, these estimates only apply if companies behave rationally and further research is required to validate them.

Table 3.9: Criteria of Appropriateness for Four Stages of Industry Lifecycle

Criteria of Appropriateness	**Stages of Industry Development**			
	Emergence	**Growth**	**Maturity**	**Decline**
Demand for Primary Innovation	Very High	High	Low	Medium
Demand for Incremental Innovation	Low	High	Very High	High
Demand for Basic Resources	High	Very High	Low	Very Low
Demand for Complementary Resources	Medium	High	Very High	Medium

In the first (emergence) stage of the industry life cycle, the structure of the industry is rather monopolistic and follows a pattern of radical and rapid product innovations. It determines very high demand for primary innovation. Product life cycle of most innovations are very short, which reduces the possibility of earning profits and makes

incremental innovation as well as a search for intellectual property rights protection irrelevant.

The high expenditures required for R&D, production and marketing induces very high industry demand for basic resources as well as more moderate demand for complementary ones.

In the second (growth) stage of the industry life cycle the number of companies is quickly growing due to relatively low barriers to entry and high profit margins and a not very effective copyright regime. Demand for primary innovation remains high because companies start to specialise to gain competitive advantage over competitors. At the same time the product life cycle is becoming longer, which leads to higher demand for incremental innovation. Specialisation also leads to high demand for specialised basic and complementary resources.

In the third (maturity) stage of the industry development when the growth market slows down, barriers to entry and the level of industry concentration increase. Slow or stagnant growth of demand for industrial outputs leads to over-capacity and to take-overs and mergers among rival or complementary firms, in order to gain economies of scale and scope. As a result demand for specialised basic assets significantly reduces. In these conditions, marketing starts playing a central role for companies' competitiveness and demand for complementary resources is becoming very high. Innovation is incremental (very high demand) and cost cutting in its nature because there are established technologies and standards. The copyright regime is very effective.

In the fourth decline or de-maturity stage of industry development companies try to avoid price competition, by focusing on product differentiation, which leads to high demand for incremental innovation. Demand for primary innovation is higher than in the mature stage of industry life cycle because companies establish new linkages with other companies from new adjacent industries mostly with the aim of new product development. That could eventually 'rejuvenate' the industry's pattern of development.

Companies sell 'peripheral' parts of their business, and enter into formal and informal linkages in order to rationalise over-capacity, which reflects very low demand for basic resources. Demand for complementary resources becomes lower because there are established trademarks and systems of marketing. The copyright regime is difficult because of expired patents and/or because forms of product differentiation are difficult to protect legally.

3.2.2 Grading the Criteria of Appropriateness (Industry Demands for Innovation and Resources)

Different sizes of industry demands were assigned with a certain numbers of points, as shown in Table 3.10. The author introduced these arbitrary coefficients for the purpose of study.

Table 3.10: Points for Different Sizes of Industry Demands

Size of Demand	Points
Very High	1.8
High	1.4
Medium	1
Low	0.6
Very Low	0.2

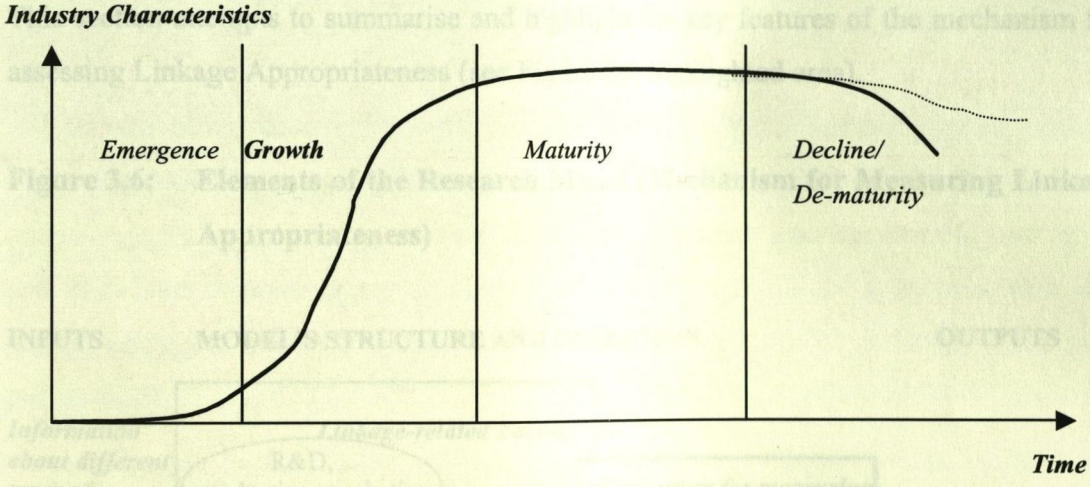
Applying graded criteria of appropriateness on linkage contents results in expressing the appropriateness of inter-company linkages numerically, which makes all kinds of analysis that involve this factor much more feasible.

Grading of industry demands for innovation and resources is one the model's assumptions. Although the logic behind this assumption was tested many times, more research should be done to validate it.

3.2.3 Identifying the Present Stage of Development of the Irish Software Industry

Figure 3.5 shows the profile of industry characteristics over its lifecycle. Each industry in its development proceeds through four stages – emergence, growth, maturity and decline or de-maturity.

Figure 3.5: Changes in Industry Characteristics over Industry Lifecycle



There are a number of Irish software industry characteristics, which have been outlined at Chapter 1 of this work. They are:

1) Number of companies operating in the industry;
2) Employment in the industry;
3) Industrial exports;
4) Industrial revenue.

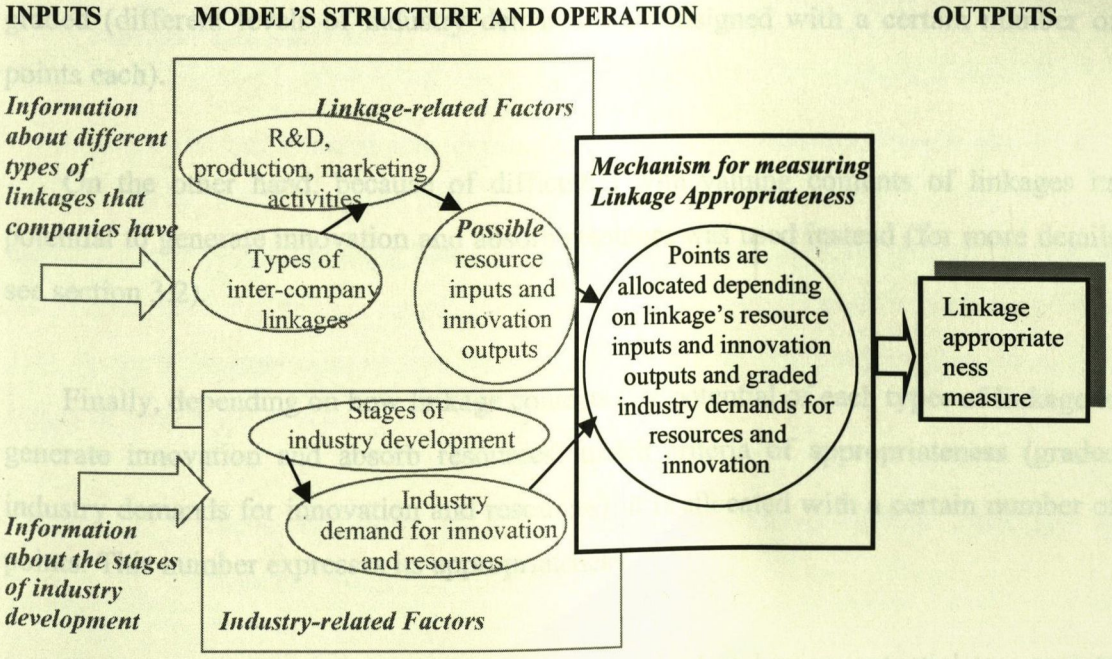
The development of these parameters over eight years between 1991 and 1997 have been analysed and shown in Appendix 3.1. According to the analysis, the Irish software industry is presently in ***the second (growth) stage of its life cycle***. It is argued this stage started in 1994.

In summarising, according to analysis of different indicators, the Irish software industry is in the growth stage of its life cycle. Unfortunately, industry characteristics are not available yet for years 1998 and 1999. Therefore it is possible that industry has already entered its third or maturity stage of development.

3.3 ASSESSING LINKAGE APPROPRIATENESS (MECHANISM FOR MEASURING LINKAGE APPROPRIATENESS)

This section attempts to summarise and highlight the key features of the mechanism for assessing Linkage Appropriateness (see Figure 3.6 highlighted area).

Figure 3.6: Elements of the Research Model (Mechanism for Measuring Linkage Appropriateness)



The section consists of four parts. The first sub-section shows how the mechanism for assessing Linkage Appropriateness works, the remaining three sub-sections describe appropriateness of different groups of inter-company linkages.

3.3.1 Mechanism for Measuring Linkage Appropriateness

In this model, inter-company linkages are defined as joint activities of two companies that require putting together different resources in order to produce innovation for the use of either or both partners. Primary and incremental innovation generated as a result of linkage-connected activities and basic and complementary resources channelled into these activities by partaking companies are understood as linkage contents. Linkage Appropriateness is assessed by reviewing how its contents comply with criteria of appropriateness.

Criteria of appropriateness, which are outlined in section 3.3 of this chapter, work as measuring tools for assessing inter-company linkages. They are defined by an industry and change while it develops. Industry demands for primary and incremental innovation and basic and complementary resources are chosen as criteria of appropriateness and graded (different levels of industry demands were assigned with a certain number of points each).

On the other hand, because of difficulties with valuing contents of linkages its potential to generate innovation and absorb resources was used instead (for more details see section 3.2).

Finally, depending on how linkage contents (the potential of each types of linkage to generate innovation and absorb resources) match criteria of appropriateness (graded industry demands for innovation and resources), it is allocated with a certain number of points. This number expresses its appropriateness.

For instance, joint ventures have been recognised as having potential to generate both primary and incremental innovation and absorb basic and complementary assets (see section 3.3). At the present growth stage of industry lifecycle the four industry demands are as follows:

Demand for primary innovation – High (1.4 points);

Demand for incremental innovation – High (1.4 points);

Demand for basic resources – Very High (1.8 points);

Demand for complementary resources – High (1.4 points).

This means that in this stage of the industry lifecycle, this types of linkage score:

$A_{(joint\ ventures)}$ =1.4+1.4+1.8+1.4=6 points.

where

A = appropriateness score

Another type of inter-company linkage – "contract-out R&D staff" - is less appropriate in this stage of industry development, because it does not have a potential to absorb complementary resources. It scores:

$A_{(contract\text{-}out\ R\&D\ staff)}$ =1.4+1.4+1.8+0=4.6 points.

It should be emphasized that linkage potential to generate innovation and absorb resources only depends on the nature of linkages and is the same at all stages of the industry lifecycle. On the other hand, industry demands change while industry develops. As a result, the same linkage may have different appropriateness at different times. Table 3.11 shows appropriateness of five different groups of inter-company linkages at all four stages of industry lifecycle.

Table 3.11: Appropriateness of Five Groups of Inter-company Linkages at Different Stages of the Industry Lifecycle

	Stages of Industry Development			
	Emergence	**Growth**	**Maturity**	**Decline**
Production-oriented Linkages	2	3.2	2.4	1.6
R&D-oriented Linkages	3.8	4.6	3	2.6
Marketing-oriented Linkages	1.6	2.8	3.6	2.4
Linkages involving various activities – Joint Ventures	4.8	6	4.8	3.6

3.3.2 Appropriateness of Production-oriented Linkages

Production-oriented linkages are most appropriate at the growth stage of the industry lifecycle when their core components – incremental innovation and basic resources are at their highest demand. The dynamics of the industry demands for these components defines the Linkage Appropriateness through the whole industry life cycle. The pattern of appropriateness for production-oriented linkage is as follows:

1) Growth (3.2);
2) Maturity (2.4);
3) Emergence (2);
4) Decline/dematurity (1.6).

Figures in the brackets show the grade of appropriateness of production-oriented linkages at different stages of industry lifecycle. This classification shows that there is a large gap in appropriateness between growth and maturity stages and then it reduces gradually from maturity through emergence to decline/de-maturity stages.

3.3.3 Appropriateness of R&D-oriented Linkages

A group of R&D-oriented linkages has a pattern of appropriateness through the industry lifecycle for innovation-intensive linkages as follows:

1) Growth (4.6);
2) Maturity (3.8);
3) Emergence (3);
4) Decline/de-maturity (2.6).

Similar to the first group, these linkages are also the most appropriate at the growth stage of the industry lifecycle. Then follows the maturity and emergence stages with a

gap of 0.8 points between each of them. The difference in appropriateness of R&D-oriented linkages at the third – emergence and fourth – decline/de-maturity stages is less – 0.4 points.

3.3.4 Appropriateness of Marketing-oriented Linkages

The ranking of the appropriateness of marketing-oriented linkages is as follows:

1) Maturity (3.6);
2) Growth (2.8);
3) Decline/de-maturity (2.4);
4) Emergence (1.6).

Unlike the linkages described above, marketing-oriented ones are the most appropriate at the maturity stage of the industry lifecycle because industry demand for complementary resources is particularly high at this stage. Then follows growth and decline/dematurity and finally – emergence stages.

3.3.5 Appropriateness of Linkages Involving Various Activities – Joint Ventures

Joint venture is the most universal types of inter-company linkage, which have potential to meet all four industry demands. The whole pattern of appropriateness for joint ventures is:

1) Growth (6);
2) Maturity and Emergence (4.8);
3) Decline/dematurity (3.6).

This pattern shows that linkages with potential to meet all four industry demands are most appropriate at the growth stage when these demands are highest, then follows the maturity and emergence stage and finally – decline/de-maturity.

As can be seen most of the inter-company linkages are most appropriate at the growth and maturity stages of industry lifecycle when the sum of four industry demands is at its highest.

CONCLUSION

The research model, which was specially developed for this study, attempts to explain the influence of inter-company linkages on company performance. Within this model, linkages are understood to be joint R&D, production and marketing activities of two companies that require putting together different resources in order to produce innovation for use of either or both partners.

The model draws on two inputs, namely information about the types of inter-company linkages that companies have and the stage of development of the industry in which these companies operate into a single output -appropriateness of inter-company linkages. Appropriateness of inter-company linkages refers to factors that govern partaking companies' ability to capture the profits generated by innovation which was created as a result of linkage activities. It is defined by the linkages' potential to generate innovation and absorb resources, which satisfy criteria of appropriateness or, in other words, there is an industry demand for them.

The information inputs are transformed into 'Linkage Appropriateness' following three stages procedure. The first stage deals with the information about linkages. Each type of linkages is assigned with potential to produce innovation and utilize resources depending on the performed activities (e.g. R&D, production, marketing).

The second stage deals with information about industry. The industry demands for innovation (induced by both competitors and clients) and resources (induced by competitors) are defined and calibrated for each stage of the industry development (e.g. emergence, growth, maturity, decline).

And finally, appropriateness of inter-company linkages is generated based on the information about linkage potential to produce innovation and utilise resources as well as industry demands for these innovation and resources (as estimated at stages one and two). It is calculated by adding together points identifying calibrated industry demands for innovation and resources. A linkage only gets these points if it has potential to satisfy these demands by producing innovation and utilising resources. As a result of this procedure, the model produces a discrete numeric output. The study's hypothesis states that companies that have linkages with higher appropriateness are likely to have better performance.

The model has a number of strengths and weaknesses as summarised in Table 3.12.

Table 3.12: Model's Strengths and Weaknesses

Strengths	Weaknesses
It describes how inter-company linkages influence company performance.	Assumption about activities performed within different types of linkages (e.g., R&D, production, marketing) is based on previously untested ideas from the existing research literature (e.g. Hagedoorn, 1990; Rothwell and Dodgson, 1993; Narula and Hagedoorn, 1999).
Although developed specifically for the Irish software industry, with minor adjustments it can be used for any other industry.	Assumption about resource inputs and innovation outputs of linkage R&D, production and marketing activities is based on previously untested ideas from the existing research literature (e.g. Narula and Hagedoorn, 1999).
It is simple to apply, because it requires only two inputs (information about types of inter-company linkages and stage of industry development).	Assumption about size of industry demands for innovation and resources is based on previously untested ideas from the existing research literature (e.g. Gemser et al, 1996; Teece, 1997).
The model's output - 'Linkage Appropriateness' is a discrete numeric variable. This enables the replication and comparison between the results of this study and further research.	Assumption about four business partnerships, namely licensing, contract-out coding/ programming, contract-out disk duplication and contract-out package assembly, as lacking potential to produce innovation is based on previously untested ideas from the existing research literature (e.g. Hagedoorn, 1990; O'Riain, 1997).

As can be seen from the above table, one of the model's strengths is that it attempts to explain how different types of inter-company linkages influence company performance and why this influence changes while an industry develops. These issues were considered in the literature on inter-company linkages and dynamics of innovation e.g., Gemser

(1997), Teece (1986) and others whose studies are reviewed in Chapter 2. But none of these works dealt with the influence of inter-company linkages on company performance explicitly. They rather exploited the possibility to profit from innovation (Teece, 1986) and the most likely types of inter-company linkages at different stages of industry development (Gemser, 1997). For more details on how the model fits into the existing body of knowledge as well as how existing studies contributed to its structure and operation, see 'Conclusion' to Chapter 2.

Because this model was not directly in line with other theoretical frameworks, some of its assumptions about different activities performed within different types of linkages (e.g., R&D, production and marketing) and about the potential of these activities to produce innovation and absorb resources as well as estimating and grading industry demands for innovation and resources were based on the ideas, which were implied but not necessarily stated and tested in the existing research literature.

The issue of validity of these assumptions highlight a major concern about the validity of the whole model. However, the logic behind these assumptions was re-examined numerous times and still no notable omissions were found. Of course, this does not mean that assumptions made in this study as well as the whole research model are the only way of approaching the issue. These assumptions can still be contested and alternative assumptions can be made. The model has therefore to stand and be tested as just one possible model, not as the only model.

In connection with this issue, it is worthwhile to be reminded that one of the model's strengths is that it is relatively easy to apply and can be re-adjusted to other industries' linkages which can be examined in further studies. It is important to mention, that the numeric nature of the model's output makes it possible to compare the results from different studies. Therefore we suggest that conducting future studies with the use of this model can further test the model's assumptions.

CHAPTER 4

METHODOLOGY

INTRODUCTION

The main purpose of this chapter is to highlight the methodological approach to this research and to justify the selection of research process. It explains methodological thinking not at the expense of technical knowledge, but as a precondition for choosing, carrying out and understanding the research process.

The chapter consists of two sections. The first section **'Defining the Elements of a Research Process'** contains information on the key decision areas in the research process namely: theoretical perspective, research question, research category, methodological strategy, data analysis and writing a thesis. Section two **'Postal Survey in the Irish Software Industry'** contains some practical details about this research, such as survey preparation, sampling, constructing a list of indigenous companies in the Irish software industry, questionnaire design and covering letter design.

4.1 DEFINING THE ELEMENTS OF A RESEARCH PROCESS

The terms research methods and research methodology are widely used in social and business enquiry. A great range of literature is provided under such titles as Business Research Methods (Brannick, 1997), Research Methods (Burgess, 1993), and Research Methods for Business (Sekaran, 2000). As a consequence, some clarification is required on the different terms that are used to discuss work on research methodology and research methods, given that both these terms are complex and ambiguous.

Some of the key terms used in work on research methodology as defined by Kuper and Kuper (1997, p. 534) are:

> ... *general methodology*, which is associated with the principles guiding an empirical enquiry; *research strategy* or *research procedure*, which refer to the way in which a particular study is designed and conducted; *research process*, which denotes the relationship between the articles that occur within a project and the principles and procedures that are used; *and research techniques* or *methods*, referring to specific fact-finding operations that yield social data. These issues are of equal importance in all forms of social research and need not to be considered in relation to each other.

Further in this chapter we will discuss the six key decision areas in the research process as defined by Brannick (1997, p.3) and showed in Figure 4.1.

Figure 4.1: The Elements of a Research Process

1) **Theoretical perspective;**
2) **Research Question;**
3) **Research Category;**
4) **Methodological strategy;**
5) **Data analysis;**
6) **Writing a thesis.**

4.1.1 Theoretical Perspective

A fundamental question, which would be concerned before starting the actual research is what is meant by scientific knowledge and truth and how it differs from the common sense knowledge.

In other words, what are the ways in which we come to believe and accept some ideas and arguments as true, how we know and how we act on that knowing? The philosophy of science concerns these issues. Presently, there are two major traditions the empiricist and the hermeneutic.

4.1.1.1 Empiricist Tradition

Empiricist tradition assumes a realist ontology and realist epistemology. It means that individuals (researchers) are believed to have direct, unmediated access to an external reality, which is the real world and knowledge (the results of research) are understood as objective that means that they are hard, secure and possible to obtain and communicate.

The empiricist tradition, also referred to as the deductive-nomological tradition or the hypothetico-deductive approach, is based on the covering-law model of science. To

explain, in this tradition, is to identify the relevant generalisations, which cover the studied phenomenon.

4.1.1.2 Hermeneutic Tradition

Hermeneutic tradition combines the realist epistemology with relativist ontology. It assumes that individuals do not have direct access to the real world – language, culture and other mediating institutions are interposed, but it is still possible for them to obtain objective knowledge about the reality.

In the hermeneutic tradition, which is sometimes called an understanding tradition, social reality is understood as unique meaning, which cannot be explained by general, all-covering law. The researcher operating within this tradition attempts to enter the culture of the phenomenon under investigation to understand the phenomenon as it reveals itself.

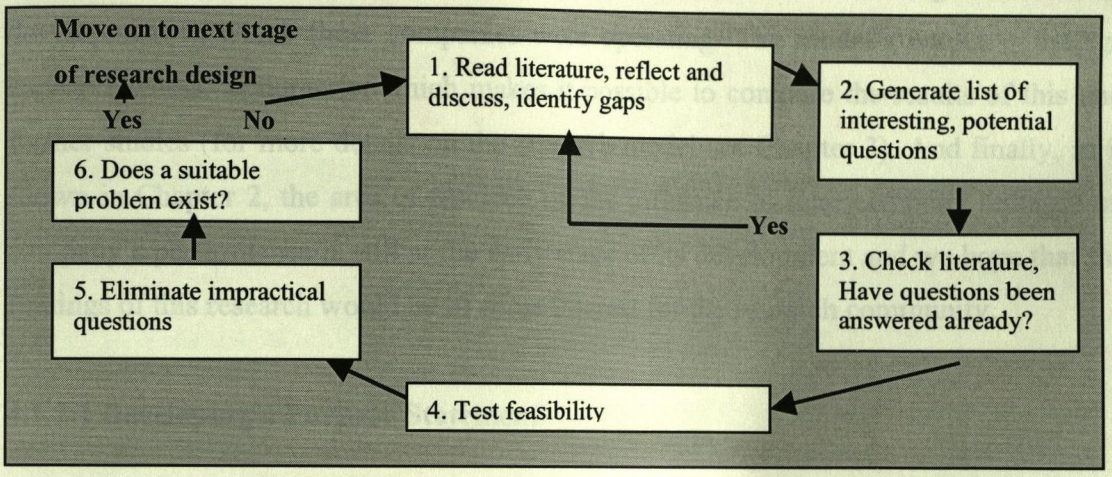
4.1.1.3 Defining the Theoretical Perspective Used in this Study

This study is done in the empiricist tradition. This tradition was chosen because it normally allows higher research efficiency (time- and resource-wise) as well as better replica ability (possibility to carry out further research in order to check the data produced by this one) compared to the hermeneutic tradition. This choice was also greatly affected by my beliefs and educational background. Having graduated with a science degree, I always had a strong preference for the empiricist tradition.

4.1.2 Research Question

Identifying a specific research problem or issue is always an exploratory and reiterative phase in the research. The classic way, which includes considering the literature on the area of interest and identifying any gaps since these indicate original areas to research was adopted in this study. Figure 4.2 shows the procedure which was used in this study.

Figure 4.2: Procedure for Identifying a Research Problem



Source: Hussey and Hussey, 1997, p.117

As illustrated in the above figure, identifying a research topic was a lengthy procedure which took about three years. During this time the research focus had moved from analysing activities of business parks through the role of government in supporting innovation clusters to analysing how inter-company linkages affect companies' performance.

A number of criteria as suggested by Creswell (1994, p. 3) have been applied while considering potential research topic. These criteria are as follows:

- Research ability of the project, given time, resources and availability of data.
- Personal interest in the topic in order to sustain attention.
- Usefulness of the results of the study for others.
- The usefulness of the project to the researcher's career goals.

The chosen topic satisfied all these criteria. First of all, the researcher is very interested in different types of business partnerships and especially their influence on company performance, which helped to sustain self-motivation through the whole study. Another important thing is that the project was researchable. The study was based on a

new research model which required only three well defined information inputs, namely type of linkages that companies had, their performance and the stage of industry development in which these companies were operating. The model's output - 'linkage appropriateness' is numeric, which makes it possible to compare the results of this and further studies (for more details on the research model see Chapter 3). And finally, as it shown in Chapter 2, the area of research on the influence of inter-company linkages on company's performance is still at the early stage of its development and we hope that the findings of this research would be of some interest for the research community.

4.1.2.1 Developing a Purpose Statement

Having chosen a suitable research problem, a purpose of the research was formulated. The purpose statement identifies the variables that are examined, the theory employed, the methods and refer to the sample being studied. (Hussey and Hussey, 1997, p. 121).

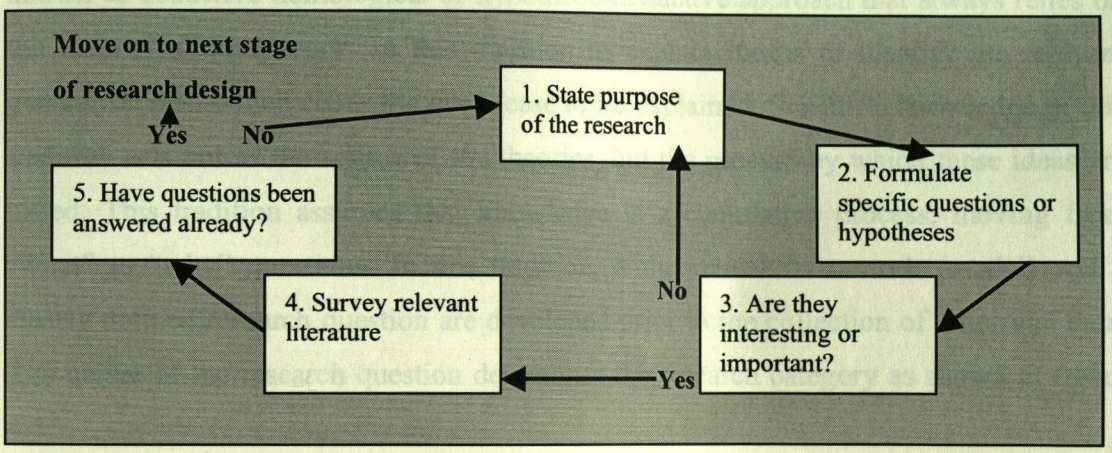
The purpose of this survey study is to test the theory that relates companies' performance to types of linkages that these companies have for software companies in Ireland. The independent variable (inter-company linkages) was defined as joint R&D, production and marketing activities of two companies that require putting together different resources in order to produce innovation for use of either or both partners. The dependent variable (companies performance) was defined as the grand total of all resources received from the sale of a firm's product or service during a stated period (one year) divided by a number of firm's employees (revenue per employee).

4.1.2.2 Developing a Research Question

Whereas the purpose statement explains the general direction of the study the research question or hypotheses expand on this by providing details. The right research question helps to collect suitable data and make sensible conclusions.

Figure 4.3 shows a model proposed by Hussey and Hussey (1997, p. 125) which was used while formulating a research question.

Figure 4.3: Developing a Research Question



Source: Hussey and Hussey (1997, p. 125)

The research question was determined by current development of knowledge in the field. Two major issues arose. These issues are as follows:

1) Absence of the theoretical model explaining the influence of inter-company linkages on company performance;
2) There is just one study on inter-company linkage in the Irish software industry.

The research questions reflects these issues is as follows: **'How and why do inter-company linkages influence company performance?'**

This research question meets the requirements to research questions which were formulated by Kerlinger (1986), namely it:

- Expresses a relationship between variables.
- Is stated in unambiguous terms in question form.
- Implies the possibility of empirical testing.

4.1.3 Research Category

This research is undertaken within the framework of empiricist tradition, which is also known as deductive-homological or hypothetic-deductive approach that always relies on the theoretical framework. In this tradition to explain means to identify the relevant generalisations, which cover the event/case to be explained. Scientific knowledge in this tradition acts not as the source of the theories, but the process by which these ideas are tested. This tradition assumes that knowledge is a cumulative process, moving from "what" to "why" questions. In this tradition, a theoretical framework (model) and a clearly defined research question are developed prior to the collection of empirical data. The nature of the research question determines the research category as shown at figure 4.4.

Figure 4.4: The Nature of the Research Question

Research Category	Research Question
Exploratory	What?
Descriptive	When? Where? Who?
Explanatory/Casual	How? Why?

4.1.3.1 Exploratory Research

Exploratory research is carried out when there is little prior knowledge and research hypothesis is not clearly defined.

4.1.3.2 Descriptive Research

Descriptive research is used when there already exists a general body of research and its main purpose is to provide an accurate description of certain aspects of the reality. In descriptive research, the hypothesis is tentative and does not cover casual relationships.

4.1.3.3 Explanatory/casual Research

The aim of explanatory/casual research is to show how one ore more variables cause or determine the values of other variables. Research hypotheses are integral to this approach and are developed to extend or disprove an already existing body of knowledge.

4.1.3.4 Defining the Research Category Used in this Study

The how-type research question determines the explanatory/casual nature of this research. At the same time, because there was little prior knowledge available, the research also has the exploratory value.

4.1.4 Methodological Strategy

According to Brannick (1997, p. 8), the choice of a specific research strategy is determined by epistemological assumptions, the nature of the research problem, the status of scientific research, theory relevant to the problem as well as time and economic resources available. The majority of business-related research uses one of three methodological strategies: experiment, survey or case-based research (see Figure 4.5).

Figure 4.5: Methodological Strategy

1) **Experiment**
2) **Survey**
3) **Case-Based Research**
   - **-Ethnography**
   - **-Action Research**
   - **-Case Study – Hypothetico-Deductive Approach**

Source: Brannick (1997, p. 8)

4.1.4.1 Experimentation

The purpose of experimentation is to detect or confirm casual relationships between variables and to qualify them. Because of the casual nature of experimental research, very precise hypotheses need to be formulated between independent, dependent and extraneous variables.

Experimentation involves the manipulation of one or more independent variables by the researcher, so the dependent variable can be determined. Experimentation always involves an after-measurement – a measurement of the dependent variable after the introduction or manipulation of the independent variables.

4.1.4.2 Case-based Research

Brannick (1997) defines case-based research as:

> ... an empirical enquiry which investigates a contemporary phenomenon within its real life context when the boundaries between phenomenon and context are not clearly understood. (p.13)

Case-based research strategies include ethnography, action research and hypothetico-deductive case studies.

1) Hypothetico-deductive Case Study Approach

The hypothetico-deductive case study approach is used to carry out exploratory, descriptive and explanatory investigations. This kind of research starts with developing a conceptual framework and hypothesis based on existing knowledge and theory. It is done to specify and refine the initial broad research problem. This stage is followed by the selection of research sites and the design of data collection techniques.

2) Ethnographic Approach

Brannick (1997, p. 14) defines ethnographic approach as:

> ...a naturalistic, inductive form of inquiry, which allows the researcher to use the socially acquired and shared knowledge available to the participants to account for observed patterns of human activity.

In this approach, the theory is developed inductively out of empirical research. It means that development of the theoretical framework and hypotheses is happening throughout the whole process of the research.

Most ethnographic studies use extended participation observation data collection technique, although semi-structured and partially directive or non-directive interviewing, secondary data sources and observation can also be used. Access to research sites is a major problem for this type of research, which often requires long-time observation.

3) Action Research

The client, rather than the researcher initiates action research. The main objective of the action research is to solve specific managerial problems, but at the same time they may contribute to theory. Action research involves direct investigation by the researcher (agreed with the client) into studying phenomenon and following monitoring and evaluating the effects of intervention.

4.1.4.3 Survey Methods

'Survey research is the systematic gathering of specific information about particular persons or entities' (Brannick, 1997, p. 11). This kind of research can be used for exploratory, descriptive and analytic investigations. Survey information is usually gathered with some form of a questionnaire although the collation of specific information is also possible.

The design of a questionnaire differs in terms of structure and directness. Structure refers to the extent to which a respondent is asked to follow the preset question content, question format and response category outlined in questionnaire. Question directness shows the extent to which the respondent is aware of the nature and purpose of the survey.

The survey can be attributed to three major groups according to the methods of communication used. These groups are:

1) Personal;
2) Telephone;
3) Postal.

An appropriate type of survey can be selected using five criteria (Figure 4.6).

Figure 4.6: Advantages and Limitations of Different Surveys

	Personal Interview	Telephone Interview	Postal Survey
1) Accuracy of data collected	Good	Good	Very good
2) Amount of data that can be collected	Excellent	Fair	Fair
3) Flexibility	Excellent	Good	Poor
4) Response rate	Excellent	Good	Poor
5) Time and cost	Poor	Good	Good

Source: Brannick (1997, p. 12)

4.1.4.4 Selecting the Methodological Strategy Most Appropriate for this Research

The decision to use a specific research strategy was determined by the origination of research, the epistemological assumptions, research category and up-to-date research data in the area availability.

This research is based on empiricist or hypothetico-deductive tradition. The use of this approach reduced the choice of the methodological strategy to experiment, hypothetico-deductive case study, action research and survey. Ethnography research is left out because it is based on the hermeneutic tradition.

The fact that this research was not started in response to a request from the client who was looking to solve a particular managerial problem makes action research inappropriate.

Out of three remaining research approaches (experiment, case study and survey) the former two were ruled out because both of them are not designed for collecting data from large numbers of companies. At the same time, having a large database was believed by a researcher to be a necessary condition for the testing of a new research model, which was specially developed for this study (see Chapter 3 for more details on the research model). The large amount of data was also necessary for fulfilling the exploratory objective of this study, namely describing inter-company linkages in the Irish software industry. Considering all these constraints, a survey was chosen as the most appropriate methodological strategy for this research.

4.1.5 Data Analysis

Because a positivistic paradigm was adopted for this research, quantitative data was collected on which statistical analysis was then conducted. Both exploratory data analysis or descriptive statistics and confirmatory data analysis were used in this study.

4.1.5.1 Descriptive Statistics

Descriptive statistics used to summarise and display quantitative data which describe different aspects of inter-company linkages in the Irish software industry (for more details see Chapter 5).

4.1.5.2 Inferential Statistics

Confirmatory data analysis or inferential statistics was used for measuring association while testing the research hypothesis (For more details see Chapter 6).

4.1.6 Writing a Thesis

By the time the final writing-up stage started, a significant amount of data and material were collected and generated. During the course of conducting research, draft chapters on literature review, research model and research methodology were written and discussed with supervisors.

4.1.6.1 Structure of the Thesis

In this section the overall thesis design is outlined. The thesis consists of six chapters, namely 'Introduction', 'Literature Review', 'Research Model', 'Methodology', 'Results' and 'Analysis, Discussion and Conclusions'. The chapters are followed by references and appendices.

The structure of this work is almost the same as the traditional structure as described by Hausey and Hausey (1997, p. 281). The only difference is that the traditional structure does not have a chapter on the research model. However, because this research is based on the model which was specially developed for it, there is a special chapter which outlines the model.

4.1.6.2 Setting a Timetable

Whilst determining the structure of the thesis, the timetable showing the critical dates when different chapters would be completed was created. In table 4.2 we give a breakdown of the main tasks fulfilled while writing the thesis.

The schedule shown in Table 4.1 assumes that some preliminary work has been done; for example, the first drafts of literature review, methodology and research model chapters were written, some of the figures and diagrams were drawn up and ready to be incorporated.

Table 4.1: Time taken to write the thesis

Chapter or task	Number of weeks
Introduction	1
Literature Review	2
Methodology	1
Research Model	2
Results	2
Analysis, Discussion and Conclusions	3
Tables, figures, references, appendices, etc.	1
Consultation with supervisors and others and revisions	1
Editing, proof reading and binding	3
Total	**16**

4.2 POSTAL SURVEY IN THE IRISH SOFTWARE INDUSTRY

This section covers a number of practical issues, which were dealt with while conducting survey research. These issues fall into five groups as follows:

1) Survey Preparation;
2) Sampling;
3) Survey Documents;
4) Maximising Response;
5) Preparation of data for analysis

4.2.1 Survey Preparation

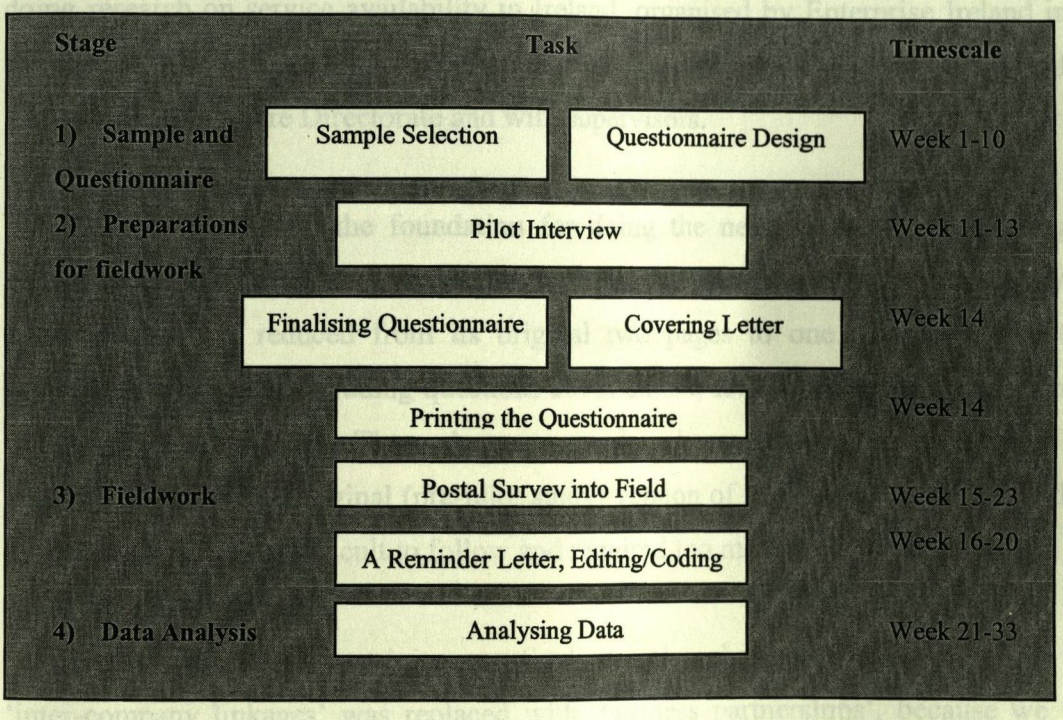
The two main factors, which influenced the time schedule for the survey, were:

1) The survey method being used;
2) The size of the sample.

The length of time, which a postal survey requires is normally influenced by the level of response required. The longer the survey is carried out the higher the rate of response is likely to be.

The size of the sample and time constraints determined the choice of four stages postal survey. The stages in this survey are shown in Figure 4.7.

Figure 4.7: Stages of the Survey



4.2.1.1 Sample and Questionnaire Preparation

The initial stage took a sizeable length of time, 10 weeks in all, due to the design of the questionnaire, which was determined by the research model that had been constantly updated and improved. The sample selection process, which took about three weeks, had been progressed concurrently during the last phase of questionnaire design.

4.2.1.2 Preparation for Fieldwork

The second – preparation for fieldwork stage took another 10 weeks. It included four sub-stages – pilot interviews, finalising the questionnaire, preparing a covering letter and photocopying the questionnaire.

The pilot survey took two weeks. It was a trial run on the main survey undertaken to test the questionnaire and the reaction of respondents. Unlike the main survey, the pilot survey was organised in the form of a personal interview with senior managers from three Irish software companies. The contacts with these managers had been established while doing research on service availability in Ireland, organised by Enterprise Ireland in the summer of 1999. Apart from that, the questionnaire was discussed with a person from The National Software Directorate and with supervisors.

The pilot study laid the foundation for doing the next sub-stage - finalising the questionnaire. Following the suggestions made by the participants of the pilot study, the questionnaire was reduced from its original two pages to one. It was achieved by improving layout and excluding questions about extent, level, participation and duration of inter-company linkages. These changes were done because the participants in the pilot study thought that the original (pre-pilot study) version of the questionnaire (as outlined in Appendix 4.2) was difficult to follow and required too much time to complete it.

The wording of the remaining questions was also changed. For instance, the term 'inter-company linkages' was replaced with 'business partnerships', because we were advised that the former term was more familiar to people in industry. The pre-pilot study and final versions of the questionnaire are given in Appendices 4.2 and 4.1.

Some changes were introduced to the covering letter as well. For example, the participants of the pilot study suggested that an offer of a brief summary of the research findings was desirable, so it was introduced in the covering letter (see Appendices 4.3 and 4.4 for pre-pilot study and final versions of the covering letter). This stage took one week.

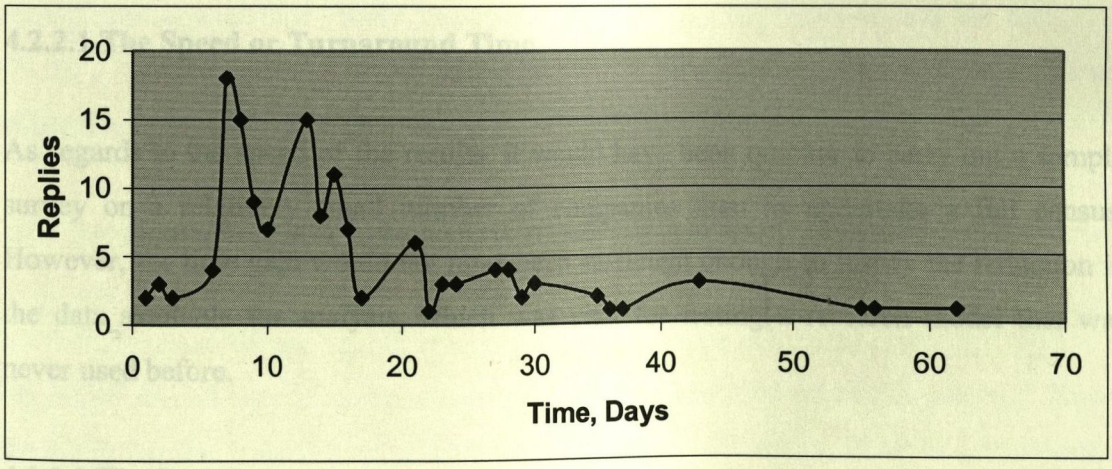
4.2.1.3 Fieldwork

Stage three saw the start of the fieldwork. The fieldwork started on 26th June 2000 when first 165 questionnaires were sent. The remaining 739 questionnaires were posted over

the next four days. The first three replies were received on 28th June 2000 - in one day after the first postage. The last questionnaire was returned on 28th August 2000, which means that the fieldwork took 63 days. Seven hundred and twenty-two reminder letters were posted on 28th August 2000 or in four weeks time after the first bunch of the questionnaires went into the field.

Figure 4.8 illustrates the response rate over this period of survey. The first five peaks on the curve correspond to the five postages of the questionnaires. The last small peak, number six, is showing the increase in a response rate which occurred as a result of the reminder letter.

Figure 4.8: The Response Rate Over the Period of the Fieldwork



4.2.1.4 Data Analysis

At the same time, a database was set for keeping a record of complete questionnaires which were returned and coding the data in preparation for analysis (coding frame is shown in Appendix 4.6). Finally, the fourth and final stage saw the data being analysed. This stage took 12 weeks.

4.2.2 Sampling

The following section contains more detailed information on the first stage of the survey, namely sample selection.

Williams (Williams, 1997, p. 62) identifies four major reasons for using samples in preference to censuses. The reasons are:

1) The speed or turnaround time for the results;
2) Budget or cost;
3) The intensity and quality of data which can be collected in a sample in contrast to what could be collected in a census;
4) Considerations of practicality and operational feasibility.

4.2.2.1 The Speed or Turnaround Time

As regards to the speed of the results, it would have been quicker to carry out a sample survey on a relatively small number of companies than to undertake a full census. However, the time gain would not have been sufficient enough to justify the reduction in the data available for analysis, which was vital for testing a research model that was never used before.

4.2.2.2 The Budget

A second and more compelling reason for carrying out a sample survey in preference to a census is the relative cost involved. In this case, the actual cost of the survey as regards money was the cost of envelopes and stamps which in our case was under £IR100 which was still reasonable for surveying the whole population of companies. The School of Business Studies at Trinity College kindly covered the costs involved.

4.2.2.3 The Quality of Data

The third advantage which a sample survey has over census enumeration is the amount, intensity and complexity of information that can be collected. However, due to the nature of the questionnaire, which ensured that the data collected were sufficient for the purpose of the research and the fact that this survey was targeted at managing directors of the companies the requested information could be collected from any number of participants by means of postal survey without using costly interview process.

4.2.2.4 The Practicality

The fourth advantage of a sample is concerned with the practical considerations or feasibility of implementation. Though with a sample size of nine hundred these considerations were not vitally important. Because of these reasons and the fact that having a sufficient amount of data is very important for testing a research model a census rather than a sample was carried out.

4.2.3 Constructing a Population List of Indigenous Companies in the Irish Software Industry

There are several lists of companies available which are used widely in surveys. These are the Enterprise Ireland list, the IDA list, the Kompass Directory, Business and Finance – Top 1,000 Companies and also specialised industry-based lists. All these have their advantages and disadvantages and constructing a list representing all companies needed access to more than one of them.

4.2.3.1 The Enterprise Ireland List

This list is updated every year and is made available to the public. Currently it contains information on three hundred and forty-seven Irish software companies. Its main

advantage is that it is stratified by sector. The main disadvantages are that it does not list contact names and only manufacturing companies are listed.

Considering that the focus of this research is on the software (manufacturing) sector, this list was used as a second major source while constructing a list of companies. 107 out of the 904 companies identified were sourced from this list.

4.2.3.2 The IDA List

A listing of companies maintained by the IDA is less extensive as that compiled by Enterprise Ireland and is largely confined to the overseas companies, which makes it less useful for this research dealing with Irish companies.

4.2.3.3 Kompass Directory

This directory contains information about over fifteen thousand companies and published by Kompass Ireland. In addition to the name, address and telephone number of each company listed, the names of directors, the sector and size of the company in terms of employment are also available. This directory was also consulted while constructing a list of Irish software companies. 173 out of the 904 companies identified in the final list were sourced from this list.

4.2.3.4 Business and Finance – Top 1,000 Companies

A listing of the top 1,000 companies is produced by Business and Finance magazine every year. The companies are ranked in terms of their annual turnover. The smallest companies which feature on the list report turnover of more than 4 billion pounds. Consequently, small companies are not represented on this list, which makes it less appropriate for this research. It was only used to check details on larger Irish software companies.

4.2.3.5 National Software Directorate List

A list of software companies maintained by the NSD contains detailed information including the name, address, contacts, and areas of expertise for approximately seven hindered software companies operating in Ireland. This list was used as a foundation while constructing a list for this research. 624 out of the 904 companies identified in the final came from this source.

4.2.3.6 List of Indigenous Companies in the Irish Software Industry

A finalised list used in the survey included 904 companies. It was based on the NSD list and enlarged by consulting the Enterprise Ireland list, as well as the Kompass Directory.

4.2.4 Questionnaire Design

The questionnaire design for a postal survey is more important compared to other survey methods, because the contact between the respondent and surveyor in this case is more indirect.

The questionnaire design for a postal survey needs to be clear, easy to follow and understandable and as short as possible. The questionnaire used in this survey is given in Appendix 4.1. In the remaining part of this chapter a few practical points concerning the questionnaire are discussed.

4.2.4.1 Length

The postal questionnaire used in this survey is one page in length, which is below the recommended average (four pages). Murphy (1997, p. 41) points out that if survey goes beyond four pages in its length it will look too demanding as regarding time commitment to potential respondents.

All seven questions asked in this questionnaire were double checked to avoid the situation where partly similar questions are being repeated. The use of a table and a chart allowed the gathering of a sufficient amount of information from a questionnaire of this length.

4.2.4.2 Layout

Because the length of the questionnaire was limited to just one page, maximising the use of space was absolutely essential. Classification questions which ask about the companies' establishment year, number of employees, revenue in 1999 and nature of the software business were placed at the beginning, so that respondents could gain confidence while answering less complex questions.

Question four (marked number one on the questionnaire) asks about sub-sectors of the software industry within which companies operate and stages of these sub-sectors development. To help the participants to identify an appropriate stage of sub-sectors development, a curve, characterising industry development was printed in grey on the background.

Questions five and six (marked number two and number three on the questionnaire) ask information about how many inter-company linkages (business partnerships) each company has and the sub-sectors of the software industry within which these partnerships exist. A table, containing the names of possible business partnerships, was placed on the right of the questions. An example illustrating how to answer these questions and putting the answers into the table was also provided. The grey line identifying the source of sub-sectors (in question 3) was drawn.

4.2.4.3 Instructions

The first four classification questions (establishment year, number of employees and revenue in 1999) were recognised as straightforward and were not supplied with any

instructions. Instructions were inserted after each of three remaining multiple choice, open ended questions on the questionnaire to avoid confusion on how a question should be answered. The comments and visual aid (the positioning the table, the chart of the industry profile on the background and an arrow) to the last three questions help the respondent to mark their answer in an appropriate column in the table.

4.2.4.4 Confidentiality

The company's name or address was not asked on the questionnaire, because it contains information such as revenue, number of employees and types of linkages, which they may not want to disclose.

If the questionnaire goes astray in the post or becomes mislaid while already received by a researcher and the name of the company is written on it, the sensitive information may become available to a third party.

To avoid this at the early stage of the survey, each company was assigned an ID number. From then on, these ID numbers were used to refer to companies, rather than real names. The company ID number with mark 'office use only' was entered onto each questionnaire before it was mailed out.

4.2.5 Covering Letter Design

The covering letter was used to introduce the survey. It was personalised and every effort was made to make it well presented and look professional (See Appendix 4.2). There are a number of important points about this letter which will be discussed in the reminding part of this chapter.

4.2.5.1 Background Information on Survey

The covering letter contained brief information about the main purpose of the survey. It also outlined what use the findings will be put to and what changes might come about as a result. The aim of the background information is to convince managing directors that participating is a worthwhile experience.

4.2.5.2 Sponsors of Survey

The survey was supported by two organisations – the School of Business Studies at Trinity College, Dublin and the National Software Directorate. This fact was mentioned in order to express gratitude and to increase the perceived validity of the survey.

4.2.5.3 Selection of Participants

There is information about the sources of company names and address (NSD List, Kompass Directory 1999 and Enterprise Ireland). This information taken together with background information was aimed to deal with concerns from respondents about where their name was received from and why their particular company was being asked to participate.

4.2.5.4 What the Survey Involves

It was outlined that participation in the survey involved completing the enclosed questionnaire and returning it back to TCD. Indication of the time commitment (10 minutes) was also given.

4.2.5.5 Confidentiality

Respondents were assured that all the information given as part of the survey would be treated in the strictest confidence. It was also emphasised that any findings may only be

available in the form of aggregate tables, so that it will be impossible to identify the reply of any individual company.

4.2.5.6 Contact Name

A researcher name, telephone and fax numbers as well as e-mail address was made available to respondents in case they had questions about the survey which had not been dealt with by the letter.

4.2.5.7 Appreciation

The cooperation of respondents was acknowledged, a brief summary of finding was offered to all interested participants.

4.2.6 Reminder Letter

The reminder letter was used to encourage those companies that did not reply in the first four weeks after mailing an original bunch of the questionnaires to do so. Following the reminder, 17 completed questionnaires (12.2 % of the total 139) were received from these companies. The reminder letter used in this study is shown in Appendix 3.5.

CONCLUSIONS

This chapter contains the description of the elements of a research process. It justifies the choice of the empiricist tradition as a basis for the research, states research questions, identifies the research category, justifies the choice of the methodological strategy as well as provides some information about data analysis and writing a thesis.

It also contains practical details about the chosen methodological strategy - the postal survey of the Irish software companies, such as information on how a list of 904 observed companies was created as well as information about the contents and layout of the

questionnaire, covering and reminder letters. It illustrates how the pilot study and the main survey were planned and carried out and how the findings made in the pilot study affected the design and layout of the questionnaire and covering letter.

Summarising, it offers an explanation of why certain data were collected, what data were collected, from where they were collected, how they were collected and how they were analysed.

CHAPTER 5

RESULTS

INTRODUCTION

Chapter five contains a presentation of the research results. It consists of two sections. The first section **'Statistical Techniques Used to Analyse the Data'** describes the different statistical techniques used in analysing data. Section two **'The Research Findings'** contains the results of both exploratory and confirmatory data analysis.

5.1 STATISTICAL TECHNIQUES USED TO ANALYSE THE DATA

Two types of statistical analysis were used while analysing data in this study, namely exploratory data analysis or descriptive statistics and confirmatory data analysis or inferential statistics. Exploratory data analysis was used for summarising and displaying the research findings, confirmatory data analysis was used to test the research hypothesis.

In this chapter we will look first at exploratory data analysis, before going on to discuss the main issues considered while conducting confirmatory data analysis. Table 5.1 lists the statistical techniques which are used in chapters five and six of this work.

Table 5.1 List of Statistical Techniques Used in This Study

	Exploratory Data Analysis	**Confirmatory Data Analysis**
Univariate Data	Frequency Distribution - Tables - Graphical Forms	
	Measuring Location - Mean - Median - Mode	
	Measuring Dispersion - Range and Interquartile Range - Standard Deviation	
Bivariate Data	Presenting frequencies - Cross Tabulations - Scatter Diagrams	Measuring Association - Spearman's Rank Correlation Coefficient (r_S) (Non Parametric)

5.1.1 Exploratory Data Analysis

Exploratory data analysis or descriptive statistics are used for describing, summarising and presenting the data in tables, charts and graphs, which enable patterns and relationships to be seen which are not apparent in the raw data. Hussey and Hussey (1997, P. 189) point out that there are four main groups of statistical techniques used in exploratory data analysis, namely:

1) Presenting frequencies;
2) Measuring Location (Central Tendency);
3) Measuring Dispersion (Spread);
4) Measuring Change.

All these groups were considered for use. However, measuring change was ruled out because it requires data for past periods, which were not available.

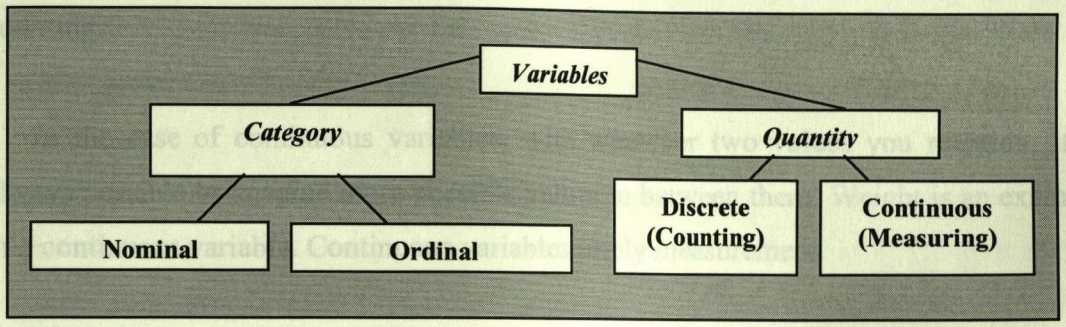
5.1.1.1 PRESENTING FREQUENCIES

The first step taken was to examine the frequency distribution for each variable.

1) Different Types of Variables

This study concerns both categorical and quantitative data. Categorical variables (variable characteristics) refer to any variables that put individuals into categories. There are two types of category variable: nominal and ordinal (see Figure 5.1). Nominal data is data classified into named categories, for example occupation or colour of eyes. Ordinal data is very similar to nominal data, except it is ordered in some way, for example, whenever a sample member is better, or bigger, or faster, or in any way has more of a certain characteristic than does another, then it can be arranged in order. This kind of category variable called an ordinal variable.

Figure 5.1: Types of Variables



Source: Rowntree, 1991, p. 33

Quantitative data refer to variables where individual sample members can be described in terms of numbers. This means that difference between individuals can be counted or measured. As with category-variable, there is more than one kind of quantity – variable.

One distinction is between quantity variables that do and those that do not use a scale of numbers on which the zero-point means that characteristic does not exist at all. Most quantity variables (e.g. income) do have such a zero point, they are called ratio data and represent the highest level of precision since this data is measured on a scale which has a fixed zero point and permits both ratio and interval measurements to be made, for example, height, weight or time data. Therefore you can say that six hours is three times as long as two hours and you can say that the interval between six hours and two hours is four hours.

But some quantity variables (interval data) do not have this kind of zero-point – temperature, for instance. An object with a temperature of 0°C is not completely lacking in heat, therefore an object with temperature of 10°C is not twice as hot as an object with the temperature 5°C, we only can say that it is 5°C hotter.

Another distinction is between quantity variables that are discrete and those that are continuous (see Figure5.1). A discrete variable is one in which the possible values are

clearly separated from one another, for example company size: a company can have 5, 10, 50, etc. employees. But it cannot have 25.5 or 5.75. Discrete variables imply counting.

In the case of continuous variables, with whatever two values you mention, it is always possible to imagine more possible values in between them. Weight is an example of a continuous variable. Continuous variables imply measurement.

Eight variables are analysed in this study. They are both primary variables - those based on the data collected directly from the companies in the Irish software industry, and secondary variables - those that were calculated based on primary variables.

There are five primary variables. The first one - 'Nature of the Software Business' is a category, nominal variable. The remaining four are quantity, discrete, ratio data. They are:

- 'Establishment year';
- 'Number of employees';
- 'Revenue in 1999';
- 'Number of business partnerships'.

Three secondary variables are also analysed in this study. These discrete, ratio variables were calculated based on 'Revenue in 1999', 'Number of Employees' and 'Number of Business Partnerships' primary data. These variables are as follow:

-'Revenue per Employee';
- 'Number of Inter-company Linkages';
- 'Linkage Appropriateness'.

2) Frequency Distribution Tables

Frequency techniques are normally applied to summarise and present both category and quantity data, although the continuous data should be organised into classes so that each item of data can be allocated within the range without ambiguity.

A frequency is a numerical value which represents the total number of observations for every variable under study. A frequency distribution is an array of the frequencies arranged in size order in a table, chart, graph or other diagrammatic form. Frequency distribution tables were applied to all five variables considered in this study (see Section 5.2.1).

3) Cross Tabulation

Cross tabulation is used to analyse bivariate data and can be constructed from any type of quantitative data. In the case of this study it is applied to analyse the interdependencies between a nominal variable 'Nature of the Software Business' and quantitative variables 'Establishment Year', 'Number of Employees', 'Revenue in 1999', Revenue per Employee', 'Number of Business Partnerships' and 'Number of Inter-company Linkages'. These numeric variables were recoded into discrete categories to enhance the analysis of the tables.

4) Charts and Graphs

Charts and graphs are suitable for both presenting and summarising frequency data and they were used together with tables to convey information precisely. Table 5.2 contains information about advantages and disadvantages of using graphs and charts.

Table 5.2: Graphical Representation of Data

Advantages	Disadvantages
Good for communicating general points	Poor for communicating specific details
Attractive to look at	Design may detract from message
Appeals to a more general audience	Can be time consuming to prepare
Relationships can be seen clearly	Can be misinterpreted
Easier to compare sets of data	Open to abuse

Source: Hussey and Hussey, 1997, p. 193

The statistical package for social sciences (SPSS) which was used in this study produces a variety of different charts and graphs, therefore the choice of appropriate ones was only determined by the type of data as shown in Table 5.3.

Table 5.3: Type of chart by type of data

Type of Data	Bar Chart	Pie Chart	Histogram	Frequency polygon
Nominal	Yes	Yes		
Ordinal	Yes			
Interval			Yes	Yes
Ratio			Yes	Yes

Source: Hussey and Hussey, 1997, p. 193

Bar charts were used for nominal variables and both bar charts and histograms histograms for quantity ratio variables. As a matter of fact, a histogram is a refinement of a bar chart where adjoining blocks touch, indicating ratio data. These blocks are proportional in area to the frequency in each class or group. The horizontal scale in histogram are marked with midpoints of the classes.

5) Frequency Representing Techniques Used in this Study

Frequency distribution tables, cross tabulations, bar charts and histograms were used for presenting and analysing data in this study.

5.1.1.2 Measuring Location

A measure of location (central tendency) is a convenient way of describing a large frequency distribution while using a single value. The data to be analysed should be quantitative. The main measures of central tendency are:

1) The Mean;
2) The Median;
3) The Mode.

1) Mean

The mean is the arithmetical average of a frequency distribution, which is calculated as follows:

Mean = $\Sigma x/n$

where

x = each observation

n = total number of observations.

2) Median

The Median (M) is the mid-value of the frequency distribution which has been arranged in size order. The formula for calculating medium is:

M=(n+1)/2

where

n = number of observations.

3) Mode

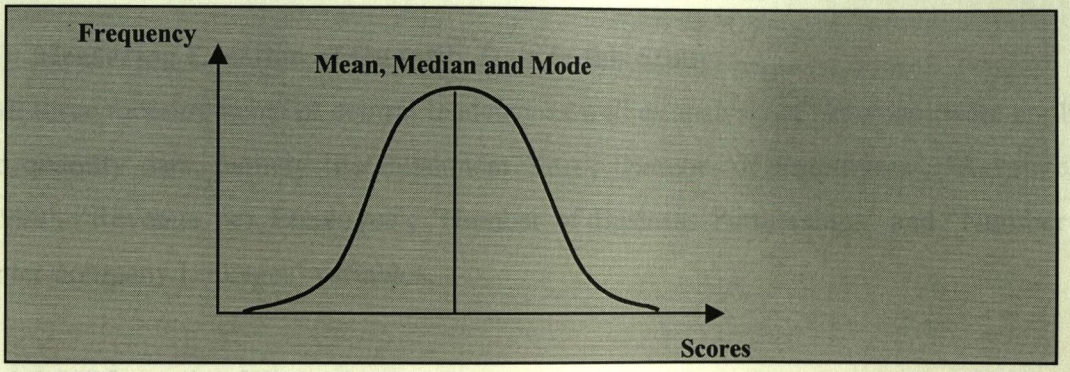
The mode (m) is the most frequently occurring value in a frequency distribution. Table 5.4 shows advantages and disadvantages of using mean, medium and mode as measures of central tendency.

Table 5.4: Comparing Mean, Median and Mode

Measure	Advantages	Disadvantages
Mean	It can be calculated exactly; It makes use of all the data; It can be used in further statistical analysis.	It is greatly affected by outliers; It can give an impossible figure when the data is discrete; It is impossible to obtain by histogram.
Median	It is not affected by outliers; It can be determined even if some of the values in the distribution are unknown; It is unaffected by open-ended classes and irregular class widths; It can represent an actual value in the data.	The value of it can only be roughly estimated for a grouped distribution; It cannot be used in further statistical calculations; When the distribution is irregular, the median may not be characteristic of the distribution.
Mode	It is unaffected by outliers; It is easy to obtain by histogram or calculation, only values near the modal class are required.	It is an unstable figure and can change dramatically as other observations are added, It cannot be found exactly when the distribution is grouped, the distribution may be multimodal; It cannot be used in further statistical work.

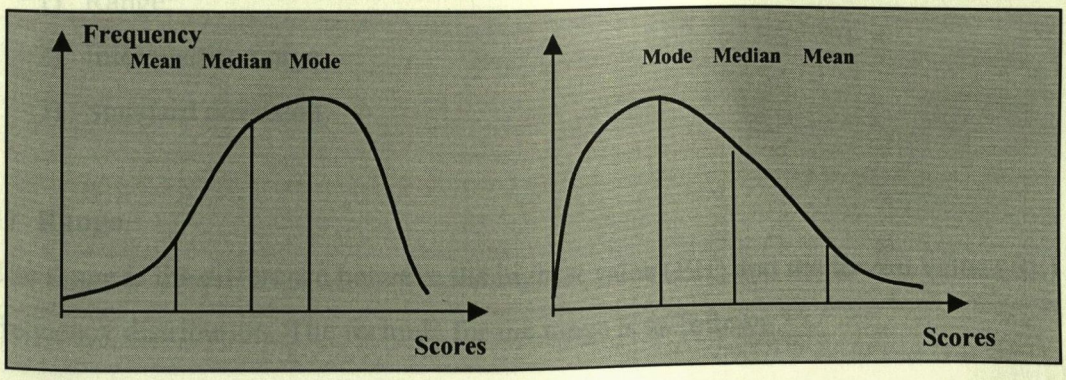
The mean, the median and the mode all use different definitions of central tendency, so you can get very different indicators of central tendency. When a frequency distribution curve is symmetrical, the mean, the median and the mode coincide (see Figure 5.2).

Figure 5.2: Frequency Distribution Curve Showing Normal Distribution



When the curve is skewed, the mean, the median and the mode have different values, with negatively skewed data, the tail is on the left and most of the data is at the upper end of the range and with positively skewed data, the tail is on right, and most of the data is at the lower end of the range (see Figure 5.3).

Figure 5.3: Distribution Curves Showing Negatively and Positively Skewed Distributions



When a frequency curve is unimodal and moderately skewed, the approximate relationships between the median, mean and mode is as follows:

Mean-Mode=3(Mean-Median)

Parametric techniques are used on normally distributed data and non-parametric techniques are used on skewed data.

4) Measuring Location of Quantity Data in this Study

All three measurements of central tendency as well as analysis of skewness were applied to quantity data, namely 'Establishment Year', 'Number of Employees', 'Revenue in 1999', 'Revenue per Employee', 'Number of Business Partnerships' and 'Number of Inter-company Linkages' variables.

5.1.1.3 Measuring Dispersion

A measure which describes the spread of values in a data distribution is called a measure of dispersion or spread. Measures of location and dispersion if used together give a concise and useful description of the distribution of the set of data. The three widely used measures of dispersion are:

1) Range;
2) Interquartile range;
3) Standard deviation.

1) Range

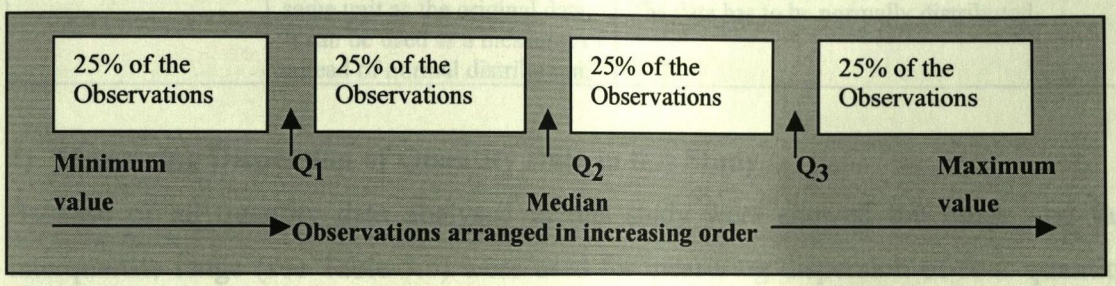
The range is the difference between the highest value (EH) and the lowest value (EL) in a frequency distribution. The formula for the range is as follows:

Range=EH-EL

2) Inter-quartile Range

Interquartile range measures the spread of the middle 50% of observations and is calculated as difference between the upper quartile - a quarter of the whole spread – (Q3) and the lower quartile (Q1) (see figure 5.4).

Figure 5.4: Inter-quartile Range



The formula for calculating the inter-quartile range is as follows:

Interquartile range= Q3-Q1

3) Standard Deviation

Standard deviation is calculated by adding together all the differences (deviations) between observations and the mean, these differences are squared and then de-squared to avoid negative values of deviations. The formula for calculating it is:

$$S = SQR[\Sigma(x - MEAN(x))^2/n]$$

where

x = an observation

MEAN(x) = the mean

n = the total number of observations

The standard deviation is a parametric technique and is only applicable to normally distributed data. Table 5.5 summarises advantages and disadvantages of using range, interquartile range and standard deviation as measures of central tendency.

Table 5.5: Comparing Range, Interquartile Range and Standard Deviation

Measure of Location	Advantages	Disadvantages
Range	It is easy to calculate.	It is easy affected by outliers (extreme values).
Interquartile Range	It is easy to calculate.	It does not use all values of the spread.
Standard Deviation	It uses every value and is the same unit as the original data; It can be used as a measures of spread of normal distribution.	It is relatively difficult to calculate. The data has to be normally distributed.

4) Measuring Dispersion of Quantity Data in this Study

Because of all quantity data analysed in this study were skewed the range and the interquartile range (see Table 5.5) were used for measuring dispersion of four quantity variables (e.g. 'Establishment Year', 'Number of Employees', 'Revenue in 1999', 'Revenue per Employee', 'Number of Business Partnerships' and 'Number of Inter-company Linkages').

5.1.2 Confirmatory Data Analysis

Confirmatory data analysis is normally used for estimating from samples, measuring association, measuring difference and forecasting. Table 5.6 summarizes the most commonly used statistics, which considered for use in analysing research findings.

Table 5.6: Confirmatory Data Analysis by Type of Data

Technique or Procedure	Type of Data
Estimating from Samples - Confidence Intervals (P)	Univariate; must be normally distributed.
Forecasting - Time Series Analysis	Univariate; must be available for several past periods of time.
Measuring Association - Pearson's Coefficient (r) (P) **- Spearman's rank Coefficient (r_s) (NP)**	Bivariate; only suitable for interval or ratio data. **Bivariate; must be at least of ordinal status.**
Measuring Difference - Chi squared (χ^2) test (NP) - Student t-test (P)	Bivariate; nominal data. Bivariate; must be at least of interval status.

P = Parametric Technique; NP = Non-parametric Technique

Source: Hussey and Hussey, 1997, p. 222

Two major factors, namely the nature of data and what we were trying to find out influenced the choice of statistical techniques. The nature of data (normally distributed or skewed) determines the use of parametric or non-parametric techniques. Parametric techniques, which only can be used on data which has normal distribution, allow the comparison of sample statistics with population parameters. Non-parametric techniques are more general and can be used on skewed data. Because they are less discriminating, the results are correspondingly less reliable (Oakshott, 1994).

As it will be shown in the remaining parts of chapters five and six, all data under analysis in this research were skewed. For this reason, all parametric techniques, namely confidence intervals, Pearson's coefficient (r), student *t*-test were ruled out.

The prime objective of this study was to check the research hypothesis, which states 'Companies that have linkages with higher appropriateness are likely to have better performance'. The test of the hypothesis requires measuring association, rather than difference, which made the chi squared (χ^2) test inappropriate. Forecasting would have been very interesting for this research, but no data for past periods were available which made this type of analysis non-applicable. Because of the above reasons the choice of confirmatory data analysis techniques was reduced to Spearman's rank correlation coefficient (r_S).

5.1.2.1 Spearman's Rank Correlation Coefficient (r_S)

Because all variables considered in this study were skewed, a non-parametric technique – spearman's rank coefficient (r_S) was used for measuring association between these data. Spearman's rank correlation coefficient (r_S) is a non-parametric technique used to measure linear association between two variables where data is not normally distributed. In order to calculate Spearman's coefficient, the data must be at least of ordinal status. The formula is as follows:

$r_S = 1 - 6SUMd^2 / n(n^2 - 1)$

where

d = difference between the two ranked variables;

n = number of data pairs.

In the case of this study, this was calculated using the SPSS computer package.

5.2 THE RESULTS OF STATISTICAL ANALYSIS OF THE RESEARCH FINDINGS

In this section the results of explanatory data analysis with use of the statistical mechanism described above are outlined.

The details on 904 companies operating in the Irish software industry were collected while preparing this research. Updating the database revealed 62 companies which were no longer in business or could not be located. The remaining 842 companies were surveyed following procedures outlined in Chapter 3. 139 questionnaires (16.5%) were returned but 26 were dropped due to incomplete data, leaving a usable sample of 123, or 14.6% of the whole population.

5.2.1 Central Tendency and Dispersion Analysis

Five primary variables were extracted from the questionnaires. Four of them, namely 'Number of Business Partnerships', 'Revenue in 1999', Number of Employees' and 'Establishment Year' were quantitative discrete, the remaining, fifth variable – 'Nature of Software Business' was category nominal.

Two secondary variables, namely 'Revenue per Employee' and 'Number of Inter-company Linkages' were considered as well. 'Revenue per Employee' was calculated by dividing 'Revenue in 1999' by 'Number of Employees'. 'Number of Linkages' was

calculated by subtracting four business partnerships that do not have potential to produce innovation, namely licensing, contract-out coding/programming, contract-out disk duplication and contract-out package assembly, from 'Number of Business Partnerships' (for more details on the difference between inter-company linkages and business partnerships see Section 3.1.5). Both of these variables are quantitative discrete.

Different statistical techniques were used to analyse these data. First an exploratory analysis was performed: frequencies, location and dispersion were measured for all seven variables, following procedures described in Section 5.1.1. Then inter-dependencies among the variables were analysed. Two distinct statistical techniques were. A category, nominal variable 'Nature of Software Business' was compared with quantity discrete variables by means of cross tabulation. Prior to doing so, values of the quantity variables were re-coded into categories. After that, quantity discrete variables were inter-correlated using the non-parametric Spearman's correlation technique.

Two secondary variables ('Revenue per Employee' and 'Number of Inter-company Linkages') were analysed together with primary variables on which they are derived from, namely 'Revenue in 1999' and 'Number of Business Partnerships'. From the point of view adopted in this study, number of linkages is more appropriate indicator of inter-company collaboration. Nevertheless, 'Number of Business Partnerships' was applied in the statistical analysis as well. This should allow better comparison of this study results with the results of previous research (e.g. O'Riain, 1997; O'Gorman, Colm, O'Malley, 1997) in which the authors use 'Number of Business Partnerships' indicator.

5.2.1.1 Central Tendency and Dispersion for 'Number of Business Partnerships' and 'Number of Inter-company Linkages'

Table 5.7 shows that 123 companies took part in the study and reported that they had a total of 659 business partnerships. 552 (83.61%) out of these 659 business partnerships were recognised as inter-company linkages. A maximum number of business partnerships per company was 60 (maximum number of inter-company linkages per company was

50). The frequency distributions (see Appendix 5.1 for 'Number of Business Partnerships' and Appendix 5.1(1) for 'Number of Inter-company Linkages') show that 78.9% (97 out 133) of observed companies reported that they had one or more business partnerships. 71.4% (95 out 133) had inter-company linkages.

Table 5.7: Frequency Distribution for 'Number of Business Partnerships' and 'Number of Inter-company Linkages'

	'Number of Business Partnerships'	'Number of Inter-company Linkages'
Valid: No of Companies	123	123
Missing	0	0
Mean	5.36	4.49
Median	3	2
Mode	0	0
Inter-quartile Range	5	4
Skewness	4.243	4.296
Std. Error of Skewness	.218	0.218
Range	60	50
Minimum	0	0
Maximum	60	50
Sum: No of Partnerships, Linkages	659	552

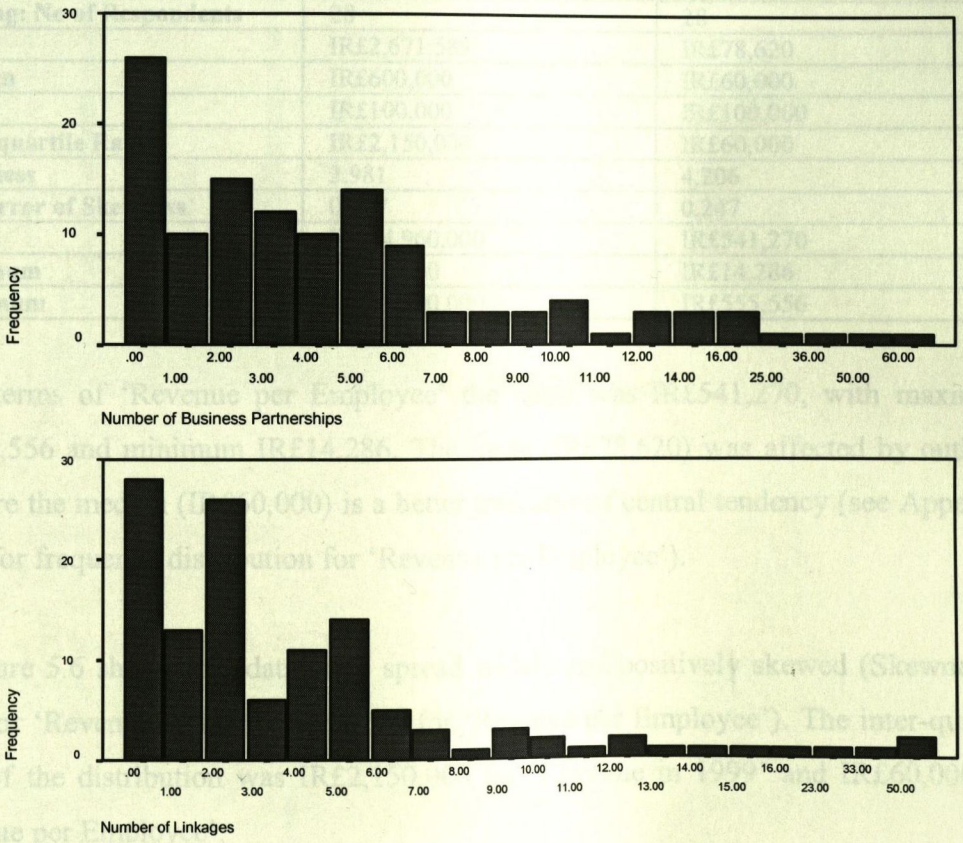
The mean and the median are two indicators of central tendency that are the most informative in these frequency distribution. The mode is 0 in both cases which only reflects the fact that it was the most frequently occurring value and does not give any information about companies that had linkages.

On average each company had 5.36 business partnerships (4.49 linkages) which are probably not the best indicators because they were greatly affected by outliers (see Figures 5.5). Therefore for these frequency distributions the median (3 for partnerships and 2 for linkages) are probably the most informative measures of central tendency.

Figure 5.5 shows that both sets of data were greatly spread (the range = 60 partnerships and 50 linkages) and positively skewed (skewness = 4.243 for partnerships and 4.296 for linkages) which indicates that majority of surveyed companies reported that they had less than 10 partnerships (8 linkages) per company. The inter-quartile range,

which indicates the spread of the middle 50% of observations was 5 partnerships and 4 linkages.

Figure 5.5: The Bar Charts Illustrating 'Number of Business Partnerships' and 'Number of Inter-company Linkages' Frequency Distributions



5.2.1.2 Central Tendency and Dispersion for 'Revenue in 1999' and 'Revenue per Employee'

Table 5.8 shows that only 95 out of 123 surveyed companies provided information about their revenue in 1999. The surveyed companies differed greatly as regards revenue they received in 1999 with minimum revenue reported – IR£40,000 and maximum – IR£35,000,000 (the range 34,960,000). The average revenue per company was IR£2,671,589. This indicator was affected by outliers (see frequency distribution for

'Revenue in 1999' in Appendix 5.2) and that is why the median – IR£600,000 is probably a more informative indicator of central tendency.

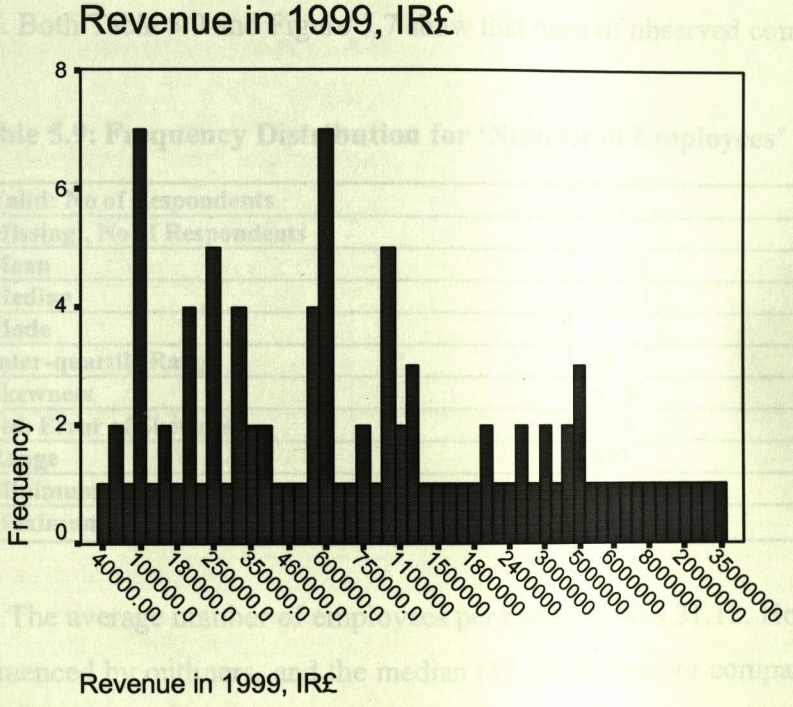
Table 5.8: Frequency Distribution for 'Revenue in 1999' and 'Revenue per Employee'

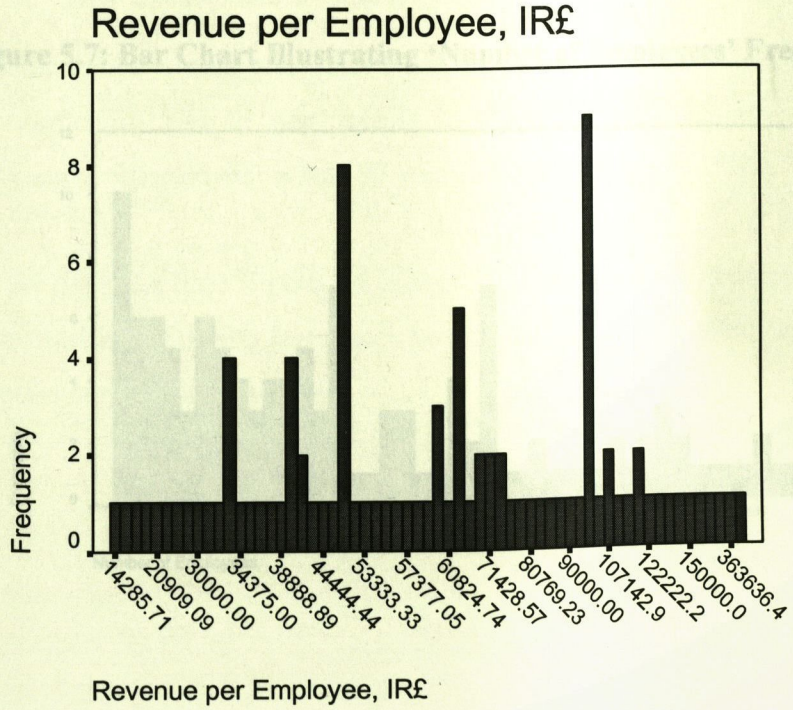
	'Revenue in 1999'	'Revenue per Employee'
Valid: No of Respondents	95	95
Missing: No of Respondents	28	28
Mean	IR£2,671,589	IR£78,620
Median	IR£600,000	IR£60,000
Mode	IR£100,000	IR£100,000
Inter-quartile Range	IR£2,150,000	IR£60,000
Skewness	3.981	4.206
Std. Error of Skewness	0.247	0.247
Range	IR£34,960,000	IR£541,270
Minimum	IR£40,000	IR£14,286
Maximum	IR£35,000,000	IR£555,556

In terms of 'Revenue per Employee' the range was IR£541,270, with maximum IR£555,556 and minimum IR£14,286. The mean (IR£78,620) was affected by outliers, therefore the median (IR£60,000) is a better indicator of central tendency (see Appendix 5.2(1) for frequency distribution for 'Revenue per Employee').

Figure 5.6 shows that data were spread widely and positively skewed (Skewness = 3.981 for 'Revenue in 1999' and 4.206 for 'Revenue per Employee'). The inter-quartile range of the distribution was IR£2,150,000 for 'Revenue in 1999' and IR£60,000 for 'Revenue per Employee'.

Figure 5.6: The Bar Charts Illustrating 'Revenue in 1999' and 'Revenue per Employee' Frequency Distributions





5.2.1.3 Central Tendency and Dispersion for 'Number of Employees'

The whole frequency distribution for 'Number of Employees' can be found in Appendix 5.3. Both Table 5.9 and Figure 5.7 show that most of observed companies were small.

Table 5.9: Frequency Distribution for 'Number of Employees'

Valid: No of Respondents	121
Missing:, No of Respondents	2
Mean	31.12
Median	12.00
Mode	1
Inter-quartile Range	24.5
Skewness	5.120
Std. Error of Skewness	.220
Range	499
Minimum	1
Maximum	500

The average number of employees per company was 31.12. However, this figure was influenced by outliners, and the median (12 employees per company) probably gives the best indication of the central tendency.

Figure 5.7: Bar Chart Illustrating 'Number of Employees' Frequency Distribution

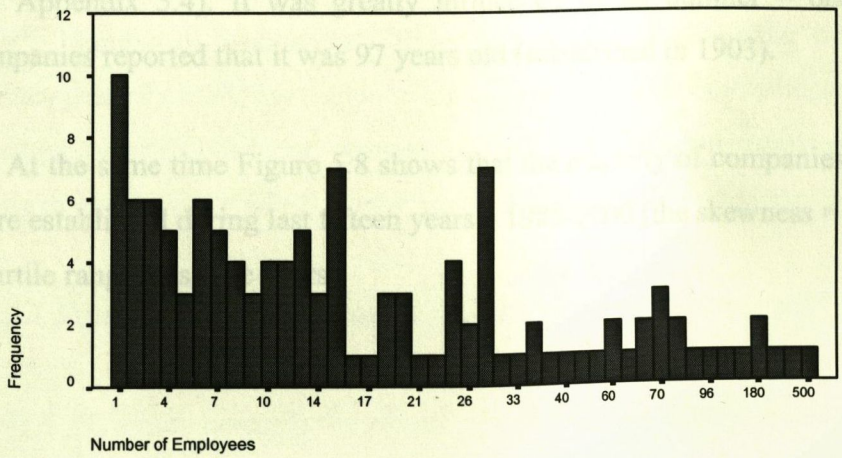


Figure 5.7 confirms that most of the observed companies were small (the skewness = 5.120). The inter-quartile range of the distribution was 24.5 employees. It shows that most occurring value (the mode) was 1 employee per company.

5.2.1.4 Central Tendency and Dispersion for 'Establishment Year'

'Establishment year' is a quantity, discrete variable and it was analysed as regards to its central tendency and dispersion. Table 5.10 shows that average age of observed companies was 9.8 years (the mean = 1990.16). The most frequently reported year was 1994.

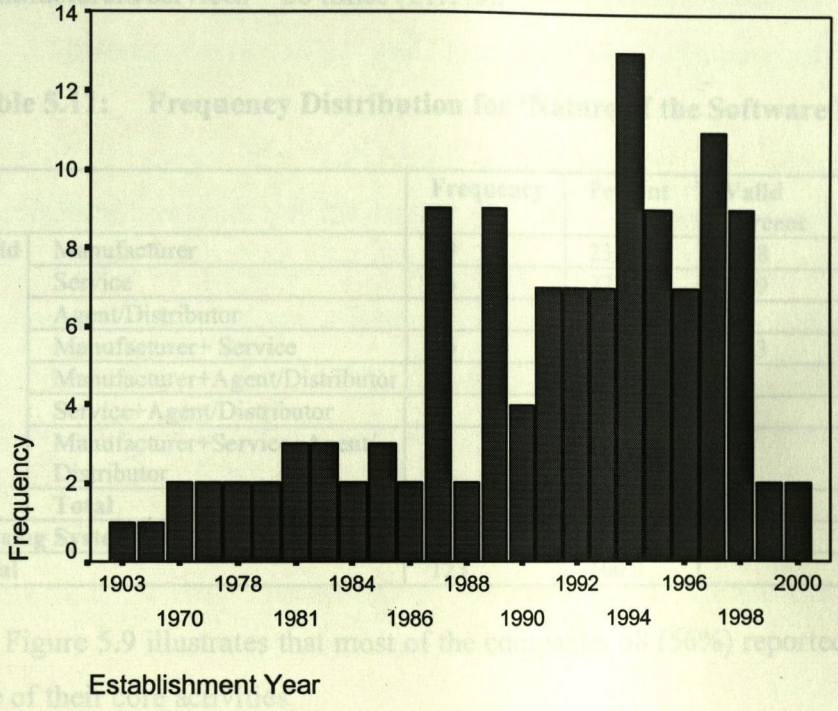
Table 5.10: Frequency Distribution for 'Establishment Year'

Mean	1990.16
Median	1992
Mode	1994
Inter-quartile Range	9
Skewness	-5.353
Std. Error of Skewness	.220
Range	97
Minimum	1903
Maximum	2000

The range of data was quite wide – 97 years (for whole frequency distribution table see Appendix 5.4). It was greatly influenced by an outliner – one of the observed companies reported that it was 97 years old (established in 1903).

At the same time Figure 5.8 shows that the majority of companies reported that they were established during last fifteen years – 1985-2000 (the skewness = -5.353). The inter-quartile range was nine years.

Figure 5.8: Bar Chart Illustrating 'Establishment Year' Frequency Distribution



5.2.2 Cross Tabulation Analysis

Cross tabulation was used for analysing the interdependencies between a nominal variable 'Nature of Software Business' and quantitative variables such as 'Establishment Year', 'Number of Employees', 'Revenue in 1999', 'Revenue per Employee', 'Number of Business Partnerships' and 'Number of Inter-company Linkages'. The numeric variables were recoded into discrete categories to make the results of cross tabulations easier to interpret (for SPSS syntax see Appendices 5.4(1) - 5.4(6)).

5.2.2.1 Frequency Distribution for 'Nature of Software Business'

Table 5.11, which contains the results of frequency distribution analysis for the 'Nature of Software Business' nominative variable, shows that participants most frequently reported service as being their core activity (34 times, 27.6% companies). It was followed

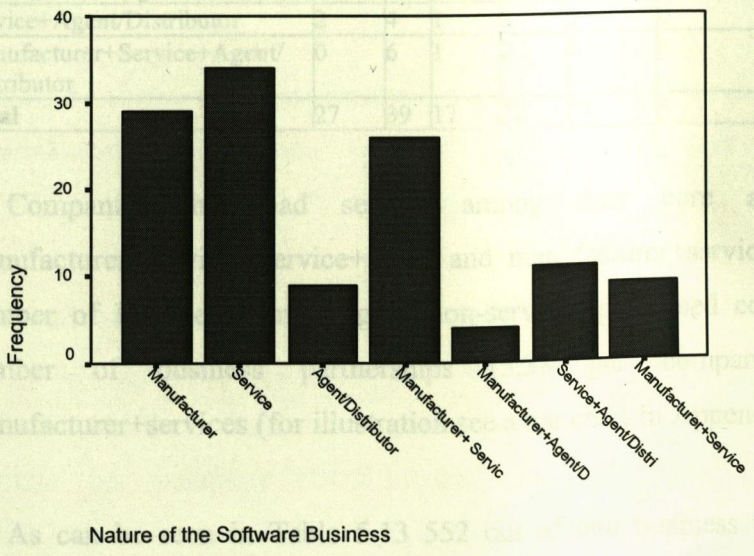
by companies specialised as manufacturers - 29 times (23.6%) and manufacturers/services – 26 times (21.1%).

Table 5.11: Frequency Distribution for 'Nature of the Software Business'

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Manufacturer	29	23.6	23.8	23.8
	Service	34	27.6	27.9	51.6
	Agent/Distributor	9	7.3	7.4	59.0
	Manufacturer+ Service	26	21.1	21.3	80.3
	Manufacturer+Agent/Distributor	4	3.3	3.3	83.6
	Service+Agent/Distributor	11	8.9	9.0	92.6
	Manufacturer+Service+Agent/ Distributor	9	7.3	7.4	100.0
	Total	122	99.2	100.0	
Missing System		1	.8		
Total		123	100.0		

Figure 5.9 illustrates that most of the companies 68 (56%) reported manufacturing as one of their core activities.

Figure 5.9: Bar Chart Illustrating Frequency Distribution for 'Nature of Software Business'



5.2.2.2 Interdependence between 'Nature of Software Business' and 'Number of Business Partnerships' and 'Number of Inter-company Linkages' Variables

Table 5.12 shows that companies specialised as manufacturers, services and manufacturer+services had the largest number of business partnerships between them (206, 188 and 88 respectively). 'Partnerships per Company' indicator can provide better information about linkages distribution among companies with different specialisation. The cross tabulation showed that companies specialised as manufacturer+agents had the highest number of partnerships per company (10.25) followed by manufacturers (7.1) and agents (6.22).

Table 5.12: Cross Tabulation of 'Nature of Software Business' and 'Number of Business Partnerships'

	'Number of Business Partnerships'						Total	The Mean Partnerships
	None	1-2	3-4	5-7	8-15	16-60		
Manufacturer	6	6	4	7	5	1	207	7.14
Service	10	10	5	4	3	2	188	5.53
Agent/Distributor	3	2	1	0	2	1	56	6.22
Manufacturer+Service	5	9	5	6	1	0	88	3.38
Manufacturer+Agent/Distributor	1	2	0	0	0	1	41	10.25
Service+Agent/Distributor	2	4	1	3	1	0	44	4.00
Manufacturer+Service+Agent/ Distributor	0	6	1	2	0	0	36	4.00
Total	27	39	17	22	12	5	660	5.36

Companies that had service among their core activities (e.g. service, manufacturer+service, service+agent and manufacturer+service+agents) had a smaller number of linkages comparing to non-service specialised companies. The minimum number of business partnerships (3.38 per company) was reported by manufacturer+services (for illustration see a bar chart in Appendix 5.5).

As can be seen in Table 5.13 552 out of 660 business partnerships (83.7%) had potential to produce innovation and consequently were recognised by the researcher as inter-company linkages. Similar to the case with business partnerships, companies

specialised as manufacturer+agent, manufacturer and agent had the largest numbers of linkages per company (9.25, 6 and 5.89 accordingly).

Table 5.13: Cross Tabulation of 'Nature of Software Business' and 'Number of Business Partnerships'

	'Number of Inter-company Linkages'						Total	The Mean Linkages
	None	1-2	3-4	5-7	8-15	16-60		
Manufacturer	6	6	4	7	5	1	174	6
Service	10	10	5	4	3	2	153	4.5
Agent/Distributor	3	2	1	0	2	1	53	5.89
Manufacturer+Service	5	9	5	6	1	0	74	2.85
Manufacturer+Agent/Distributor	1	2	0	0	0	1	37	9.25
Service+Agent/Distributor	2	4	1	3	1	0	36	3.27
Manufacturer+Service+Agent/ Distributor	0	6	1	2	0	0	25	2.78
Total	27	39	17	22	12	5	552	4.49

Companies that were specialised in providing services alone or with other activities had less linkages compared to companies specialised in non-service activities. (see Appendix 5.5(1) for a bar chart).

5.2.2.3 Interdependence between 'Nature of Software Business' and 'Revenue in 1999' and 'Revenue per Employee' Variables

Table 5.14 shows that manufacturers, manufacturer/services and service/agents were the greatest earners of revenue in 1999. Between them they reported IR£80,730,000; IR£57,200,000 and IR£41,281,000 respectively.

Similar to the case with business partnerships and inter-company linkages, revenue per company can give a better idea about performance of companies specialised in different activities. Companies specialised as service+agents had the highest average revenue per company (IR£6,356,000) followed by manufacturer+service+agents (IR£3,730,000) and manufacturers (IR£3,670,000).

Table 5.14: Cross Tabulation of 'Nature of Software Business' and 'Revenue in 1999'

		'Revenue in 1999', IR£1,000						Total Revenue, IR£1,000	The Mean Revenue, IR£1,000
		1-100	100-500	500-1,000	1,000-5,000	5,000-10,000	10,000-40,000		
Nature of the Software Business	Manufacturer	3	6	3	7	1	2	80,730	3,670
	Service	3	7	7	7	1	0	30,250	1,210
	Agent/Distributor	1	3	1	0	1	0	8,950	1,492
	Manufacturer+ Service	1	9	2	7	3	0	41,281	1,876
	Manufacturer+ Agent/Distributor	0	1	0	2	0	0	5,550	1,850
	Service+Agent/ Distributor	2	2	1	1	1	2	57,200	6,356
	Manufacturer+Service+Agent/ Distributor	1	2	3	1	0	1	29,840	3,730
Total		11	30	17	25	7	5	253,801	2,672

The data in Table 5.14 (see also a bar chart in Appendix 5.6) shows that companies specialised in multiple activities tended to have higher revenues than companies specialised in a single activity with the exception of manufacturers. Companies specialised in manufacturing had higher revenue. Comparing data from tables 5.13 and 5.14 shows that companies with higher average number of linkages did not necessarily have more revenue.

Table 5.15 contains the results of 'Nature of the Software Business' - 'Revenue per Employee' cross-tabulation (for bar chart see Appendix 5.6(1)). It shows that companies specialised as service+agent, manufacturer and manufacturer+agent had the best performance in terms of revenue per employee (IR£116,975, IR£87,767 and IR£81,507 respectevly).

Similar to the case with 'Revenue in 1999', companies specialised in multiple activities had better performance than companies specialised in a single activity (excluding manufacturing). Companies that had manufacturing among their core activities had higher 'Revenue per Employee'.

Table 5.15: Cross Tabulation of 'Nature of Software Business' and 'Revenue per Employee' Data

		'Revenue per Employee', IR£1,000						The Mean Revenue per Employee
		1-20	20-40	40-60	60-80	80-120	120-600	
Nature of the Software Business	Manufacturer	2	6	3	3	5	3	87,767
	Service	1	6	8	3	6	1	63,485
	Agent/Distributor	0	1	3	0	2		64,880
	Manufacturer+ Service	0	7	4	4	5	2	76,660
	Manufacturer+ Agent/Distributor	0	0	1		2		81,507
	Service+Agent/ Distributor	0	0	2	3	1	3	116,975
	Manufacturer+Service+Agent/ Distributor	0	1	3	2	1	1	72,229
Total		3	21	24	15	22	10	78,620

5.2.2.4 Interdependence between 'Nature of Software Business' and 'Company Size' Variables

Table 5.16 shows that manufacturers, services, service+agents and manufacturer+services were the largest employers having 954, 938, 695 and 653 employees respectively (see also a bar chart in Appendix 5.7).

Table 5.16: Cross Tabulation of 'Nature of Software Business' and 'Number of Employees'

	'Number of Employees'						Total Number of Employees	The Mean Number of Employees
	1-10	11-30	31-50	51-70	71-100	101-500		
Manufacturer	9	13	3	1	1	2	954	33
Service	15	13	0	3	2	1	938	28
Agent/Distributor	5	3	0	1	0	0	162	18
Manufacturer+ Service	11	9	1	2	3	0	653	25
Manufacturer+ Agent/Distributor	1	2	1		0	0	72	18
Service+Agent/ Distributor	6	1	2	1	0	1	695	63
Manufacturer+Service+Agent/ Distributor	5	1	0	1	0	1	291	36
Total	52	42	7	9	6	5	3765	31

Breaking these figures up by the number of companies shows that companies specialised as service+agent reported the highest average number of employees per company (63), followed by manufacturer+service+agent (36) and manufacturers (33).

The number employed by companies specialised as service+agent was greatly influenced by an outlier – the largest company surveyed employed 500 people. So, excluded, the average for services is 22 employees per company.

5.2.2.5 Interdependence between 'Nature of Software Business' and 'Establishment Year' Variables

Table 5.17 (see also Appendix 5.8 for a bar chart) shows that the average age of companies of all specialisations was quite similar (close to overall average – 9.8 years).

Table 5.17: Cross Tabulation of 'Nature of Software Business' and 'Establishment Year'

	'Establishment Year'						Average Age, years
	1900-1980	1981-1985	1986-1990	1991-1994	1995-1997	1998-2000	
Manufacturer	9	13	3	1	1	2	7.3
Service	15	13	0	3	2	1	7.6
Agent/Distributor	5	3	0	1	0	0	12.1
Manufacturer+ Service	11	9	1	2	3	0	9.8
Manufacturer+Agent/Distributor	1	2	1	0	0	0	12
Service+Agent/Distributor	6	1	2	1	0	1	17.5
Manufacturer+Service+Agent/ Distributor	5	1	0	1	0	1	10.6
Total	52	42	7	9	6	5	

High average age in the case of service+agents was caused by an outlier (the oldest company in the database which was established in 1903). With this company excluded, the average age of companies specialising as service+agent is 9.6 years. Companies that carried agent activities alone or in combination with other activities were older compared to other companies (e.g. manufacturers, services, manufacturer+services).

5.2.3 Correlation Analysis

Seven numeric continuous variables, namely 'Number of Linkages', 'Number of Business Partnerships', 'Revenue in 1999', 'Revenue per Employee', 'Number of Employees' and 'Establishment Year' and 'Revenue per Employee' were analyzed in pairs in order to find association among them.

First of all, these variables were checked as regard to their skewness. The results of the analysis (see Appendices 5.9 – 5.18) showed that all these data were skewed.

Spearman's rank correlation coefficient (r_S) was the non-parametric technique used to measure linear association between two variables where data is not normally distributed.

5.2.3.1 Correlation 'Number of Business Partnerships'/'Number of Inter-company Linkages' – 'Revenue in 1999'/'Revenue per Employee'

Table 5.18 which contains results of the correlation of 'Number of Business Partnerships' and 'Revenue in 1999' variables shows that there was a positive significant correlation (Correlation Coefficient = 0.270, r=0.01). Scatter plots illustrating results of this and following correlations are in Appendices 5.19 – 5.26.

Table 5.18: Correlation 'Number of Business Partnerships' – 'Revenue in 1999'

		Number of Business Partnerships	Revenue in 1999
Number of Business Partnerships	Correlation Coefficient	1.000	.270**
	Sig. (2-tailed)	.	.008
	N	123	95
Revenue in 1999	Correlation Coefficient	.270**	1.000
	Sig. (2-tailed)	.008	.
	N	95	95

** Correlation is significant at the .01 level (2-tailed).

Another indicator of companies' performance used in this study is 'Revenue per Employee'. Table 5.19 contains the results of correlation of 'Revenue per Employee' with 'Number of Business Partnerships'.

Table 5.19: Correlation 'Number of Business Partnerships' – 'Revenue per Employee'

		Number of Business Partnerships	Revenue per Employee
Number of business Partnerships	Pearson Correlation	1.000	-.036
	Sig. (2-tailed)	.	.732
	N	123	95
Revenue per Employee	Pearson Correlation	-.036	1.000
	Sig. (2-tailed)	.732	.
	N	95	95

One can see that there was a very weak, non-significant correlation (Correlation Coefficient = -0.036, Significance = 0.732).

The results of the above two correlation indicate that companies with more business partnerships tended to have higher revenue, however there was not any notable interdependence between 'Revenue per Employee' and 'Number of Business Partnerships'.

Table 5.20 contains the results of 'Number of Inter-company Linkages' - 'Revenue in 1999' correlation. It shows that there was positive significant inter-dependence (Correlation Coefficient = 0.293**, Significance = 0.004).

5.20 Correlation 'Number of Inter-company Linkages' – 'Revenue in 1999'

		Number of Linkages	Revenue in 1999
Number of Linkages	Correlation Coefficient	1.000	.293**
	Sig. (2-tailed)	.	.004
	N	123	95
Revenue in 1999	Correlation Coefficient	.293**	1.000
	Sig. (2-tailed)	.004	.
	N	95	95

** Correlation is significant at the .01 level (2-tailed).

The data in Table 5.21 show that no significant inter-dependence was found between 'Number of Inter-company Linkages' and 'revenue per Employee' variables (Correlation Coefficient = 0.036, Significance = 0.728).

5.21 Correlation 'Number of Inter-company Linkages' – 'Revenue per Employee'

		Revenue per Employee	Number of Linkages
Revenue per Employee	Correlation Coefficient	1.000	.036
	Sig. (2-tailed)	.	.728
	N	95	95
Number of Real Linkages	Correlation Coefficient	.036	1.000
	Sig. (2-tailed)	.728	.
	N	95	123

Overall, it can be said that the results of correlations 'Number of Business Partnerships' and 'Number of Inter-company Linkages' with 'Revenue in 1999'/'Revenue per Employee' were similar.

5.2.3.2 Correlation 'Number of Business Partnerships'/'Number of Inter-company Linkages' – 'Number of Employees'

As can be seen from Table 5.22 there was positive correlation between 'Number of Business Partnerships' and 'Number of Employees' variables (Correlation Coefficient = 0.281). This correlation was significant (Significance = 0.002).

Table 5.22: Correlation 'Number of Business Partnerships' – 'Number of Employees'

		Number of Business Partnerships	Number of employees
Number of Business Partnerships	Correlation Coefficient	1.000	.281**
	Sig. (2-tailed)	.	.002
	N	123	121
Number of employees	Correlation Coefficient	.281**	1.000
	Sig. (2-tailed)	.002	.
	N	121	121

** Correlation is significant at the .01 level (2-tailed).

Similar inter-dependence was found while analyzing 'Number of Inter-company Linkages' - 'Number of Employees' correlation (see Table 5.23). This means that in the Irish software industry, larger companies tend to have more business partnerships/linkages than smaller companies

Table 5.23: Correlation 'Number of Inter-company Linkages' – 'Number of Employees'

		Number of Linkages	Number of Employees
Number of Linkages	Correlation Coefficient	1.000	.293**
	Sig. (2-tailed)	.	.001
	N	123	121
Number of Employees	Correlation Coefficient	.293**	1.000
	Sig. (2-tailed)	.001	.
	N	121	121

** Correlation is significant at the .01 level (2-tailed).

5.2.3.3 Correlation 'Number of Business Partnerships'/'Number of Inter-company Linkages' – 'Establishment Year'

Table 5.24 contains the evidence that there was a very weak (Correlation Coefficient = 0.061), non-significant (Significance = 0.507) correlation between 'Number of Business Partnerships' and 'Establishment Year'.

Table 5.24: Correlations 'Number of Business Partnerships' – 'Establishment Year'

		Number of Business Partnerships	Establishment Year
Number of Business Partnerships	Correlation Coefficient	1.000	.061
	Sig. (2-tailed)	.	.507
	N	123	121
Establishment Year	Correlation Coefficient	.061	1.000
	Sig. (2-tailed)	.507	.
	N	121	121

Similar trend was found while analyzing 'Number of Inter-company Linkages' - 'Establishment Year' correlation (see Table 5.25). This means that the age of observed companies did not have any notable influence on numbers of partnerships or linkages that companies had.

Table 5.25: Correlations 'Number of Inter-company Linkages' – 'Establishment Year'

		Number of Linkages	Establishment Year
Number of Linkages	Correlation Coefficient	1.000	.066
	Sig. (2-tailed)	.	.473
	N	123	121
Establishment Year	Correlation Coefficient	.066	1.000
	Sig. (2-tailed)	.473	.
	N	121	121

5.2.3.4 Correlation 'Revenue in 1999'/'Revenue per Employee' – 'Establishment Year'

The results of the analysis shown in Table 5.26 indicate negative significant correlation between 'Revenue' and 'Establishment Year' variables (Correlation Coefficient = -0.215, Significance = 0.037).

Table 5.26: Correlation 'Revenue in 1999' – 'Establishment Year'

		Revenue in 1999	Establishment Year
Revenue in 1999	Correlation Coefficient	1.000	-.215*
	Sig. (2-tailed)	.	.037
	N	95	95
Establishment Year	Correlation Coefficient	-.215*	1.000
	Sig. (2-tailed)	.037	.
	N	95	121

* Correlation is significant at the .05 level (2-tailed).

Table 5.27 shows that there also was a negative (Correlation Coefficient = -0.201), significant (Significance = 0.050) correlation between 'Revenue per Employee' and 'Establishment Year'.

Table 5.27: Correlation 'Revenue per Employee' – 'Establishment Year'

		Revenue per Employee	Establishment Year
Revenue per Employee	Correlation Coefficient	1.000	-.201
	Sig. (2-tailed)	.	.050
	N	95	95
Establishment Year	Correlation Coefficient	-.201	1.000
	Sig. (2-tailed)	.050	.
	N	95	121

The results of the above correlations provide evidence that older companies in the Irish software industry tend to have better performance both in terms of revenue and revenue per employee than younger ones.

5.2.3.5 Correlation 'Revenue in 1999'/'Revenue per Employee' – 'Number of Employees'

Table 5.28 shows that there was a very strong (Correlation Coefficient = 0.910) positive significant correlation between 'Revenue in 1999' and 'Number of Employees' variables.

Table 5.28: Correlations 'Revenue in 1999' – 'Number of Employees'

		Revenue in 1999	Number of employees
Revenue in 1999	Correlation Coefficient	1.000	.910**
	Sig. (2-tailed)	.	.000
	N	95	95
Number of employees	Correlation Coefficient	.910**	1.000
	Sig. (2-tailed)	.000	.
	N	95	121

** Correlation is significant at the .01 level (2-tailed).

At the same time there was no notable (Correlation Coefficient = 0.044) correlation between 'Revenue per Employee' – 'Number of Employees' (see Table 5.29).

Table 5.29: Correlation 'Revenue per Employee' – 'Number of Employees'

		Revenue per Employee	Number of employees
Revenue per Employee	Correlation Coefficient	1.000	.044
	Sig. (2-tailed)	.	.672
	N	95	95
Number of Employees	Correlation Coefficient	.044	1.000
	Sig. (2-tailed)	.672	.
	N	95	121

The results of these correlations show that larger companies not necessarily have better performance results (in terms of revenue per employee) than smaller companies.

5.2.3.6 Correlation 'Number of Employees' – 'Establishment Year'

There was significant negative (Correlation Coefficient = - 0.197) correlation between 'Number of Employees' and 'Establishment Year' variables (see Table 5.30).

Table 5.30: Correlation 'Number of Employees' – 'Establishment Year'

		Number of employees	Establishment Year
Number of employees	Correlation Coefficient	1.000	-.197**
	Sig. (2-tailed)	.	.030
	N	121	121
Establishment Year	Correlation Coefficient	-.197**	1.000
	Sig. (2-tailed)	.030	.
	N	121	121

* Correlation is significant at the .05 level (2-tailed).

This means that older companies in the Irish software industry tend to be larger than younger ones.

5.2.4 Cross-sectional Analysis

Cross sectional analysis was undertaken in order to investigate the influence of variables, both continuous such as 'Establishment Year', 'Number of employees', 'Revenue in 1999', 'Revenue per Employee', 'Number of Business Partnerships' and 'Number of

Linkages as well as a discrete variable - 'Nature of the Software Business' on the bivariate correlations of the above continuous variables (for more details on these correlations see Section 5.2.3).

Scatter graphs displaying the relation between pairs of continuous variables from the list above were run several times each with a marker set by five remaining variables (those that were not correlated). Originally these graphs appeared to be very dense, because nearly every dot on them had its own value, which made visual analysis difficult to perform. In order to simplify this analysis, all continuous data were re-coded into six categories each (for SPSS syntax see Appendices 5.4(1) - 5.4(6)). Recoding the data reduced the variety of marks to six which made spotting the trends while analysing the scatter graphs easier (For scatter graphs see Appendices 5.27 - 5.91).

Table 5.31 The Results of Cross-sectional Analysis

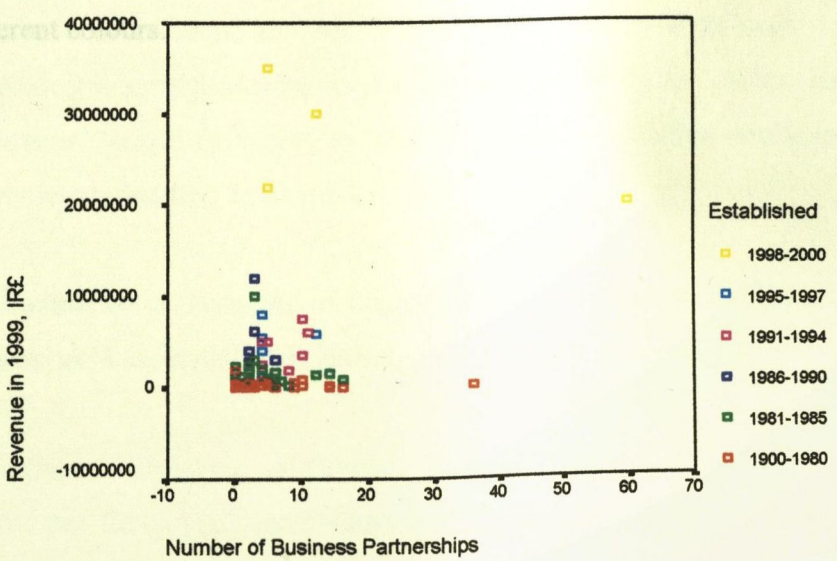
Correlations	Establishment Year	Number of Employees	Nature of the Software Business	Revenue in 1999	Revenue per Employee	Number of Linkages	Number of Business Partnerships
'Number of Business Partnerships' - 'Revenue in 1999'	No Influence	No Influence	YES	No Influence		No Influence	
'Number of Business Partnerships' - 'Revenue per Employee'	No Influence	YES	No Influence		No Influence	No Influence	
'Number of Business Partnerships' - 'Number of Employees'	No Influence		YES	No Influence	No Influence	No Influence	
'Number of Business Partnerships' - 'Establishment Year'		No Influence	No Influence	No Influence	No Influence	No Influence	
'Revenue in 1999' - 'Establishment Year'		No Influence	No Influence		No Influence	No Influence	No Influence
'Revenue per Employee' - 'Establishment Year'			No Influence	No Influence		No Influence	No Influence
'Revenue in 1999' - 'Number of Employees'	No Influence		No Influence		No Influence	No Influence	No Influence
'Revenue per Employee' - 'Number of Employees'	No Influence		No Influence	No Influence		No Influence	No Influence
'Number of Employees' - 'Establishment Year'			No Influence	No Influence	No Influence	No Influence	No Influence
'Revenue in 1999' - 'Number of Linkages'	No Influence	No Influence	YES		No Influence		No Influence
'Revenue per Employee' - 'Number of Linkages'	No Influence	YES	No Influence	No Influence			No Influence
'Number of Employees' - 'Number of Linkages'	No Influence		YES	No Influence	No Influence		No Influence
'Establishment Year' - 'Number of Linkages'		No Influence	No Influence	No Influence	No Influence		No Influence

Table 5.31 above summarises the results of cross-sectional analysis. The rows of this table display thirteen correlations. The columns show six continuous and one discrete variables which were analysed as regard to their potential to influence the above correlations.

The blank cell on the cross between the column representing a correlation and a row representing a variable indicates that this variable is one of the correlated pair. A sign 'No Influence' on the cross between a column and a row, illustrates that the visual analysis of a scatter graph displaying the relation between two continuous variables, as shown in the row with a marker set by a variable (as shown in the column), showed that this variable did not have a noticeable pattern in the correlation.

Figure 5.10 illustrates the results of the 'negative' (No Influence) analysis. It shows a scatter graph displaying the relation between 'Number of Business Partnerships' and 'Revenue in 1999', with a marker set by the 'Establishment Year' variable (the first cell in the top left corner of Table 5.31).

Figure 5.10: Scatter Illustrating the Influence of the 'Establishment Year' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation

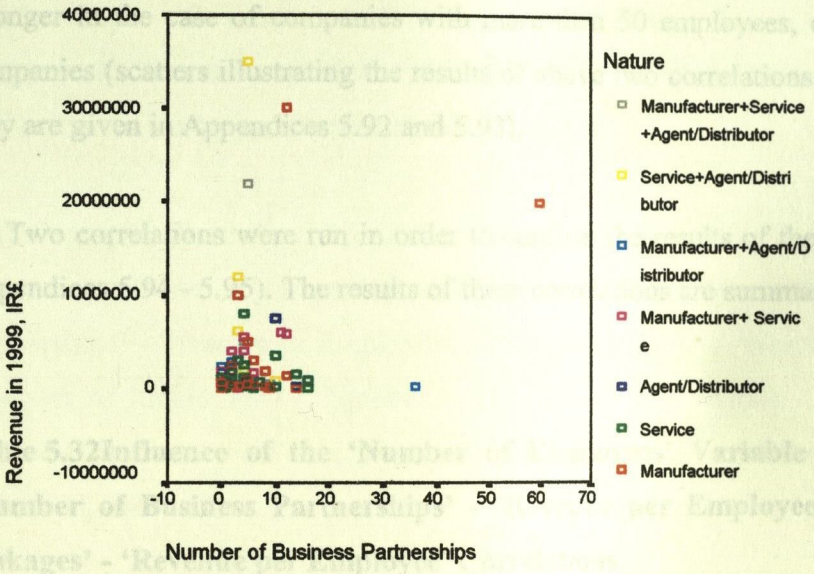


One can see that none of six colour-coded categories, namely companies established in 1998-2000, 1995-1997, 1991-1996, 1986-1990, 1981-1985 and 1900-1980, formed any visible trends. This means that there was no influence of 'Establishment Year' variable on the results of 'Number of Business Partnerships' - 'Revenue in 1999' correlation. While analysing the scatter graphs, their horizontal and vertical size was changed (when still on the screen of the computer) in order to spot possible trends.

A sign 'YES' means that the visual analysis of a scatter graph revealed some trend in one of the values of a variable set as a marker. It means that correlation was stronger and more significant for some data. Six cases like that were found while doing cross-sectional analysis (see Table 5.31). All of these six cases were connected to two variables, namely 'Number of Employees' and 'Nature of the Software Business'.

The scatter graph in Figure 5.11 illustrates one of these six 'positive' cases - the influence of the 'Nature of the Software Business' variable on the 'Number of Business Partnerships' - 'Revenue per Employee' correlation (cell number three in the first row in Table 5.28). Six values of the 'Nature of the Software Business' variable, such as groups of companies specialised as manufacturer+service+agent, service+agent, manufacturer+agent, manufacturer+service, agent, service and manufacturer, were coded in different colours.

Figure 5.11: Scatter Illustrating the Influence of the 'Nature of the Software Business' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation



The visual analysis revealed that violet dots identifying companies specialised as manufacturer+service tended to form a stronger linear relationship (were closer scattered around an imaginary line) compared to dots of other colours identifying companies specialised in other activities. Then, the correlation analysis was run to test the discovery made as a result of visual analysis. The results of the correlation analysis confirmed that correlation was stronger (correlation coefficient = 0.435*) for companies specialised as manufacturer+service compared to other companies (correlation coefficient = 0.270**) - for more details see also Section 5.2.5.2.

5.2.4.1 Influence of 'Number of Employees' on 'Number of Business Partnerships' - 'Revenue per Employee' Correlation

Scatter graphs displaying relationship between 'Number of Business Partnerships' - 'Revenue per Employee' and 'Number of Linkages' - 'Revenue per Employee' with a

marker set by 'Number of Employees' were analysed following the procedure outlined in Section 5.2.5 (for scatters see Appendices 5.33 and 5.78).

This analysis revealed that the relation between variables in both correlations was stronger in the case of companies with more than 50 employees, compared to smaller companies (scatters illustrating the results of above two correlations for large companies only are given in Appendices 5.92 and 5.93).

Two correlations were run in order to confirm the results of the visual analysis (see Appendices 5.94 - 5.95). The results of these correlations are summarised in Table 5.32.

Table 5.32Influence of the 'Number of Employees' Variable on the Results of 'Number of Business Partnerships' - 'Revenue per Employee' and 'Number of Linkages' - 'Revenue per Employee' Correlations

	'Number of Employees'			
	Large Companies (50-500 Employees)		All Companies	
	Correlation Coefficient	Significance	Correlation Coefficient	Significance
'Revenue per Employee' - 'Number of Business Partnerships'	0.736	0.076	-0.036	0.732
'Revenue per Employee' - 'Number of Linkages'	0.639**	0.006	0.036	0.728

** Correlation is significant at .01 level

As can be seen from the table, the results of visual analysis were confirmed. Both correlations were stronger in case of large companies. It was particularly noticeable for 'Revenue per Employee' - 'Number of Linkages' correlation: correlation coefficient = 0.639**, significance = 0.006 for large companies comparing to correlation coefficient = 0.036, significance = 0.728 for all companies.

A number of explanations was considered while considering this phenomenon (for more details see Section 6.4.4). The one that suggests that large companies were more

likely to get innovation created as a result of linkages, which positively affected their performance, was chosen as a preferred explanation.

5.2.4.2 Influence of 'Nature of the Software Business' on 'Number of Business Partnerships' - 'Revenue in 1999', 'Number of Business Partnerships' - 'Number of Employees', 'Revenue in 1999' - 'Number of Linkages' and 'Number of Employees' - 'Number of Linkages' Correlations

Scatter graphs illustrating 'Number of Business Partnerships' - 'Revenue in 1999', 'Number of Business Partnerships' - 'Revenue per Employee'; 'Number of Business Partnerships' - 'Number of Employees'; 'Revenue in 1999' - 'Number of Linkages' and 'Number of Employees' - 'Number of Linkages' with a marker set by 'Nature of the Software Business' were subjected to visual analysis (for scatters see Appendices 5.29, 5.38, 5.74, and 5.83).

The visual analysis revealed trends with companies specialising as manufacturer+services (one of the values of 'Nature of the Software Business' variable) in all scatter graphs which signalled a stronger correlation for these (manufacturer+service) companies (Scatter graphs in Appendices 5.96 - 5.99 illustrate these trends).

Four correlation analyses were performed in order to test the results of the visual analysis (for more details see Appendices 5.100 - 5.103). Table 5.33 summarisers the results of the correlation analysis for manufacturer+services and shows how these results compare to the results of correlation analysis applied to all companies.

Table 5.33: Influence of the 'Nature of the Software Business' Variable on 'Number of Business Partnerships' - 'Revenue in 1999', 'Number of Business Partnerships' - 'Number of Employees', 'Revenue in 1999' - 'Number of Linkages' and 'Number of Employees' - ''Number of Linkages' Correlations

	'Nature of the Software Business'			
	Manufacturer+Services		All Companies	
	Correlation Coefficient	Significance	Correlation Coefficient	Significance
'Number of Business Partnerships' - 'Revenue in 1999'	0.435*	0.043	0.270**	0.008
'Number of Business Partnerships' - 'Number of Employees'	0.520**	0.006	0.281**	0.002
'Revenue in 1999' - 'Number of Linkages'	0.390	0.073	0.293**	0.004
'Number of Employees' - 'Number of Linkages'	0.482*	0.013	0.293**	0.001

** Correlation is significant at the .01 level (2-tailed)
* Correlation is significant at the .05 level (2-tailed)

CONCLUSIONS

One hundred and twenty-three software companies operating in the Irish software industry took part in this research. These companies were asked to supply information on 'Establishment Year', 'Number of Employees', 'Nature of the Software Business', 'Revenue in 1999', 'Revenue per Employee', 'Number of Business Partnerships' and 'Number of Linkages. Both exploratory and confirmatory methods of statistical analysis were applied to analyse data received from the companies.

According to explanatory analysis (summarized in Table 5.34) the average company was established in 1992, had 12 employees, was specialising as manufacturer or manufacturer+service and reported IR£600,000 in revenue in 1999 (IR£60,000 in revenue per employee). It had three business partnerships, two of which were linkages (had potential to produce innovation).

Table 5.34: The Major Findings Made while Conducting the Analysis of Central Tendency and Dispersion

Variables	The major findings
'Establishment Year'	The average company was established in 1992 (the median). The oldest company that took part in the research was established in 1903, the youngest ones in 2000.
'Number of Employees'	The average company had 12 people employed (the median). The most occurring number of employees per company was 1. The largest company that took part in the study reported that it had 500 employees.
'Nature of Software Business'	The largest proportions of companies that took part in the study reported that they were services (27.6%), manufacturers (23.6%), and manufacturer+services (21.3%).
'Revenue in 1999'	The average company had IR£600,000 in revenue in 1999 (the median). The lowest revenue reported was IR£40,000, the highest – IR£35,000,000.
'Revenue per Employee'	The average company had IR£60,000 (the median) in 'Revenue per Employee'. The lowest 'Revenue per Employee' was IR£14,286 and the highest 'Revenue per Employee' - IR£555,556.
'Number of Business Partnerships'	123 observed companies reported that they had 659 business partnerships among them. 97 companies (78.9%) had one or more partnerships, 26 companies (21.1%) did not have any partnerships. An average company (the median) had 3 partnerships. The largest number of partnerships per company – 60.
Number of Linkages	123 observed companies reported that they had 552 linkages. This means that 83.61% of all business partnerships were assumed to have potential to produce innovation. 95 companies (71.4%) reported one or more linkages. An average company (the median) had 2 linkages. The largest number of linkages per company was 50.

Tables 5.35-5.36 presents the results of association analysis. Cross-tabulation was applied to analyse association between category nominal variable 'Nature of the Software Business' and four quantity discrete variables, namely 'Establishment Year', 'Number of Employees', 'Revenue in 1999', 'Revenue per Employee', 'Number of Business Partnerships' and 'Number of Linkages'. This analysis (see Table 5.35) showed that companies specialising as manufacturer+agents had the largest average number of business partnerships per company (10.25) as well as the largest average number of linkages per company (9.25). Companies specialising as service+agents reported the highest average revenue (IR£5,200,000) as well as largest average number of employees (63.2). At the same time, companies specialising as service+ agent reported the highest average revenue per employee (IR£116,975).

Table 5.35: The Major Findings Made while Conducting Cross-tabulation

Cross Tabulations	The Major Findings
'Nature of Software Business' – 'Number of Business Partnerships'	Manufacturer/agents, manufacturers and agents had largest numbers of linkages per company (10.25, 7.1 and 6.2). Companies specialising in services tended to have fewer linkages.
'Nature of Software Business' - 'Number of Linkages'	Companies specialising as manufacturer+agent, manufacturer and agent had the largest numbers of linkages per company (9.25, 6 and 5.89 accordingly).
'Nature of Software Business' – 'Revenue in 1999'	Service/agents, manufacturer/service/agents and manufacturers had highest revenue per company (IR£5,200,000; IR£3,316,000 and IR£2,784,000) Companies specialising in multiple activities tended to have higher revenue.
'Nature of Software Business' - 'Revenue per Employee'	Similar to the case with 'Revenue in 1999', companies specialising in multiple activities had more 'Revenue per Employee' compared to companies specialising in one activity (excluding manufacturing). Companies that had manufacturing among their core activities had higher 'Revenue per Employee'. Companies specialising as service+agent, manufacturer and manufacturer+agent reported highest 'Revenue per Employee' (IR£116,975, IR£87,767 and IR£81,507 accordingly).
'Nature of Software Business' – 'Number of Employees'	Service/agents, manufacturers and manufacturer/services had largest numbers of employees per company (63.2, 32.9 and 32.3).
'Nature of Software Business' – 'Establishment Year'	There was a difference in age between companies specializing in different activities. Companies specializing in some form of agent activities were older.

Association between four quantity discrete variables was measured by applying Spearman's correlation coefficient. This analysis (see Table 5.36) showed that larger companies had more business partnerships/linkages and higher revenue. At the same time, larger companies did not have better performance in terms of revenue per employee compared to smaller companies.

Older companies had more employees, more business partnerships/linkages as well as higher revenue/revenue per employee figures compared to younger companies. Companies with more business partnerships/linkages tended to have higher revenue. At the same time, older companies did not necessarily have more business partnerships.

Table 5.36: The Major Findings Made while Conducting Correlations

Correlation	The Major Findings
'Number of Business Partnerships' - 'Revenue in 1999'	Companies with more linkages tended to have higher revenue (Correlation coefficient = 0.270**, Significance = 0.008).
'Number of Business Partnerships' - 'Revenue per Employee'	No significant correlation was found (Correlation coefficient = -0.036, Significance = 0.732).
'Number of Linkages' - 'Revenue in 1999'	Companies with more linkages tended to have more revenue (Correlation coefficient = 0.293**, Significance = 0.004).
'Number of Linkages' - 'Revenue per Employee'	No significant correlation was found (Correlation coefficient = 0.036, Significance = 0.728).
'Number of Business Partnerships' - 'Number of Employees'	Larger companies tended to have slightly more business partnerships than smaller ones (Correlation coefficient = 0.281**, Significance = 0.002).
'Number of Linkages' - 'Number of Employees'	Larger companies tended to have more linkages than smaller ones (Correlation coefficient = 0.293**, Significance = 0.001).
'Number of Business Partnerships' - 'Establishment Year'	No significant correlation was found (Correlation coefficient = 0.061, Significance = 0.507).
'Number of Linkages'- 'Establishment Year'	No significant correlation was found (Correlation coefficient = 0.066, Significance = 0.473).
'Revenue in 1999' - 'Establishment Year'	Older companies tended to have more revenue than younger ones (Correlation coefficient = -0.215*, Significance = 0.037).
'Revenue per Employee' - 'Establishment Year'	Older companies tended to have higher 'Revenue per Employee' than younger ones (Correlation coefficient = 0.201, Significance = 0.050).
'Revenue in 1999' - 'Number of Employees'	Larger companies had higher revenue than smaller ones (Correlation coefficient = 0.910**, Significance = 0.000).
'Revenue per Employee' - 'Number of Employees'	No significant correlation was found (Correlation coefficient = 0.044, Significance = 0.672).
'Number of Employees' - 'Establishment Year'	Older companies tended to be larger than younger ones (Correlation coefficient = 0.197*, Significance = 0.030).

* Correlation is significant at the .05 level (2-tailed)
** Correlation is significant at the .01 level (2-tailed)

The results of cross-sectional analysis of the above correlations revealed that 'Revenue per Employee' - 'Number of Business Partnerships' and 'Revenue per Employee' - 'Number of Linkages' associations were stronger for large companies (50-500 employees) compared to smaller companies. The results of 'Number of Business Partnerships' - 'Revenue in 1999', 'Number of Linkages' - 'Revenue in 1999', 'Number of Business Partnerships' - ' 'Number of Employees' and 'Number of Linkages' - 'Number of Employees' were stronger for companies specialising as manufacturer+services compared to companies of other specialisation.

CHAPTER 6

ANALYSIS, DISCUSSION AND CONCLUSIONS

INTRODUCTION

This chapter contains an analysis of the research results (see also Chapter 5). It shows how the research model has been tested and outlines the contribution to knowledge which has been made by this study. In the course of the discussion the limitations of the research methodology were highlighted.

The chapter consists of four sections. The first section 'Establishing the Data Analysis Procedure' outlines the procedure used for the data analysis. Section two 'Hypothesis Testing' contains the results of correlation of 'Linkage Appropriateness' and 'Revenue per Employee' which had been undertaken in order to test the research hypothesis, which predicts that companies that have linkages with higher appropriateness have better performance. A number of factors which could have caused the weak correlation between these two variables are discussed in section three 'Possible Explanations for the Weak Correlation between 'Linkage Appropriateness' and 'Revenue per Employee', which indicated that the hypothesis is not fully supported. The most probable explanations are summarised in the fourth section 'Preferred Explanations for the Weak Correlation between 'Linkage Appropriateness' and 'Revenue per Employee'. Section five shows how different factors affect 'Linkage Appropriateness' - 'Revenue per Employee' correlation. The contribution to knowledge made by this study is discussed in the sixth section 'Contribution to Knowledge'. The seventh, final, section of the chapter outlines the suggestions for further research.

6.1 ESTABLISHING THE DATA ANALYSIS PROCEDURE

The hypothesis developed for this study states: '**Companies that have linkages with higher appropriateness have better performance**'. In order to test this hypothesis it was necessary to find out whether, if companies establish linkages with higher 'Appropriateness' (independent variable), the 'Revenue per Employee' of these companies increases (dependent variable).

Figure 6.1 outlines the principle decisions that were made while analysing data for association.

Figure 6.1 The Principle Decisions which were made while Analysing Data

1. **Determining the type of data. If the data is normally distributed, a parametric technique is used; if the data is skewed, a non-parametric technique is used.**
2. **Deciding on the nature of sample (related or independent).**
3. **Deciding whether difference or association is measured, which determine specific technique to use.**
4. **Deciding on the nature of hypothesis (one- or two-tailed).**
5. **Establishing the acceptable level of significance.**

6.1.1 Determining the Type of Data under Analysis

First of all, both variables under analysis, namely 'Linkage Appropriateness' (calculated as described in Section 3.3) and 'Revenue per employee', were examined with regard to skewness.

Table 6.1 contains the results of the skewness analysis for the 'Linkage Appropriateness' variable. It shows the that data were positively skewed (skewness = 4.081). This means that this did not have a normal distribution (see Chapter 5), that its peak is offset to the right (positive) side, and that most of this data are at the lower end of the range (see Figures 6.2 and 6.3).

Table 6.1: Skewness of 'Linkage Appropriateness' Data

Valid	123
Missing	0
Skewness	4.081
Standard Error of Skewness	0.218

Figure 6.2 illustrates the skewed character of the frequency distribution for the 'Linkage Appropriateness' variable.

Figure 6.2: Histogram of 'Linkage Appropriateness' Data

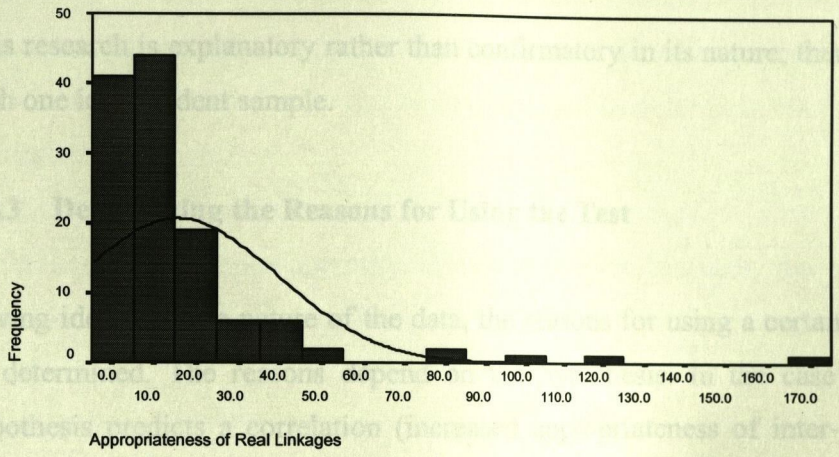


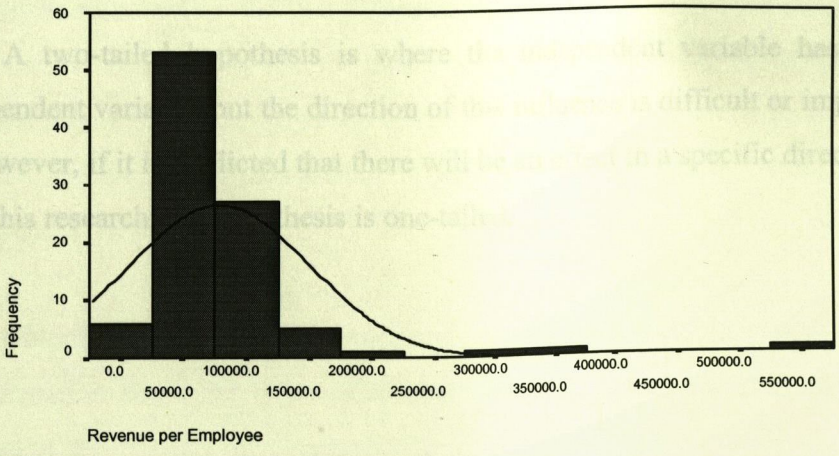
Table 6.2 shows that 'Revenue per Employee' data was also positively skewed (Skewness = 4.206).

Table 6.2: Skewness of 'Revenue per Employee' Data

Valid	95
Missing	28
Skewness	4.206
Standard Error of Skewness	0.247

Figure 6.3 confirms that the frequency distribution for 'Revenue per Employee' data was skewed.

Figure 6.3: Histogram for 'Revenue per Employee' Data



6.1.2 The Nature of Sample

This research is explanatory rather than confirmatory in its nature; therefore it deals only with one independent sample.

6.1.3 Determining the Reasons for Using the Test

Having identified the nature of the data, the reasons for using a certain type of test must be determined. The reasons depend on the hypothesis. In the case of this study the hypothesis predicts a correlation (increased appropriateness of inter-company linkages leads to better performance); therefore statistical techniques for measuring association are used.

Because both variables are skewed, a non-parametric technique – Spearman's Rank Correlation Coefficient (r_S) was used for measuring association between these data.

6.1.4 Determining the Nature of Hypothesis

Hussey and Hussey (1997, p. 222) define an hypothesis as

> '... an idea or proposition which can be tested against empirical evidence (data which is based on observation or experience)'.

A two-tailed hypothesis is where the independent variable has an effect on the dependent variable, but the direction of this influence is difficult or impossible to predict. However, if it is predicted that there will be an effect in a specific direction, as is the case of this research, the hypothesis is one-tailed.

6.1.5 Establishing the Acceptable Level of Significance

There are two traditional probability levels used in statistics – 5 percent (1 in 20) probability that the results are due to chance; and 1 per cent (1 in 100) probability that the results are due to chance.

In keeping with the majority of social science research, the 5 percent level of significance is adopted for this study.

6.2 HYPOTHESIS TESTING

The main objective of this study was to get empirical evidence to test the study's hypothesis that states that: **'Companies that have linkages with higher appropriateness have better performance'**.

While deciding on an appropriate performance indicator for this research, 'Revenue per Employee' was chosen as the most practical alternative. This choice was preconditioned by two factors. Firstly, revenue or revenue per employee performance indicators were most commonly used in up-to-date studies on linkages in the Irish software industry (for more details see Section 2.1.1). Therefore, using this indicator would make easier a comparison of this study's results with the data from previous research. And, secondly, in the course of a pilot study, we were advised that companies could be reluctant to disclose information other than revenue per employee performance indicators because they may be either not immediately available or may be considered to be confidential. The information necessary for calculating this indicator was collected by means of asking questions about companies' 1999 revenue and number of employees (see Appendix 4.1).

Calculating Linkage Appropriateness required two information inputs, namely information about the types of linkages that companies had and information about the stage of the industry development (for more details see Chapter 3).

6.2.1 Analysing Information about the Stage of Industry Development

While working on the research methodology, it was suggested that different sub-sectors within the Irish software industry could be in different stages of their development. In order to test this suggestion, the companies were asked to indicate the stage of development of each sub sector within which they had operations (question 1 in the questionnaire - see Appendix 4.1).

The analysis of the answers shows that most of the sub-sectors, namely general business application products, bespoke development, banking/finance systems, software tools/systems software, computer-based training, telecommunication software, firmware, agricultural software, marketing multimedia software, software for legal sector, library automation software, property management software and specialist labelling applications, reported that they were in their growth stage of development. A second group of sub sectors such as software localisation, measurement software, service implementation and integration, ERP implementation and process control software, were reported as being at the maturity stage of development. And finally, aeronautics, CRM software, ASP software and portal/vortal development were stated as being at an emergent state of development (for frequency distributions see Appendices 6.1-6.22).

One can see that majority of sub-sectors (13 out of 22) reported that they were in their growth stage of development. This largely coincides with the results of the analysis of the secondary data characterising the Irish software industry, namely number of companies, employment, exports and total revenue. The analysis of the profile of these factors development showed that the whole industry is in its growth stage of development (for more details see Section 3.2.3).

6.2.2 Analysing the Information about the Types of Linkages that Companies Reported

The information on the types of linkages that companies had was collected by means of asking question 2 in the questionnaire (see Appendix 4.1). Not all types of linkages listed in the questionnaire were used in the analysis because four of them, namely licensing, contract-out coding/programming, contract-out disk duplication and contract-out package assembly do not comply with the definition of linkages used in this study i.e. they had not been believed to have a potential to generate either primary or incremental innovation. These four types of business partnership were observed in order to increase the descriptive value of the research.

6.2.3 Correlating 'Linkage Appropriateness' and 'Revenue per Employee'

Based on the above information linkage appropriateness and an indicator of performance - revenue per employee were calculated. These data were tested with regard to their skewness. The analysis (see Appendices 6.23-6.24) shows that they are positively skewed, which suggests the choice of a non-parametric technique (Spearman's rho) for correlating them. Table 6.3 contains the results of this correlation.

Table 6.3: Correlation of 'Linkage Appropriateness' and 'Revenue per Employee'

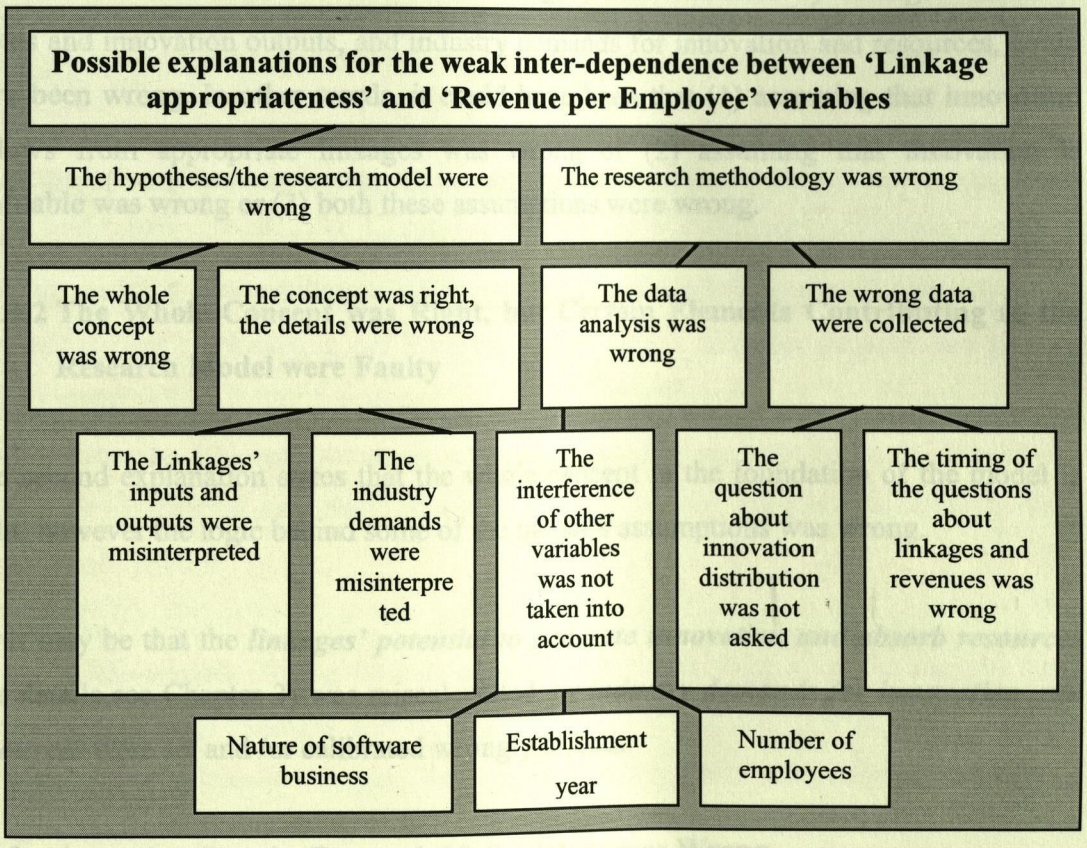
		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	.027
	Sig. (1-tailed)	.	.398
	N	123	95
Revenue per Employee	Correlation Coefficient	.027	1.000
	Sig. (1-tailed)	.398	.
	N	95	95

It shows a very weak (correlation coefficient = 0.027) non significant (significance = 0.398) correlation, which was not sufficient for accepting the research hypothesis.

6.3 POSSIBLE EXPLANATIONS FOR THE WEAK CORRELATION BETWEEN 'LINKAGE APPROPRIATENESS' AND 'REVENUE PER EMPLOYEE'

Figure 6.4 below illustrates possible explanations for the weak interdependence between the data.

Figure 6.4: Possible Explanations for the Weak Inter-dependence Between 'Linkage Appropriateness' and 'Revenue per Employee' Variables



6.3.1 Assuming that the Hypotheses/Research Model was Wrong

The first explanation for the weak correlation is that the hypothesis was wrongly formulated because the underpinning model was faulty.

Assuming that the research model was non-functional, one can put forward two possible explanations: the first one is that the whole concept was wrong; and the second that the whole concept was right but that certain details (parts of the model) were faulty.

6.3.1.1 The Whole Concept was Wrong

The whole idea of understanding linkage appropriateness (the ability to profit from the innovation created as a result of these linkages) as determined by linkages' resource inputs and innovation outputs, and industry demands for innovation and resources, could have been wrong. In other words, it could have been that (1) assuming that innovation follows from appropriate linkages was wrong or (2) assuming that innovation is profitable was wrong or (3) both these assumptions were wrong.

6.3.1.2 The Whole Concept was Right, but Certain Elements Contributing to the Research Model were Faulty

The second explanation states that the whole concept in the foundation of the model is right, however the logic behind some of the model's assumptions was wrong.

It may be that the ***linkages' potential to generate innovation and absorb resources*** (for details see Chapter 3) was miscalculated, or ***industry demands for innovation and resources*** were set and /or calibrated wrongly or both.

6.3.2 Assuming that the Research Methodology was Wrong

Another approach to explaining the weak correlation between the data is based on the assumption that the research model was right, but something in the research design was wrong, which led to either collecting insufficient or wrong data or misinterpretation of the correct data.

6.3.2.1 Collecting Insufficient or Wrong Data

Two potentially problematic areas in data collection have been identified, namely the question about innovation distribution was not asked and the timing of questions about linkages and revenue could be wrong (see Figure 6.4).

As regards the first (innovation distribution) concern, under assumption that all companies have access to innovation, created as result of linkages' activities, the question about the distribution of innovation outputs between companies with linkages was not asked.

If this assumption was wrong, the model's predictions would only be correct for those companies which get access to innovation. Companies that establish and sustain linkages, without gaining innovation outputs, should be excluded from the 'Linkage Appropriateness' - 'Revenue per Employee' correlation analysis, because the gain in performance, which in the framework of this model is foreseen for the companies with more appropriate linkages comes as a result of profiteering from linkages' innovation outputs. It is obvious, that those companies, which do not have access to innovation, cannot profit from it.

As to the second (wrong timing) concern, companies were asked to identify their present-time (2000) linkages and the last (1999) year revenue, therefore the possible effect of the most recent linkages (those established in 2000) did not have a chance to affect companies' performance.

6.3.2.2 Miscalculation of the Correct Data

It is also a possibility that the data were miscalculated because of wrong analysis design and/or statistical techniques. The results of the correlation of 'Linkage Appropriateness' and 'Revenue per Employee' could have been influenced by other independent variables such as 'Nature of Software Business', 'Establishment Year' and 'Number of Employees'.

6.4 PREFERRED EXPLANATIONS FOR THE WEAK CORRELATION BETWEEN 'LINKAGE APPROPRIATENESS' AND 'REVENUE PER EMPLOYEE'

Figure 6.5 illustrates the grounds on which different explanations for the weak correlation (as described above) were accepted/rejected.

Figure 6.5: The Reasons for Accepting/Rejecting Different Explanations for the Weak Correlation between "Linkage Appropriateness' and 'Revenue per Employee'

The Explanation	The grounds on which it was accepted/rejected
The Hypothesis/The Research Model was Wrong	
The Whole Concept was Wrong **The Concept was Right, the Details were Wrong** - The Linkages' inputs and outputs were misinterpreted; - The industry demands were misinterpreted.	**REJECTED** The research model was re-examined and no notable logical omissions were found either in the whole concept or the model's elements.
The Model was Right, the Research Design was Wrong	
The Wrong Data was Collected - The question about the distribution of innovation was not asked	**ACCEPTED:** The analysis shows that the model only worked for large companies (for details see Sub-sections 6.4.3.1-6.4.3.3). This was explained by the fact that large companies were more likely to get innovation created as a result of linkages. In order to test this assumption, one needed information about distribution of linkages' innovation outputs which is missing.
- The timing of questions about linkages and revenue was wrong	**ACCEPTED:** Because the companies were asked to identify their present time linkages, and revenue that they had in 1999, the most recent linkages (those established in 2000) did not have a chance to be reflected in companies performance (revenue per employee).
The Data were Miscalculated - Interference of different variables (i.e. 'Nature of Software Business', 'Establishment Year' and 'Number of Employees') into correlation had not been taken into account	**ACCEPTED:** The analysis shows that that the model worked differently for companies of different size i.e. 'Number of Employees' variable influenced the correlation (for details see Sub-sections 6.4.3.1 - 6.4.3.3).

As it can be seen in Figure 6.5, all basic assumptions and logic behind the research model (for more details see Chapter 3) were re-examined and still no notable mistakes or omissions were found, therefore it is still believed that the model is right and the research methodology-connected issues were believed to cause the weak correlation between 'Linkage Appropriateness' and 'Revenue per Employee'.

6.4.1 The Information on the Distribution of the Innovation had not been Collected

The failure to collect information about the distribution of innovation, created as a result of linkage activities was believed to be likely to disturb the models predictions, which could only be correct if a company gets access to the linkage innovation outputs.

6.4.2 The Timing of the Questions about Linkages and Revenue was Wrong

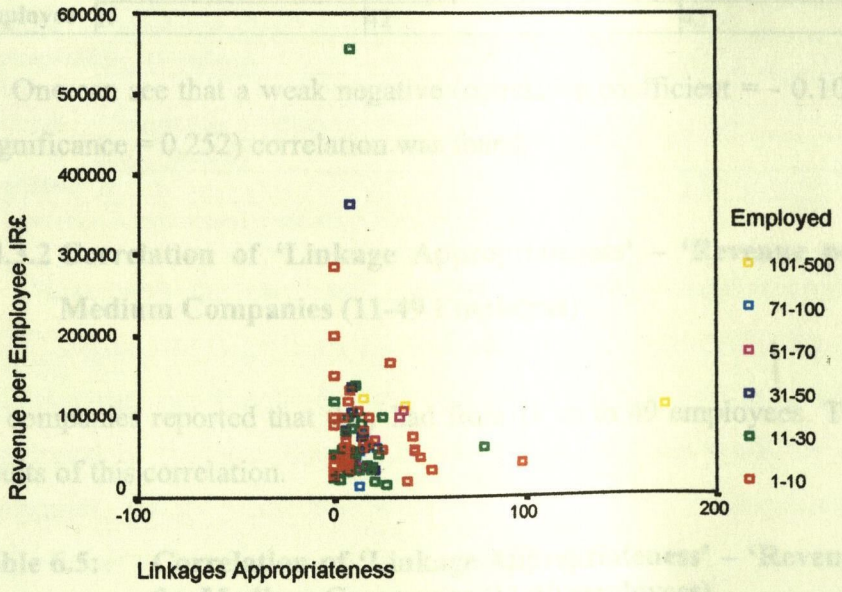
The timing of the questions about linkages and revenue was also believed to be likely to disturb the results of correlation, because the last (1999) year revenues were used for calculating the performance figures and present time (2000) linkages were uncounted while calculating the appropriateness.

6.4.3 Interference of Different Variables into the Correlation had not been taken into Account

Either 'Nature of Software Business', 'Establishment Year', 'Number of Employees' or 'Revenue in 1999' variables could have influenced the correlation. Unlike other issues with the research design, such as not asking the questions about the distribution of innovation and getting the timing wrong, the 'incorrect calculation' suggestions could easily be tested and, if necessary, fixed. To do so, the interference of the above three variables on the correlation has been checked (see Appendices 6.25-6.28).

The analysis showed there was no interference in the cases of 'Nature of Software Business', 'Establishment Year', 'Revenue in 1999' and there was some in the case of 'Number of Employees'. Figure 6.6 illustrates this interference. Six categories contributing to the 'Number of Employees' variable, namely companies employing 1-10, 11-30, 31-50, 51-70, 71-100 and 101-500 people were colour-coded as shown in the figure. The visual analysis revealed that lilac, light blue and yellow dots identifying companies employing 51-70, 71-100 and 101-500 people tended to form a stronger linear relationship compared to dots of other colours.

Figure 6.6 Influence of 'Number of Employees' on 'Linkage Appropriateness' 'Revenue per Employee' Correlation



To explore this interference three separate correlations were performed for small companies (1-10 employees), medium companies (11-49 employees) and large companies (50-500 employees).

6.4.3.1 Correlation of 'Linkage Appropriateness' – 'Revenue per Employee' for Small Companies (1-10 Employees)

53 out of the total 123 companies that took part in the survey reported that they had less than 11 employees. Table 6.4 contains the results of 'Linkage Appropriateness' - 'Revenue per Employee' correlation for these companies.

Table 6.4: Correlation of 'Linkage Appropriateness' – 'Revenue per Employee' for Small Companies (1-10 employees)

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	-.106
	Sig. (1-tailed)	.	.252
	N	53	42
Revenue per Employee	Correlation Coefficient	-.106	1.000
	Sig. (1-tailed)	.252	.
	N	42	42

One can see that a weak negative (correlation coefficient = - 0.106), non-significant (significance = 0.252) correlation was found.

6.4.3.2 Correlation of 'Linkage Appropriateness' – 'Revenue per Employee' for Medium Companies (11-49 Employees)

50 companies reported that they had from 11 up to 49 employees. Table 6.5 shows the results of this correlation.

Table 6.5: Correlation of 'Linkage Appropriateness' – 'Revenue per Employee' for Medium Companies (11-49 employees)

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	-.034
	Sig. (1-tailed)	.	.422
	N	49	36
Revenue per Employee	Correlation Coefficient	-.034	1.000
	Sig. (1-tailed)	.422	.
	N	36	36

As can be seen, a very weak, negative (correlation coefficient = -0.034) non-significant (significance = 0.422) correlation was found in the case of medium-sized companies.

6.4.3.3 Correlation of 'Linkage Appropriateness' – 'Revenue per Employee' for Large Companies (50-500 Employees)

20 companies that took part in the survey reported that they had more than 49 employees. Table 6.6 contains the results of the correlation.

Table 6.6: Correlation of 'Linkage Appropriateness' – 'Revenue per Employee' for Large Companies (50-500 Employees)*

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	.456*
	Sig. (1-tailed)	.	.033
	N	20	17
Revenue per Employee	Correlation Coefficient	.456*	1.000
	Sig. (1-tailed)	.033	.
	N	17	17

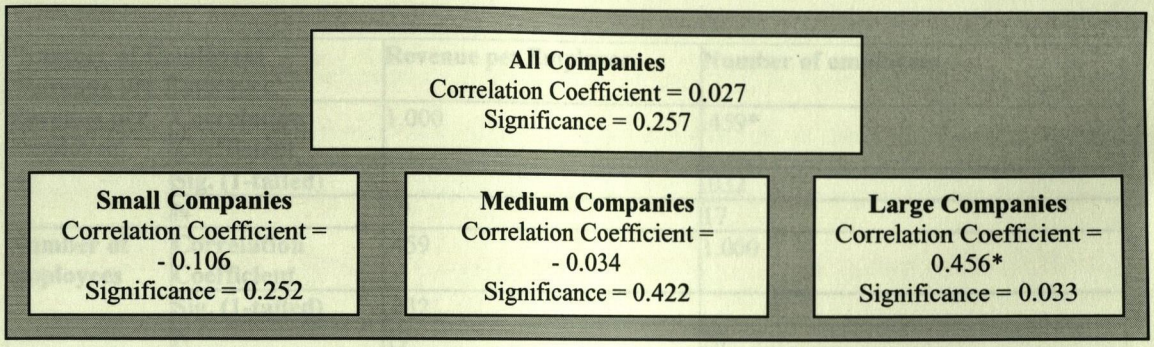
* Correlation is significant at the 0.05 level (1-tailed).

Unlike with the small and medium companies, strong (correlation coefficient = 0.456), significant (significance = 0.033) correlation between 'Linkage Appropriateness' and 'Revenue per Employee' was discovered for the large companies. This could be interpreted as evidence that the research model did not work for small and medium companies, but its predictions were correct in the case of large companies. A further analysis was undertaken to explain this phenomenon.

6.4.4 Explaining the Influence of 'Number of Employees' Variable into the Correlation 'Linkage Appropriateness' - 'Revenue per Employee'

Figure 6.7 illustrates four sets of results that are to be explained. One can see that there is a positive correlation between the size of the companies and the correlation coefficient. There are two possible explanations for this trend.

Figure 6.7: The Results of Correlation of 'Linkage Appropriateness' and 'Revenue per Employee' for Small, Medium and Large Companies



* Correlation is significant at the 0.05 level (one-tailed)

We must start by explaining why the model predictions were right for large companies. It could be explained by suggesting that large companies had both more linkages and better performance and that this trend had nothing to do with the model. Alternatively, this trend could be explained by applying the research model.

6.4.4.1 The Trend was due to the Fact that Larger Companies had both more Linkages and Better Performance

Appropriateness of inter-company linkages is determined by the number of linkages that companies have (for more details see Chapter 3). Therefore, the possible correlation between 'Linkage Appropriateness' and 'Revenue per Employee' could be explained not by the fact that the research hypothesis was right in the case of large companies, but simply by the fact that the larger a company was, the more linkages and the better performance it had.

In order to test this suggestion the pairs of data, such as (1) ('Employees Number' – 'Revenue per Employee') and (2) ('Number of Employees' – 'Linkage Appropriateness') were checked with regard to their inter-dependence. To prove that the above suggestion was right, both correlations should be positive and significant. Table 6.7 contains the results of these two correlations.

Table 6.7: Correlations of 'Number of Employees' with 'Revenue per Employee' and 'Linkage Appropriateness' Data

'Number of Employees' – 'Revenue per Employee'		Revenue per Employee	Number of employees
Revenue per Employee	Correlation Coefficient	1.000	.459*
	Sig. (1-tailed)	.	.032
	N	17	17
Number of employees	Correlation Coefficient	.459	1.000
	Sig. (1-tailed)	.032	.
	N	17	20
'Number of Employees' – Linkage Appropriateness		Number of employees	Linkage Appropriateness
Number of employees	Correlation Coefficient	1.000	.094
	Sig. (1-tailed)	.	.346
	N	20	20
Linkage Appropriateness	Correlation Coefficient	.094	1.000
	Sig. (1-tailed)	.346	.
	N	20	20

* Correlation is significant at the .05 level (1-tailed).

One can see that there was a strong, positive (correlation coefficient = 0.459), significant (significance = 0.032) correlation between 'Number of Employees' and 'Revenue per Employee'.

At the same time, a very weak (correlation coefficient = 0.094), non-significant (significance = 0.346) correlation existed between 'Number of Employees' and 'Linkage Appropriateness'.

This means that the strong correlation between 'Linkage Appropriateness' and 'Revenue per Employee', in the case of large companies, can not be explained simply by the fact that they had more linkages and better performance compared to smaller companies.

6.4.4.2 The Trend was due to the fact that Larger Companies were more likely to get Innovation Created as a Result of Linkages

A suggestion, which is believed to explain both the fact that the correlation was weak for all companies, and that it was stronger for larger companies, is that the research model works only in the case where companies have access to innovation created as a result of linkage activities.

Large companies were assumed to be more capable to capture innovation created as result of linkage activities because compared to smaller companies they normally have more resources. Besides that large companies that took part in this research were older and consequently more experienced. There is also evidence form the previous research (Rothwell and Dodgson, 1989, 1993) that larger companies often establish linkages with smaller firms primarily to get linkage's innovation. It explains the fact that the model only worked for large companies.

But even in the case of large companies (50-500 employees) the model did not work perfectly. The analysis (see Table 6.8) showed there was stronger correlation between 'Number of Linkages' and 'Revenue per Employee' (correlation coefficient = 0.639, significance = 0.003), than between 'Linkage Appropriateness' and 'Revenue per Employee' (correlation coefficient = 0.456, significance = 0.033).

Table 6.8: Correlation of 'Number of Linkages' – 'Revenue per Employee' for Large Companies (50-500)

		Revenue per Employee	Number of Linkages
Revenue per Employee	**Correlation Coefficient**	1.000	.639*
	Sig. (1-tailed)	.	.003
	N	17	17
Number of Linkages	**Correlation Coefficient**	.639*	1.000
	Sig. (1-tailed)	.003	.
	N	17	20

* Correlation is significant at the .01 level (1-tailed).

This could be explained by the fact that large companies, although they were likely to get innovation created as a result of linkages activities, were still sometimes giving the innovation outputs to the partners.

6.5 INFLUENCE OF DIFFERENT FACTORS ON 'LINKAGE APPROPRIATENESS' - 'REVENUE PER EMPLOYEE' CORRELATION

This section outlines the results of analysis of the Influence of 'Establishment Year', 'Number of Employees', Nature of the Software Business' and 'Revenue in 1999' Variables on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large and All Companies. It also shows how the model work in the3 case if companies that not reported linkages are excluded from the analysis.

6.5.1 Investigating the Potential Influence of 'Establishment Year', 'Number of Employees', Nature of the Software Business' and 'Revenue in 1999' Variables on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large Companies

Cross-sectional analysis was undertaken to investigate the influence of 'Establishment Year', 'Number of Employees', Nature of the Software Business' and 'Revenue in 1999' variables on 'Linkage Appropriateness' - 'Revenue per Employee' correlation for large and all companies. Three variables, namely 'Number of Linkages', 'Number of Business Partnerships' and 'Revenue per Employee' were excluded from this cross-sectional analysis because they were involved in the correlation under investigation, either directly as 'Revenue per Employee' or indirectly as 'Number of Linkages' and 'Number of Business Partnerships'.

Prior to starting visual analysis of the scatter graphs, these four continuous variables were re-coded into six categories each which was done in order to simplify this analysis (for more details on the visual analysis of scatter graphs see Section 5.1).

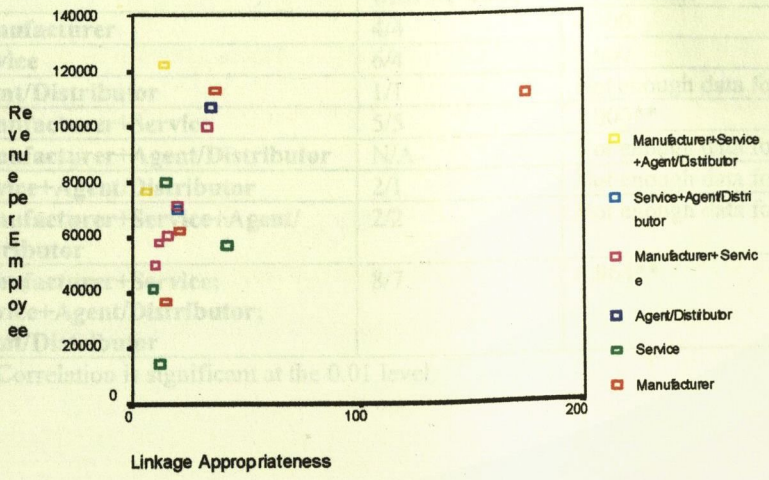
Table 6.9 summarises the results of this visual analysis (see Appendices 6.29 - 6.32 for scatter graphs). It indicates that some trend was discovered while analysing the scatter graph, illustrating the relationship between 'Linkage Appropriateness' and 'Revenue per Employee' for large (50-500 employees) companies with market set by 'Nature of the Software Business'.

Table 6.9 Influence of 'Establishment Year', 'Number of Employees', Nature of the Software Business' and 'Revenue in 1999' Variables on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large and All Companies

	'Linkage Appropriateness' - 'Revenue per Employee' Correlation	
	Large	**All**
Establishment Year	No Influence	No Influence
Number of Employees	No Influence	No Influence
Nature of the software Business	**YES**	No Influence
Revenue in 1999	No Influence	No Influence

Figure 6.8 illustrates a stronger correlation trend discovered in the case of companies specialising as manufacturer+services (lilac dots on the diagram).

Figure 6.8 The influence of 'Nature of the Software Business' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large Companies



In order to confirm the results of visual analysis a number of 'Linkage Appropriateness' - 'Revenue per Employee' correlations were run for companies specialising in different activities. These activities act as values in the 'Nature of the Software Business' variable (for more details on these correlations see Appendices 6.33 - 6.40).

Table 6.10 summarises the results of the correlation analysis. The rows of this table display seven values contributing to 'Nature of the Software Business' variable and a combination of three of these seven values - manufacturer+service; service+agent/distributor and agent/distributor. This combination of values forms a stronger correlation trend as shown in Figure 6.6. The table's columns show a number of companies of each specialisation as well as a number of companies of each specialisation that reported revenue and consequently were used in correlations. The last column displays the results of these correlations.

Table 6.10The Results of 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Different Values of the 'Nature of the Software Business' Variable

'Nature of the Software Business'	Number of Companies/ No. of Companies with Revenue	'Linkage Appropriateness' - 'Revenue per Employee' Correlation	
		Correlation Coefficient	Significance
Manufacturer	4/4	0.600	0.142
Service	6/4	0.600	0.200
Agent/Distributor	1/1	Not enough data for correlation analysis	
Manufacturer+Service	5/5	1.000**	0.000
Manufacturer+Agent/Distributor	N/A	Not enough data for correlation analysis	
Service+Agent/Distributor	2/1	Not enough data for correlation analysis	
Manufacturer+Service+Agent/ Distributor	2/2	Not enough data for correlation analysis	
Manufacturer+Service; Service+Agent/Distributor; Agent/Distributor	8/7	0.964**	0.000

** Correlation is significant at the 0.01 level

The results presented in Table 6.10 confirm the visual analysis and reveal very strong, significant correlations for large companies specialising as manufacturer+services (correlation coefficient = 1.000**, significance = .000) and strong correlation for a group consisting of companies with three different specialisations, namely manufacturer+service; service+agent/distributor and agent/distributor (correlation coefficient = 0.964**, significance = .000).

One of several possible explanations for this phenomenon is that large companies with a certain specialisation, namely service+agent/distributor, agent/distributor and especially manufacturer+service, were more likely to get innovation created as result of linkages and consequently to profit from this innovation, compared to manufacturers, services, manufacturer+service+agent/distributors.

However, there is not enough data to test this explanation. For example, individual correlations for agent/distributors, manufacturer+agent/distributor, service+agent/distributor and manufacturer+service+agent/distributor could not be run because the existing database has a small (less than three) number of companies specialising in this areas.

Another interesting thing about manufacturer+services is the perfection of correlation (correlation coefficient = 1.000). It should be reminded that the model did not work perfectly even in the case of large companies. In other words, there was stronger correlation between 'Number of Linkages' - 'Revenue per Employee' than between 'Linkage Appropriateness' - 'Revenue per Employee'. This was explained by suggesting that even large companies were not always getting the linkages' innovation outputs, therefore the model did not functional perfectly for them (access to innovation is a necessary condition for applying the research model - for more details see Section 4.). A number of additional correlations was run to investigate how the model works for large companies of different specialisation as shown in Table 6.11.

This table contains the results of the correlation of 'Revenue per Employee' with 'Linkage Appropriateness', 'Number of Linkages' and 'Number of Business Partnerships' for large companies specialising as manufacturer+services, large companies with three different specialisations (manufacturer+service; service+agent/distributor and agent/distributor) as well as all large companies.

Table 6.11 Correlating 'Revenue per Employee' with 'Linkage Appropriateness', 'Number of Linkages' and 'Number of Business Partnerships' for Large Companies with Different Specialisation

	Manufacturer +service	**Manufacturer+Service; Service+Agent/Distributor; Agent/Distributor**	**All Large Companies**
'Linkage Appropriateness' - 'Revenue per Employee'	Correlation Coefficient = 1.000** Significance = 0.000	Correlation Coefficient = 0.964** Significance = 0.000	Correlation Coefficient = 0.456* Significance = 0.033
'Number of Linkages' - 'Revenue per Employee'	Correlation Coefficient = 0.975** Significance = 0.005	Correlation Coefficient = 0.946** Significance = 0.001	Correlation Coefficient = 0.639* Significance = 0.006
Number of Business Partnerships' - 'Revenue per Employee'	Correlation Coefficient = 0.677 Significance = 0.219	Correlation Coefficient = 0.582 Significance = 0.170	Correlation Coefficient =0.432 Significance =0.083

In case of large companies specialising as manufacturer+services as well as a group of companies with different specialisations ((manufacturer+service; service+agent/distributor and agent/distributor) 'Linkage Apropriateness' - 'Revenue per Employee' correlation was stronger than 'Number of Linkages' - 'Revenue per Employee' correlation. This is different for all companies where 'Number of Linkages' - 'revenue per Employee' correlation is actually stronger.

These trends could be interpreted as further evidence confirming that certain companies, especially manufacturer+services, were more likely to get innovation created

as result of linkages. Specifically, all five manufacturer+services that took part in this research got linkages' innovation output, therefore the model worked perfectly for them.

Another interesting detail which can be seen in this table is that correlations 'Number of Business Partnerships' - 'Revenue per Employee' were weaker than correlations 'Number of Linkages' - 'Revenue per Employee' for large companies of all specialisations. It can be interpreted as if those four business partnerships which were not qualified to be linkages did not have potential to produce innovation as it was hypothesised (for more details see Table 3.7). Therefore companies which established these business partnerships did not have the chance to profit from their innovation outputs, which caused the weaker correlation.

6.5.2 Running the Model for Companies With Linkages Only

According to the model all companies with and without linkages should be included in analysis (see Chapter 3), however it may be interesting to see how the model works with companies without linkages excluded from the analysis. Table 6.12 contains the results of 'Linkage Appropriateness' - 'Revenue per Employee' correlations run for all companies that took part in research and companies that reported linkages only (for more details on correlations see Appendices 6.41-6.44).

Table 6.12: The results of 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for All Companies (With and Without Linkages) and Companies with Linkages

	Companies With and Without Linkages		Companies With Linkages Only	
	Correlation Coefficient	Significance	Correlation Coefficient	Significance
Companies of All Sizes	0.027	0.257	0.052	0.328
Large Companies	0.456*	0.033	0.456*	0.033
Medium Companies	-0.034	0.422	-0.194	1.000
Small Companies	-0.106	0.252	0.058	1.000

* Correlation is significant at the 0.05 level (1-tailed)

The Results of correlations for all companies that took part in the survey and those companies that had linkages are quite similar. It may be explained by the fact that most of companies that took part in the survey (95 out of 128) said they had linkages. At the same time, 10 out of 28 companies that reported that they did not have linkages, declined to report their revenue, so they were excluded from the correlation analysis.

Another interesting detail that can be seen in the table - the correlation coefficient and significance have the same values in case of large companies. 19 out of 20 large companies reported that they had linkages and the only company, which said it did not have linkages, did not provide information about its revenue as well, and consequently was not included in the correlation analysis.

6.6 THE CONTRIBUTION TO KNOWLEDGE MADE BY THIS RESEARCH

The contribution to knowledge made by this research has been considered from two angles – the theoretical contribution to knowledge about inter-company linkages and their influence on companies' performance and the empirical, descriptive contribution to knowledge about linkages in the Irish software industry.

6.6.1 Empirical (Descriptive and Confirmatory) Contribution to Knowledge about Inter-company Linkages in the Irish Software Industry

Table 6.13 summarises the study's findings about inter-company linkages in the Irish software industry and shows how it relates to the findings of other research in the area.

Table 6.13: Empirical Contribution to Knowledge about Inter-company Linkages in the Irish Software Industry

The Study's Finding	The findings of the Previous Research
123 observed companies reported that they had 659 linkages among them. 97 companies (78.9%) had one or more linkages, 26 companies (21.1%) did not have linkages. An average company (the median) had 3 linkages. The largest number of linkages per company – 60.	Coincides with O'Riain (1997): only 14.1% of Irish firms and 17.2% of overseas had no linkages at all. Coincides with O'Gorman, Colm, O'Malley (1997): a large majority of indigenous companies have had linkages with foreign MNFs.
Manufacturer/agents, manufacturers and agents had largest numbers of linkages per company (10.25, 7.1 and 6.2). Companies specialising in services tended to have fewer linkages.	No previous evidence was found.
Companies (especially large ones) with more linkages have higher revenue.	No previous evidence was found.
Larger companies have slightly more linkages than smaller ones	Coincides with O'Riain (1997): There is evidence that the size of firms had positive influence on the likelihood of establishing linkages.
The age of companies had no influence on the likelihood of establishing linkages (no correlation between 'Number of Linkages' – 'Establishment Year' was found).	No previous evidence was found.

6.6.2 Theoretical Contribution to Knowledge about Inter-company Linkages and their Influence on Companies' Performance

A model that seeks to explain how different types of inter-company linkages can influence companies' performance was developed and tested in the course of this research.

The empirical evidence (outlined in Section 6.2) shows that there was not sufficient correlation between 'Linkage Appropriateness' and 'Revenue per Employee' (for more details see Chapter 3) to claim that the model's predictions were correct.

One possible explanation for this weak correlation was that the model was faulty, but as it is shown in section 6.4 of this chapter this is not necessarily true. Deeper analysis (see Section 6.4.3) has shown that the model actually worked for large (more than 50 employees) companies, and its failure to predict how linkages influence small and medium sized companies performance could be explained by the mistakes in the research methodology.

An attempt was made to explain the negative correlation between linkage appropriateness and companies' performance in the case of small and medium companies as well as where the correlation coefficient was higher for larger companies, by suggesting that the model only worked in the case where companies were getting access to the linkages' innovation outputs. Please note, these two correlation were weak and not statistically significant.

Smaller companies were hypothesised to be less likely to gain these innovation outputs. In these conditions linkages with higher appropriateness may negatively influence companies' performance, because they require inputs of resources which are in high demand at the given stage of industry development.

The above suggestion provides a possible explanation for both the negative correlation coefficient for small and medium companies and the empirical evidence showing that it was more positive for larger companies.

This explanation could mean that the model was viable and its malfunction in the case of small and medium companies was caused by the wrong research design (the question about the distribution of innovation created as a result of linkages was not included in the

questionnaire under the wrong assumption, that it was distributed evenly). However further research should be undertaken to test whether this explanation is true.

6.7 SUGGESTIONS FOR FURTHER RESEARCH

The research model, which was developed and used in this study, was re-examined and still no major omissions in its logical structure and operation were found, therefore it is still believed that this model is satisfactory and can be used in further research. This further research could contribute to the knowledge about inter-company linkages as well as add validity to the model through:

1) Testing the model's assumptions;
2) Dealing with issues raised in the course of this research;
3) Revealing some mistakes and omissions, which have not been discovered yet.

6.7.1 Testing the Model's Assumptions

Four model's assumptions (see also Table 3.12) were based on previously untested ideas from the existing research literature. These assumptions are (1) assumption about activities performed within different linkages, (2) assumption about resource inputs and innovation outputs of three activities (R&D, production and marketing), (3) assumption about size of industry demands for innovation and resources and (4) assumption about four business partnerships (licensing, contract-out coding-programming, contract-out disk duplication and contract-out package assembly) as lacking potential to produce innovation.

In order to test the first assumption, in further research, companies should be asked about activities performed within different types of linkages. A question can be formulated as (a) 'What activities (R&D, production, marketing) were performed within linkages which your company sustains?'. The second assumption can be tested by asking question (b) 'What are the resource inputs and innovation outputs of linkages which your

company sustains?'. Assumption number three can be tested by asking participants of further research to answer question (c) 'What are industry demands for innovation (primary and incremental) and resources (basic and complimentary) at different stages of industry development?'. And finally, to test assumption number four, participants of further research should be offered question (d) 'Do licensing, contract-out coding-programming, contract-out disk duplication and contract-out package assembly types of business partnerships have potential to produce innovation?'. Testing these assumptions in the course of further research would add validity to the research model.

6.7.2 Dealing with Issues Raised while Doing this Research

Two mistakes were found while re-examining a research model and research methodology (for more details see Section 6.4). Firstly, under the assumption that innovation created as result of linkage activities was evenly distributed, companies that took part in this study were not asked to indicate if they had access to linkage's innovation outputs. After analysing the research findings this assumption was questioned. It was hypothesised that large companies were more likely to gain linkage's innovation outputs. To avoid this confusion in the future research, partaking companies should be asked to answer question (e) 'How innovation created as result of linkage activities was distributed between partaking companies?'.

Secondly, in this research companies were asked to indicate linkages, which they were sustaining in 2000 and revenue that they had in 1999. This could potentially disturb the model's predictions in the case of companies with new linkages (those that had been established in 2000), because the time gap between establishing of linkages and the moment when the effect of these linkages on companies' performance begins was not taken into consideration. To avoid this controversial situation, in the future research companies should be asked question (f) 'What linkages was your company sustaining over the last three (five) years? What was your company performance over this period of time?'. Data collected by means of asking these questions would allow incorporation of the time gap between the moment a linkage is established and the moment when it starts

producing innovation. Companies should also be asked to express their opinion on how big is this gap.

6.7.3 Choosing Appropriate Research Strategy

Adding questions (a)-(f) to the questionnaire (shown in Appendix 3.1) would make it longer, more complex and more difficult to understand. As a result, potential respondents may find it too demanding and subsequently would hesitate to take part in the postal survey.

This issue can be dealt with by means of revising of the methodological strategy. Assuming that new research would be based on empiricist or hypothetico-deductive tradition like this one (for details see Section 3.1.1.3), the researcher would have three different options, while choosing the most appropriate research strategy. These options are (1) experiment; (2) survey (personal interview / telephone interview) and (3) case-based research (hypothetico-deductive approach).

The experiment method can be very useful. For instance, companies can be asked to establish certain types of linkages as prescribed by the model and the influence of these linkages on companies' performance can be closely monitored. However, this option requires very good contacts with companies in order to convince them to participate in the experiment.

There are three types of survey, namely postal, telephone interview and interview (for more details see Section 3.1.4.3). A postal survey was used in this research, because it allowed reaching the whole population of the Irish software companies. Having a large number of respondents was important while testing the model's overall structure and operation (in this study, the research model was used for the first time). However, this research strategy has its limitations. It is not suitable for collecting large amounts of information (participants normally hesitate answering long questionnaires). That is why postal survey was ruled out while choosing a research strategy for further research.

Telephone interviewing is more flexible than postal survey, but may be irrelevant when there is a need for information which is not immediately available, for example, linkages performance figures for the last few years (questions (e) and (f.)). Face to face interview can be a more attractive choice when collecting this kind of data.

Case-based research is well suited for conducting explanatory and confirmatory research. Specifically, it is suitable for collecting complicated information, such as time-series data about performance, and innovation. However, similar to experiment, it requires an effort in building up the contacts with companies.

Table 6.14 summarise the above arguments for using different types of research strategies in terms of suitability for collecting additional time-series information about the distribution of linkages' innovation outputs and revenue as well as its time/cost.

Table 6.14Choice of Research Strategy for Further Research

	Experiment	**Case-based Research**	**Interview**	**Telephone Interview**
Possibility to collect information for testing the model's assumptions (questions (a)-(d))	Good	Good	Fair	Fair
Possibility to collect accurate time series of data about linkages, innovation and performance (questions (e) and (f))	Excellent	Excellent	Good	Poor
Time, cost	Poor	Fair	Good	Good

The above table indicates, that two types of research strategies (i.e. experiment and telephone interview) have serious limits as regard to time/cost (experiment) or the possibility of collecting accurate time-series data about linkages, innovation and performance (telephone interview).

The time and cost concern indicates that experiment requires either establishing one or more companies with certain linkages or having very good contacts in the industry, which is difficult and may require substantial time and resources.

The accuracy of time-series data collection concern in the case of telephone interview is based on two assumptions. First, although the telephone interview allows a substantial level of flexibility, it still may be difficult to talk about such complicated constructs as innovation on the phone. And second, the time series data, which is to be collected, may require some substantial effort on part of a potential respond in order to access the necessary information, especially so if this person joined a company recently. The telephone interview is not the most appropriate form of communication if the respondent needs to move around the office (in order to check the company's records).

Having these limitations, case-based research and interview may be considered as more appropriate choices.

6.8 What I learned while Doing this Research

First of all, while doing this research I have learned about the nature and determinants of inter-institutional collaboration. I developed a keen interest in the linkages and especially their effect on company performance, while still doing my primarily degree back in Russia, and I am very grateful that I was given a chance to investigate it properly at the School of Business Studies at Trinity College, Dublin.

A research model, which attempts to identify types of linkages that are likely to effect positively company performance at different stages of industry development was specially developed in the course of this study. Naturally, while developing this model the author had been hoping that its predictions would be correct. The study showed that the model only worked for large companies (those employed 50-500 people), which was already quite satisfactory (personally), especially considering that the model's fault to provide right predictions for small and medium companies could have been caused by the mistakes in the research design (a subject for further investigation).

Then, through attending research seminars organised by the School of Business Studies I got good theoretical knowledge about general research methodology. This

knowledge was of critical importance for designing research strategy for this study. While doing the study, I had an opportunity to master the practical use of different research techniques and methods.

I also learned a lot about the social principles and the code of conduct of both the academic community (through interacting with my supervisors, as well as other academics and fellow postgraduates at the department) and the business community (through organising and conducting interviews at the pilot study stage of the research).

And finally, I found that doing research in the academic community provides a very good environment for cross-cultural enquiry. Everyday interactions with colleagues from Trinity College, Dublin have given me a brilliant opportunity to learn a lot about the Irish culture. And finally, I believe, that my spoken and written English (although still far from perfection) has improved dramatically through doing the research routines.

CONCLUSIONS

The research hypothesis, which states that: '**Companies that have linkages with higher appropriateness have better performance**' was tested in the course of this research. Positive, significant correlation between 'Linkage Appropriateness' and 'Revenue per Employee' (a performance indicator) was found in the case of large companies (those employed 50-500 people). This can be interpreted as evidence that a research model worked for large companies.

At the same time, the study's hypothesis was not correct for smaller companies (employed 1-49 people). In order to explain this phenomenon, the model's logical structure and operation was re-examined numerous times. Even after this test, it was still thought that the whole concept behind the model was satisfactory, although re-examining (enlightened) revealed two mistakes in the research methodology. Firstly, a time gap necessary for recent linkages to be reflected in companies' performance was not allowed for (companies were asked to indicate linkages which they were sustaining in 2000 and

their 1999 performance indicators). Secondly, companies were not asked to indicate if they got access to innovation created as result of linkage activities (model only applies if a company has access to innovation).

These two mistakes were taken into account while formulating suggestions for further research. In these suggestions we also proposed to test four model's assumptions, namely assumption about activities performed within different linkages, assumption about resource inputs and innovation outputs of three activities (R&D, production and marketing), assumption about size of industry demands for innovation and resources and assumption about four business partnerships as lacking potential to produce innovation.

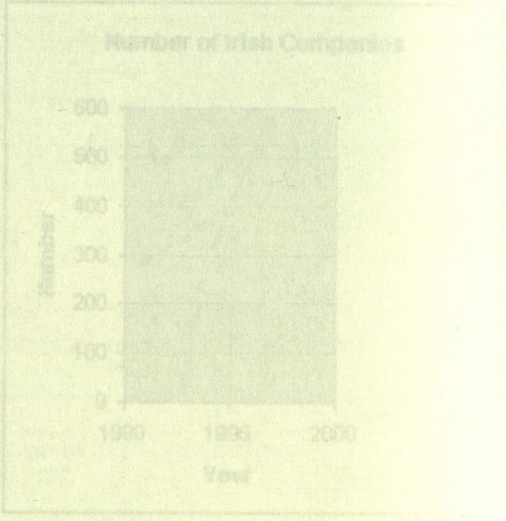
Summarising, this study is believed to make both empirical contribution to knowledge about inter-company linkages in the Irish Software Industry, and (conditionally) theoretical contribution about the nature of inter-company linkages and their influence on companies' performance. However further research is required to test the model's assumptions and to deal with issues raised in the course of this study.

APPENDICES TO CHAPTER 3

Appendix 3.1 Identifying of the Stage of The Irish Software Industry Development

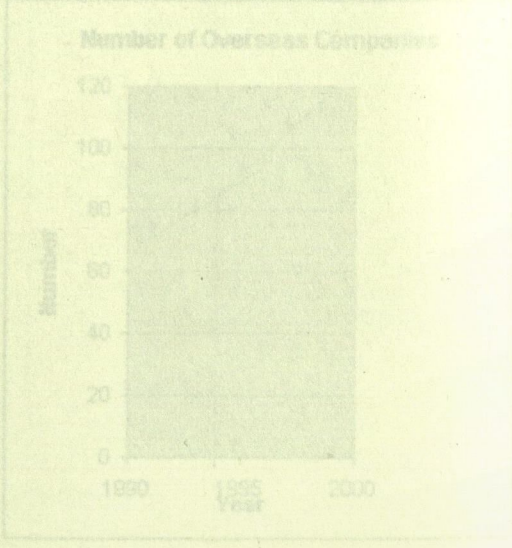
1. Number of Irish Companies

Year	1991	1992	1993	1994	1995	1996	1997
Number of Irish Companies	291	N/A	326	N/A	390	N/A	571



2. Number of Overseas Companies

Year	1991	1992	1993	1994	1995	1996	1997
Number of OverseasCompanies	74	N/A	84	N/A	93	N/A	109



APPENDIXES TO CHAPTER 3

Appendix 3.1 Identifying of the Stage of The Irish Software Industry Development

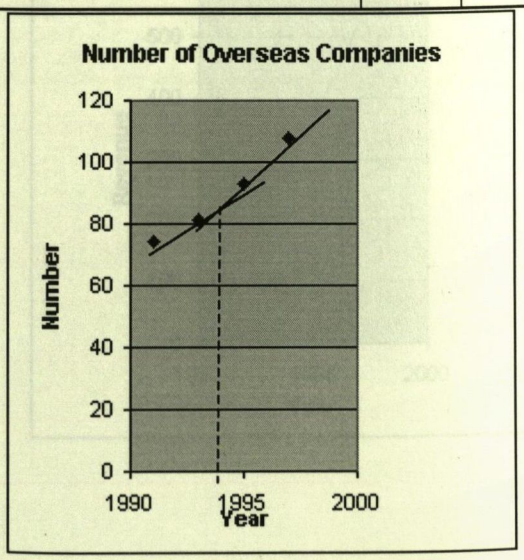
1. Number of Irish Companies

Year	1991	1992	1993	1994	1995	1996	1997
Number of Irish Companies	291	N/A	336	N/A	390	N/A	571



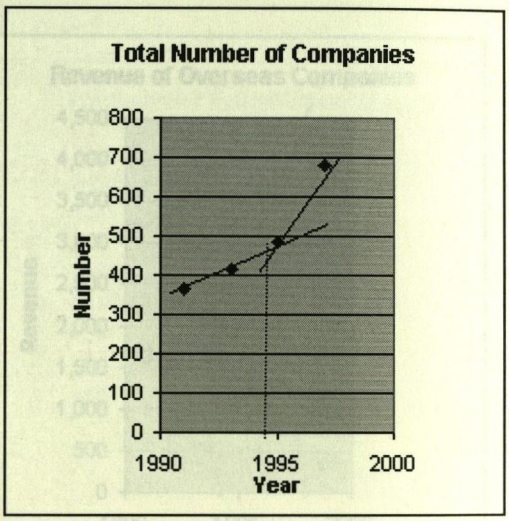
2. Number of Overseas Companies

Year	1991	1992	1993	1994	1995	1996	1997
Number of OverseasCompanies	74	N/A	81	N/A	93	N/A	108



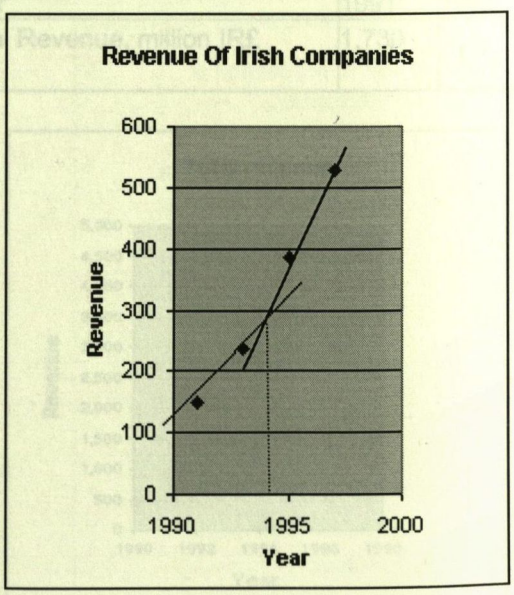
3. Total Number of Companies

Year	1991	1992	1993	1994	1995	1996	1997
Total Number of Companies	365	N/A	417	N/A	483	N/A	679



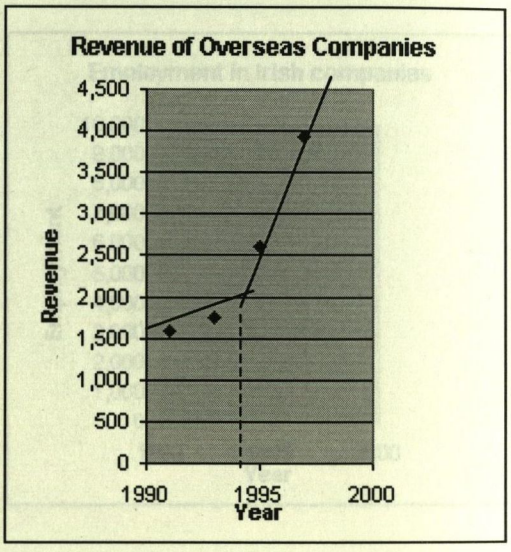
4. Revenue of Irish Companies

Year	1991	1992	1993	1994	1995	1996	1997
Revenue of Irish Companies, million IR£	150	N/A	236	N/A	386	N/A	528



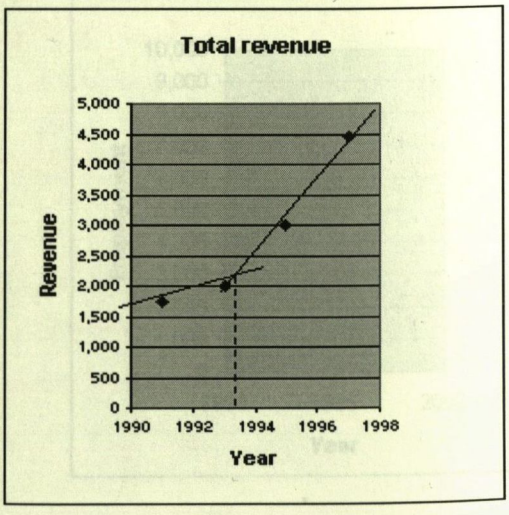
5. Revenue of Overseas Companies

Year	1991	1992	1993	1994	1995	1996	1997
Revenue of Overseas Companies, million IR£	1,580	N/A	1,756	N/A	2,611	N/A	3,933



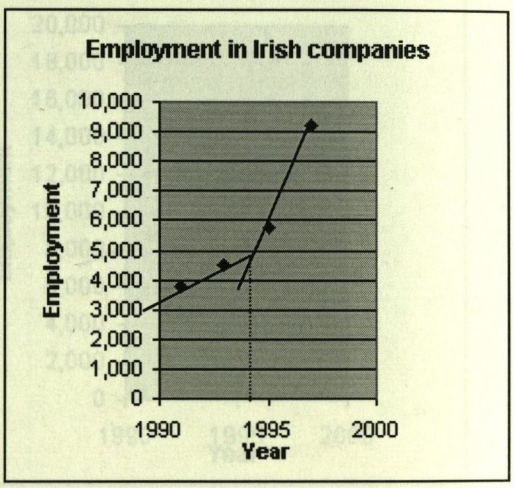
6. Total Revenue

Year	1991	1992	1993	1994	1995	1996	1997
Total Revenue, million IR£	1,730		1,992		2,997		4,461



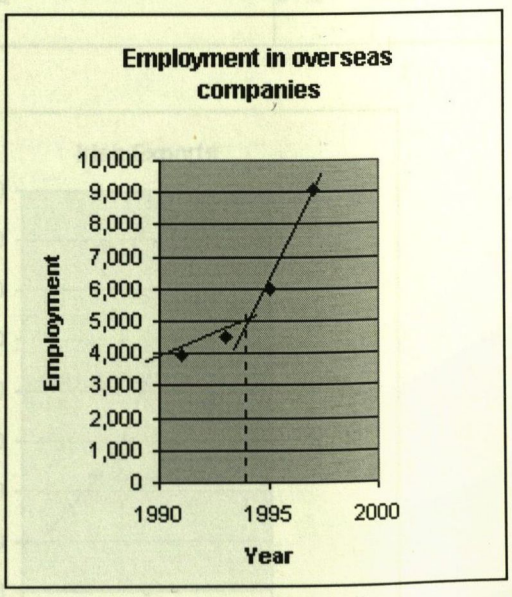
7.Employment in Irish Companies

Year	1991	1992	1993	1994	1995	1996	1997
Number of Employees	3,801	N/A	4,495	N/A	5,773	N/A	9,200



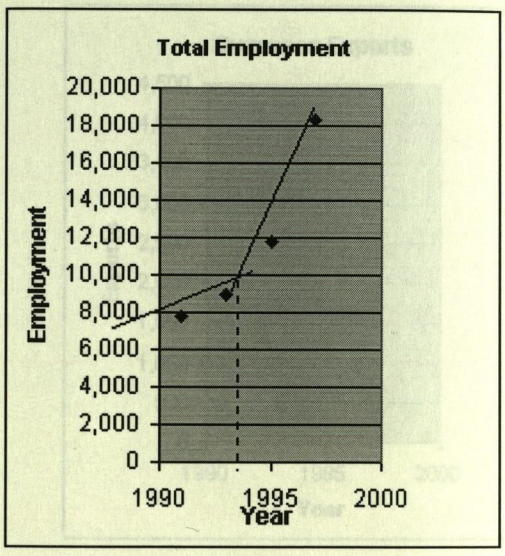
8. Employment in Overseas Companies

Year	1991	1992	1993	1994	1995	1996	1997
Number of Employees	3,922	N/A	4,498	N/A	6,011	N/A	9,100



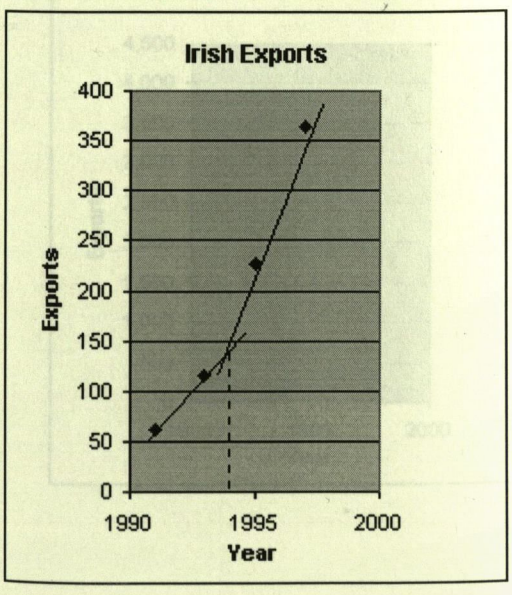
9. Total Number of Employees

Year	1991	1992	1993	1994	1995	1996	1997
Total Number of Employees	7,793	N/A	8,943	N/A	11,784	N/A	18,300



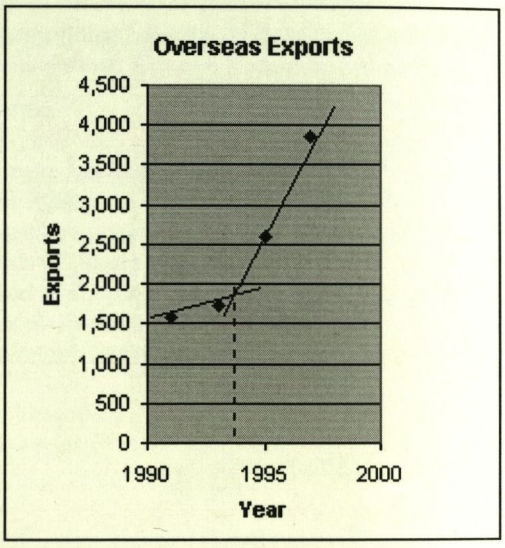
10. Exports by Irish Companies

Year	1991	1992	1993	1994	1995	1996	1997
Exports by Irish Companies, million IR£	61.3	N/A	116	N/A	226	N/A	365



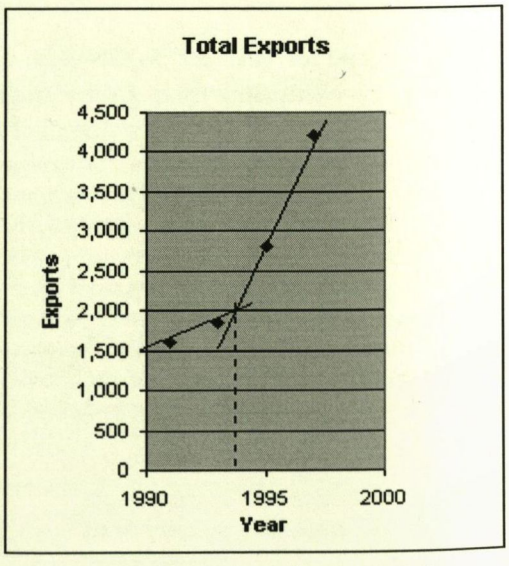
11. Exports by Overseas Companies

Year	1991	1992	1993	1994	1995	1996	1997
Exports by Overseas Companies, million IR£	1,584	N/A	1,726	N/A	2,585	N/A	3,854



12. Total Exports

Year	1991	1992	1993	1994	1995	1996	1997
Total Exports, million IR£	1,609	N/A	1,842	N/A	2,811	N/A	4,219



APPENDICES TO CHAPTER 4

Appendix 4.1

The Final Version of the Questionnaire (see next page)

School of Business Studies, Trinity College, Dublin. 17/07/00

Business Partnerships in the Software Industry

OFFICE USE ONLY
Company No:

Information about Your Company

Establishment year: _____ Number of Employees at the end of 1999: _____ Revenue in 1999: _____

Nature of the Software Business (please tick appropriate boxes – multiple responses are possible)

Manufacturer ☐ Service ☐ Agent/Distributor ☐

1. Within which sub-sectors of the software industry does your company operate and what is the stage of each of these sub-sectors' development?

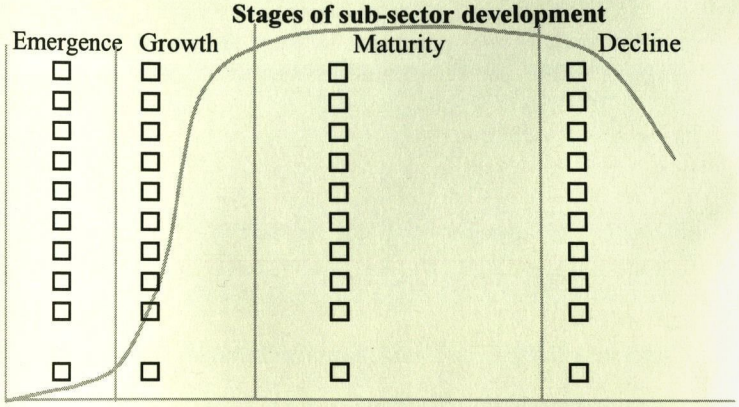
Please choose appropriate sub-sectors from the list below and tick the box which you think identifies the stage of each of these sub-sectors' development. Answers should be provided only for the sub-sectors within which your company has operations.

List of Sub-sectors

1. General Business Application Products
2. Bespoke Development
3. Banking / Finance Systems
4. Software Tools / Systems Software
5. Internet-related Software
6. Computer-based Training (Internet or other)
7. Telecommunication Software
8. Firmware
9. Software Localisation
10. Other (Please specify in the space below)

_____

Stages of sub-sector development



Information about Your Business Partnerships

2. How many business partnerships of each given type does your company have?

*Please indicate in the **second column** how many business partnerships of each type listed **in the table** your company has. Where your company has partnerships which are not listed, please write the names and numbers of these partnerships in the space provided.*

3. What is the sub-sector of the software industry within which your company has business partnerships?

*Please choose appropriate sub-sectors from the **list of sub-sectors in question 1 above** and insert their numbers in the **third column** in the table. In the case if your company having two or more partnerships of any given type within different sub-sectors please indicate all the sub-sectors. For example, if your company has two "Agent Agreement" business partnerships within the "Internet-related Software" and "Firmware" sub-sectors it should be indicated as follow:*

Types of Business Partnerships	*Number of Partnerships of each given type*	*Sub-sector*
Agent Agreement	2	5;8

Types of Business Partnerships	*Number of Partnerships of each Given Type*	*Sub-sector*
1	2	3
Joint R&D		
1. Contract-out Software Development		
2. Joint Software Development Pact		
Joint Software Production		
1. Contract-out Design/ Multimedia		
2. Contract-out Product Adaptation		
3. Contract-out Translation/ Localisation		
4. Contract-out Coding/ Programming		
5. Contract-out Software Testing		
6. Contract-out Assembly of Package		
7. Contract-out After-sale Service		
8. Contract-out Disk Duplication		
9. Licensing		
Joint Marketing		
1. Agent Agreement		
2. Reciprocal Agent Agreement		
3. Joint Venture		
Labour Contracting		
1. Contract-out R&D Staff		
2. Contract-out Production Staff		
3. Contract-out Marketing Staff		
Equity Investment		
1. Sponsored Spinout		
2. Venture Nurturing		
Other Types of Business Partnerships (Not Listed Above)		
1.		
2.		
3.		
4.		

If you would like a summary of the findings please tick the box ☐

Appendix 4.2

The Pre-pilot Study Version of the Questionnaire (see next two pages)

School of business studies, Trinity College Dublin

COMPANY No: _____

1) Information about Company

Establishment year: _____ Number of Employees at the end of 1999: _____ Revenue in 1999: _____

Nature of Software Business (please tick an appropriate box – multiple response is possible)

Manufacturer ☐ Service ☐ Agent/Distributor ☐

2) Information about Linkage

1. What type of linkage does your company have?

*Please mark in the **first** column of the table. Mark the linkage your company has with "1" and these which it does not have with "0". Please place a 1 or 0 in each row. In case your company has linkages, which are not listed, please write the names of these linkages in the space provided.*

Questions 2-7 relate only to linkages yours company has (mark "1" in the first column)

2. What is the extent* of linkage that your company has?

*Please mark in the **second and third** columns of the table for each type of linkage that you company has. Mark the applicable option with "1" and the option that does not apply with "0".*

3. What is the level* of linkage that your company has?

*Please mark in the **fourth and fifth** columns of the table for each type of linkage that you company has. Mark the applicable option with "1" and the option that does not apply with "0".*

4. What is the participation* in linkage your company has?

*Please mark in the **sixth and seventh** columns of the table for each type of linkage that you company has. Mark the applicable option with "1" and the option that does not apply with "0".*

5. What is the duration* of linkage that your company has?

*Please mark in the **eighth and ninth** columns of the table for each type of linkage that you company has. Mark the applicable option with "1" and the option that does not apply with "0".*

3) Information about the Software Sub-sector where Your Company Has Its Linkage

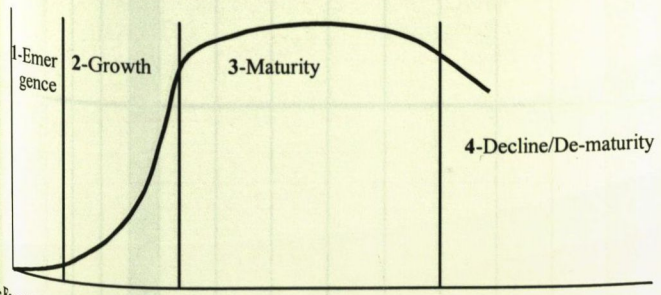
6. What is the sub-sector of the software industry in which your company has its linkages?

Please choose an appropriate sector from the list bellow and put its number in the **tenth** column of the table (multiple response is possible if your company has the same type of linkage at different sub-sectors)

1 – General Business Application Products;
2 – Bespoke Development;
3 – Banking / Finance Systems;
4 – Telecommunication Software;
5 – Software Tools / Systems Software;
6 – Internet-related Software;
7 – Software Localisation;
8 – Firmware;
9 – Computer-based Training;
10 – Other (Please specify _____)

7. What is the stage of this sub-sector development?

Please identify an appropriate stage of development for each of sub-sector in which your company has its linkages. Choose an appropriate number as shown in the chart bellow and put this number in the **eleventh** column of the table.



*For definitions please see the table below

	Question 1	Question 2		Question 3		Question 4		Question 5		Question 6	Question 7
	Type	**Intra-industrial Linkages** refer to linkages formed by companies from the same (software) industry. **Inter-industrial Linkages** are formed by companies from different industries.		**Horizontal linkages** refers to linkages formed by companies from the same level of value chain. **Vertical linkages** are formed by companies different levels of val. ch.		**Irish-Irish Linkages** refer to linkages formed Irish companies only **Mixed Linkages** are formed by Irish and foreign companies companies.		**Short-term Linkages** refer to linkages that are sustained for less than two years. **Long-term** linkages are sustained for more than two years		**Sub-sector of the Software Industry in which your company has its linkage**	**Stage of Sub-sector Development** 1 - Emergence 2 - Growth 3 - Maturity 4 – Decline
		Intra-indus.	Inter-indus.	Horizontal	Vertical	Irish-Irish	Mixed	Short-term	Long-term		
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Joint Venture											
Joint R&D											
1. Contract-out R&D											
2. Joint R&D pacts											
Joint Production											
1. Co-production											
2. Sub-supply											
3. Licensing											
Joint Marketing											
1. Agent agreements											
2. Collaborative marketing											
Equity Investment											
1. Venture Nurturing											
2. Sponsored Spinouts											
Contracting for Service/Product											
1. Contracting for a Software Product											
2. Contracting for Design/ Multimedia Services											
3. Contracting for Product Adaptation Services											
4. Contracting for Translation Localisation Services											
5. Contracting for Coding/ Programming Services											
6. Contracting for Packaging Services											
7. Contracting for after-sale Services											
8. Contracting for Disk Duplication											
Labour Contracting											
1. R&D Staff Contracting											
2. Production Staff Contracting											
3. Marketing Staff Contracting											
Other Types of linkages											
1.											
2.											

Appendix 4.3 The Final Version of the Covering Letter

Mr. John Smith
Managing Director
Irish Software Company
Dublin

17 July 2000

Dear Mr Smith,

I am a doctoral student of the School of Business Studies in Trinity College Dublin. As a part of my research, I am undertaking a survey on business partnerships between companies in the software industry. The survey, conducted with the support of the **National Software Directorate**, is designed to gather information on the nature of inter-company partnerships and their effect on company performance.

I would be very grateful if you would participate in this project by completing the enclosed questionnaire. All companies manufacturing, servicing or distributing software in Ireland (including yours) are being asked to take part in the survey. The census is based on the lists of companies from the National Software Directorate, Enterprise Ireland and the Kompass Directory.

The questionnaire seeks information about different types of business partnerships, which your company may have, and also some details about your company including the number of employees and company revenue in 1999. The information collected in this study will be treated in **the strictest confidence**, and will only be used to produce statistical tables. It will not be possible to identify the responses of any individual company from the results produced. The questionnaire is not very long and should only take about **ten minutes** to complete. A reply-paid envelope is provided for your convenience. I thank you in advance for your cooperation and support.

I believe that the results of this investigation will help companies improve their productivity and performance and would be very happy to supply **a brief summary of my findings** to all who participate. If you have any queries or require any further information, please do not hesitate to contact me.

Yours sincerely,

Vladimir Shugurov
School of Business Studies,
Trinity College Dublin,
Telephone: (353-1) 608 2706
Fax: (353-1) 679 9503
E.mail: shugurov@tcd.ie

Appendix 4.4 The Pre-pilot Study Version of the Covering Letter

Mr. John Smith
Managing Director
Software Company
Grafton Street
Dublin 2

15 June 2000

Dear Mr Smith

I am a doctoral student of the School of Business Studies in Trinity College Dublin. As a part of my research there, I am undertaking a survey of linkage between companies in the software sector in Ireland. The survey, which is conducted in collaboration with National Software Directorate is designed to gather information on the nature of inter-company linkages and its effect on company performance. It is hoped that the results of the survey will allow the prediction of what kind of linkages are likely to lead to better company performance as well as give a broad view of the nature of linkage in the sector.

I would be very grateful if you would participate in this project by completing the enclosed questionnaire. All companies manufacturing, servicing or distributing software in Ireland (including your one) are asked to take part in the survey. The census was based on the lists of companies from the National Software Directorate, Enterprise Ireland and the Kompass Directory.

The questionnaire asks about different characteristics of linkage, which your company may have and also some details about your company including the number of employees and company revenue in 1999. The latter questions are asked because of the main objective of the study – to investigate how linkages influence company performance. The information collected in this study will be treated in the strictest confidence, and will only be used to produce statistical tables. It will not be possible to identify the responses of any individual company from the results produced. The questionnaire is not very long and should only take about twenty minutes to complete. A reply-paid envelope is provided for your convenience. I thank you in advance for your cooperation and friendly support.

If you have any queries or require any further information, please do not hesitate to contact me.

Yours sincerely,

Vladimir Shugurov
School of Business Studies,
Trinity College Dublin,
Telephone: (353-1) 608 2706
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E.mail: shugurov@tcd.ie

Appendix 4.5: The Reminder Letter

24 July 2000

Dear Mr. Smith,

Recently, a questionnaire was sent to you which requested information about different types of business partnerships.

If you have already returned this questionnaire to me, please accept my sincere thanks. If not, I would be very grateful **if you could do so at your earliest convenience**.

This questionnaire seeks information about **companies with and without business partnerships** and it is hoped that the results of the survey will help companies improve their productivity and performance and will give a broad view of the nature and extent of the business partnerships in the industry.

If by some chance you did not receive the questionnaire, or it was misplaced, please do not hesitate to contact me at - shugurov@tcd.ie. Another questionnaire will be forwarded to you immediately.

Thank you again for your help.

Yours sincerely,

Vladimir Shugurov

School of Business Studies,
Trinity College Dublin,
Telephone: (353-1) 608 2706
Fax: (353-1) 679 9503

Appendix 4.6: **The Coding Frame Used in this Study (see the next page)**

$FL2@(#) SPSS DAT Y {Y@1:54 NUMBER C
Automati on ASP ASP Software PRCONSOF Proces

SUBSEC Sub-sect Stages of sub-sector development

SOFDEV &Contract- Contract-out Software Development

SOFDEV &Contract- Contract-out Software Development

SOFDEV &Contract- Contract-out Software Development

SOFDEV &Contract- Contract-out Software Development

SOFDEV &Contract- Contract-out Software Development

SOFDEV &Contract- Contract-out Software Development SOFDEV

DEVPAC %Joint Sof joint software development pacts

DEVPAC %Joint Sof joint software development pacts

DEVPAC %Joint Sof joint software development pacts DEVPAC

DESIMUI 1 tract-out design/multimedia

DISIMUL 2#Contract / tract-out design/multimedia

DISIMUL 3#Contract / tract-out Design/Multimedia

DESIMUI 4#Contract / tract-out Design/Multimedia DISIMUL

PRODAL 1#Contract / tract-out Product Adaptation

PRODAL 2#Contract / tract-out Product Adaptation

PRODAL 3#Contract / tract-out Product Adaptation PRODADA

TRANLO 1*Contract (1) y of Contract-out Translation/Localisation

TRANLO 2*Contract (2) y of Contract-out Translation/Localisation

TRANLO 3*Contract (3) y of Contract-out Translation/Localisation

TRANLO 4*Contract (2) y of Contract-out Translation/Localisation

TRANLO 5*Contract (2) y of Contract-out Translation/Localisation TRANLOC

CODPRC 1 tract-out Coding/Programming

CODPRC 2$Contract / tract-out Coding/Programming

CODPRC 3$Contract / tract-out Coding/Programming

CODPRC 4$Contract / tract-out Coding/Programming

CODPRC 5$Contract / tract-out Coding/Programming

APPENDIXES TO CHAPTER 5

5.1 Frequency Distribution Table for 'Number of Business Partnerships'

Number of Business Partnerships		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	26	21.1	21.1	21.1
	1.00	10	8.1	8.1	29.3
	2.00	15	12.2	12.2	41.5
	3.00	12	9.8	9.8	51.2
	4.00	11	8.9	8.9	60.2
	5.00	13	10.6	10.6	70.7
	6.00	9	7.3	7.3	78.0
	7.00	3	2.4	2.4	80.5
	8.00	3	2.4	2.4	82.9
	9.00	3	2.4	2.4	85.4
	10.00	4	3.3	3.3	88.6
	11.00	1	.8	.8	89.4
	12.00	3	2.4	2.4	91.9
	14.00	3	2.4	2.4	94.3
	16.00	3	2.4	2.4	96.7
	25.00	1	.8	.8	97.6
	36.00	1	.8	.8	98.4
	50.00	1	.8	.8	99.2
	60.00	1	.8	.8	100.0
Total		123	100.0	100.0	

5.1(1) Frequency Distribution Table for 'Number of Inter-company Linkages'

Number of Linkages		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.00	28	22.8	22.8	22.8
	1.00	13	10.6	10.6	33.3
	2.00	26	21.1	21.1	54.5
	3.00	6	4.9	4.9	59.3
	4.00	11	8.9	8.9	68.3
	5.00	14	11.4	11.4	79.7
	6.00	5	4.1	4.1	83.7
	7.00	3	2.4	2.4	86.2
	8.00	1	.8	.8	87.0
	9.00	3	2.4	2.4	89.4
	10.00	2	1.6	1.6	91.1
	11.00	1	.8	.8	91.9
	12.00	2	1.6	1.6	93.5
	13.00	1	.8	.8	94.3
	14.00	1	.8	.8	95.1
	15.00	1	.8	.8	95.9
	16.00	1	.8	.8	96.7
	23.00	1	.8	.8	

See the next page for the remaining part of this table ↓

	No. of Linkages	Frequency	Percent	Valid Percent	Cumulative Percent
	33.00	1	.8	.8	98.4
	50.00	2	1.6	1.6	100.0
Total		123	100.0	100.0	

5.2 Frequency Distribution Table for 'Revenue in 1999'

Revenue in 1999, IR£		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	40000.000	1	.8	1.1	1.1
	50000.000	2	1.6	2.1	3.2
	80000.000	1	.8	1.1	4.2
	100000.000	7	5.7	7.4	11.6
	120000.000	1	.8	1.1	12.6
	150000.000	2	1.6	2.1	14.7
	180000.000	1	.8	1.1	15.8
	200000.000	4	3.3	4.2	20.0
	230000.000	1	.8	1.1	21.1
	250000.000	5	4.1	5.3	26.3
	261000.000	1	.8	1.1	27.4
	300000.000	4	3.3	4.2	31.6
	350000.000	2	1.6	2.1	33.7
	400000.000	2	1.6	2.1	35.8
	450000.000	1	.8	1.1	36.8
	460000.000	1	.8	1.1	37.9
	490000.000	1	.8	1.1	38.9
	500000.000	4	3.3	4.2	43.2
	600000.000	7	5.7	7.4	50.5
	650000.000	1	.8	1.1	51.6
	740000.000	1	.8	1.1	52.6
	750000.000	2	1.6	2.1	54.7
	800000.000	1	.8	1.1	55.8
	1000000.000	5	4.1	5.3	61.1
	1100000.000	2	1.6	2.1	63.2
	1200000.000	3	2.4	3.2	66.3
	1250000.000	1	.8	1.1	67.4
	1500000.000	1	.8	1.1	68.4
	1600000.000	1	.8	1.1	69.5
	1700000.000	1	.8	1.1	70.5
	1800000.000	1	.8	1.1	71.6
	2000000.000	2	1.6	2.1	73.7
	2100000.000	1	.8	1.1	74.7
	2400000.000	1	.8	1.1	75.8
	2500000.000	2	1.6	2.1	77.9
	2900000.000	1	.8	1.1	78.9
	3000000.000	2	1.6	2.1	81.1
	3500000.000	1	.8	1.1	82.1
	4000000.000	2	1.6	2.1	84.2
	5000000.000	3	2.4	3.2	87.4

See the next page for the remaining part of this table ↓

	Revenue in 1999, IR£	Frequency	Percent	Valid Percent	Cumulative Percent
	5600000.000	1	.8	1.1	88.4
	5900000.000	1	.8	1.1	89.5
	6000000.000	1	.8	1.1	90.5
	6200000.000	1	.8	1.1	91.6
	7500000.000	1	.8	1.1	92.6
	8000000.000	1	.8	1.1	93.7
	10000000.000	1	.8	1.1	94.7
	12000000.000	1	.8	1.1	95.8
	20000000.000	1	.8	1.1	96.8
	22000000.000	1	.8	1.1	97.9
	30000000.000	1	.8	1.1	98.9
	35000000.000	1	.8	1.1	100.0
	Total	95	77.2	100.0	
Missing System		28	22.8		
Total		123	100.0		

5.2(1) Frequency Distribution Table for 'Revenue per Employee'

Revenue per Employee, IR£		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	14285.71	1	.8	1.1	1.1
	16666.67	1	.8	1.1	2.1
	20000.00	1	.8	1.1	3.2
	20833.33	1	.8	1.1	4.2
	20909.09	1	.8	1.1	5.3
	24000.00	1	.8	1.1	6.3
	25000.00	1	.8	1.1	7.4
	29000.00	1	.8	1.1	8.4
	30000.00	1	.8	1.1	9.5
	31818.18	1	.8	1.1	10.5
	32000.00	1	.8	1.1	11.6
	33333.33	4	3.3	4.2	15.8
	34375.00	1	.8	1.1	16.8
	37037.04	1	.8	1.1	17.9
	37500.00	1	.8	1.1	18.9
	38333.33	1	.8	1.1	20.0
	38888.89	1	.8	1.1	21.1
	40000.00	4	3.3	4.2	25.3
	41666.67	2	1.6	2.1	27.4
	42857.14	1	.8	1.1	28.4
	44444.44	1	.8	1.1	29.5
	48000.00	1	.8	1.1	30.5
	50000.00	8	6.5	8.4	38.9
See the next page for the remaining part of this table ↓	52857.14	1	.8	1.1	40.0
	53333.33	1	.8	1.1	41.1
	53571.43	1	.8	1.1	42.1
	54545.45	1	.8	1.1	43.2
	56666.67	1	.8	1.1	44.2

	Revenue per Employee, IR£	Frequency	Percent	Valid Percent	Cumulative Percent
	57377.05	1	.8	1.1	45.3
	58333.33	1	.8	1.1	46.3
	59523.81	1	.8	1.1	47.4
	60000.00	3	2.4	3.2	50.5
	60824.74	1	.8	1.1	51.6
	62500.00	5	4.1	5.3	56.8
	65000.00	1	.8	1.1	57.9
	70000.00	2	1.6	2.1	60.0
	71428.57	2	1.6	2.1	62.1
	75000.00	2	1.6	2.1	64.2
	76923.08	1	.8	1.1	65.3
	80000.00	1	.8	1.1	66.3
	80769.23	1	.8	1.1	67.4
	82857.14	1	.8	1.1	68.4
	83333.33	1	.8	1.1	69.5
	85714.29	1	.8	1.1	70.5
	90000.00	1	.8	1.1	71.6
	91666.67	1	.8	1.1	72.6
	100000.00	9	7.3	9.5	82.1
	105263.16	1	.8	1.1	83.2
	107142.86	2	1.6	2.1	85.3
	111111.11	1	.8	1.1	86.3
	113207.55	1	.8	1.1	87.4
	120000.00	2	1.6	2.1	89.5
	122222.22	1	.8	1.1	90.5
	133333.33	1	.8	1.1	91.6
	137777.78	1	.8	1.1	92.6
	138888.89	1	.8	1.1	93.7
	150000.00	1	.8	1.1	94.7
	166666.67	1	.8	1.1	95.8
	200000.00	1	.8	1.1	96.8
	285714.29	1	.8	1.1	97.9
	363636.36	1	.8	1.1	98.9
	555555.56	1	.8	1.1	100.0
	Total	95	77.2	100.0	
Missing System		28	22.8		
Total		123	100.0		

5.3 Frequency Distribution Table for 'Number of Employees'

Number of Employees		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	10	8.1	8.3	8.3
	2	6	4.9	5.0	13.2
	3	6	4.9	5.0	18.2
See the next page for the remaining part of this table ↓	4	5	4.1	4.1	22.3
	5	3	2.4	2.5	24.8
	6	6	4.9	5.0	29.8
	7	5	4.1	4.1	33.9
	8	4	3.3	3.3	37.2

	No. of Employees	Frequency	Percent	Valid Percent	Cumulative Percent
	9	3	2.4	2.5	39.7
	10	4	3.3	3.3	43.0
	11	4	3.3	3.3	46.3
	12	5	4.1	4.1	50.4
	14	3	2.4	2.5	52.9
	15	7	5.7	5.8	58.7
	16	1	.8	.8	59.5
	17	1	.8	.8	60.3
	18	3	2.4	2.5	62.8
	20	3	2.4	2.5	65.3
	21	1	.8	.8	66.1
	24	1	.8	.8	66.9
	25	4	3.3	3.3	70.2
	26	2	1.6	1.7	71.9
	30	7	5.7	5.8	77.7
	32	1	.8	.8	78.5
	33	1	.8	.8	79.3
	35	2	1.6	1.7	81.0
	38	1	.8	.8	81.8
	40	1	.8	.8	82.6
	45	1	.8	.8	83.5
	54	1	.8	.8	84.3
	60	2	1.6	1.7	86.0
	61	1	.8	.8	86.8
	65	2	1.6	1.7	88.4
	70	3	2.4	2.5	90.9
	80	2	1.6	1.7	92.6
	84	1	.8	.8	93.4
	96	1	.8	.8	94.2
	97	1	.8	.8	95.0
	100	1	.8	.8	95.9
	180	2	1.6	1.7	97.5
	220	1	.8	.8	98.3
	265	1	.8	.8	99.2
	500	1	.8	.8	100.0
	Total	121	98.4	100.0	
MissingSystem		2	1.6		
Total		123	100.0		

5.4 Frequency Distribution Table for 'Establishment Year'

Establishment Year		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1903	1	.8	.8	.8
	1968	1	.8	.8	1.7
	1970	2	1.6	1.7	3.3
	1975	2	1.6	1.7	5.0
	1978	2	1.6	1.7	6.6
	1980	2	1.6	1.7	8.3
	1981	3	2.4	2.5	10.7
	1982	3	2.4	2.5	13.2
	1984	2	1.6	1.7	14.9
	1985	3	2.4	2.5	17.4
	1986	2	1.6	1.7	19.0
	1987	9	7.3	7.4	26.4
	1988	2	1.6	1.7	28.1
	1989	9	7.3	7.4	35.5
	1990	4	3.3	3.3	38.8
	1991	7	5.7	5.8	44.6
	1992	7	5.7	5.8	50.4
	1993	7	5.7	5.8	56.2
	1994	13	10.6	10.7	66.9
	1995	9	7.3	7.4	74.4
	1996	7	5.7	5.8	80.2
	1997	11	8.9	9.1	89.3
	1998	9	7.3	7.4	96.7
	1999	2	1.6	1.7	98.3
	2000	2	1.6	1.7	100.0
	Total	121	98.4	100.0	
Missing System		2	1.6		
Total		123	100.0		

5.4(1) SPSS Syntax for Re-coding 'Establishment Year' Continues Variable into six Categories

```
RECODE
  year
  (1900 thru 1980=1) (1981 thru 1985=2) (1986 thru 1990=3)
  (1991 thru 1994=4) (1995 thru 1997=5) (1998 thru
  2000=6) INTO period.
VARIABLE LABELS period 'Established'.
EXECUTE .
```

5.4(2) SPSS Syntax for Re-coding 'Number of Employee' Continues Variable into six Categories

```
RECODE
 employee
 (1 thru 10=1) (11 thru 30=2) (31 thru 50=3)
 (51 thru 70=4) (71 thru 100=5) (101 thru
 500=6) INTO empl6gr.
VARIABLE LABELS empl6gr 'Employed'.
EXECUTE .
```

5.4(3) SPSS Syntax for Re-coding 'Revenue in 1999' Continues Variable into six Categories

```
RECODE
 revenue
 (1 thru 100000=1) (100001 thru 500000=2) (500001 thru 1000000=3)
 (1000001 thru 5000000=4) (5000001 thru 10000000=5) (10000001 thru
 40000000=6) INTO rev6grou .
VARIABLE LABELS rev6grou 'Revenue in six groups'.
EXECUTE .
```

5.4(4) SPSS Syntax for Re-coding 'Revenue per Employee' Continues Variable into six Categories

```
RECODE
 revenemp
 (1 thru 20000=1) (20001 thru 40000=2) (40001 thru 60000=3)
 (60001 thru 80000=4) (80001 thru 120000=5) (120001 thru
 600000=6) INTO revemp6g.
VARIABLE LABELS revemp6g 'Revenue/Employee'.
EXECUTE .
```

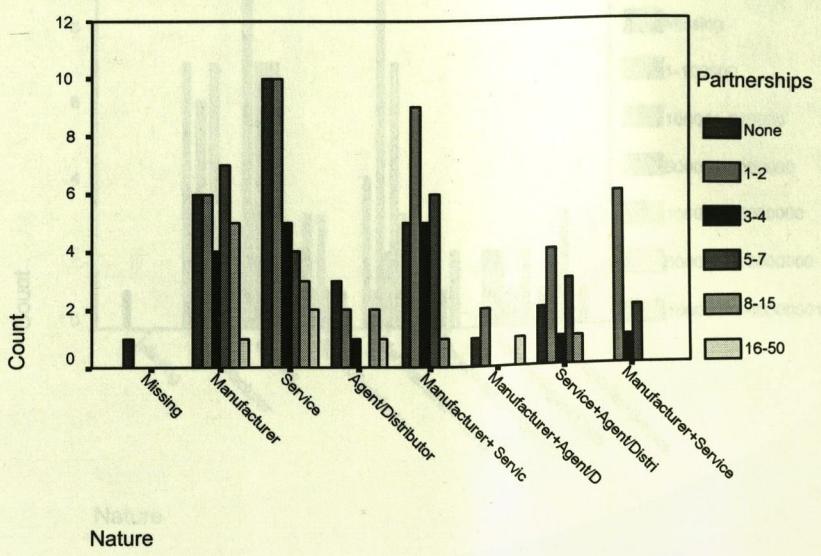
5.4(5) SPSS Syntax for Re-coding 'Number of Business Partnerships' Continues Variable into six Categories

```
RECODE
  linknumb
  (0=1)  (1 thru 2=2)  (3 thru 4=3)
  (5 thru 7=4)  (8 thru 15=5)  (16 thru
  50=6)  INTO  part6gr.
VARIABLE LABELS part6gr 'Partnerships'.
EXECUTE .
```

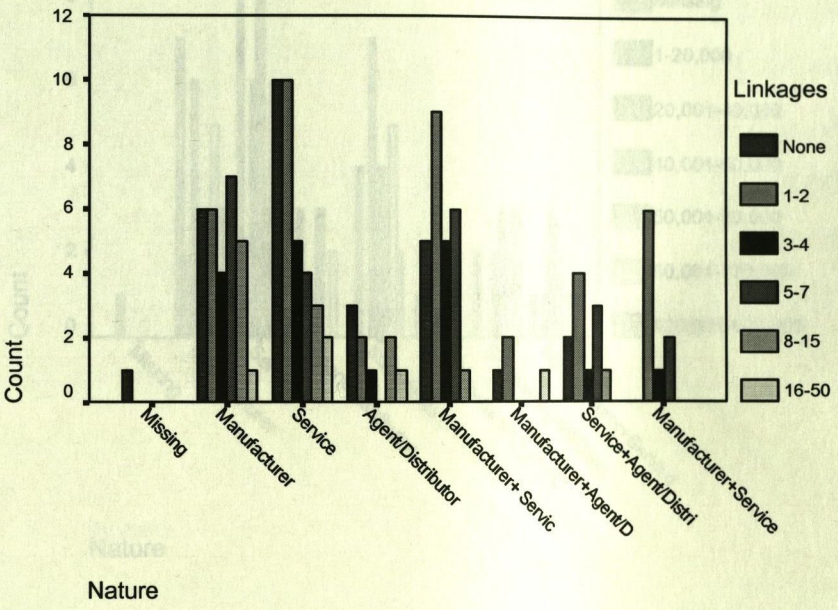
5.4(6) SPSS Syntax for Re-coding 'Number of Linkages' Continues Variable into six Categories

```
RECODE
  linkreal
  (0=1)  (1 thru 5=2)  (6 thru 10=3)  (11 thru 20=4)  (21 thru 40=5)  (41
  thru 60=6)  INTO  realingr .
VARIABLE LABELS realingr 'Linkages'.
EXECUTE .
```

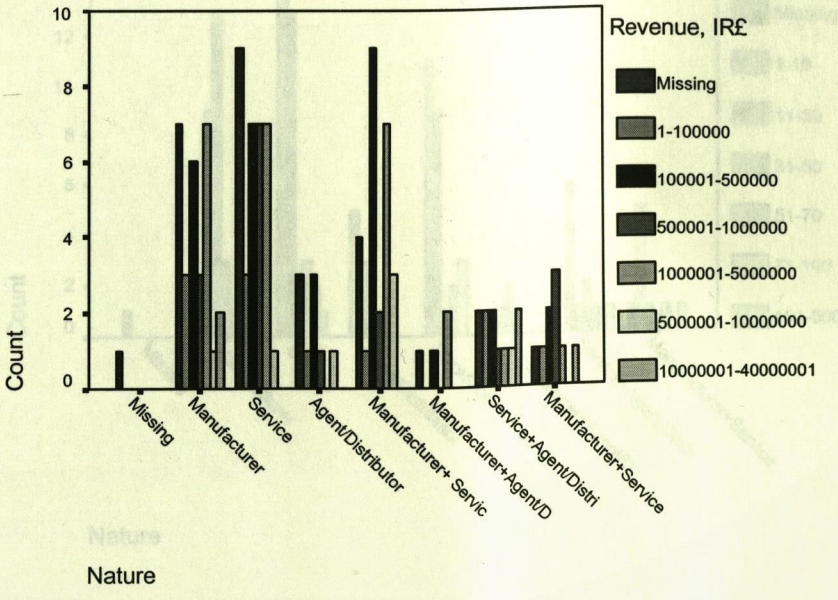
5.5 Cross tabulation 'Nature of the Software Business' – 'Number of Business Partnerships'



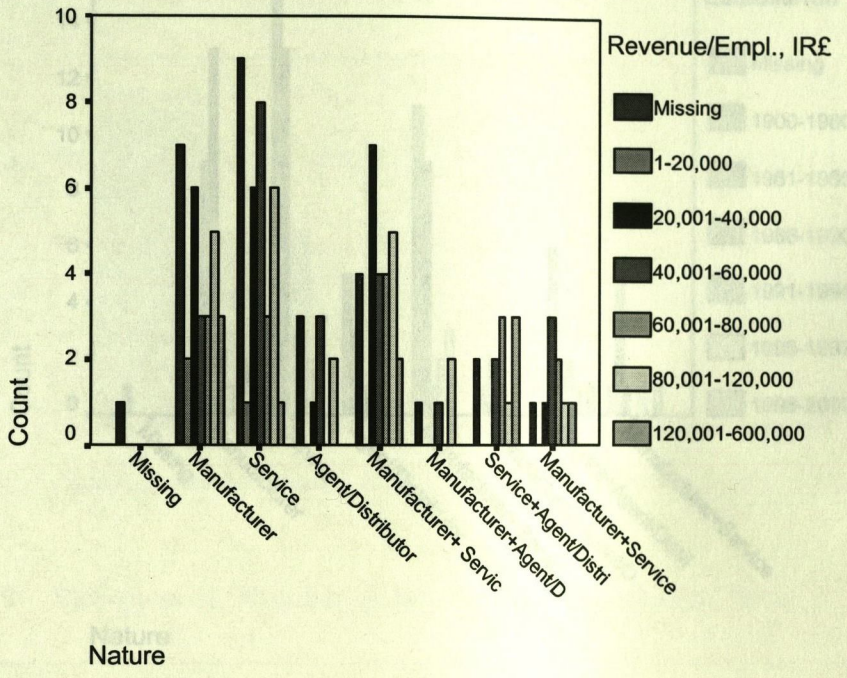
5.5(1) Cross tabulation 'Nature of the Software Business' – 'Number of Inter-company Linkages'



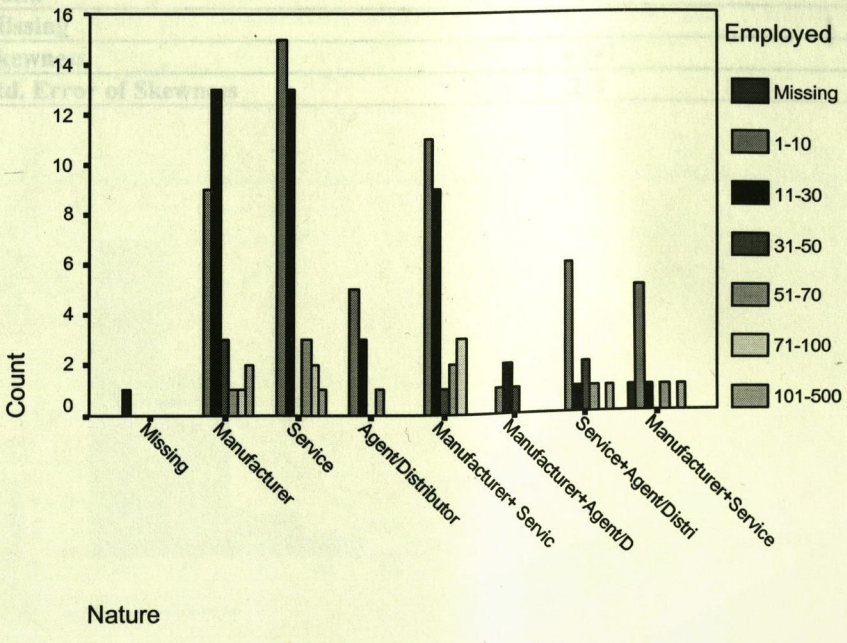
5.6 Cross tabulation 'Nature of the Software Business' – 'Revenue in 1999'



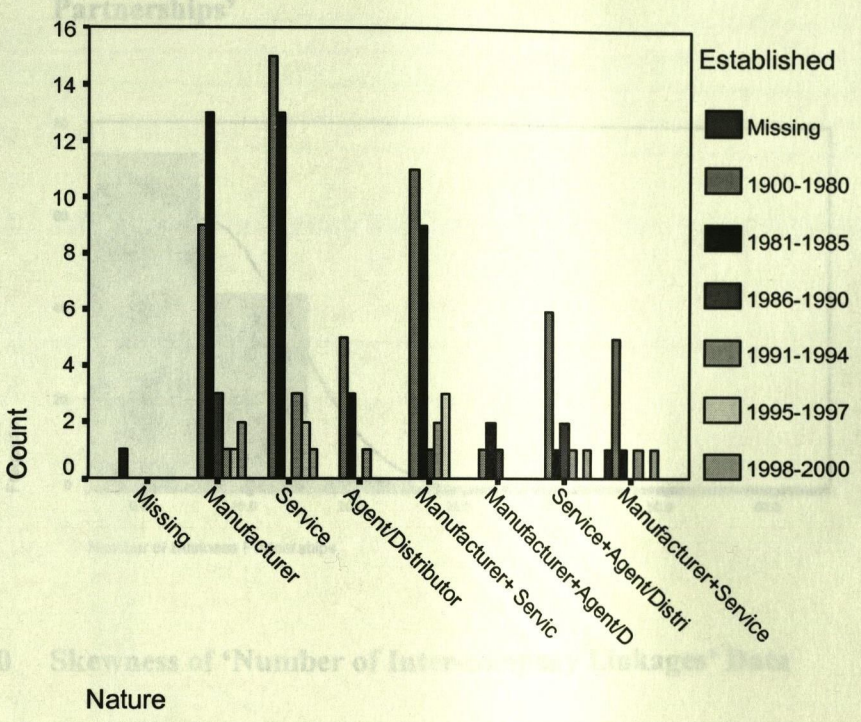
5.7 Cross tabulation 'Nature of the Software Business' – 'Revenue in 1999'



5.8 Cross tabulation 'Nature of Software Business' – 'Number of Employees'



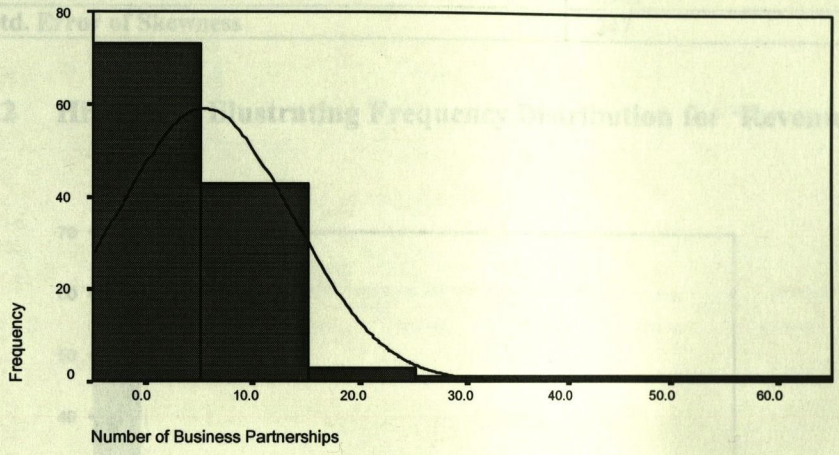
5.8 (1) Cross tabulation 'Nature of Software Business' – 'Establishment Year'



5.9 Skewness of 'Number of Business Partnerships' Data

Valid	123
Missing	0
Skewness	4.241
Std. Error of Skewness	.218

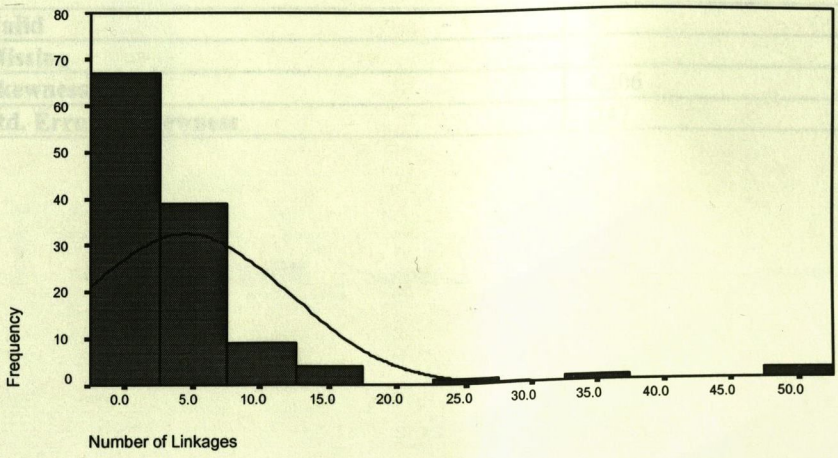
5.9(1) Histogram Illustrating Frequency Distribution for 'Number of Business Partnerships'



5.10 Skewness of 'Number of Inter-company Linkages' Data

Valid	123
Missing	0
Skewness	4.296
Std. Error of Skewness	.218

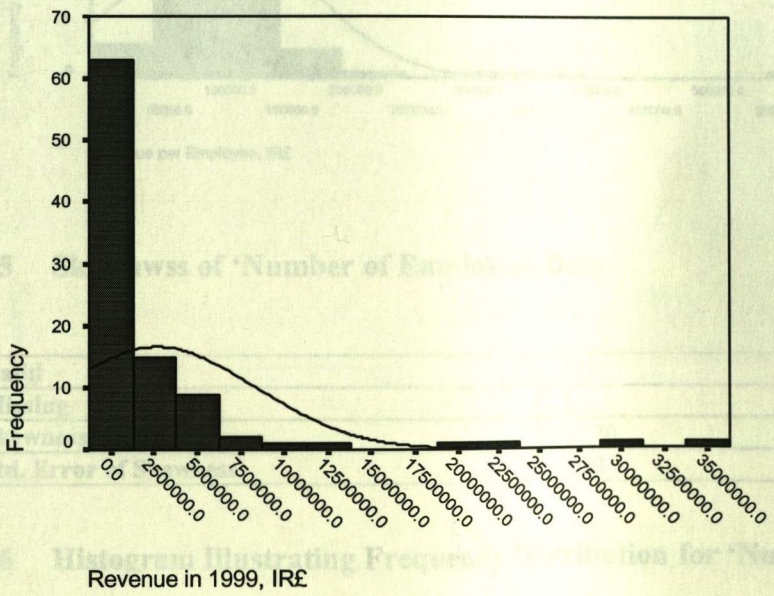
5.10(1) Histogram Illustrating Frequency Distribution for 'Number of Inter-company Linkages'



5.11 Skewness of 'Revenue in 1999' Data

Valid	95
Missing	28
Skewness	3.981
Std. Error of Skewness	.247

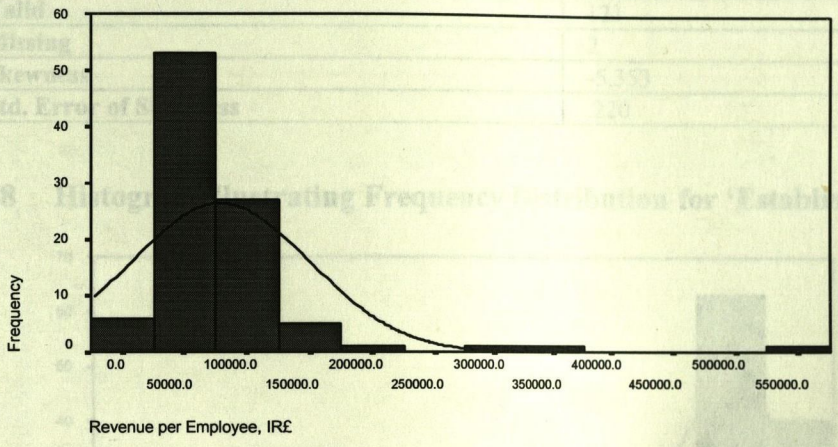
5.12 Histogram Illustrating Frequency Distribution for 'Revenue in 1999'



5.13 Skewness of 'Revenue per Employee' Data

Valid	95
Missing	28
Skewness	4.206
Std. Error of Skewness	.247

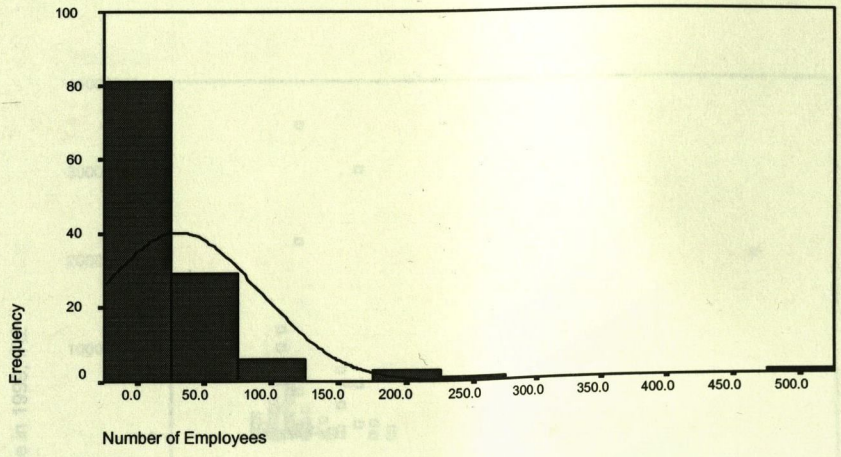
5.14 Histogram Illustrating Frequency Distribution for 'Revenue per Employee'



5.15 Skewnwss of 'Number of Employees Data

Valid	121
Missing	2
Skewness	5.120
Std. Error of Skewness	.220

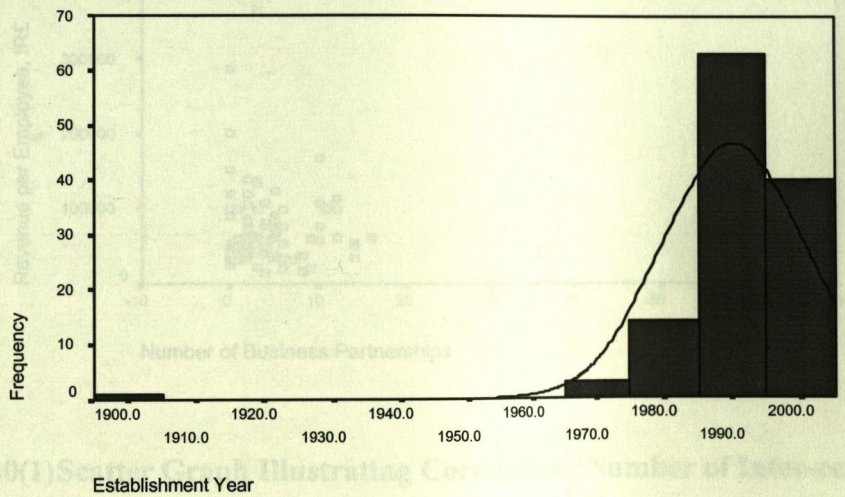
5.16 Histogram Illustrating Frequency Distribution for 'Number of Employees'



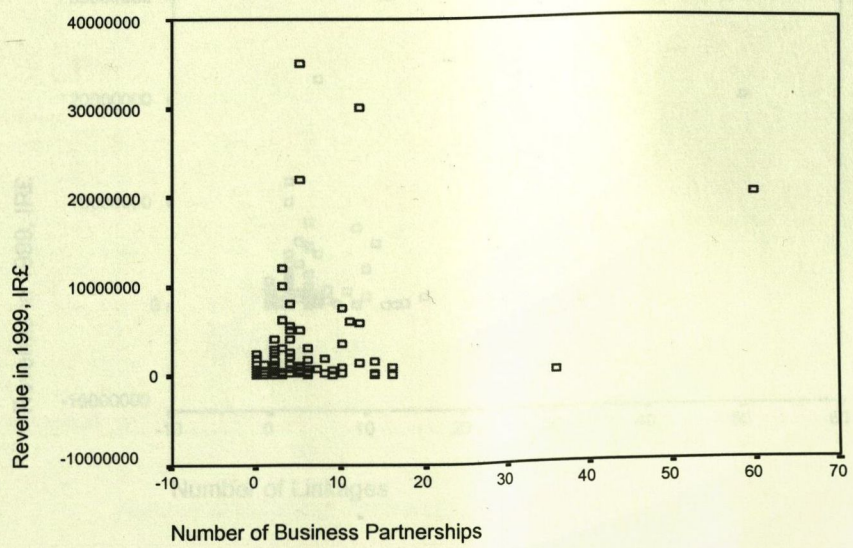
5.17 Skewness of 'Establishment Year' Data

Valid	121
Missing	2
Skewness	-5.353
Std. Error of Skewness	.220

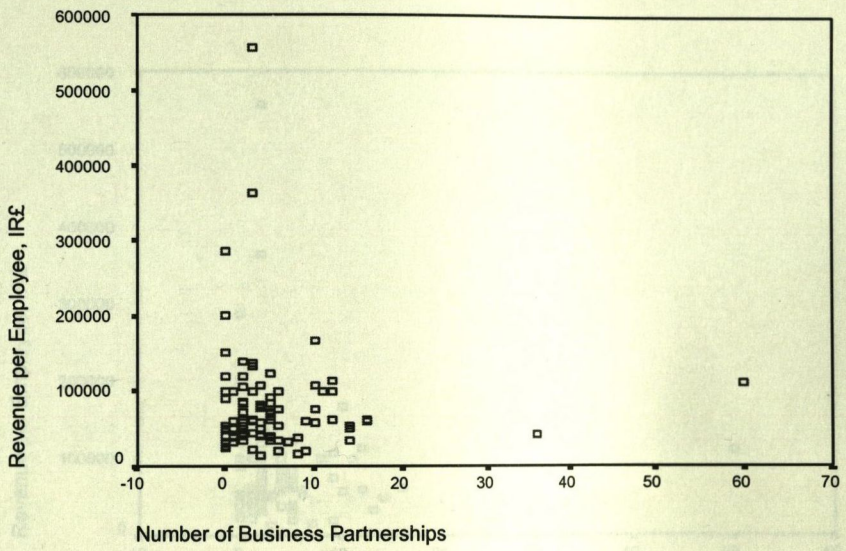
5.18 Histogram illustrating Frequency Distribution for 'Establishment Year'



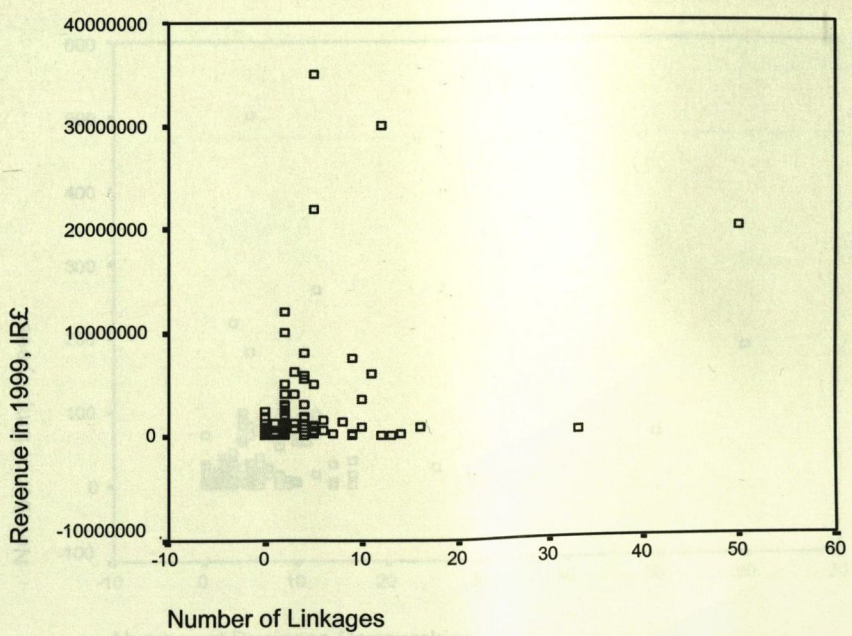
5.19 Scatter Graph Illustrating Correlation 'Number of Business Partnerships' – 'Revenue in 1999'



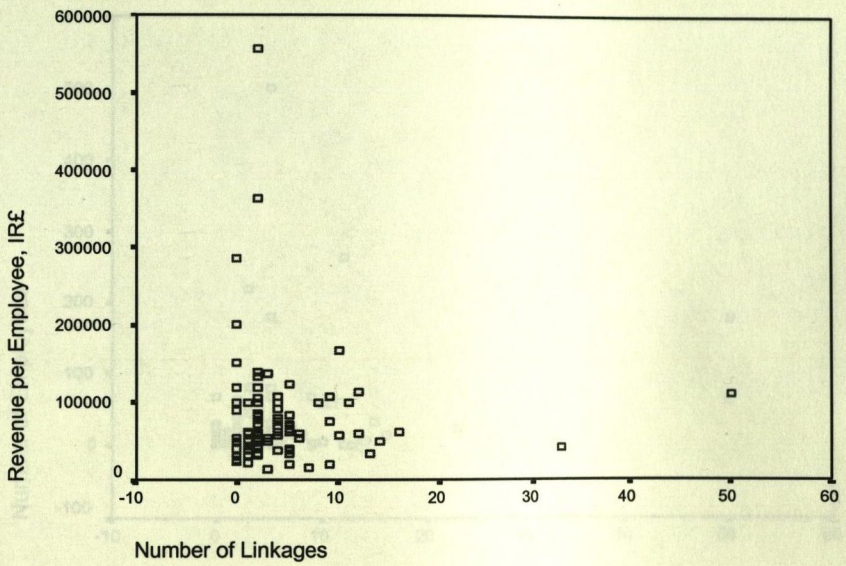
5.20 Scatter Graph Illustrating Correlation 'Number of Business Partnerships' – 'Revenue per Employee'



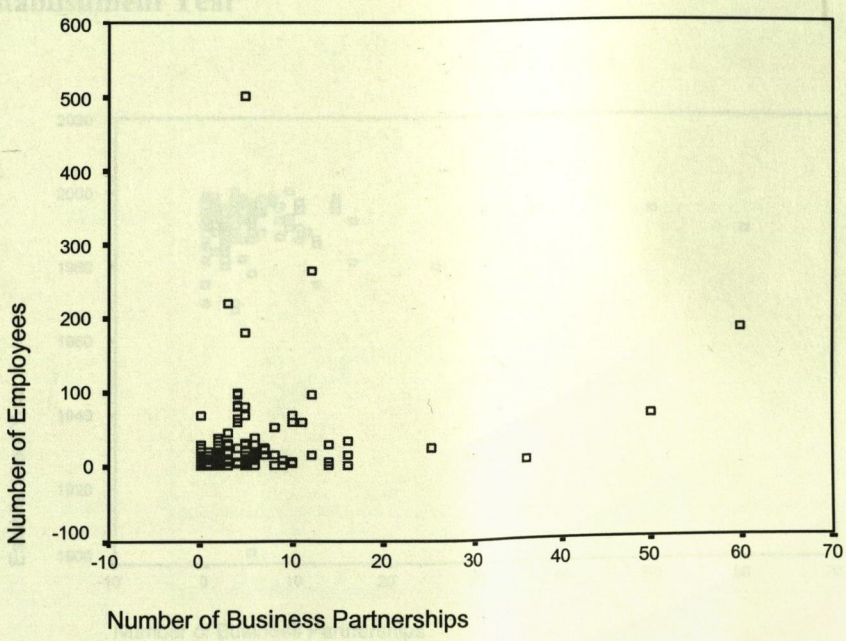
5.20(1)Scatter Graph Illustrating Correlation 'Number of Inter-company Linkages' – 'Revenue in 1999'



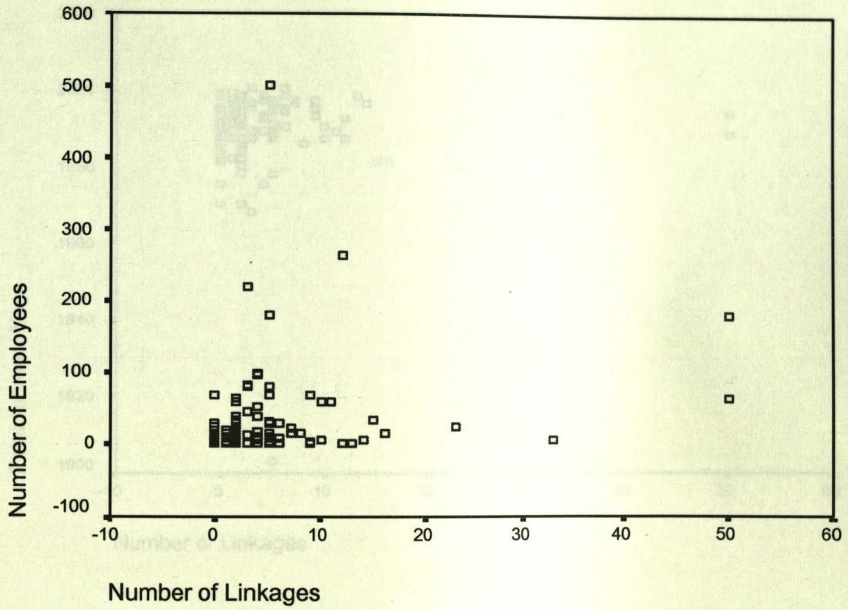
5.20(2)Scatter Graph Illustrating Correlation 'Number of Inter-company Linkages' – 'Revenue per Employee'



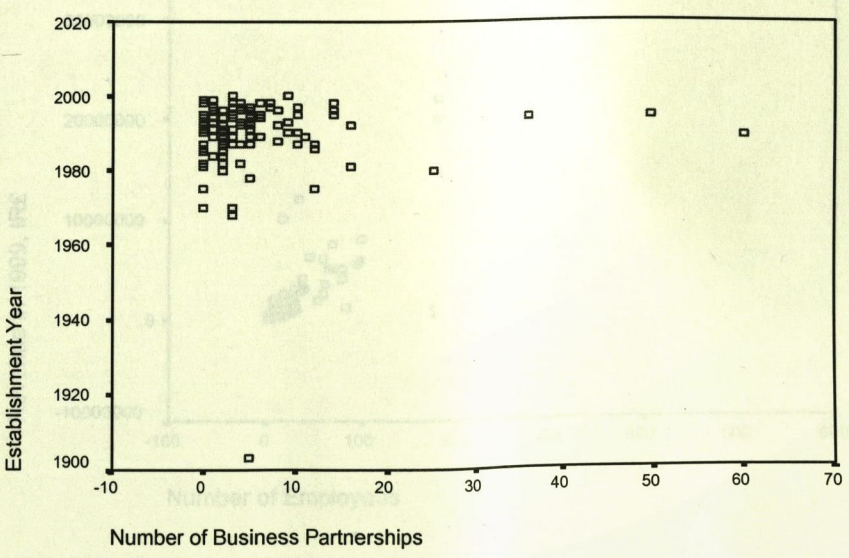
5.21 Scatter Graph Illustrating Correlation 'Number of Business Partnerships' – 'Number of Employees'



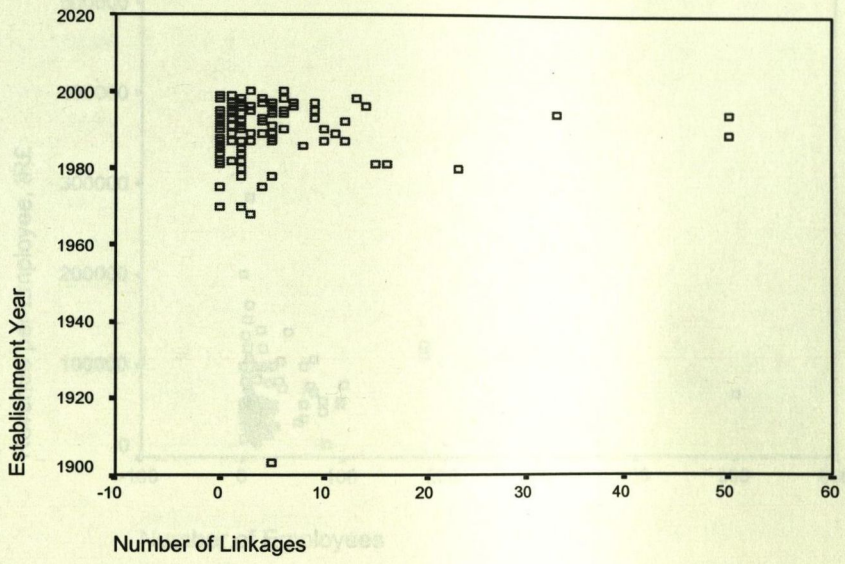
5.21(1)Scatter Graph Illustrating Correlation 'Number of Inter-company Linkages' – 'Number of Employees'



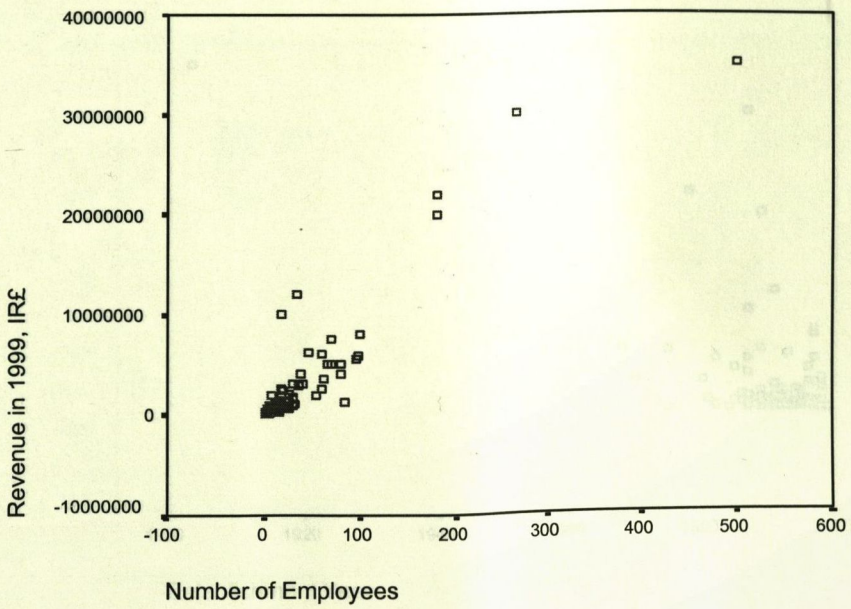
5.22 Scatter Graph Illustrating Correlation 'Number of Business Partnerships' – 'Establishment Year'



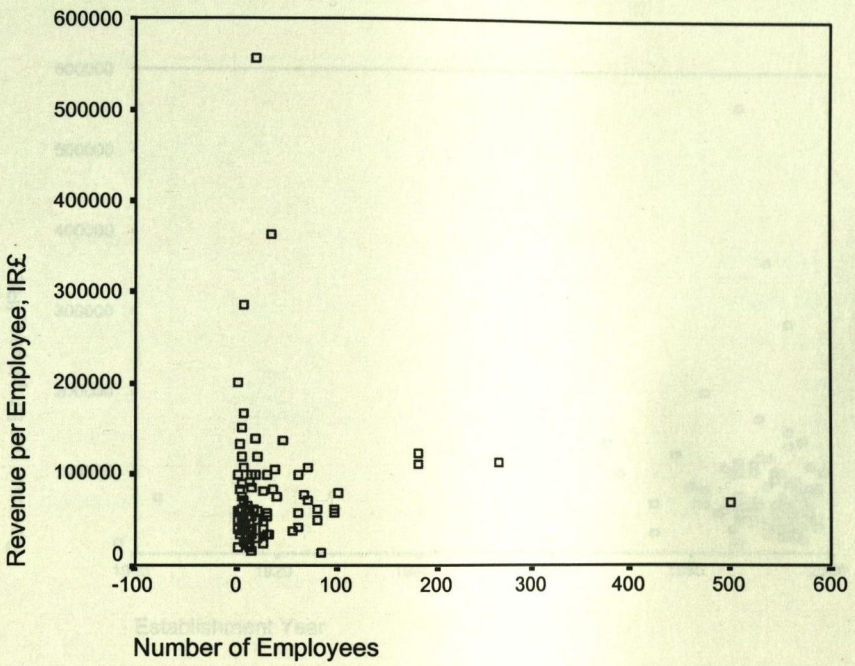
5.22(1)Scatter Graph Illustrating Correlation 'Number of Business Partnerships' – 'Establishment Year'



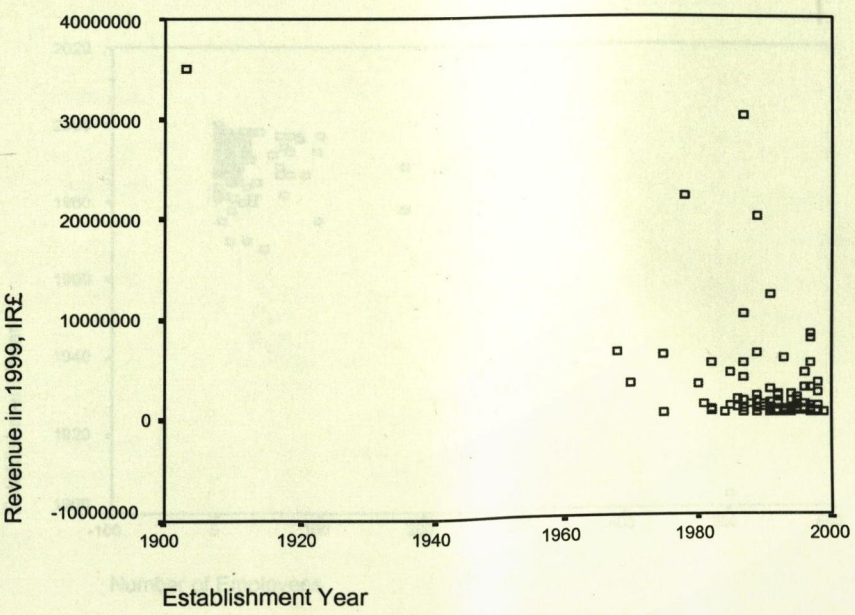
5.23 Scatter Illustrating Correlation 'Revenue in 1999' – 'Number of Employees'



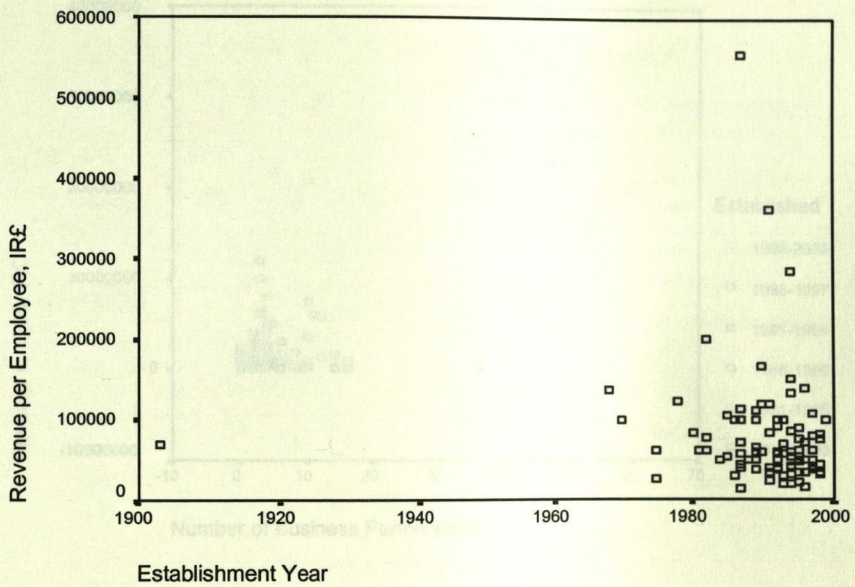
5.24 Scatter Illustrating Correlation 'Revenue per Employee' – 'Number of Employees'



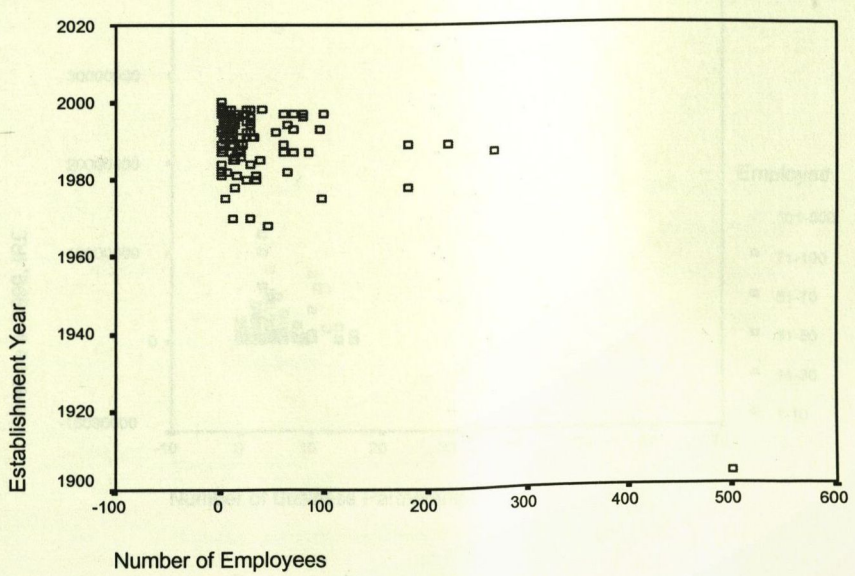
5.23 Scatter Illustrating Correlation 'Revenue in 1999' – 'Establishment Year'



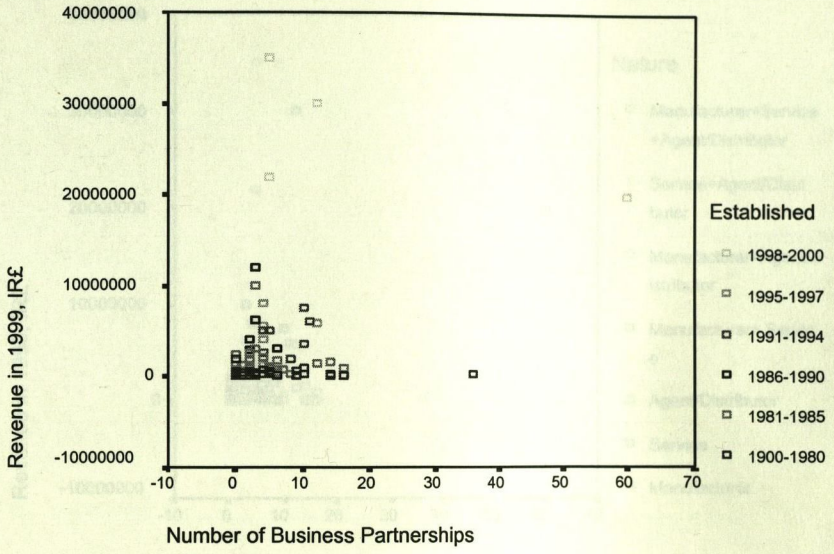
5.25 Scatter Illustrating Correlation 'Revenue per Employee' – 'Establishment Year'



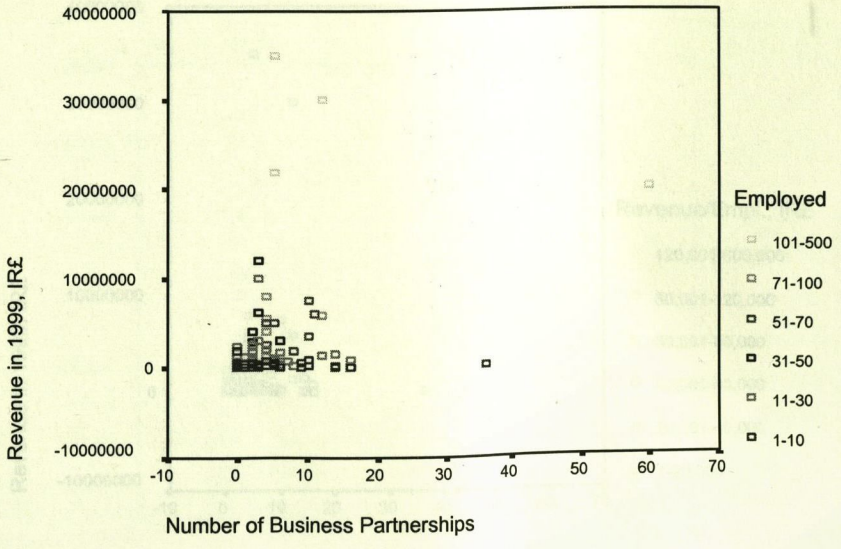
5.26 Scatter Illustrating Correlation 'Number of Employees' – 'Establishment Year'



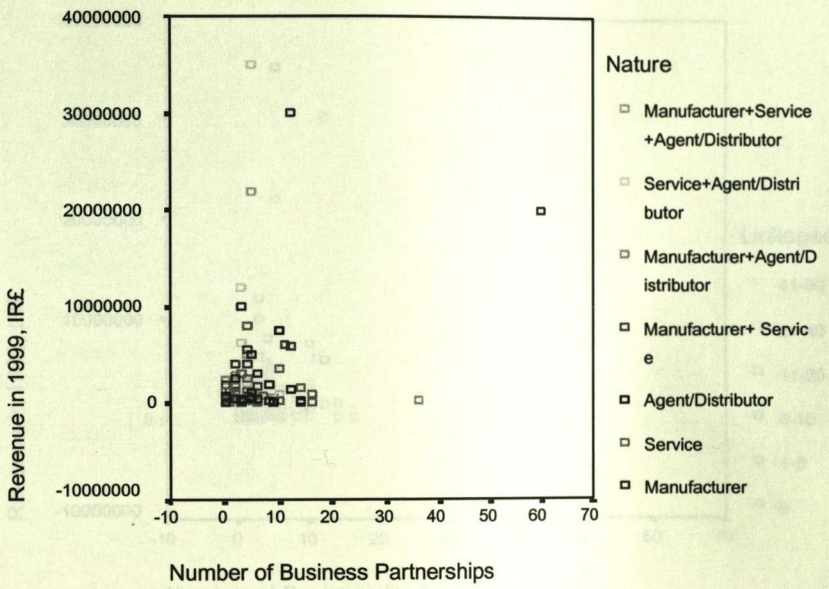
5.27 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation



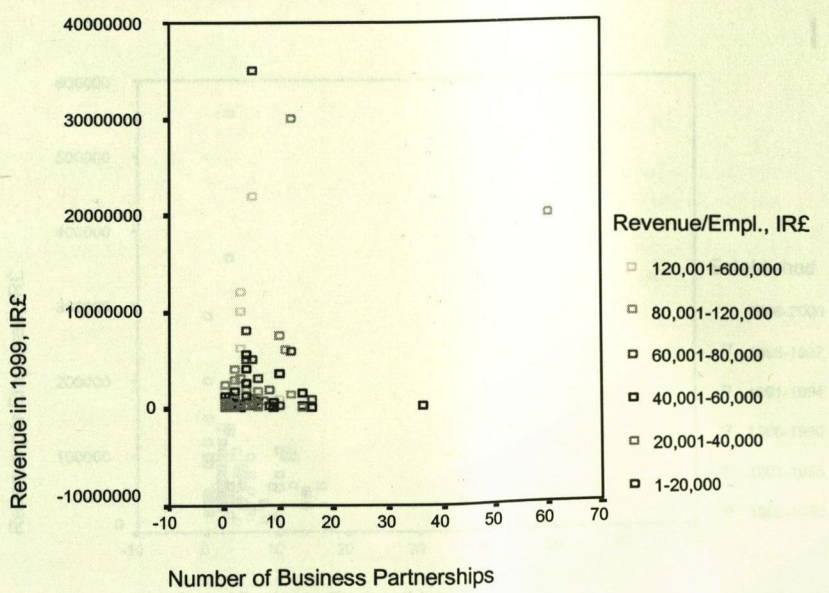
5.28 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation



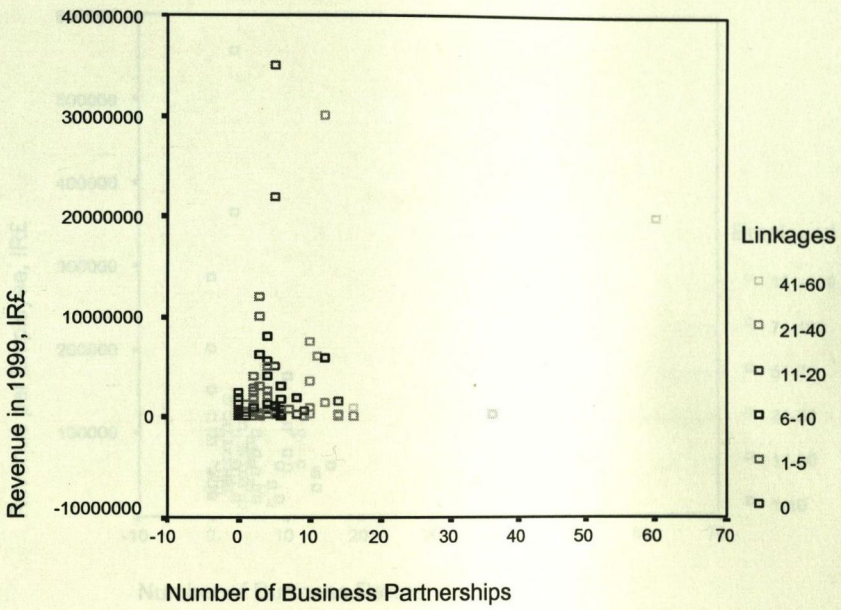
5.29 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation



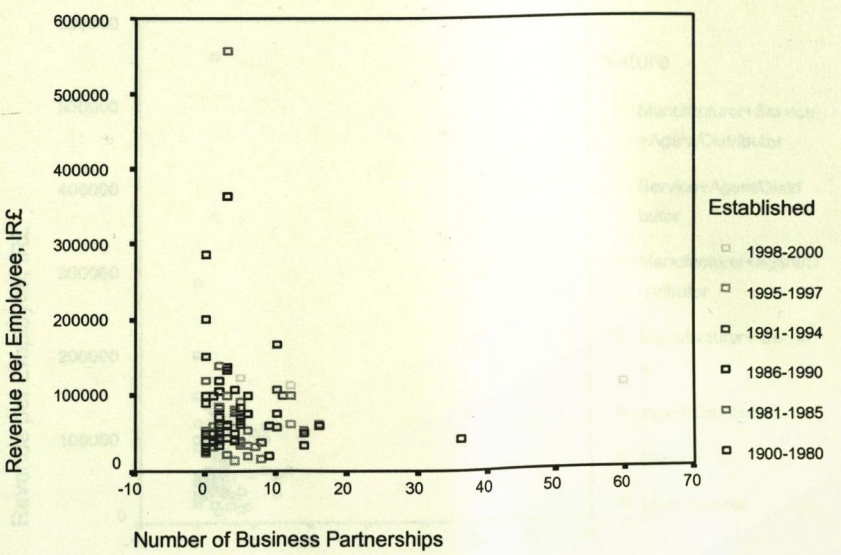
5.30 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation



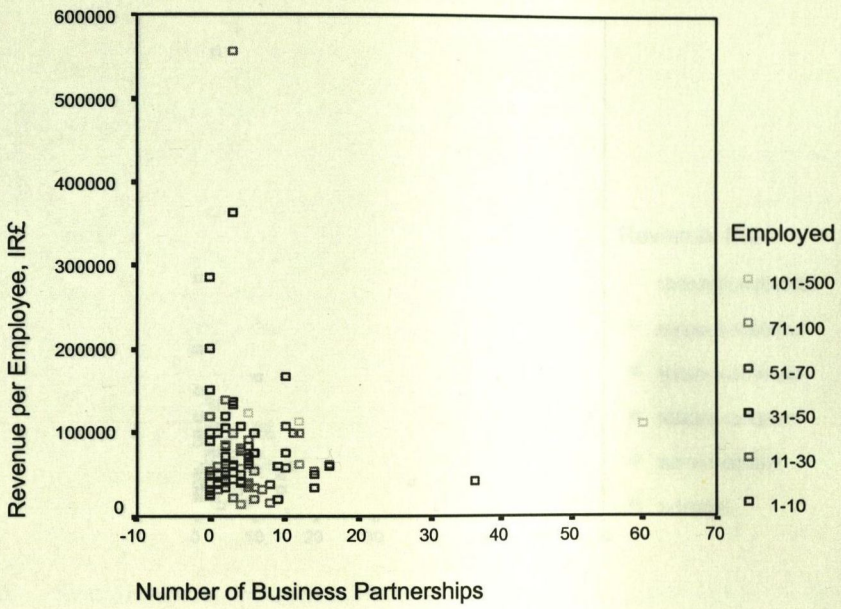
5.31 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Number of Business Partnerships' - 'Revenue in 1999' Correlation



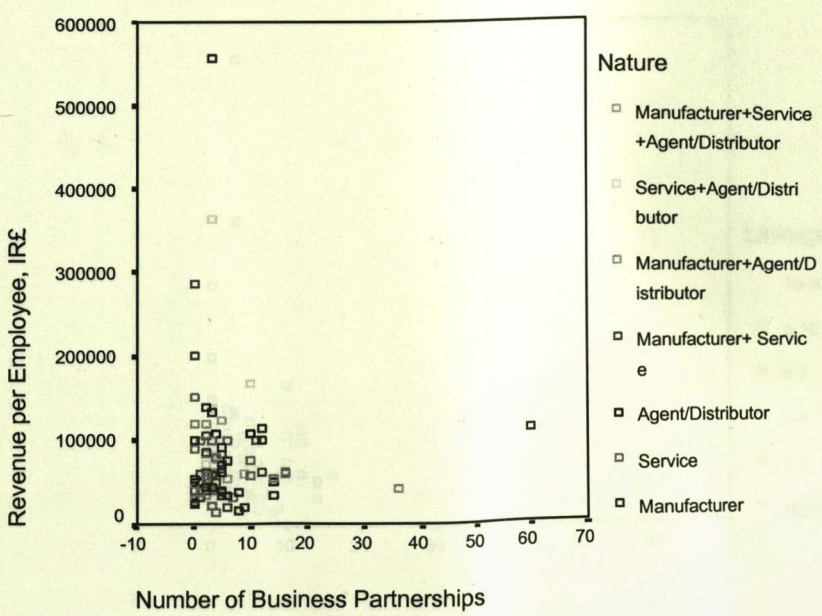
5.32 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Number of Business Partnerships' - 'Revenue per Employee' Correlation



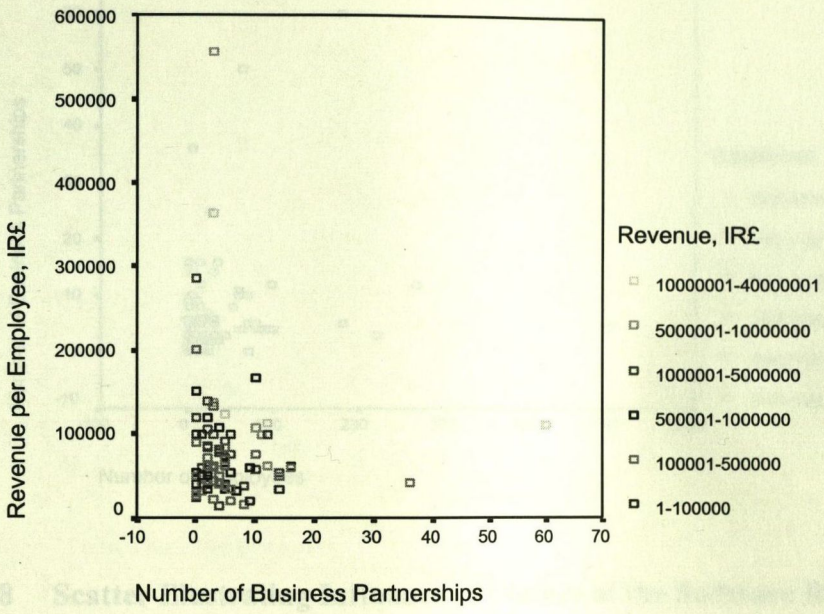
5.33 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Number of Business Partnerships' - 'Revenue per Employee' Correlation



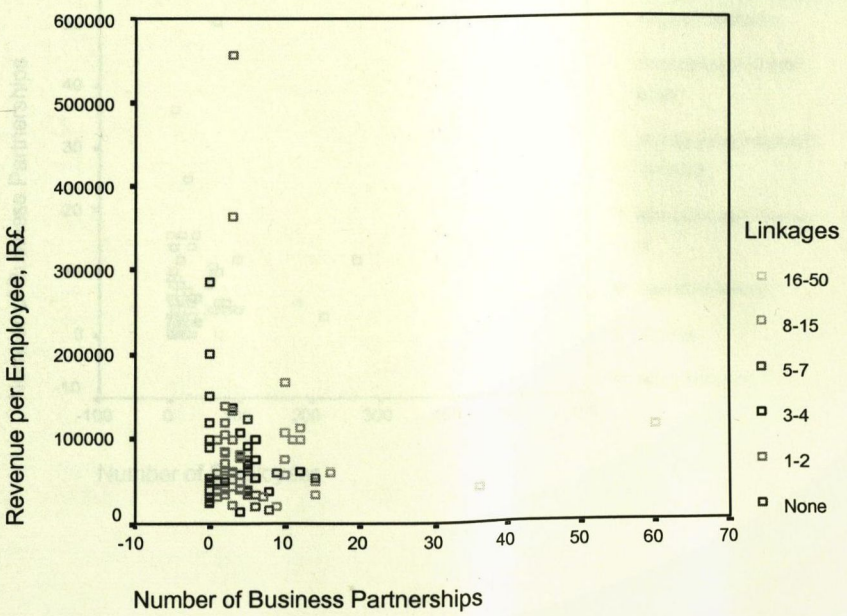
5.34 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Number of Business Partnerships' - 'Revenue per Employee' Correlation



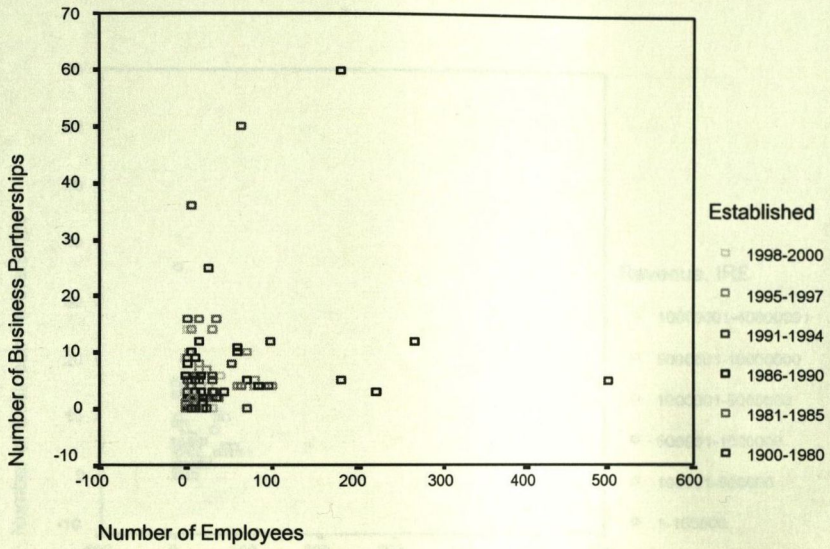
5.35 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Number of Business Partnerships' - 'Revenue per Employee' Correlation



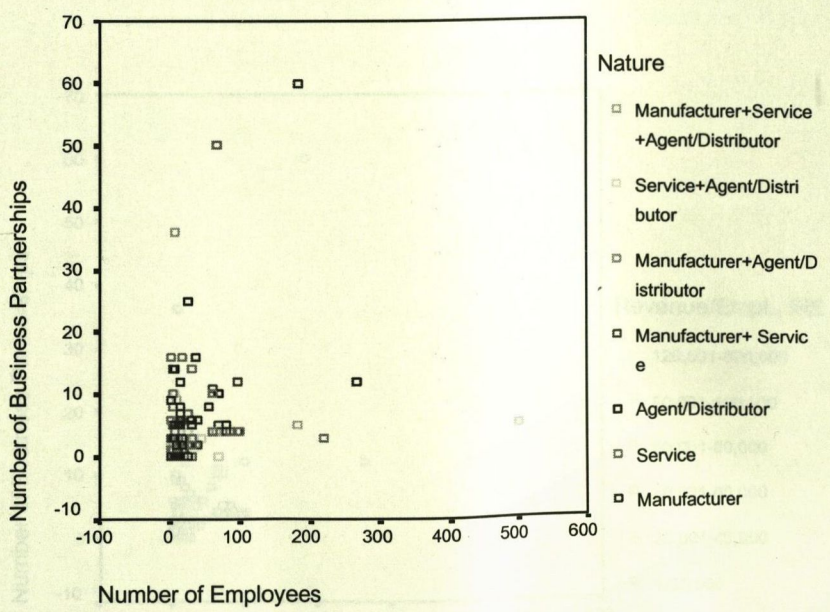
5.36 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Number of Business Partnerships' - 'Revenue per Employee' Correlation



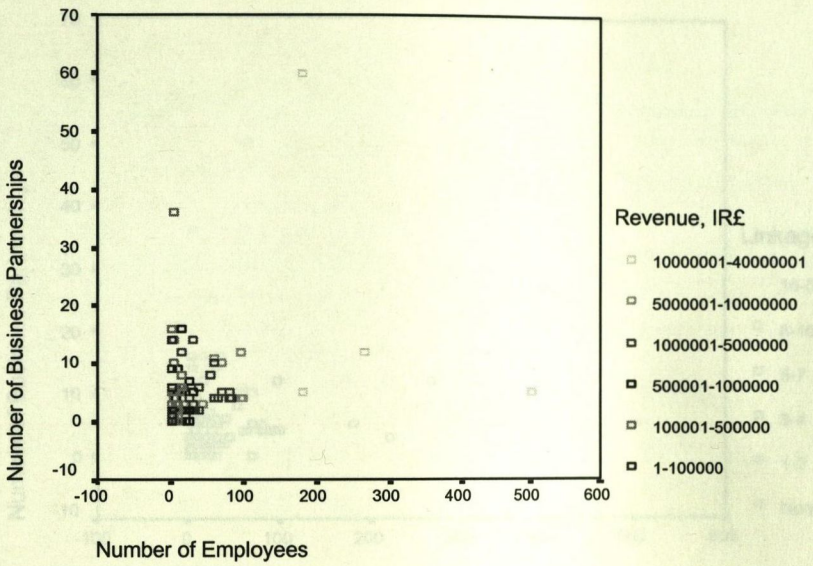
5.37 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Number of Business Partnerships' - 'Number of Employees' Correlation



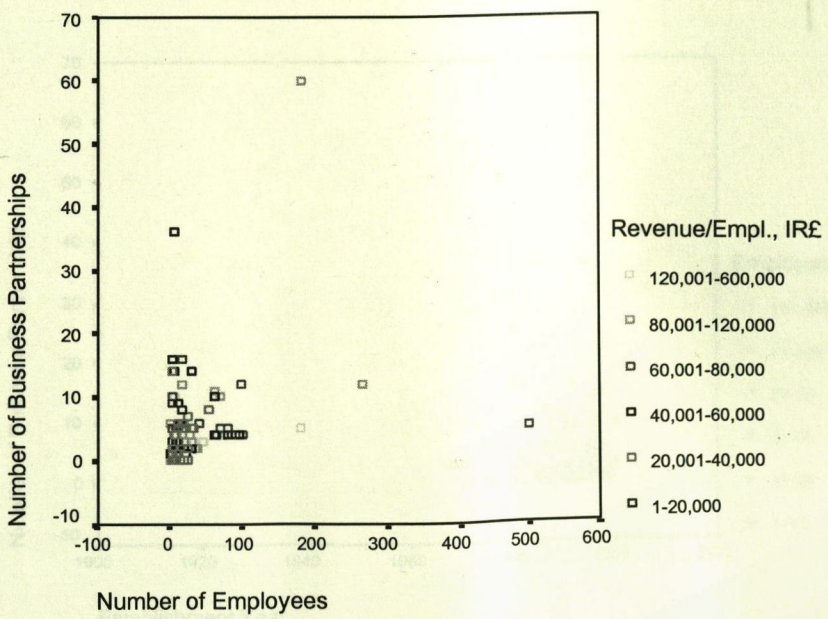
5.38 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Number of Business Partnerships' - 'Number of Employees' Correlation



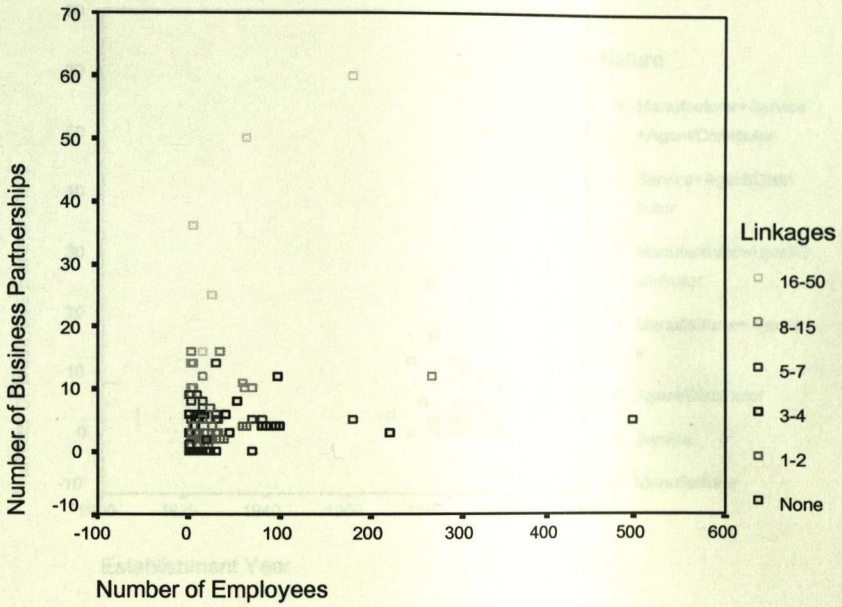
5.39 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Number of Business Partnerships' - 'Number of Employees' Correlation



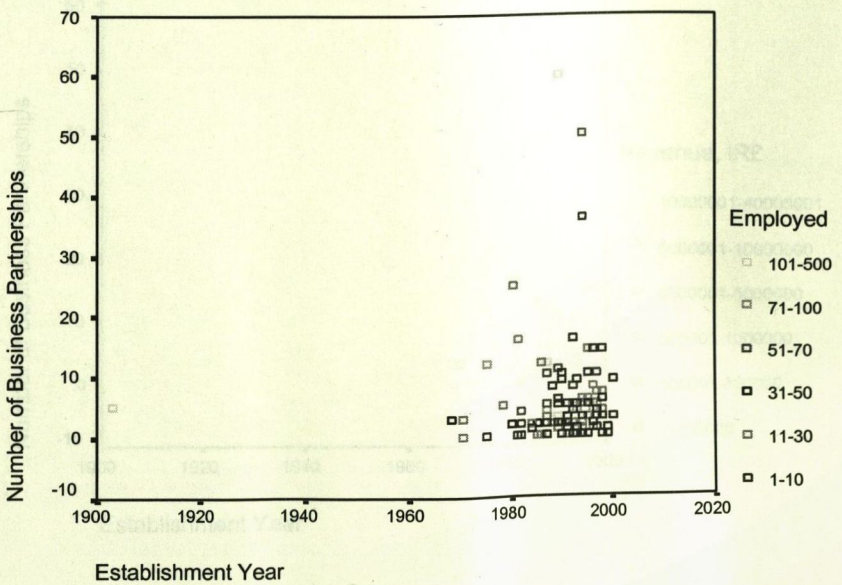
5.40 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Number of Business Partnerships' - 'Number of Employees' Correlation



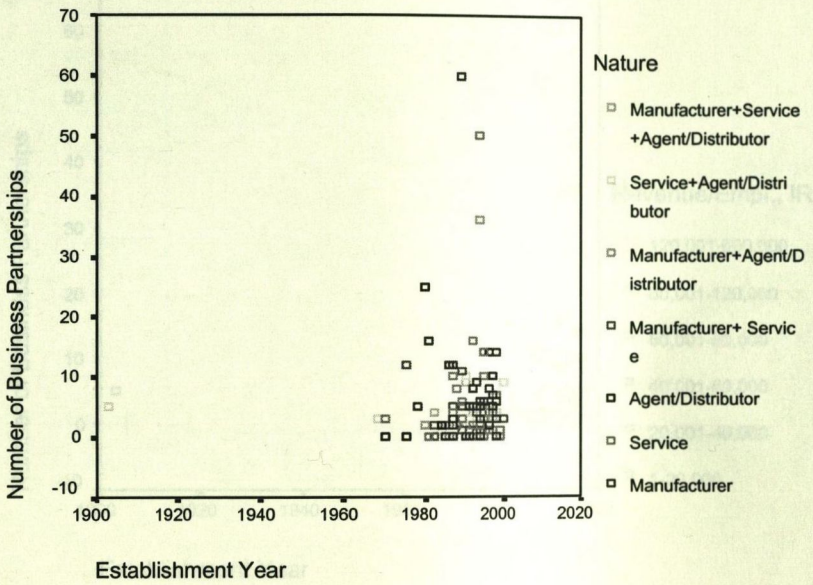
5.41 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Number of Business Partnerships' - 'Number of Employees' Correlation



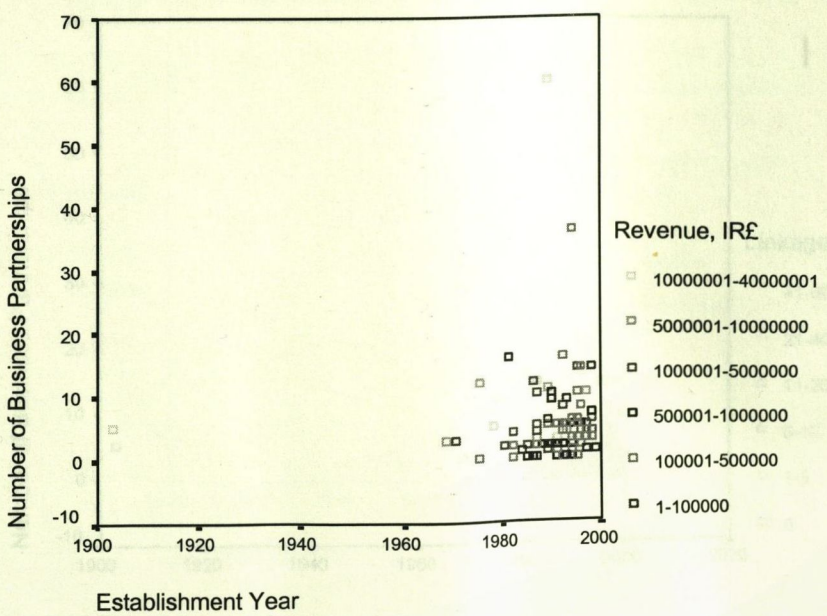
5.42 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Number of Business Partnerships' - 'Establishment Year' Correlation



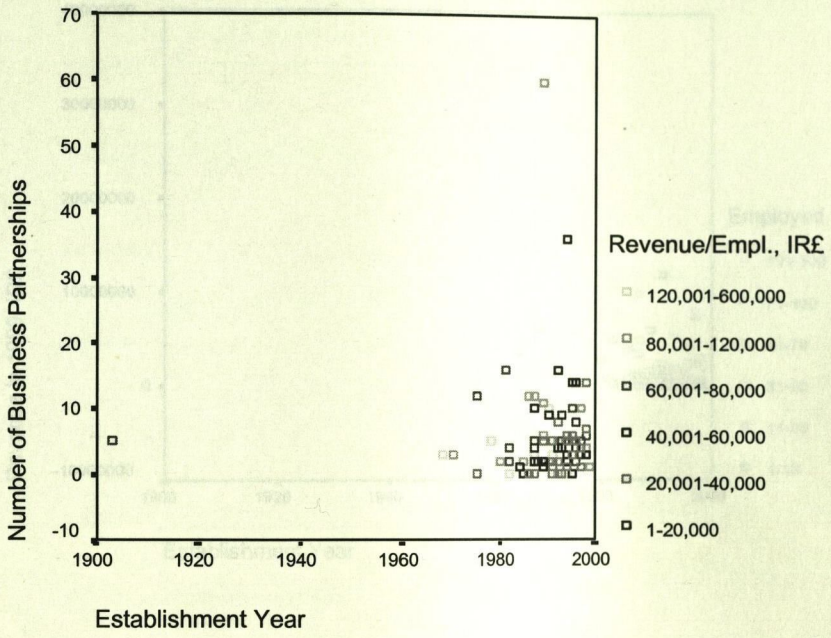
5.43 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Number of Business Partnerships' - 'Establishment Year' Correlation



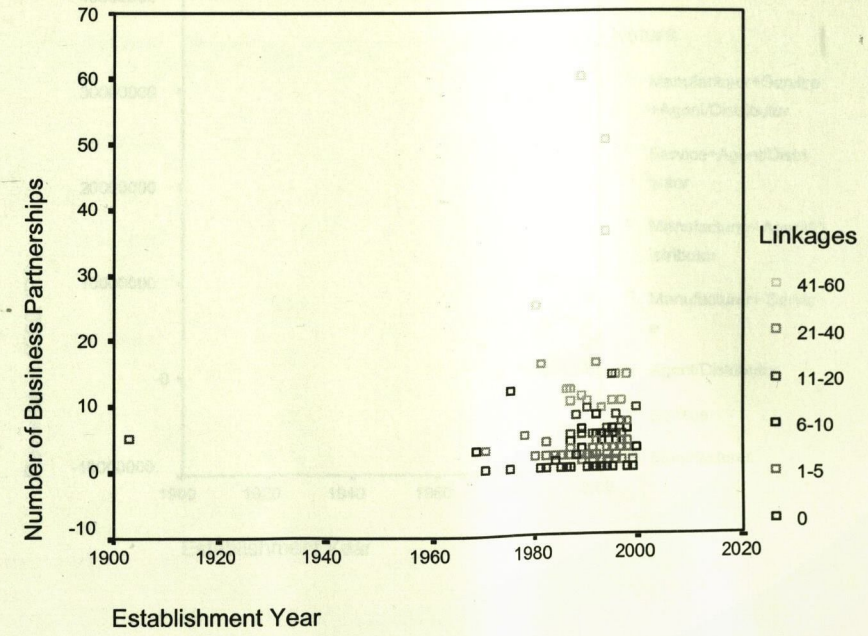
5.44 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Number of Business Partnerships' - 'Establishment Year' Correlation



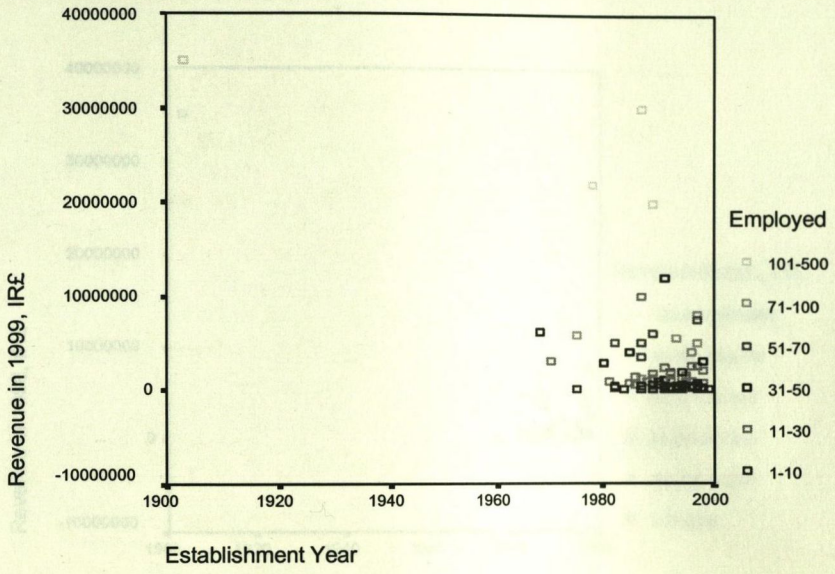
5.45 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Number of Business Partnerships' - 'Establishment Year' Correlation



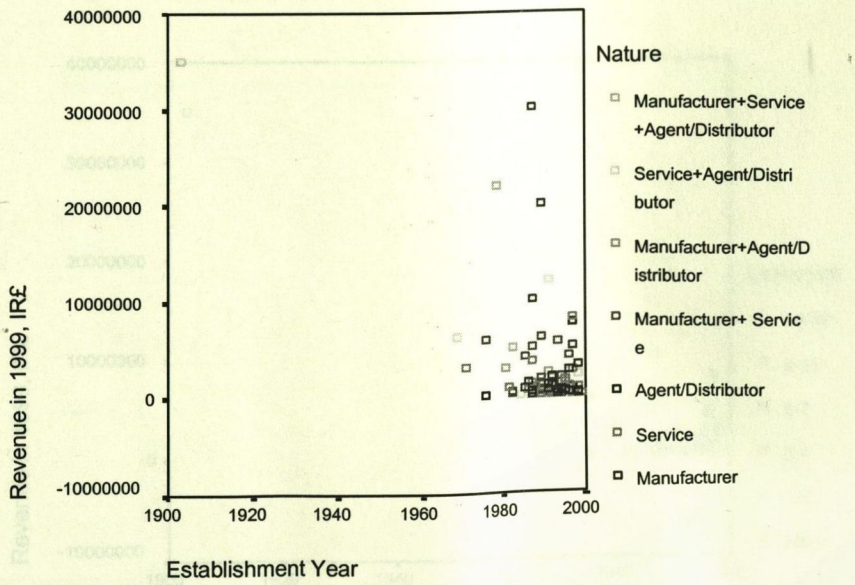
5.46 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Number of Business Partnerships' - 'Establishment Year' Correlation



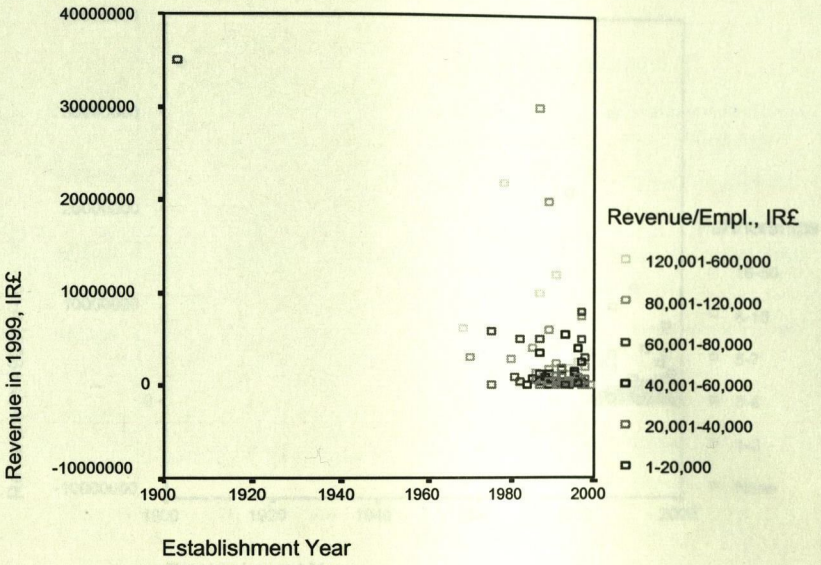
5.47 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Revenue in 1999' - 'Establishment Year' Correlation



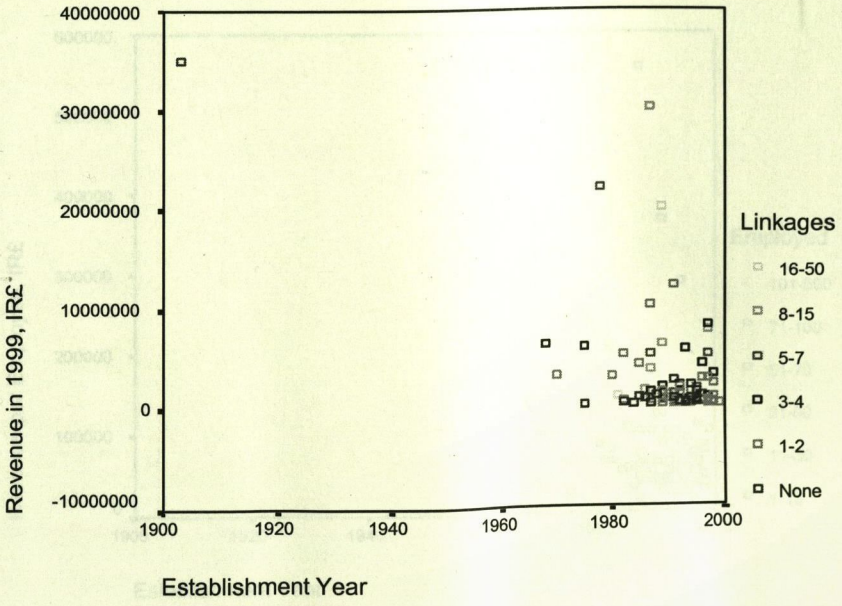
5.48 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Revenue in 1999' - 'Establishment Year' Correlation



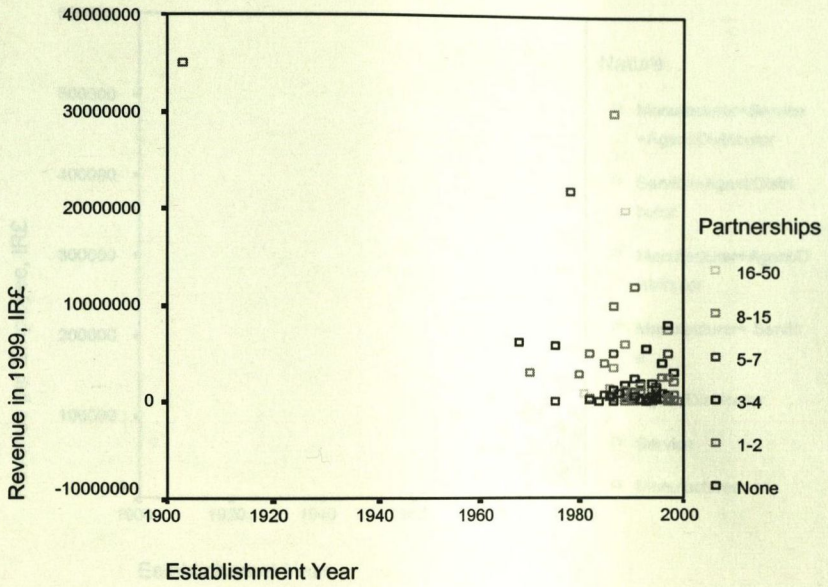
5.49 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Revenue in 1999' - 'Establishment Year' Correlation



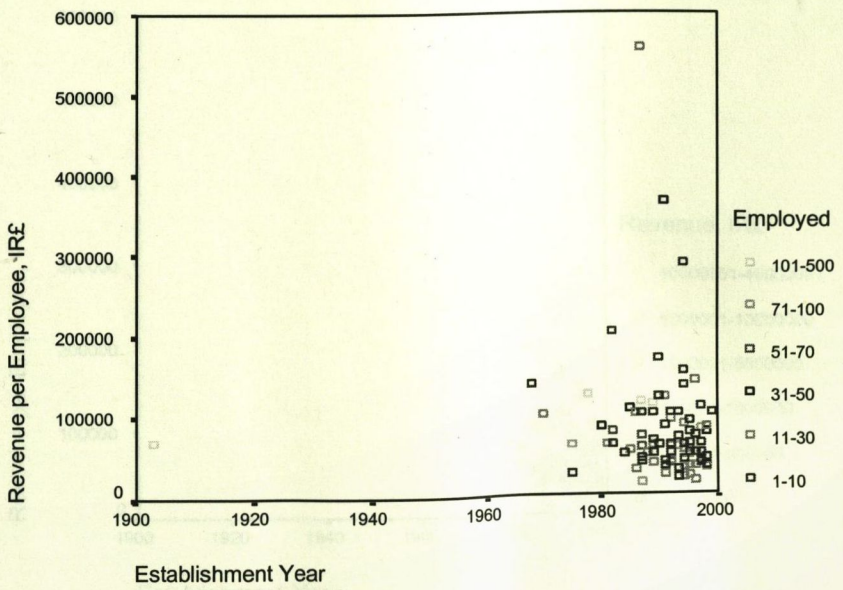
5.50 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Revenue in 1999' - 'Establishment Year' Correlation



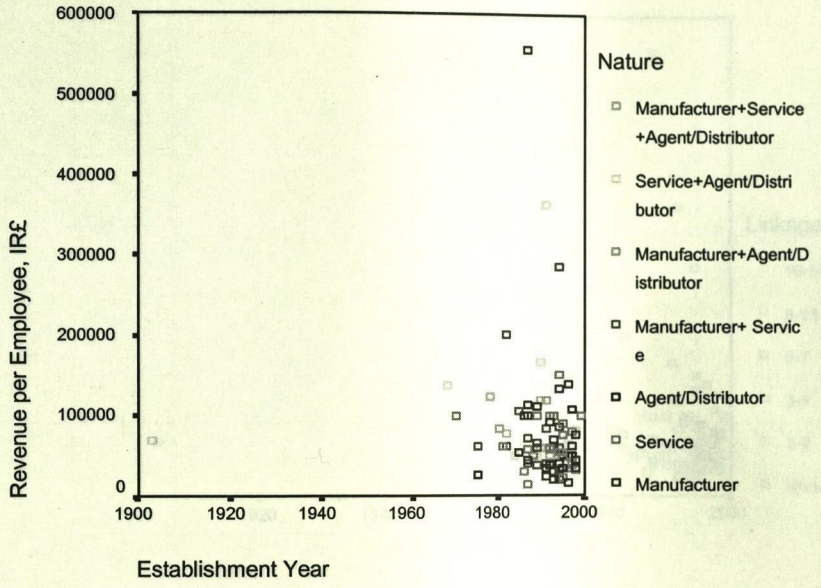
5.51 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Revenue in 1999' - 'Establishment Year' Correlation



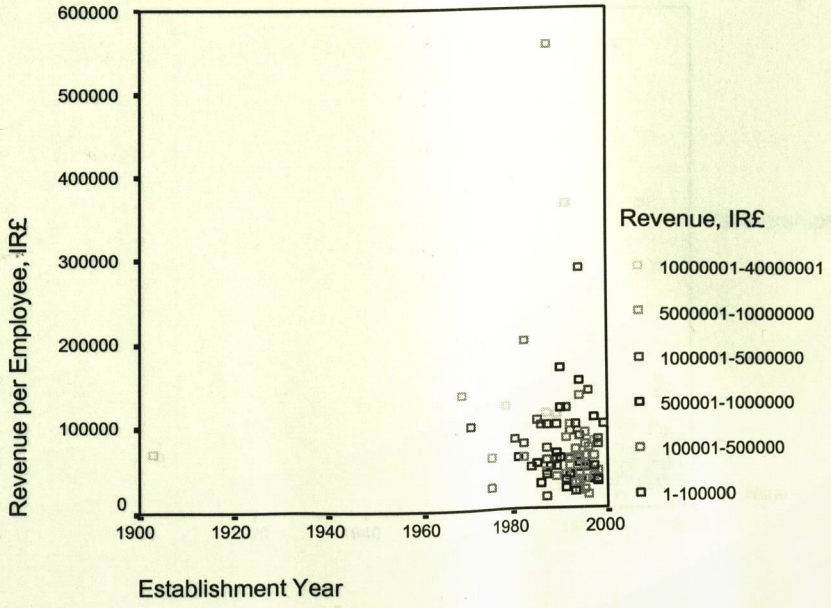
5.52 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Revenue per Employee' - 'Establishment Year' Correlation



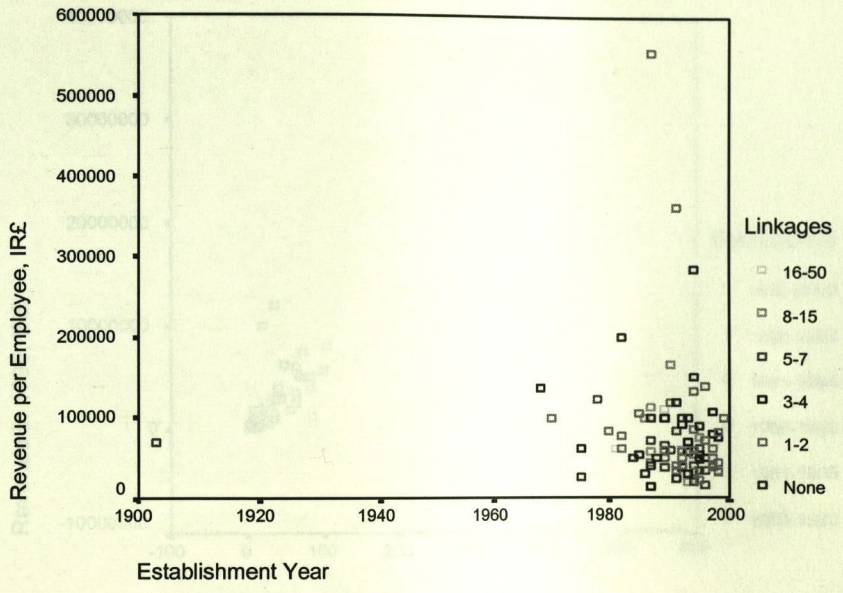
5.53 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Revenue per Employee' - 'Establishment Year' Correlation



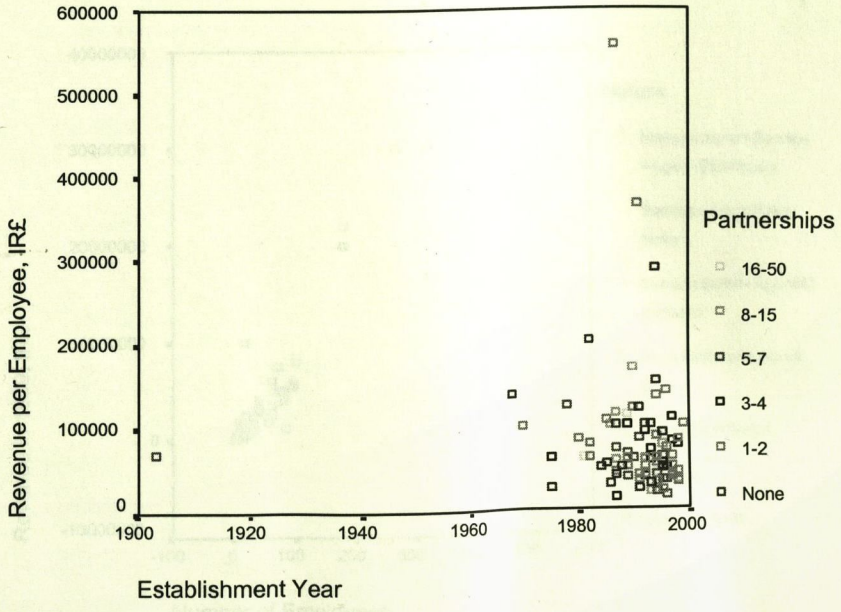
5.54 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Revenue per Employee' - 'Establishment Year' Correlation



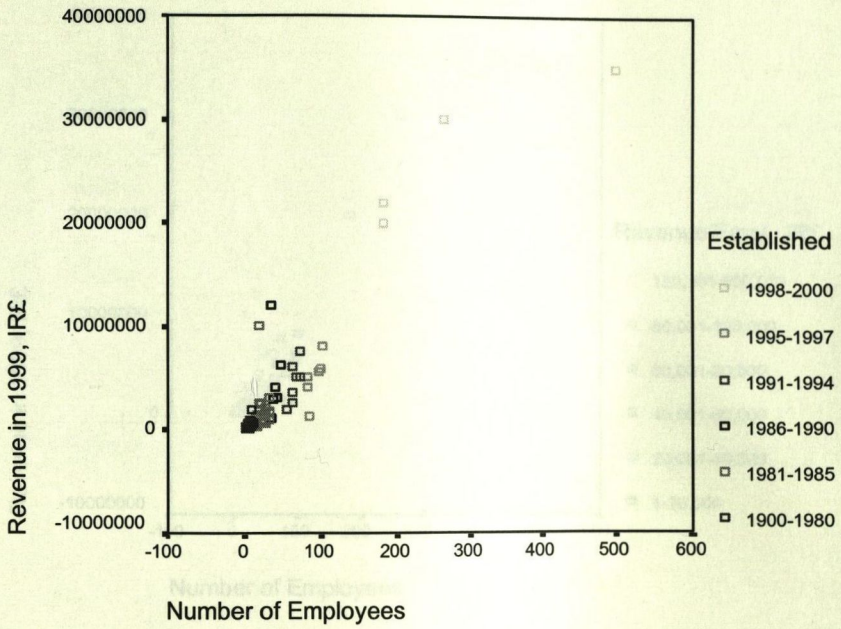
5.55 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Revenue per Employee' - 'Establishment Year' Correlation



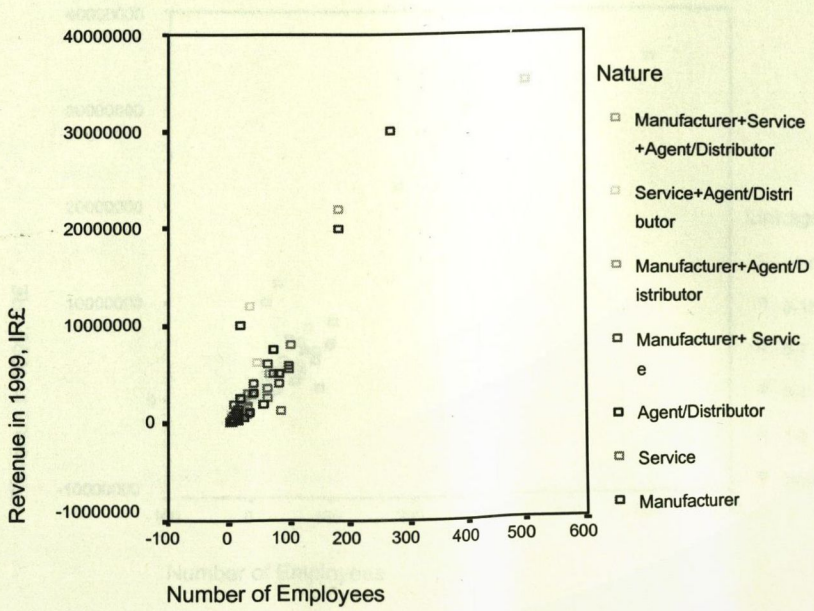
5.56 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Revenue per Employee' - 'Establishment Year' Correlation



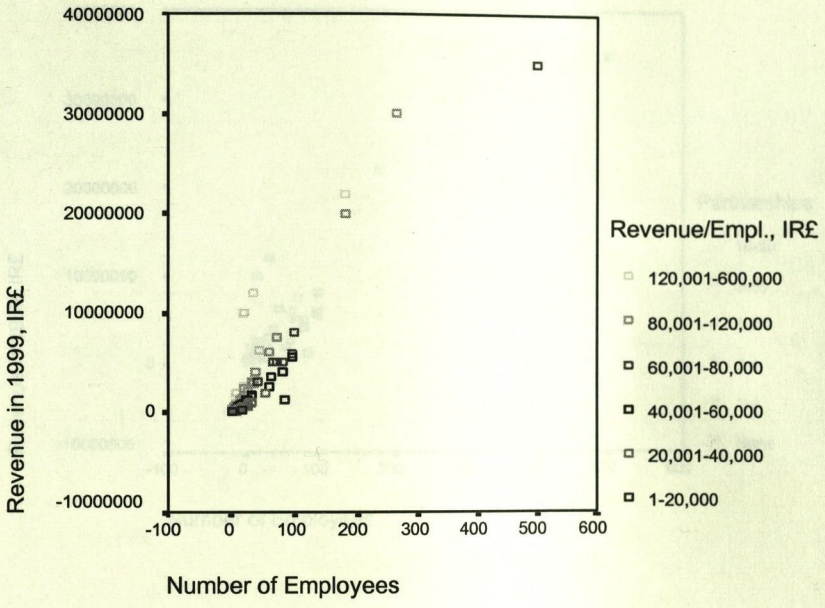
5.57 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Revenue in 1999' - 'Number of Employees' Correlation (Look up 1991-1994)



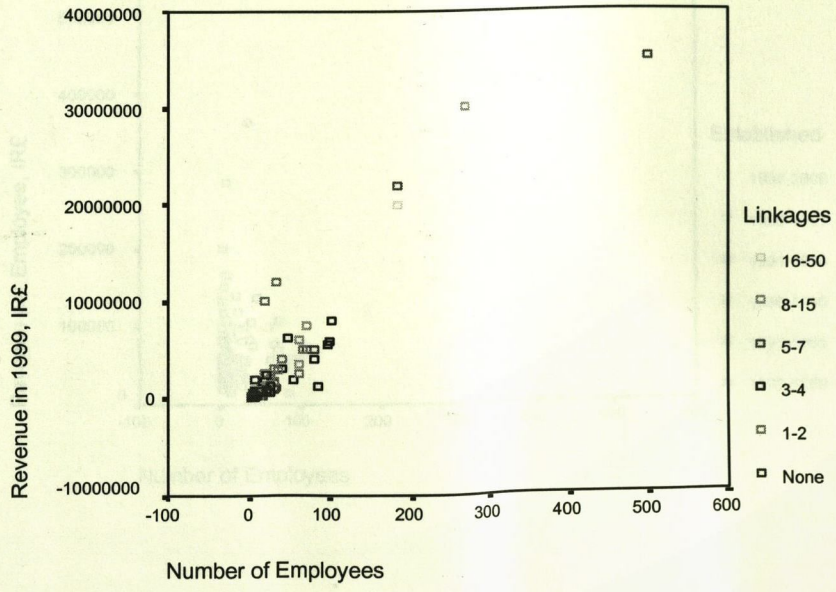
5.58 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Revenue in 1999' - 'Number of Employees' Correlation (Look up)



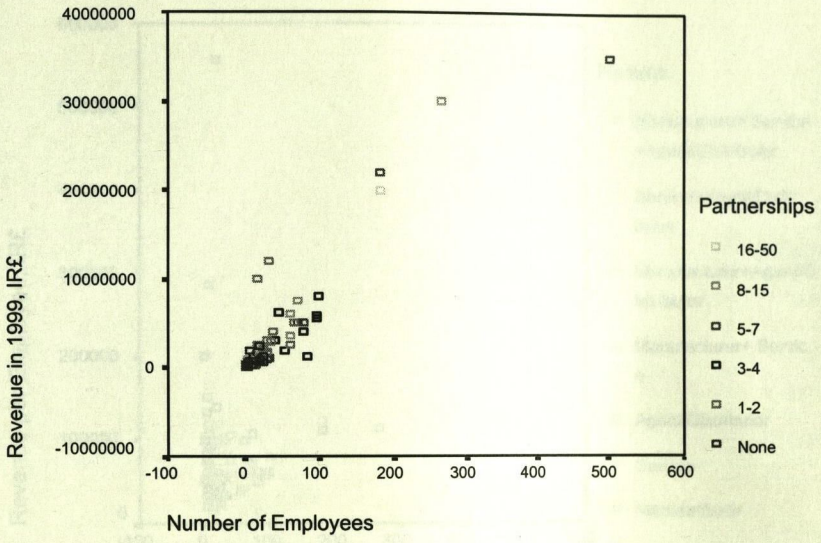
5.59 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Revenue in 1999' - 'Number of Employees' Correlation



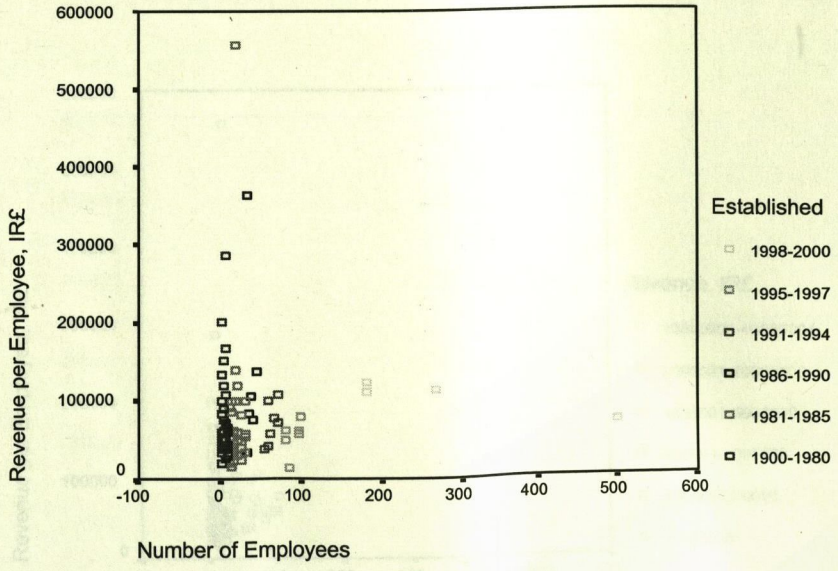
5.60 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Revenue in 1999' - 'Number of Employees' Correlation



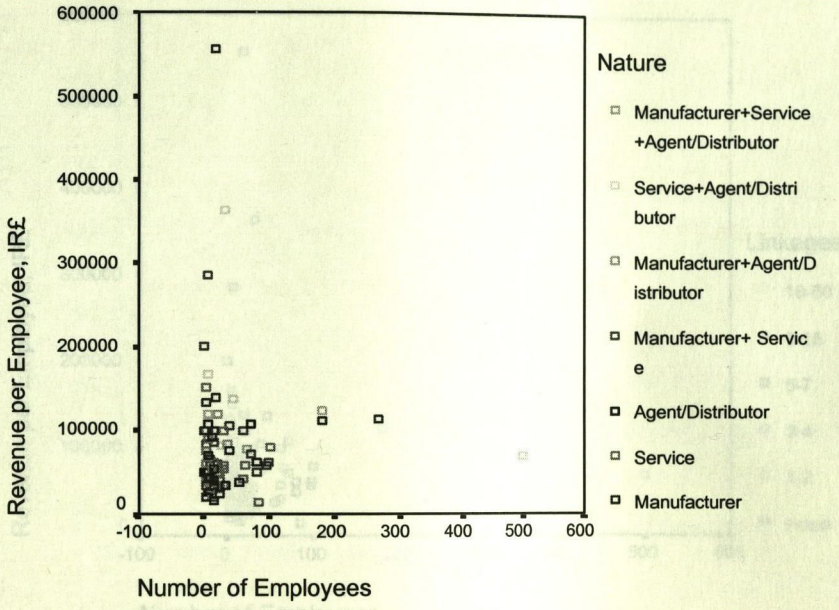
5.61 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Revenue in 1999' - 'Number of Employees' Correlation



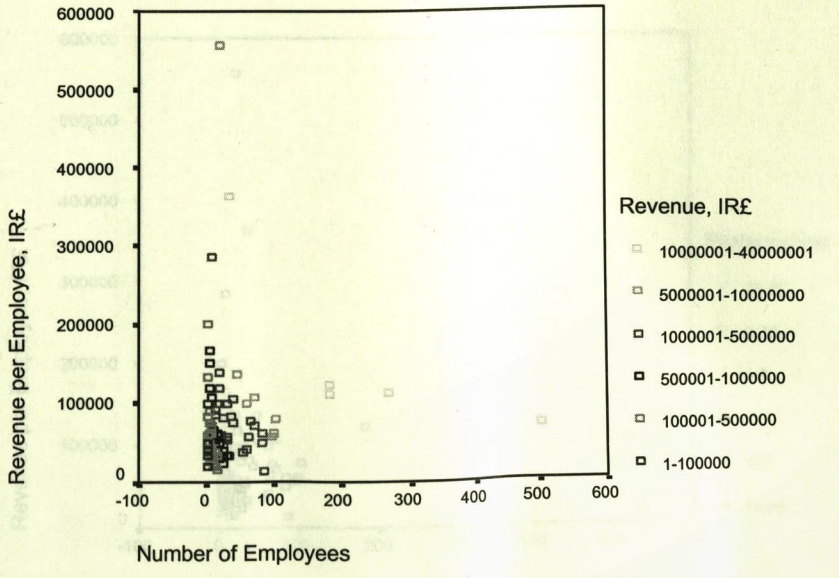
5.62 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Revenue per Employee' - 'Number of Employees' Correlation



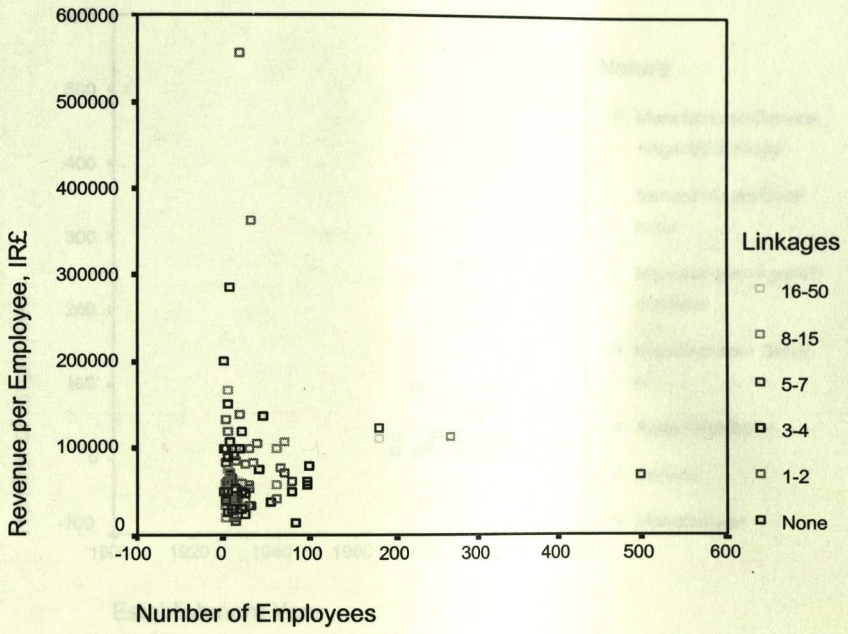
5.63 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Revenue per Employee' - 'Number of Employees' Correlation



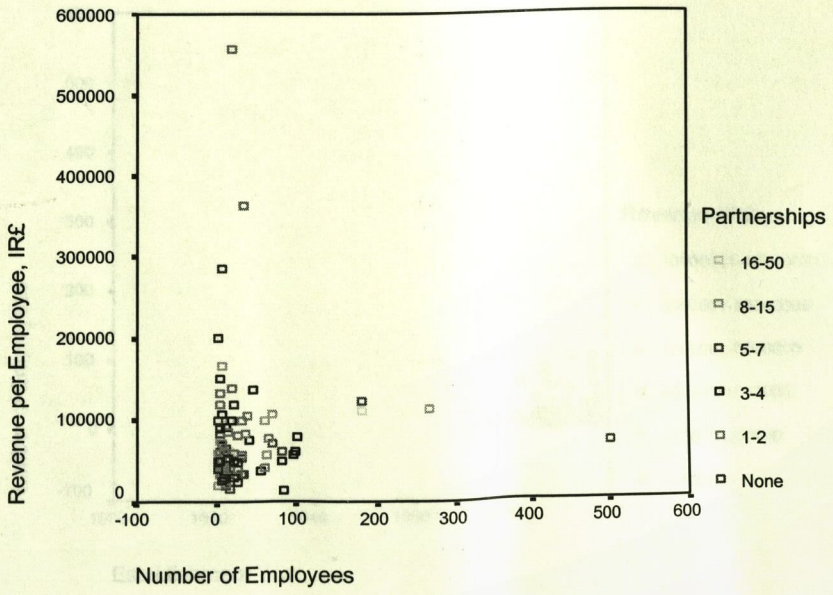
5.64 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Revenue per Employee' - 'Number of Employees' Correlation



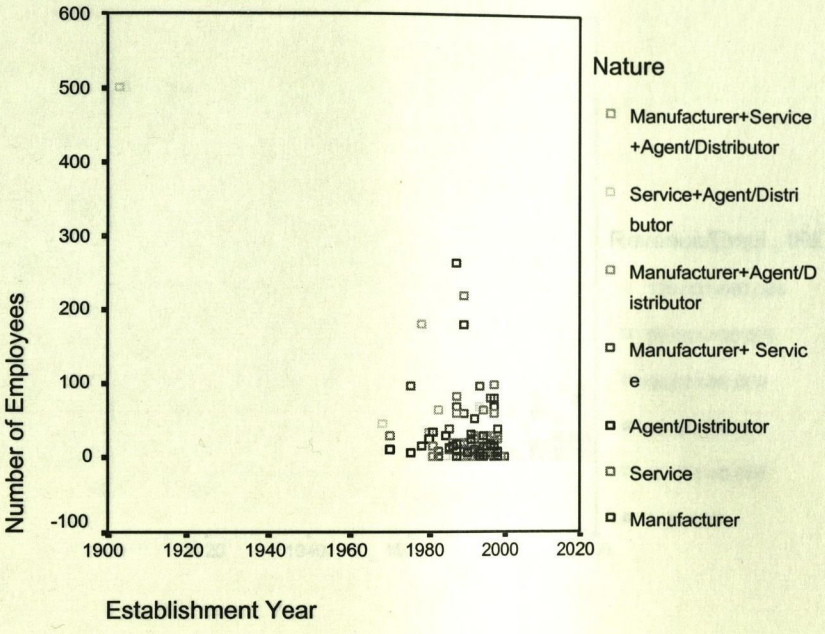
5.65 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Revenue per Employee' - 'Number of Employees' Correlation



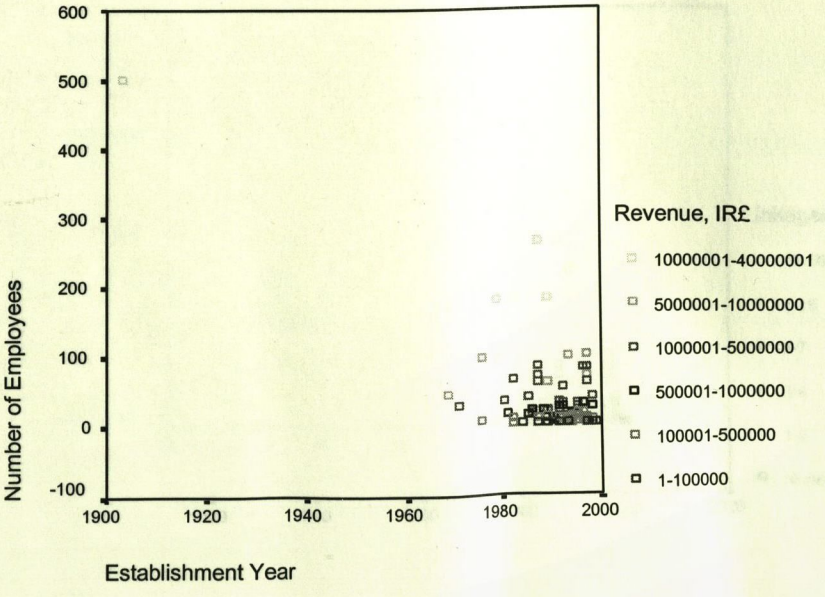
5.66 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Revenue per Employee' - 'Number of Employees' Correlation



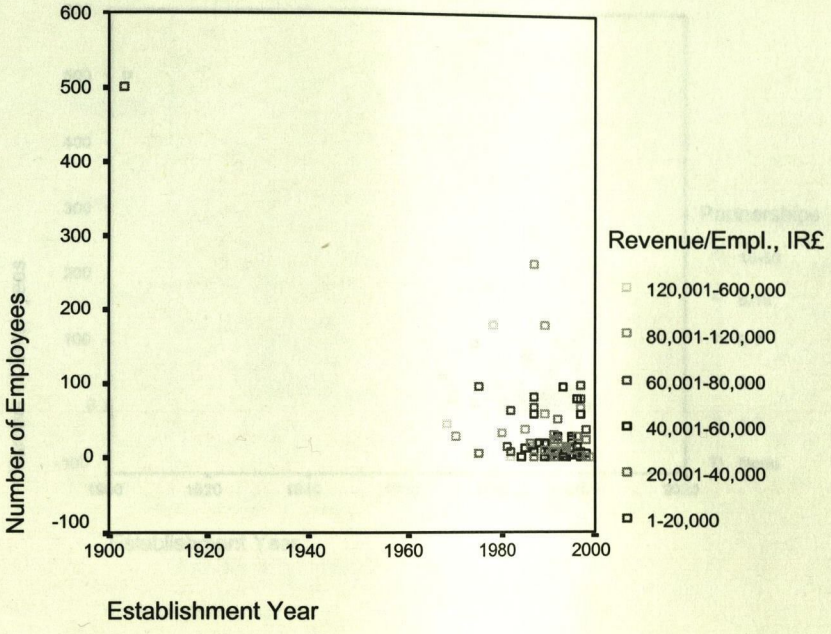
5.67 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Number of Employees' - 'Establishment Year' Correlation



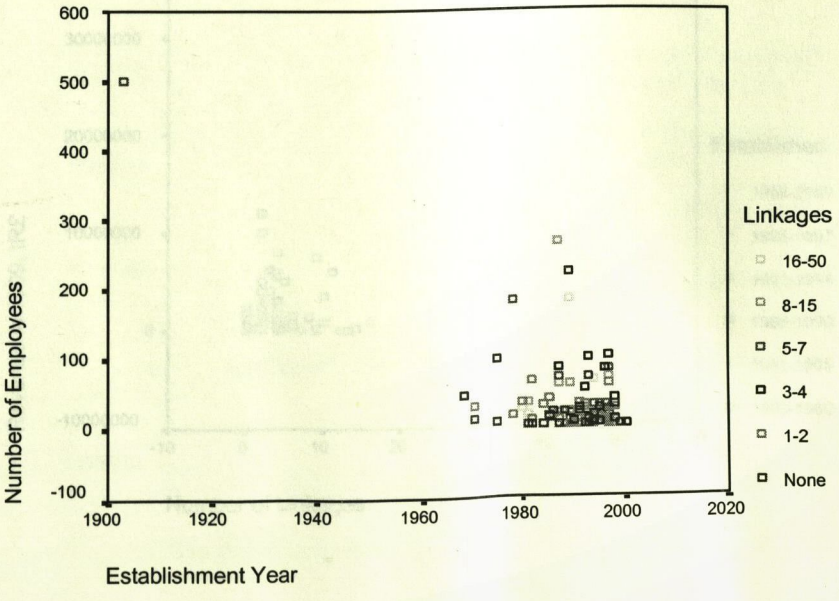
5.68 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Number of Employees' - 'Establishment Year' Correlation



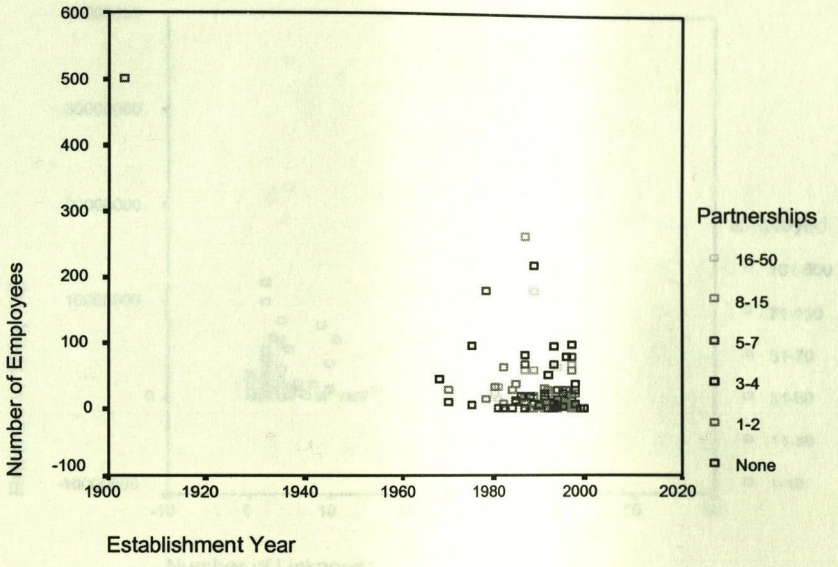
5.69 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Number of Employees' - 'Establishment Year' Correlation



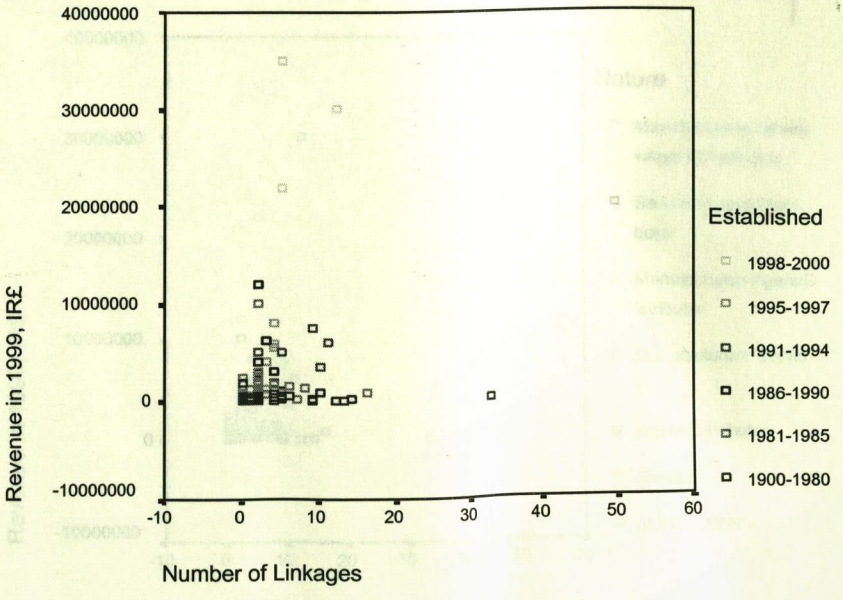
5.70 Scatter Illustrating Influence of 'Number of Linkages' Variable on 'Number of Employees' - 'Establishment Year' Correlation



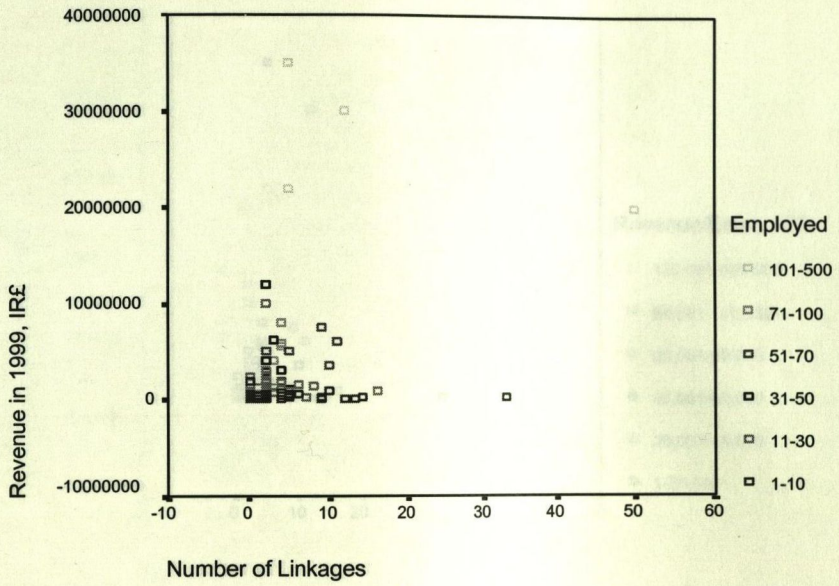
5.71 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Number of Employees' - 'Establishment Year' Correlation



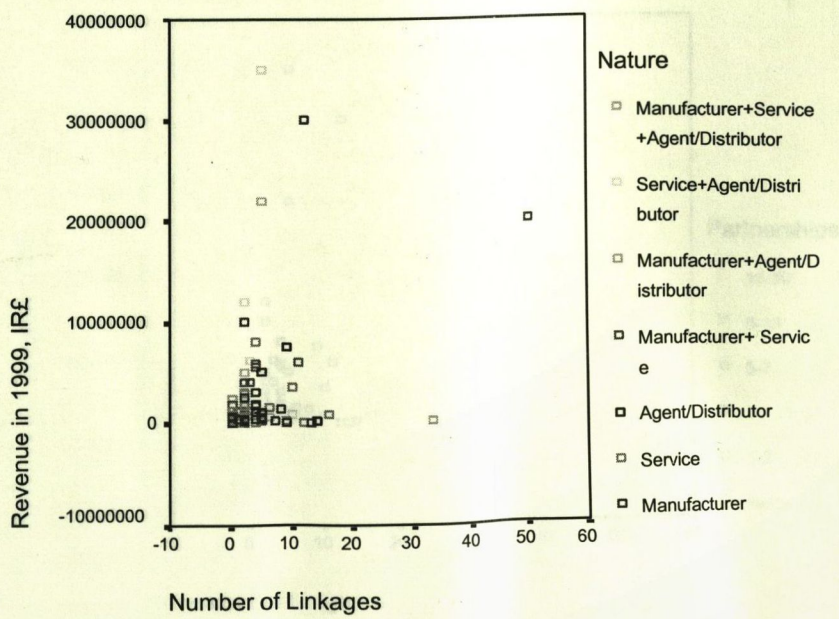
5.72 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Revenue in 1999' - 'Number of Linkages' Correlation



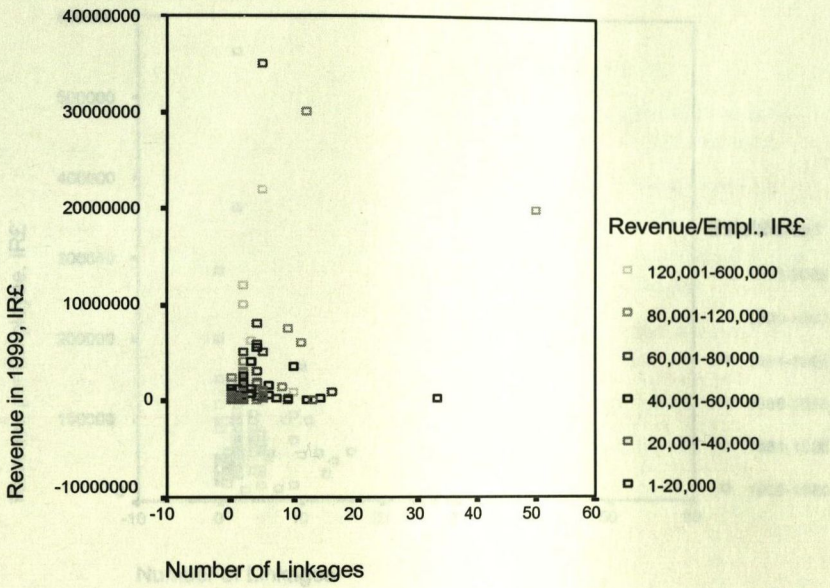
5.73 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Revenue in 1999' - 'Number of Linkages' Correlation



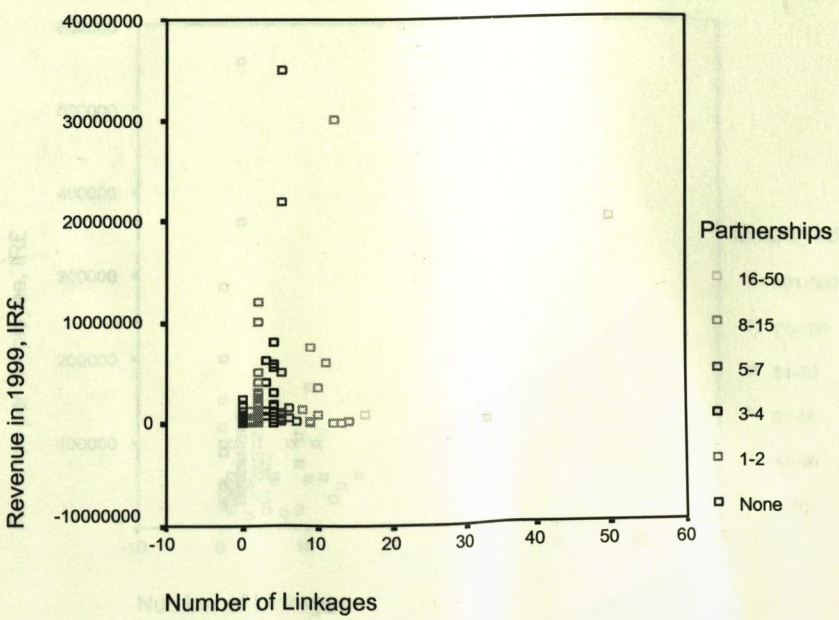
5.74 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Revenue in 1999' - 'Number of Linkages' Correlation



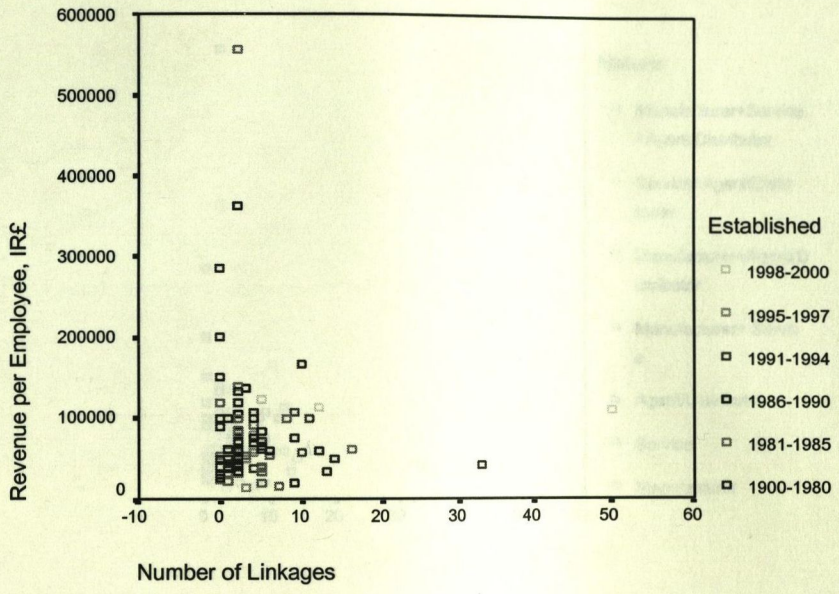
5.75 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Revenue in 1999' - 'Number of Linkages' Correlation



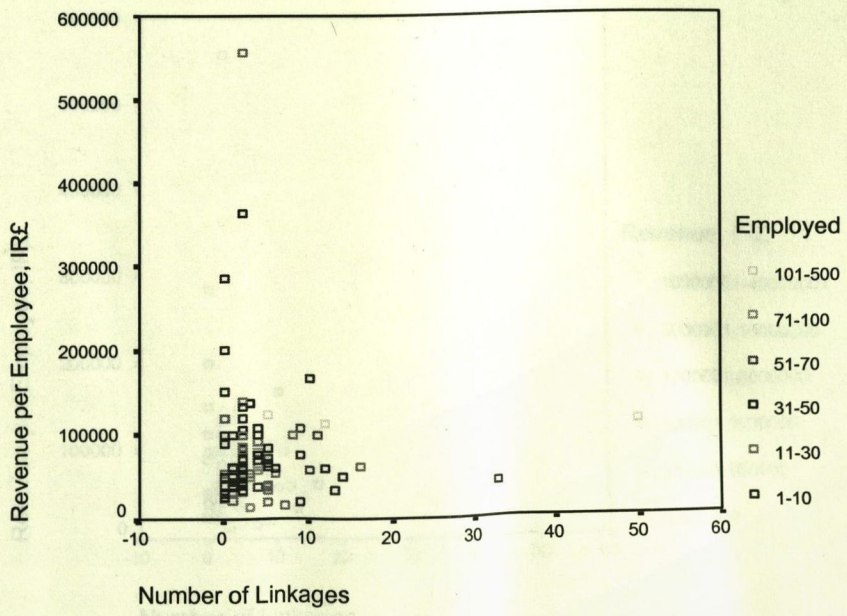
5.76 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Revenue in 1999' - 'Number of Linkages' Correlation



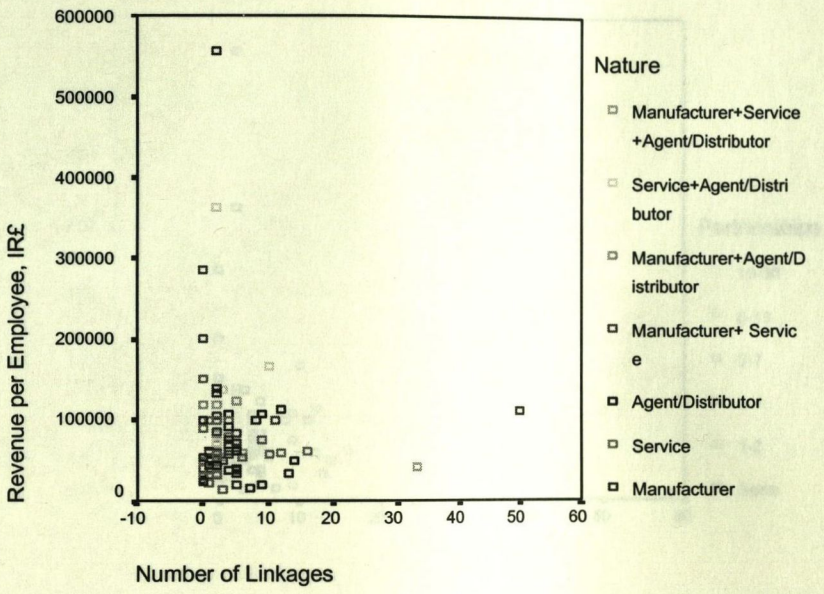
5.77 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Revenue per Employee' - 'Number of Linkages' Correlation



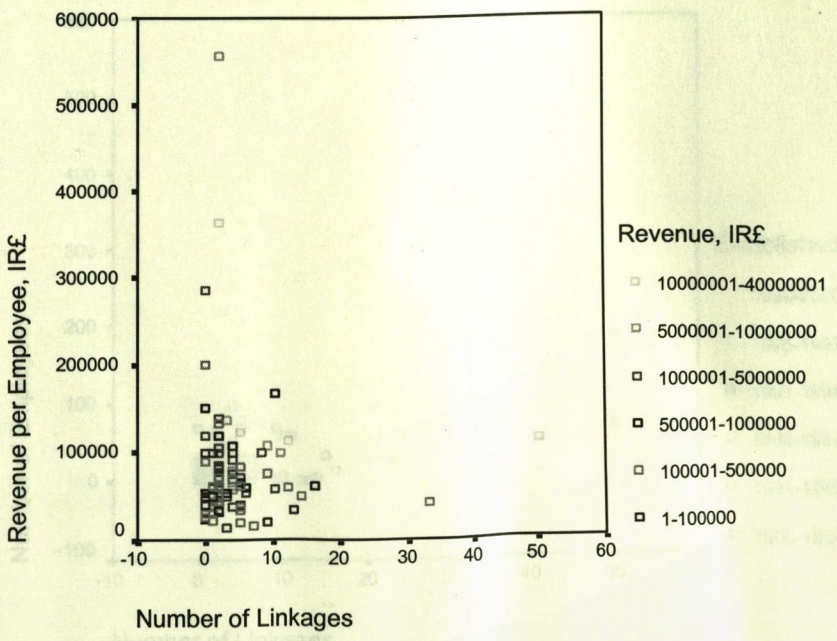
5.78 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Revenue per Employee' - 'Number of Linkages' Correlation



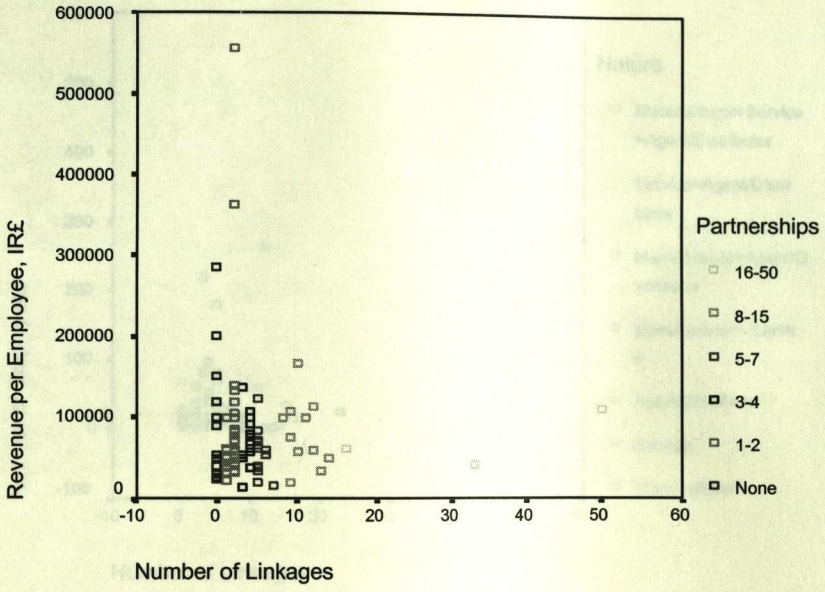
5.79 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Revenue per Employee' - 'Number of Linkages' Correlation



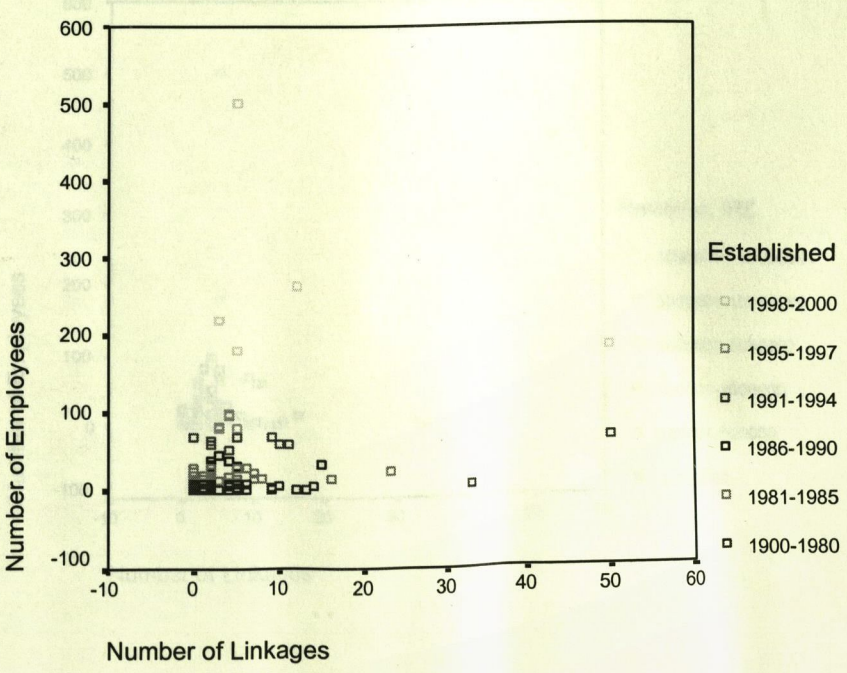
5.80 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Revenue per Employee' - 'Number of Linkages' Correlation



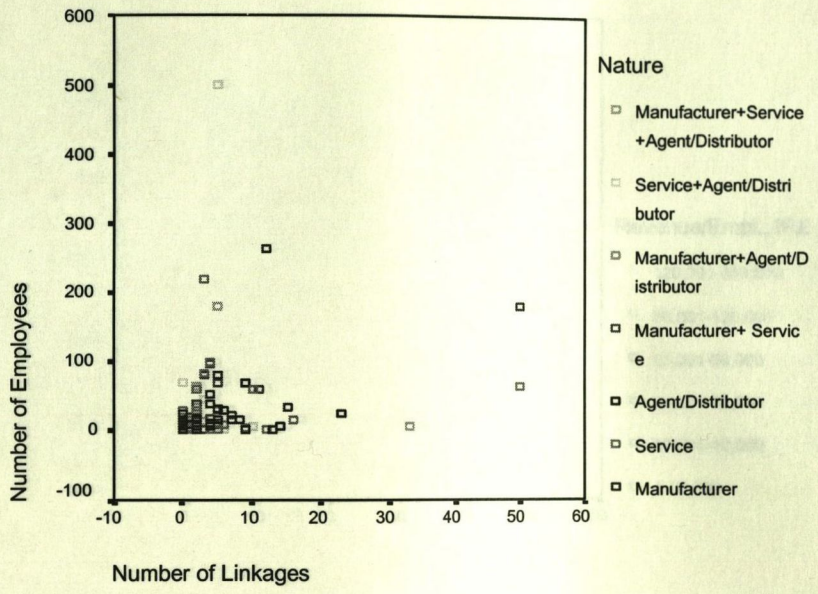
5.81 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Revenue per Employee' - 'Number of Linkages' Correlation



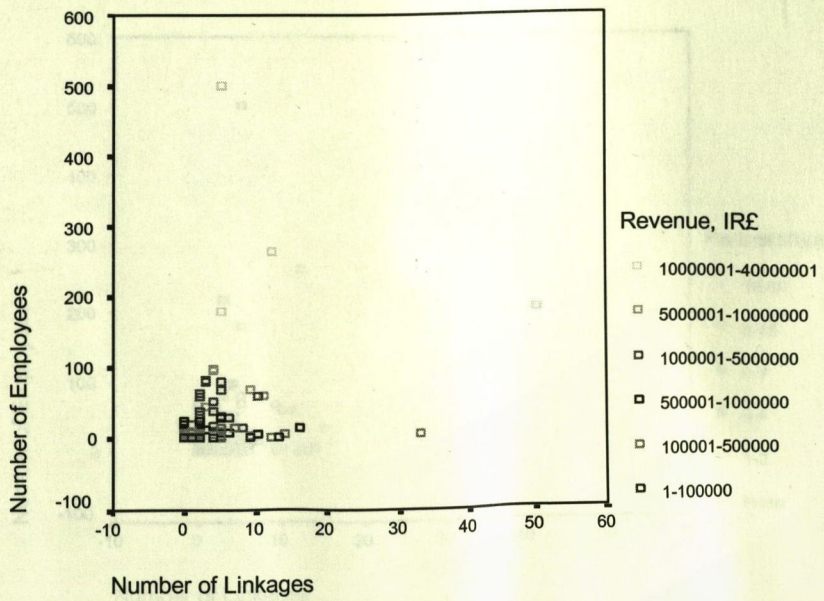
5.82 Scatter Illustrating Influence of 'Establishment Year' Variable on 'Number of Employees' - 'Number of Linkages' Correlation



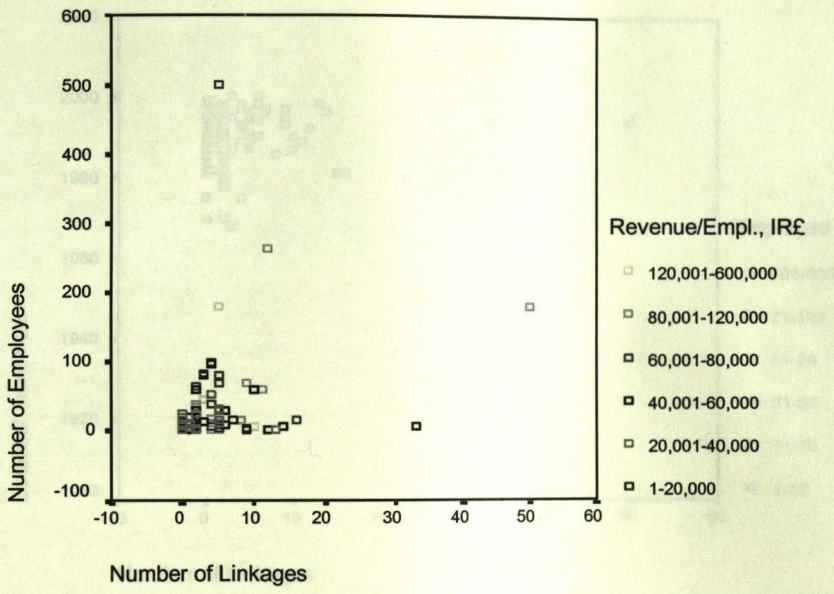
5.83 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Number of Employees' - 'Number of Linkages' Correlation



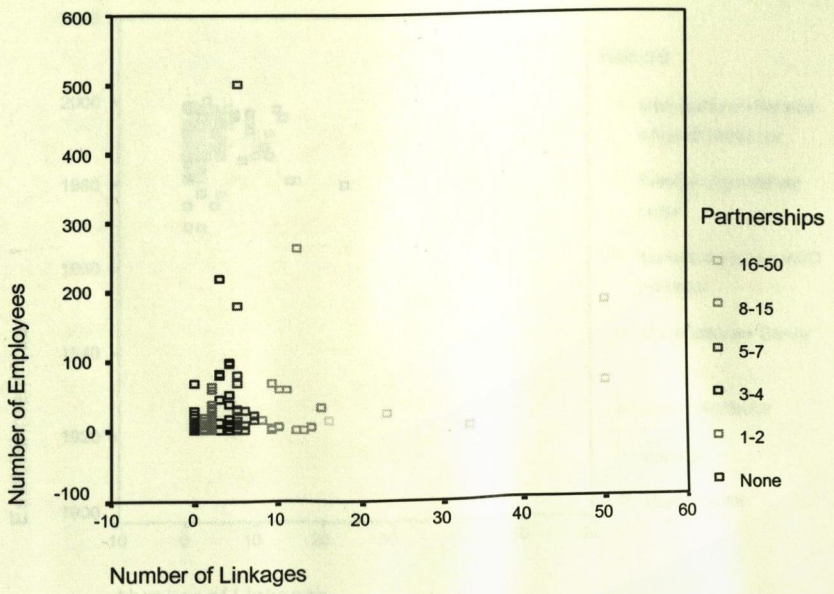
5.84 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Number of Employees' - 'Number of Linkages' Correlation



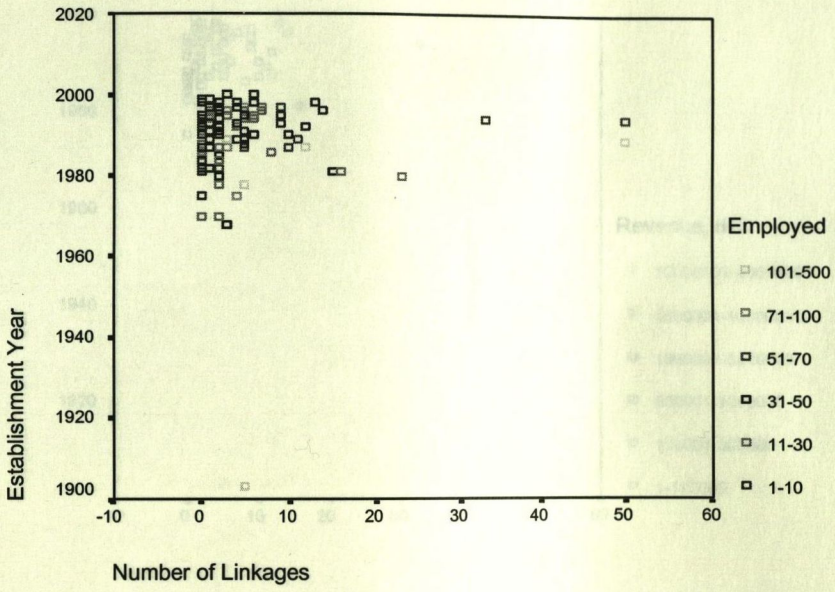
5.85 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Number of Employees' - 'Number of Linkages' Correlation



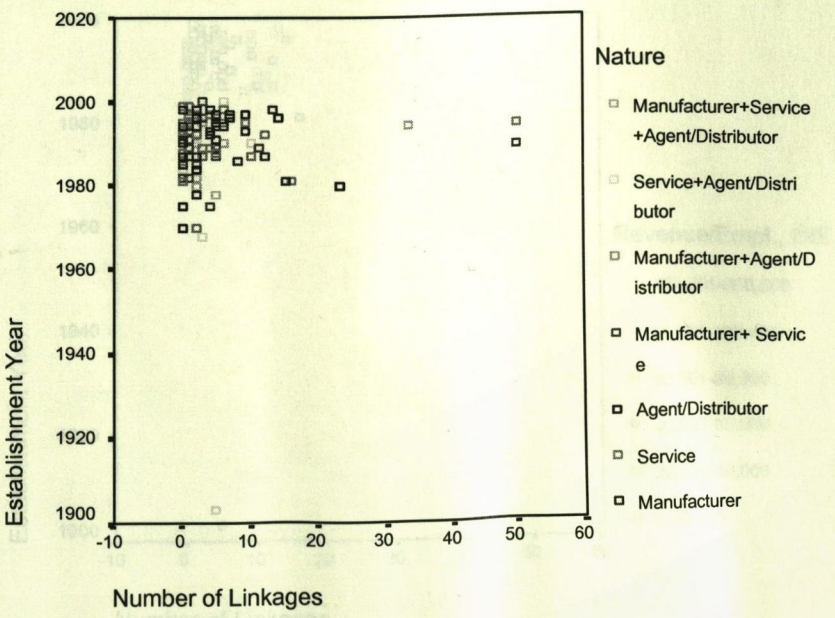
5.86 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Number of Employees' - 'Number of Linkages' Correlation



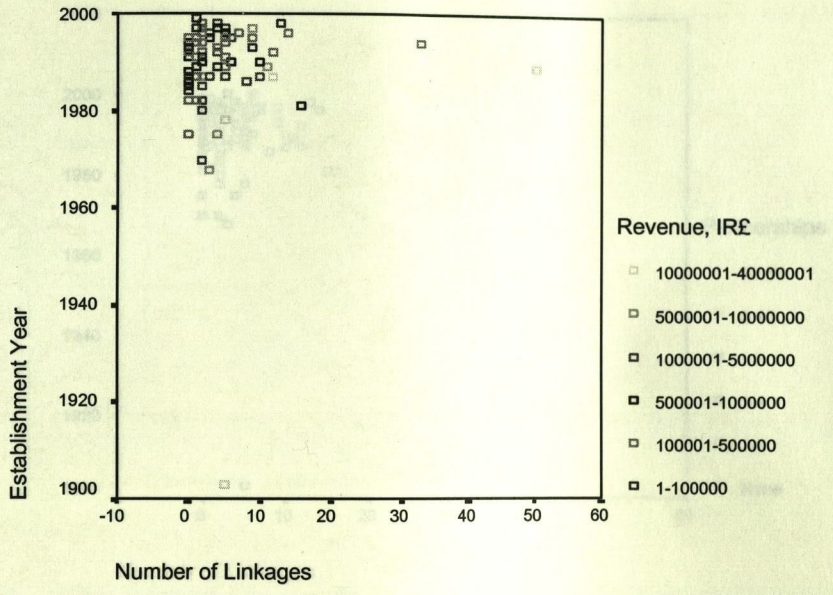
5.87 Scatter Illustrating Influence of 'Number of Employees' Variable on 'Establishment Year' - 'Number of Linkages' Correlation



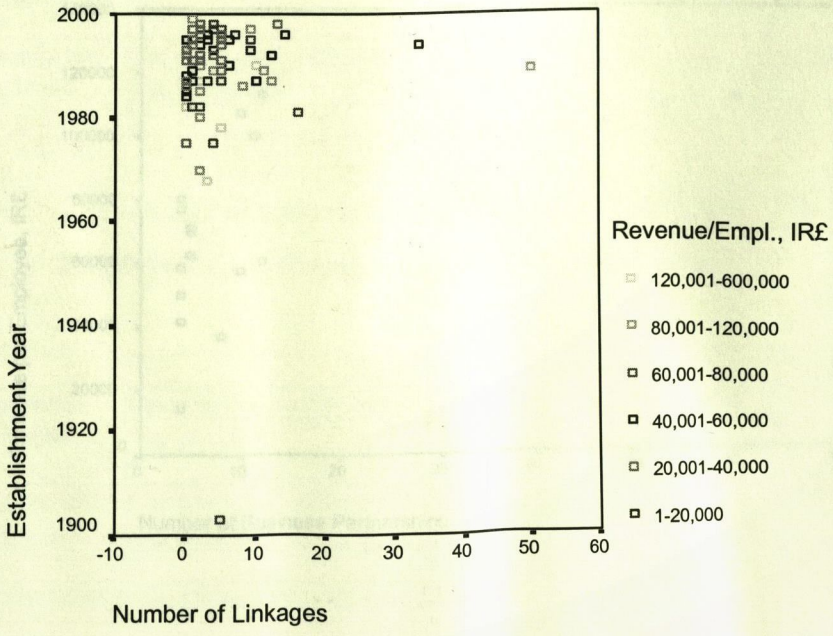
5.88 Scatter Illustrating Influence of 'Nature of the Software Business' Variable on 'Establishment Year' - 'Number of Linkages' Correlation



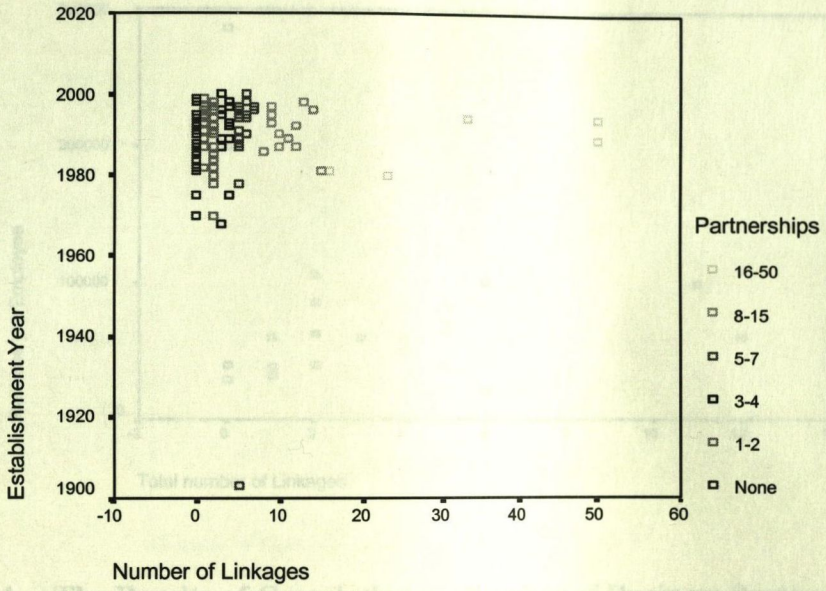
5.89 Scatter Illustrating Influence of 'Revenue in 1999' Variable on 'Establishment Year' - 'Number of Linkages' Correlation



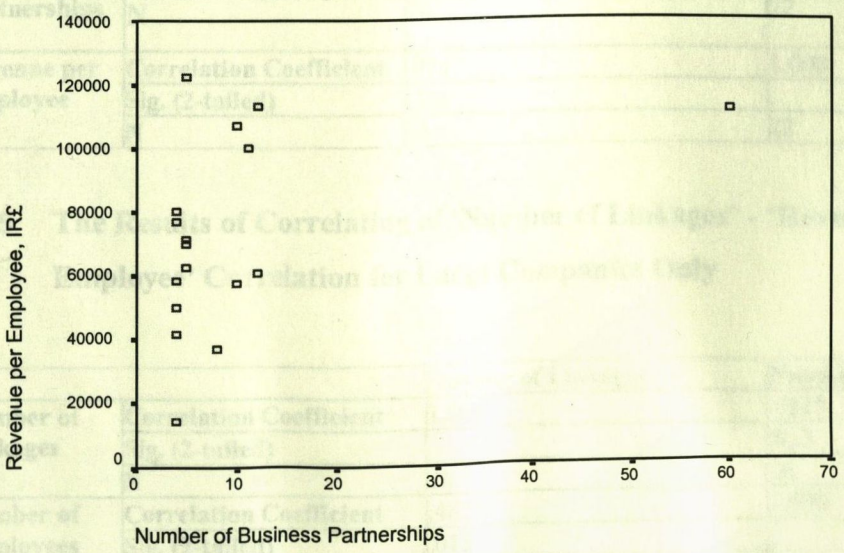
5.90 Scatter Illustrating Influence of 'Revenue per Employee' Variable on 'Establishment Year' - 'Number of Linkages' Correlation



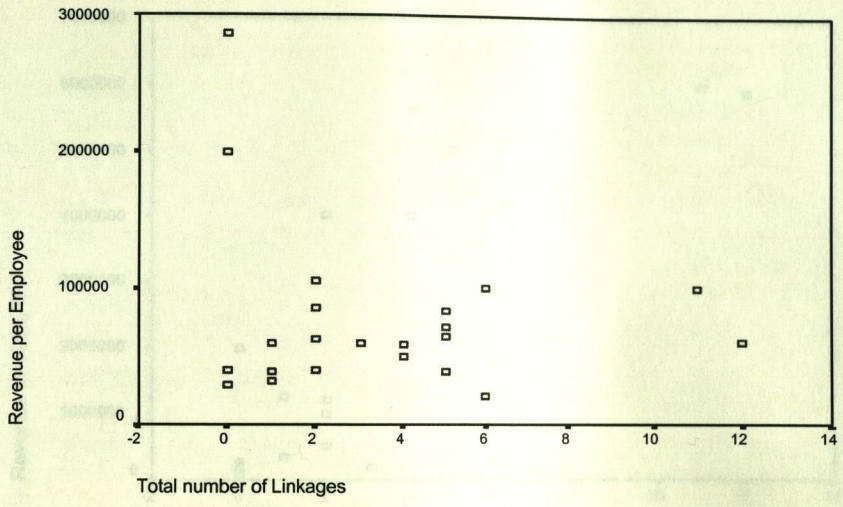
5.91 Scatter Illustrating Influence of 'Number of Business Partnerships' Variable on 'Establishment Year' - 'Number of Linkages' Correlation



5.92 Scatter Illustrating the Results of 'Number of Business Partnerships' - 'Revenue per Employee' Correlation for Large Companies Only



5.93 Scatter Illustrating the Results of 'Number of Linkages' - 'Revenue per Employee' Correlation for Large Companies Only



5.94 The Results of Correlating of 'Number of Business Partnerships' - 'Revenue per Employee' Correlation for Large Companies Only

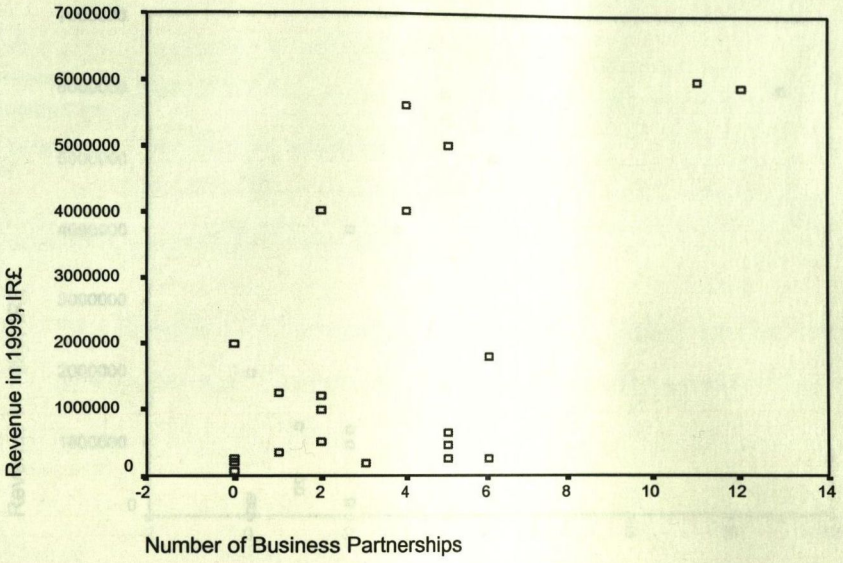
		Number of Business Partnerships	Revenue per Employee
Number of Business Partnerships	**Correlation Coefficient**	1.000	.076
	Sig. (2-tailed)	.	.736
	N	26	22
Revenue per Employee	**Correlation Coefficient**	.076	1.000
	Sig. (2-tailed)	.736	.
	N	22	22

5.95 The Results of Correlating of 'Number of Linkages' - 'Revenue per Employee' Correlation for Large Companies Only

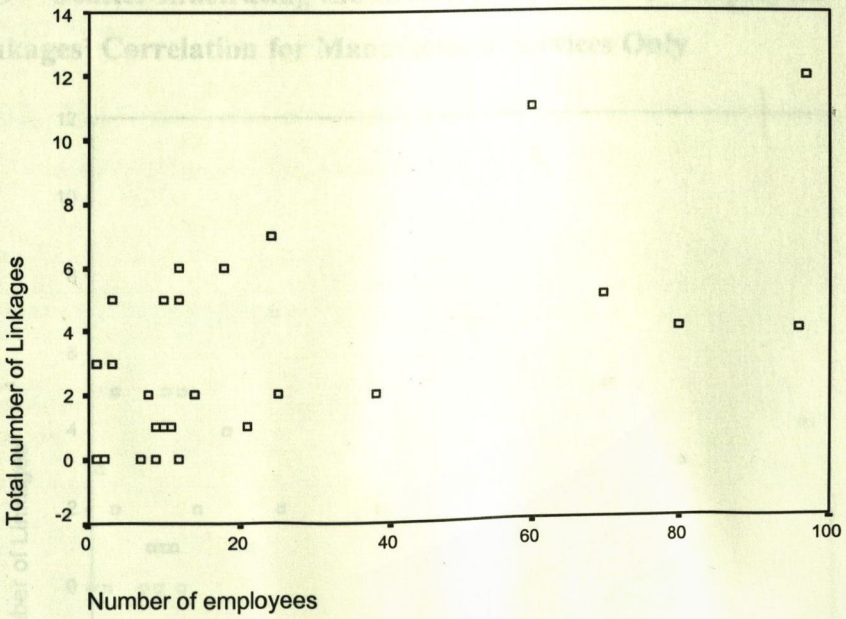
		Number of Linkages	Number of Employees
Number of Linkages	**Correlation Coefficient**	1.000	.482*
	Sig. (2-tailed)	.	.013
	N	26	26
Number of Employees	**Correlation Coefficient**	.482*	1.000
	Sig. (2-tailed)	.013	.
	N	26	26

* Correlation is significant at the .05 level (2-tailed).

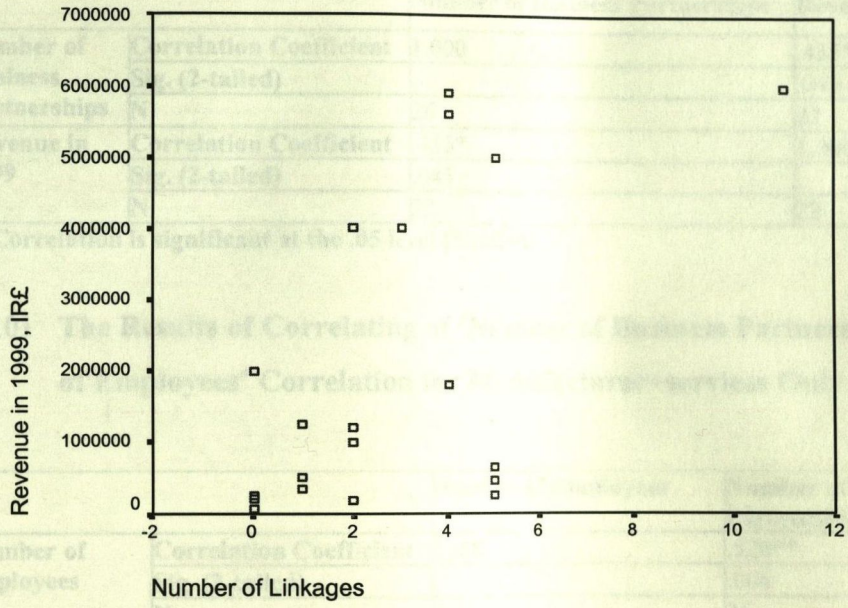
5.96 Scatter Illustrating the Results of 'Number of Business Partnerships' - 'Revenue in 1999' Correlation for Manufacturer+services only



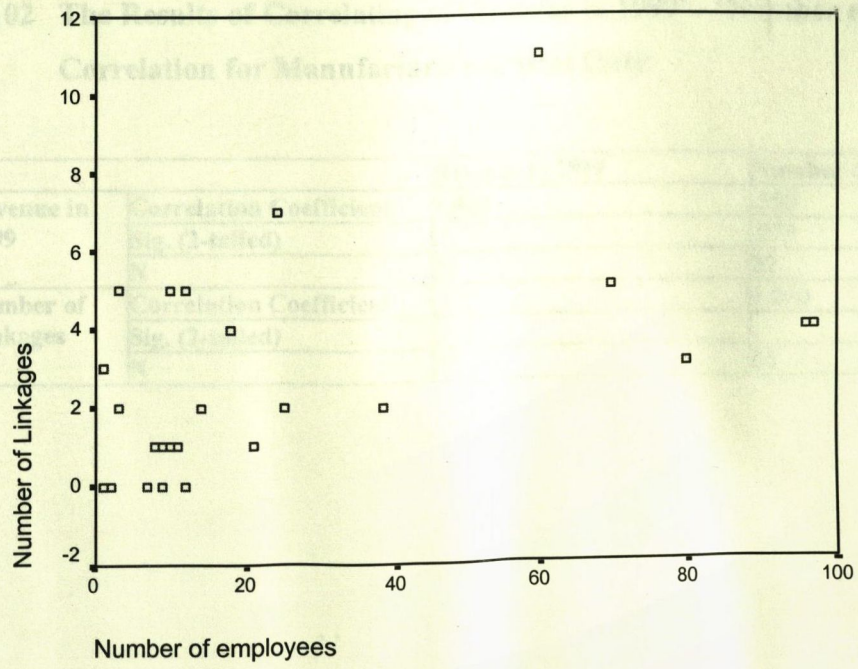
5.97 Scatter Illustrating the Results of 'Number of Business Partnerships' - 'Number of Employees' Correlation for Manufacturer+services Only



5.98 Scatter Illustrating the Results of 'Revenue in 1999' - 'Number of Linkages' Correlation for Manufacturer+services Only



5.99 Scatter Illustrating the Results of +'Number of Employees' - 'Number of Linkages' Correlation for Manufacturer+services Only



5.100 The Results of Correlating of 'Number of Business Partnerships' - 'Revenue in 1999' Correlation for Manufacturer+services Only

		Number of Business Partnerships	Revenue in 1999
Number of Business Partnerships	Correlation Coefficient	1.000	.435*
	Sig. (2-tailed)	.	.043
	N	26	22
Revenue in 1999	Correlation Coefficient	.435*	1.000
	Sig. (2-tailed)	.043	.
	N	22	22

* Correlation is significant at the .05 level (2-tailed).

5.101 The Results of Correlating of 'Number of Business Partnerships' - 'Number of Employees' Correlation for Manufacturer+services Only

		Number of Employees	Number of Business Partnerships
Number of employees	Correlation Coefficient	1.000	.520**
	Sig. (2-tailed)	.	.006
	N	26	26
Number of Business Partnerships	Correlation Coefficient	.520**	1.000
	Sig. (2-tailed)	.006	.
	N	26	26

** Correlation is significant at the .01 level (2-tailed).

5.102 The Results of Correlating of 'Revenue in 1999' - 'Number of Linkages' Correlation for Manufacturer+services Only

		Revenue in 1999	Number of Linkages
Revenue in 1999	Correlation Coefficient	1.000	.390
	Sig. (2-tailed)	.	.073
	N	22	22
Number of Linkages	Correlation Coefficient	.390	1.000
	Sig. (2-tailed)	.073	.
	N	22	26

5.103 The Results of Correlating of 'Number of Employees' - 'Number of Linkages' Correlation for Manufacturer+services Only

		Number of Linkages	Number of Employees
Number of Linkages	**Correlation Coefficient**	1.000	.482*
	Sig. (2-tailed)	.	.013
	N	26	26
Number of Employees	**Correlation Coefficient**	.482*	1.000
	Sig. (2-tailed)	.013	.
	N	26	26

* Correlation is significant at the .05 level (2-tailed).

APPENDICES TO CHAPTER 6

6.1 General Business Application Products

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	3	2.4	5.7	5.7
	Growth	27	22.0	50.9	56.6
	Maturity	23	18.7	43.4	100.0
	Total	53	43.1	100.0	
Missing System		70	56.9		
Total		123	100.0		

6.2 Bespoke Development

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	10	8.1	15.2	15.2
	Growth	30	24.4	45.5	60.6
	Maturity	18	14.6	27.3	87.9
	Decline	8	6.5	12.1	100.0
	Total	66	53.7	100.0	
Missing System		57	46.3		
Total		123	100.0		

6.2 Banking/ Finance Systems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	6	4.9	15.8	15.8
	Growth	20	16.3	52.6	68.4
	Maturity	10	8.1	26.3	94.7
	Decline	2	1.6	5.3	100.0
	Total	38	30.9	100.0	
Missing System		85	69.1		
Total		123	100.0		

6.3 Software Tools/ Systems Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	3	2.4	10.0	10.0
	Growth	18	14.6	60.0	70.0
	Maturity	8	6.5	26.7	96.7
	Decline	1	.8	3.3	100.0
	Total	30	24.4	100.0	
Missing System		93	75.6		
Total		123	100.0		

6.4 Internet-related Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	29	23.6	42.0	42.0
	Growth	37	30.1	53.6	95.7
	Maturity	3	2.4	4.3	100.0
	Total	69	56.1	100.0	
Missing System		54	43.9		
Total		123	100.0		

6.5 Computer-based Training (Internet or other)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	7	5.7	36.8	36.8
	Growth	9	7.3	47.4	84.2
	Maturity	3	2.4	15.8	100.0
	Total	19	15.4	100.0	
Missing System		104	84.6		
Total		123	100.0		

6.6 Telecommunication Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	3	2.4	16.7	16.7
	Growth	12	9.8	66.7	83.3
	Maturity	3	2.4	16.7	100.0
	Total	18	14.6	100.0	
Missing System		105	85.4		
Total		123	100.0		

6.7 Firmware

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	2	1.6	16.7	16.7
	Growth	5	4.1	41.7	58.3
	Maturity	3	2.4	25.0	83.3
	Decline	2	1.6	16.7	100.0
	Total	12	9.8	100.0	
Missing System		111	90.2		
Total		123	100.0		

6.8 Software Localization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	2	1.6	16.7	16.7
	Growth	4	3.3	33.3	50.0
	Maturity	6	4.9	50.0	100.0
	Total	12	9.8	100.0	
Missing System		111	90.2		
Total		123	100.0		

6.9 Agricultural Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Growth	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.10 Marketing Multimedia Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Growth	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.11 Measurement

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maturity	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.12 Aeronautics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	1	.8	50.0	50.0
	Growth	1	.8	50.0	100.0
	Total	2	1.6	100.0	
Missing System		121	98.4		
Total		123	100.0		

6.13 Software for Legal Sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Growth	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.14 Services Implementation and Integration

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maturirty	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.15 Library Automation Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Growth	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.16 CRM Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.17 Property Management

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Growth	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.18 ERP Implementation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maturity	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.19 ASP Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.20 Process Control Software

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Maturity	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.21 Specialist Labeling Applications

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Growth	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

6.22 Portal/Vortal Development

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Emergence	1	.8	100.0	100.0
Missing System		122	99.2		
Total		123	100.0		

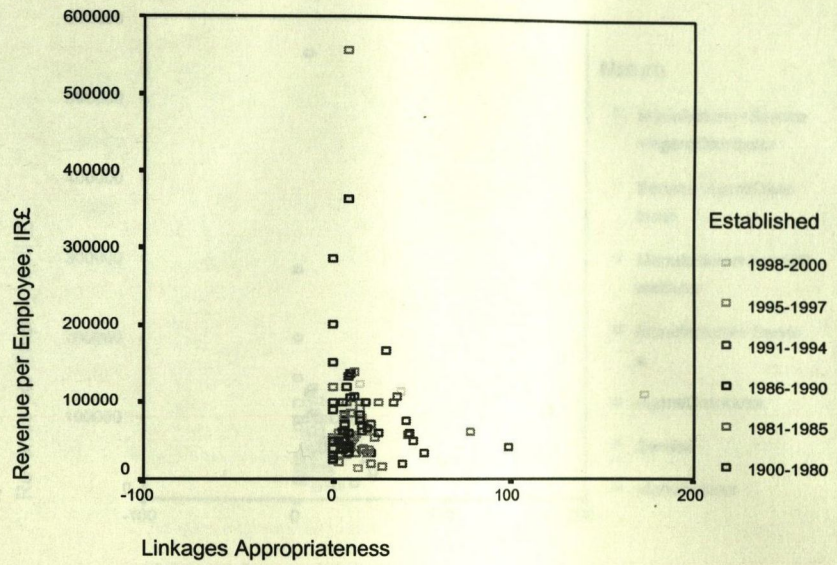
6.23 Skewness of 'Linkages' Appropriateness'

Valid	123
Missing	0
Skewness	3.838
Std. Error of Skewness	.218

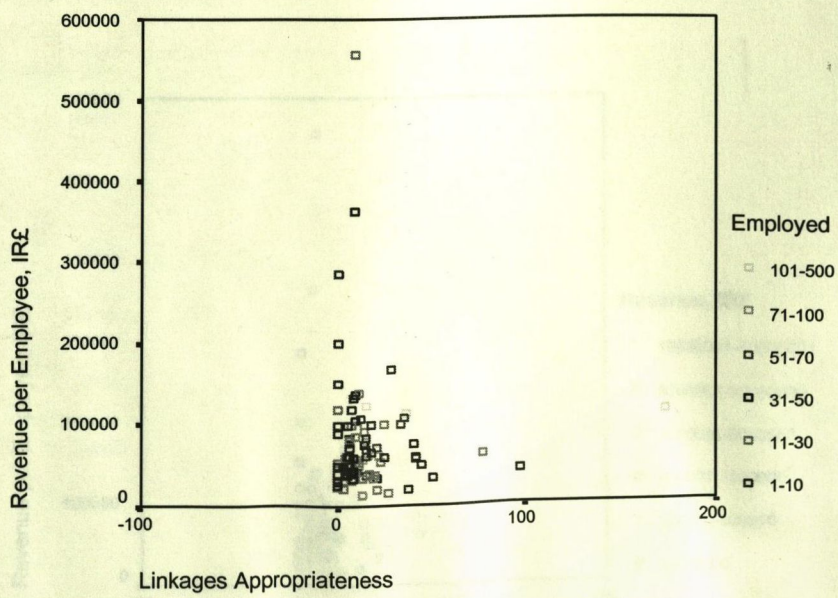
6.24 Skewness of 'Revenue per Employee'

Valid	95
Missing	28
Skewness	4.206
Std. Error of Skewness	.247

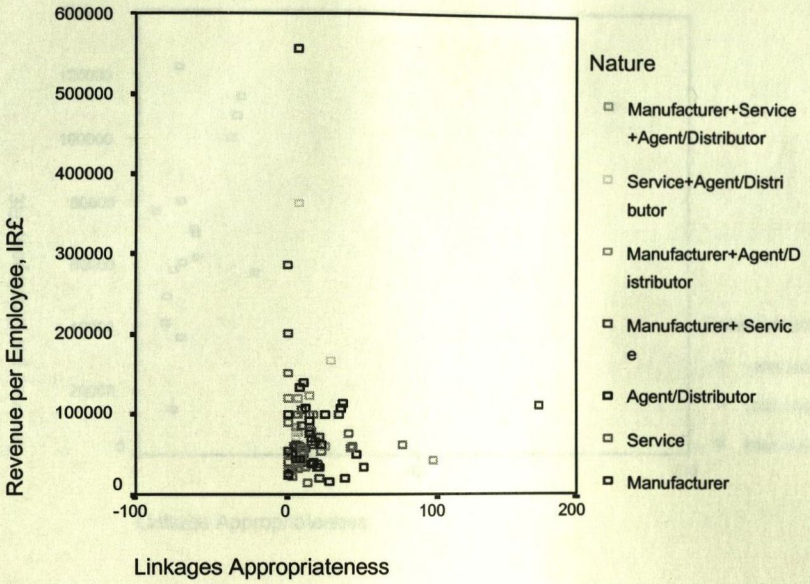
6.25 Influence of 'Establishment Year' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for All Companies



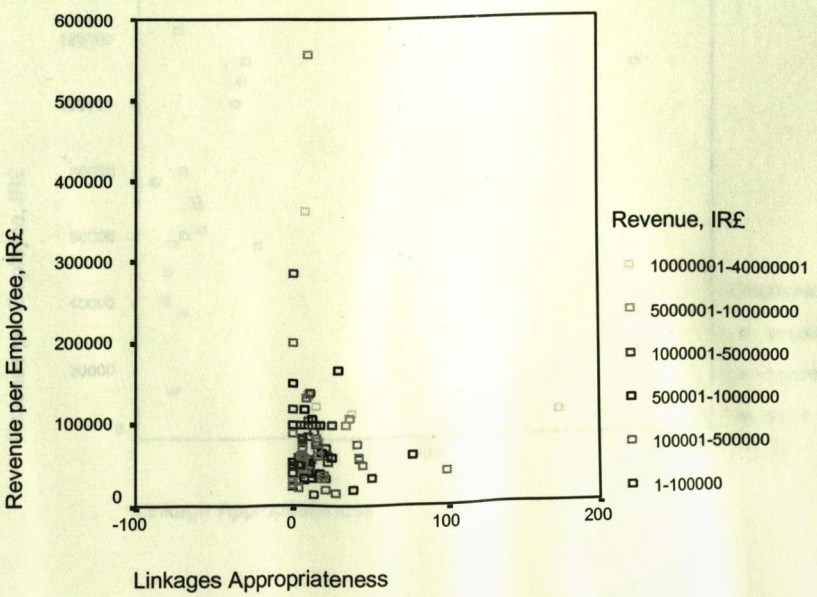
6.26 Influence of 'Number of Employees' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for All Companies



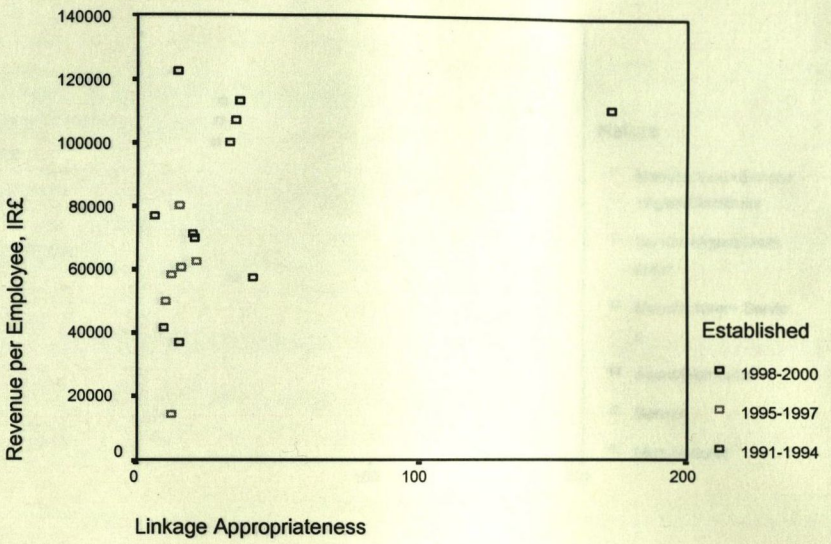
6.27 Influence of 'Nature of the Software Business' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for All Companies



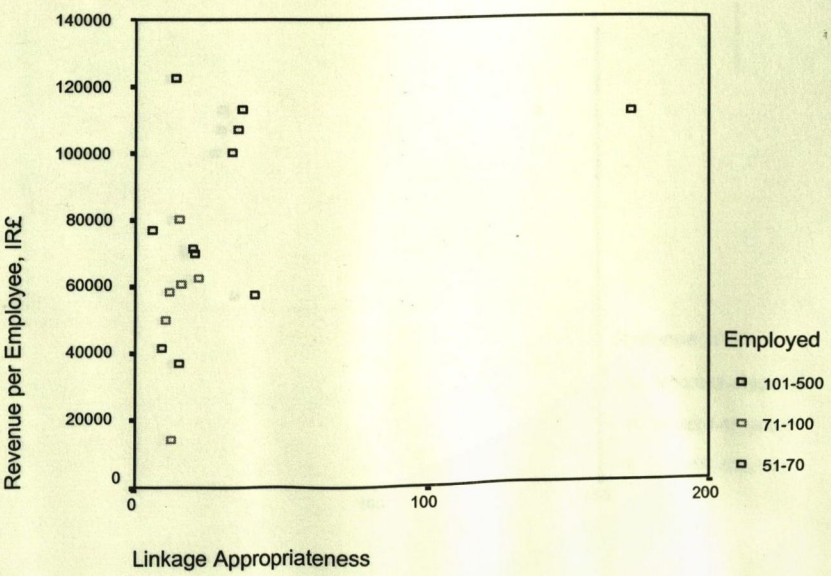
6.28 Influence of 'Revenue in 1999' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for All Companies



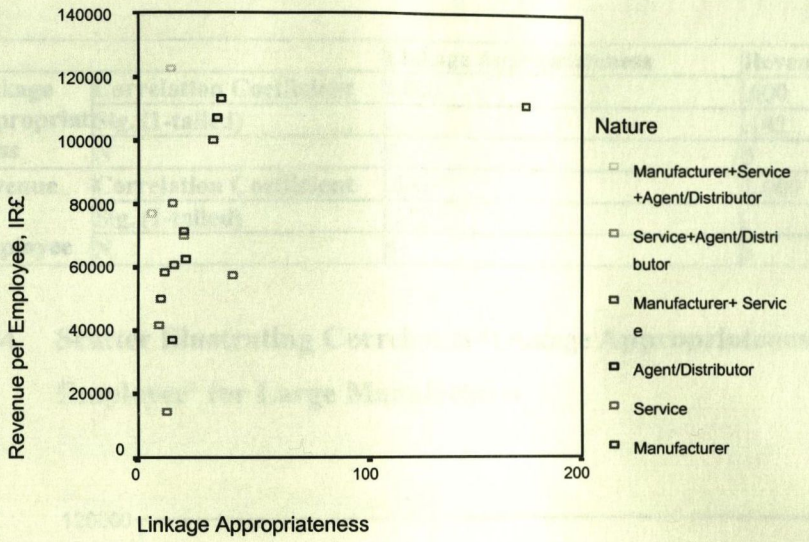
6.29 Influence of 'Establishment Year' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large Companies



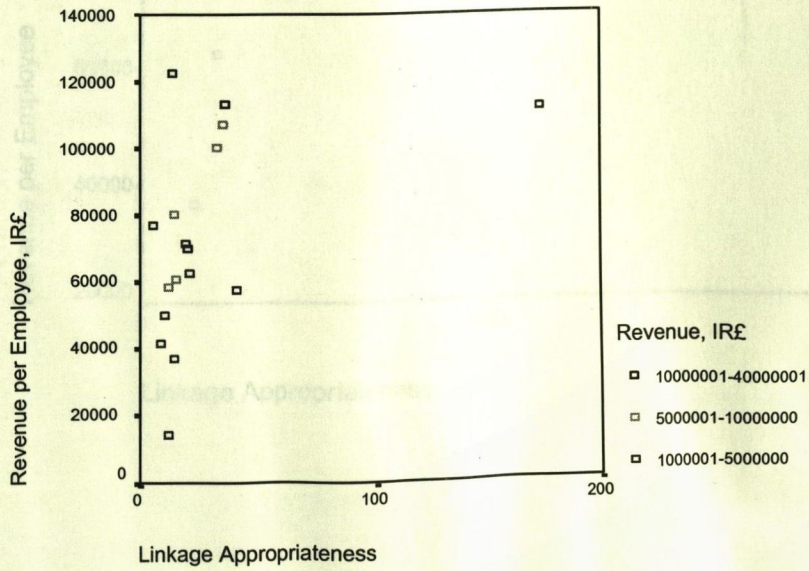
6.30 Influence of 'Number of Employees' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large Companies



6.31 Influence of 'Nature of the Software Business' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large Companies



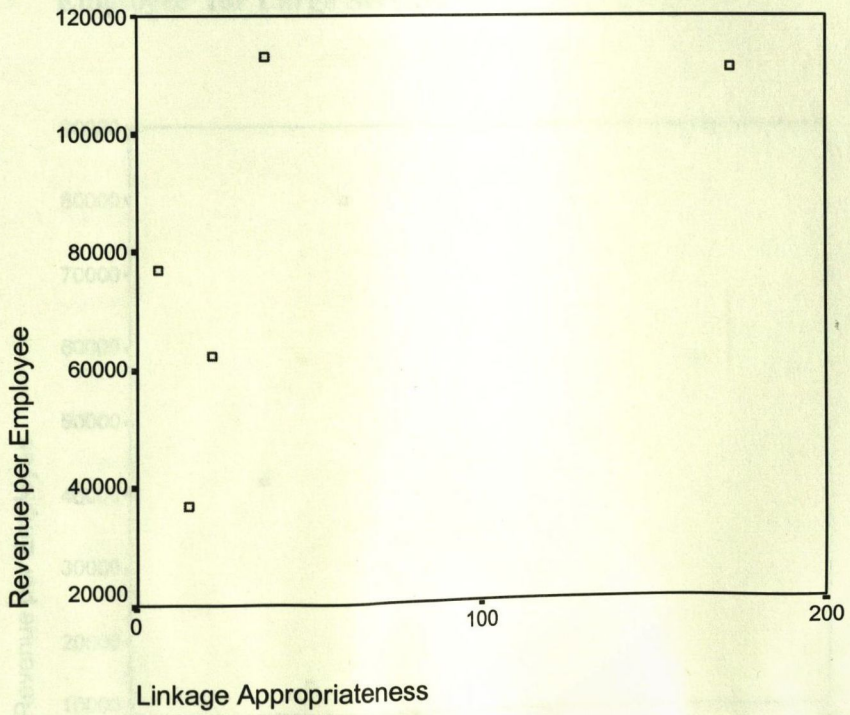
6.32 Influence of 'Revenue in 1999' on 'Linkage Appropriateness' - 'Revenue per Employee' Correlation for Large Companies



6.33 Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Manufacturers

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	**Correlation Coefficient**	1.000	.600
	Sig. (1-tailed)	.	.142
	N	5	5
Revenue per Employee	**Correlation Coefficient**	.600	1.000
	Sig. (1-tailed)	.142	.
	N	5	5

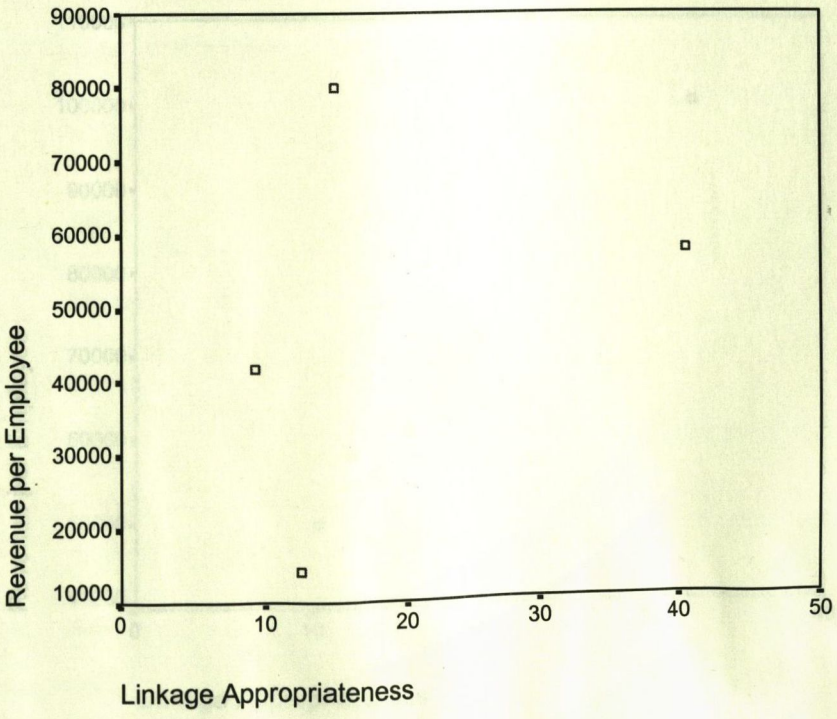
6.34 Scatter Illustrating Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Manufactures



6.35 Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Services

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	**Correlation Coefficient**	1.000	.600
	Sig. (1-tailed)	.	.200
	N	6	4
Revenue per Employee	**Correlation Coefficient**	.600	1.000
	Sig. (1-tailed)	.200	.
	N	4	4

6.36 Scatter Illustrating Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Services

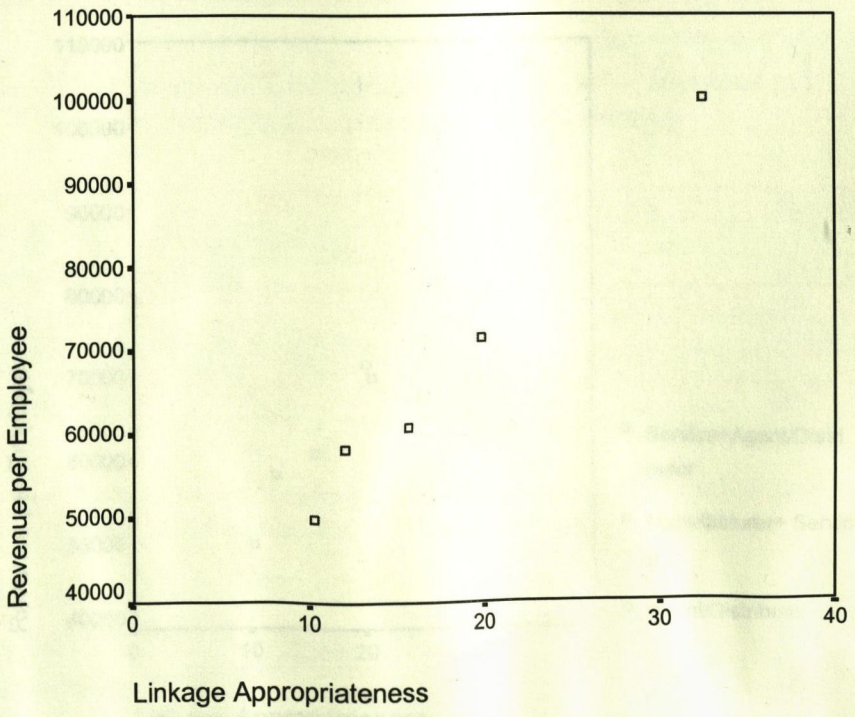


6.37 Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Manufacturer+Services

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	1.000**
	Sig. (1-tailed)	.	.
	N	5	5
Revenue per Employee	Correlation Coefficient	1.000**	1.000
	Sig. (1-tailed)	.	.
	N	5	5

** Correlation is significant at the .01 level (1-tailed).

6.38 Scatter Illustrating Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Manufacturer+Services

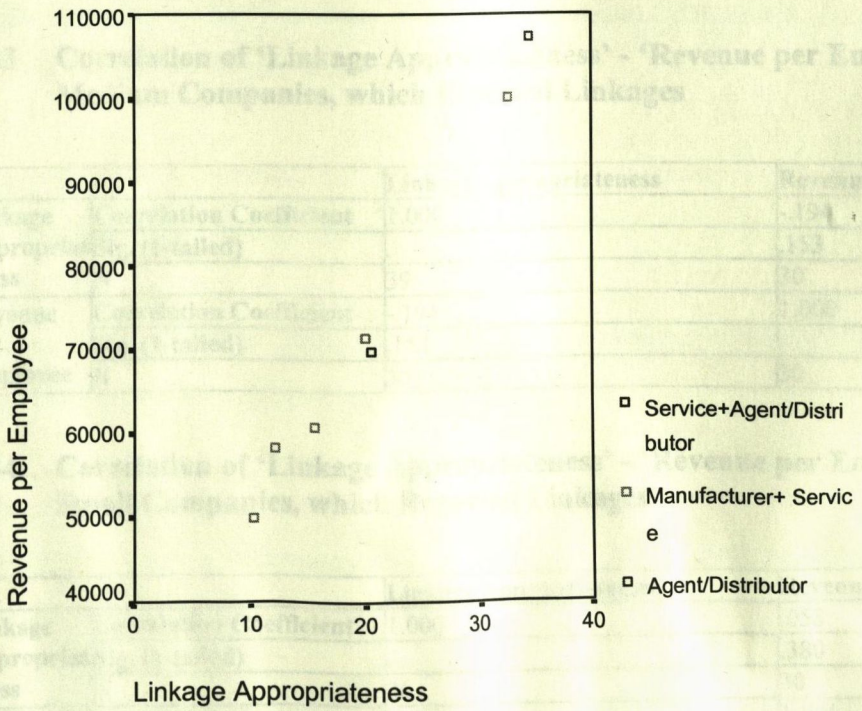


6.39 Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Manufacturer+Service; Service+Agent/Distributor and Agent/Distributor Companies

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	.964**
	Sig. (1-tailed)	.	.000
	N	8	7
Revenue per Employee	Correlation Coefficient	.964**	1.000
	Sig. (1-tailed)	.000	.
	N	7	7

** Correlation is significant at the .01 level (1-tailed).

6.40 Scatter Illustrating Correlation 'Linkage Appropriateness' - 'Revenue per Employee' for Large Manufacturer+Service; Service+Agent/Distributor and Agent/Distributor Companies



6.41 Correlation of 'Linkage Appropriateness' - 'Revenue per Employee' for Companies of All Sizes, which Reported Linkages

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	.052
	Sig. (1-tailed)	.	.328
	N	95	77
Revenue per Employee	Correlation Coefficient	.052	1.000
	Sig. (1-tailed)	.328	.
	N	77	77

6.42 Correlation of 'Linkage Appropriateness' - 'Revenue per Employee' for Large Companies, which Reported Linkages

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	.456*
	Sig. (1-tailed)	.	.033
	N	19	17
Revenue per Employee	Correlation Coefficient	.456*	1.000
	Sig. (1-tailed)	.033	.
	N	17	17

* Correlation is significant at the .05 level (1-tailed).

6.43 Correlation of 'Linkage Appropriateness' - 'Revenue per Employee' for Medium Companies, which Reported Linkages

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	-.194
	Sig. (1-tailed)	.	.153
	N	39	30
Revenue per Employee	Correlation Coefficient	-.194	1.000
	Sig. (1-tailed)	.153	.
	N	30	30

6.44 Correlation of 'Linkage Appropriateness' - 'Revenue per Employee' for Small Companies, which Reported Linkages

		Linkage Appropriateness	Revenue per Employee
Linkage Appropriateness	Correlation Coefficient	1.000	.058
	Sig. (1-tailed)	.	.380
	N	36	30
Revenue per Employee	Correlation Coefficient	.058	1.000
	Sig. (1-tailed)	.380	.
	N	30	30

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