Local knowledge spillovers in high-tech clusters in developing countries : the case of the Uruguayan software cluster

Local Knowledge Spillovers in High Tech Clusters in Developing Countries

The Case of the Uruguayan Software Cluster

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CHAPTER 1

INTRODUCTION

1.1 THE AIM OF THE THESIS

The importance of localised knowledge spillovers (LKS) for innovation in advanced economies has been stressed in theoretical and empirical works (Jaffe, 1989; Jaffe et al., 1993; Audretsch and Feldman, 1996B). Local knowledge spillovers have received less attention by scholars whose work focuses on developing countries. Hence, with this academic effort, I intend to enrich the body of literature regarding less developed countries (LDCs) by examining whether local knowledge spillovers enhance the innovative performance of firms within these countries. Next, despite the richness of the local knowledge spillovers literature in advanced economies, more emphasis is paid to the connection between local knowledge spillovers and innovation, than to the characteristics of local knowledge spillovers themselves. Therefore, in this thesis, I will also attempt to divert the attention from the classic pattern followed by the literature in advanced economies through the provision of an in-depth study of the concept of knowledge spillover itself and of the ways in which spillovers take place in a geographic context.

Knowledge constitutes one of the most important ingredients of innovation, especially in high-tech sectors or so-called knowledge intensive industries. Firms in high-tech sectors tend to cluster in order to take advantage of local knowledge spillovers (Audrech and Feldman, 1996). These spillovers are interpreted in the field of economics as accidental transfers of knowledge (Griliches, 1979) (especially in tacit form) that positively influence the innovative performance of firms within clusters. The main argument put forward to justify the aforementioned claims is that the process of knowledge transfer is more successful when firms are located in close proximity to each other (Keeble and Wilkinson, 1998; Lawson and Lorenz, 1999). Tacit knowledge requires face-to-face interaction, and the co-location of firms in clusters facilitates the development of personal contacts.

While these claims have been researched in developed economies, not much is known about whether they work similarly in developing countries. Research in LDCs has focused on the examination of clusters and stressed the advantages that they generate for firms. However, existing works have not addressed separately the different types of agglomeration advantages; as a consequence, local knowledge spillovers have not become the central subject of recent studies in developing countries.

Consequently, the first aim of this thesis is to examine whether the theoretical premises regarding the relation of LKS and innovation raised and empirically tested in advanced economies are also relevant in the context of less developed countries. In order to provide an answer to this riddle I will test whether local knowledge spillovers increase the innovative and

economic performance of firms within clusters in a developing country. This study will hopefully contribute towards the verification or rejection of the alleged relation between LKS and innovation in developing countries: the implications of this test may be crucial for the economic development of poor countries. Thanks to modern economic theory we are able to know today that innovation and technological change boost economic growth, since innovation creates conditions of increasing returns in production (Romer, 1986, 1990; Griliches, 1992). Such conditions accelerate long-term economic growth –a crucial condition for the development of LCDs – and local knowledge spillovers could be one of the key mechanisms through which this occurs.

While considerable efforts have been made by researchers in developed economies to examine the relation between knowledge spillovers and innovation, not much is known about knowledge spillovers *per se*. There is no agreement, for instance, regarding whether knowledge spillovers consist solely of spontaneous flows of knowledge or whether they may also include intentional flows. The processes through which knowledge spillovers take place have received even less attention. As Audretsch et al (2003, p.13) pointed out **"...**there is no understanding of the way in which spillovers occur and are realized at the geographic level".

A second aim of this study is to elucidate the concept of knowledge spillovers and to comprehend how they take place within clusters. LKS are local positive technological externalities that derive from the inability of firm A to retain the economic returns of its innovation activity. As a consequence, firm B can take advantage of the new product or knowledge directly and without compensating firm A. They comprise: mobility of key scientist or engineers; information from patents and scientific literature; leakage of information at conferences or trade fairs; imitation of products through reverse engineering, and finally industrial espionage (Griliches, 1979; Saxenian, 1994). While economists stress that knowledge spillovers are spontaneous or unintended flows of knowledge (Griliches, 1979), scholars in the field of innovation management suggest that knowledge spillovers may also "occur intentionally –hence, they can be called voluntary information spillovers" (Harhoff, Henkel and von Hippel, 2003, p. 1767). In development literature, emphasis is given to intentional external economies as well (Schmitz, 1999). Therefore, I will seek to clarify the ambiguity that characterises knowledge spillovers and to unravel the channels through which knowledge spillovers occur. Furthermore, by taking a close look at the local knowledge network I will attempt to comprehend how effectively knowledge spills over amongst local actors and to identify the key relations for the circulation of knowledge within a cluster.

1.2 RESEARCH QUESTIONS

As I have stated before, this study focuses on local knowledge spillovers, one of the three advantages that are generated from the geographic proximity of firms (see section 2.2.2.1 on the agglomeration advantages literature). Keeping this in mind, I assess the importance of LKS for the innovation of firms within a cluster in the context of LDCs. Since I started my research on LKS, I have been confronted by a myriad of questions: some predictable, others startling. Ultimately I took the decision to concentrate upon the following:

- How important are local knowledge spillovers for the innovative and economic performance of firms within clusters in developing countries?
- Which are the mechanisms by which knowledge spills over among firms, their suppliers and customers, and public and private institutions? Does it happen through (a) inter-firm interactions, (b) labour mobility, and/or, (c) spin-offs?

- How effectively does knowledge spill over amongst local actors within a cluster in a developing country? Which is the morphology of a local knowledge network?

I began to work with the aforementioned questions and while looking for an appropriate research setting I came across the software sector in Uruguay. The software sector offers a propitious ground to test whether knowledge spillovers play, as Audretsch and Feldman argued in 1996B, a key role for the innovative performance of firms in high-tech sectors. The Uruguayan software cluster is exceptional because it consists mainly of local firms, which offer sophisticated products and services to foreign as well as to local markets. Noteworthy is also the fact that all software firms are agglomerated in the capital city of Montevideo and that their sales and exports have experienced a significant growth during the last decade.

1.3 STRUCTURE OF THE THESIS

This thesis consists of eight chapters and is structured as follows. The second chapter reviews the theoretical and empirical debates regarding two bodies of literature, on the innovation of the firm and technological learning and on regional agglomeration; in particular on localised knowledge spillovers. With this endeavour I also offer a new assessment of these literatures in the context of both developed and developing countries.

Chapter three introduces the conceptual framework upon which the research analysis is based. It also discusses the methodology, the operationalisation of the research questions and the data collection.

Chapter four takes a close look at the software sector in the context of the Uruguayan economy. I begin with a review of the main productive sectors in Uruguay, to finally introduce the historical evolution of the Uruguayan software industry and to compare it with the respective industries in other developing countries.

In chapter five, I look at the impact of local knowledge spillovers upon the innovative and economic performance of firms within the Uruguayan software cluster using quantitative methods. Initially, a regression analysis is used in order to estimate the contribution of local knowledge spillovers to the innovative performance of firms within the software cluster in Montevideo. Systems method estimation is then applied in order to examine the importance of local knowledge spillovers for the economic performance of firms within this cluster. With this analysis I shall explore how local knowledge spillovers influence the economic performance of the firms, and particularly whether their impact is direct or indirect (through innovation). Finally, using the systems method estimation I tackle the question of whether local knowledge spillovers are contingent on the absorptive capacity of firms.

Chapter six decodes the ‘black box’ of local knowledge spillovers. Utilising qualitative analysis, this chapter sheds light on the inter-firm mechanisms of knowledge spillovers and stresses the motivation for firms’ unintentional and/or intentional participation in the process of knowledge diffusion. Labour mobility and spin-off channels of knowledge spillovers are also discussed. Furthermore, I seek to understand whether the mechanisms of knowledge spillovers are related to specific sources of knowledge.

In chapter seven, I resort to network analysis in order to examine the knowledge network within the Uruguayan software cluster. At the macro level I analyse the cohesiveness of the local knowledge network, while at the micro level I seek to understand whether the position

of the firm within the local knowledge network is related to its innovative and economic performance. Finally, I address the reasons that lie behind the advantageous (or disadvantageous) position of firms within local knowledge networks.

Chapter eight provides conclusions, a summary of the research findings, the main policy recommendations that can be drawn from this thesis, and suggestions for further research.

CHAPTER 2

INNOVATION AND LOCAL KNOWLEDGE SPILLOVERS: AN OVERVIEW OF THE LITERATURE

2.1 INTRODUCTION

This chapter presents the theoretical and empirical debates on two bodies of literature. The first one concerns firm-level innovation and technological learning, while the second one refers to the literature on regional agglomeration and, in particular, localised knowledge spillovers (LKS). In the following pages, I will assess the contributions of these literatures for both developed and developing countries. This division serves not only theoretical but also methodological objectives. The discrepancy between the two contexts is so great that a specific focus on development issues is warranted in most fields of current research (economics, sociology, geography, environment etc.). In the field of technological change and innovation, empirical studies have observed that technology transfer to the South did not provide sufficient conditions for the technological development of LDCs. New technologies had to be adjusted to the requirements of the local context, and then modified in order to achieve improved quality and efficiency (Katz, 1987). In other words, firms in developing countries *innovate* by learning from existing technologies (improving them and adapting them). Their process of knowledge acquisition is thus different from that of firms in advanced economies. This has implications for the nature of LKS as well. Consequently, the LKS phenomenon warrants separate analysis in the context of developing countries.

There are theoretical and methodological differences in the way that the geographical dimension of knowledge spillovers and its relation to innovation has been explored in developed and developing countries. The literature on advanced economies has given a prominent role to the concept of local knowledge spillovers. LKS are one of the externalities created as a result of the agglomeration of firms in the same location. The main argument behind the relation between LKS and innovation refers to the tacit nature of knowledge. Tacit knowledge is one of the vital components of the creation of new knowledge and innovation (Maskell and Malmberg, 1999). The fact that tacit knowledge is experienced-based and context-specific means that it cannot be transferred over long distances (Polanyi, 1996). It can be assimilated only by observation and face-to-face interaction, and in turn spill over to firms located in the vicinity. This is why geographic proximity facilitates innovation: because it enables the diffusion of tacit knowledge through face-to-face contact. The main body of literature on advanced economies then focuses mainly on the relationship between LKS and innovation; while it pays less attention to the nature of LKS and the way in which they occur.

The main divergence between the studies on developed and developing countries lies in the interpretation of the notion of innovation. In advanced economies, innovation is seen as the creation of new products and processes, the discovery of new markets, and new forms of

organization. In the respective literature on developing countries, innovation is regarded as an advance in knowledge below the technological frontier. In developing countries innovation refers mainly to the acquisition of capabilities by firms that enable them to adapt and change substantially a product and/or process. This can refer to the adaptation of a technology developed in another context and/or the modification of a technology to serve new needs. Thus, while in advanced economies technological innovations are pushing forward the frontier, in developing countries technological innovations try to catch up with it.

The divergence in the interpretation of the concept of innovation has important methodological implications for innovation and LKS. First, the demonstration of technological progress in developing countries is not as straightforward as in developed countries. Much of the innovation in developing countries is informal and often cannot be measured directly through patents, new products, and R&D, as is usually the case with empirical studies on advanced economies. Thus, not surprisingly, empirical studies in developing countries are methodologically different from those in developed countries. Second, most of the state-of-the-art technology existing in developing countries is imported from advanced economies. Therefore, a large part of the literature on industrial development in LDCs focuses on the advantages deriving from the creation of linkages between local firms and international actors (for a good review see Evenson and Westphal, 1995). Similarly, several essential studies on technology transfer (Enos, 1989) and on new trade theory (Coe at al, 1997) focus on the benefits that accrue to firms well-integrated into the international economy. Therefore, while the importance of foreign knowledge is apparent, it is not yet clear how *local* knowledge spillovers can have an economic impact on the context of developing countries. However, empirical research on industrial clusters in developing countries gives us some evidence regarding the importance of local advantages (i.e., Schmitz, 1999; Rabellotti, 1995; Nadvi, 1996). Concepts such as "active collective efficiency" underline the importance of collaborative behaviour for improving the competitiveness of firms within clusters. Nonetheless, these studies have made no proper distinction between cost advantages and knowledge spillovers. As a result, we still know very little about the nature of LKS and the role that they could play in developing countries.

By reviewing the existing literature, I will attempt to unravel the theoretical and methodological debates on both developed and developing countries with the intention of elucidating the nature of innovation and local knowledge spillovers, and the relation existing between them. This chapter is structured as follows: Initially, I review the literature on innovation and LKS in advanced economies starting with the presentation of the literature concerning the innovation of the firm. Then, I discuss the main contributions provided by theorists of regional agglomeration whose main objective has been to discern the sources of cluster dynamism. In this section, I also introduce the theoretical building blocks concerning LKS and, finally, I present methodological and empirical evidence on the relation between LKS and firm-level innovative performance.

I continue the review by looking at the respective developments in the literature on clusters and innovation in developing countries. I begin by examining the studies on technological progress in LDCs which shed light on the process of technological learning and acquisition of capabilities at the firm level. I, then, proceed with a discussion regarding cluster dynamism in LDCs. Finally, I assess the main methodological and empirical studies on the relationship between clustering and technological progress.

2.2 A REVIEW OF THE LITERATURE IN ADVANCED ECONOMIES

2.2.1 Theoretical Insights on Firm-level Innovation

Until the 1980s, some key theoretical contributions suggested that innovation is a linear process. It starts with scientific research at public and private laboratories, generating inventions, following with the practical application or commercial spectrum of the invention, namely innovation, and concluding with the diffusion of the innovations. Later studies have challenged the linear conception of innovation and emphasised the feedback mechanisms that take place at every stage (Kline and Rosenberg, 1986). Innovation is now seen as a cumulative and interactive process integrating technology push and market pull (Dosi, 1988; Lundvall, 1992). Consequently, not only producers participate in the innovation process but also consumers, universities, and public and private institutes; they constitute what is called the 'National System of Innovation' (Nelson, 1993; Edquist, 2004).

That learning is cumulative indicates that it is not a rapid 'leap to wisdom' but rather, learning is a gradual process whereby new knowledge is built upon previous understandings (Usher, 1954; Nelson and Winter, 1982). Incremental changes in the known parts unravel the unknown aspects of the matter. This is why knowledge spillovers and, consequently, innovation have a *local* dimension; regions that have accumulated knowledge can more easily produce new knowledge than other areas that are in the formative stages of the learning process. The tacitness of knowledge is another major reason why knowledge spillovers, and in turn innovation, are *locally* bounded processes.

Knowledge Creation and its Tacit Character

Researchers from different disciplines have made many attempts to understand knowledge and its functions. However, the peculiar nature of knowledge, which is the fundamental resource of any innovative activity, raises its own difficulties. In the 1960s, Polanyi (1966) introduced the distinction between tacit and explicit knowledge. Tacit knowledge, in his opinion, is part of the experience of people and is context-specific.

The tacit feature of knowledge had a major influence on organisational theory. Nonaka and Takeuchi (1995) argued that the main difference between Western and Japanese organisations is the importance given to tacit knowledge in the Japanese environment. In particular, they argued that tacit knowledge retains the following properties: First, it refers to knowledge of [a physical] experience (body), which is subjective. Second, tacit knowledge is produced in a specific context. Thus, it cannot be expressed in universal meanings and understandings. On the other hand, they argued that explicit knowledge is the outcome of a rational (mental) process and it is objective. Therefore, explicit knowledge has an abstract character and is not related to specific context.

Consequently, explicit or codified knowledge can be articulated, diffused, imitated and sold. Moreover, the output of codifiable knowledge (i.e. books, CDs) can be reproduced at small cost and profit from economies of scale. But the tacit part of knowledge cannot be traded: it can only be learned through experience, since it is embodied in people and institutions.

The process of knowledge creation involves a combination of tacit and codified knowledge (Nonaka and Takeuchi, 1995). However, tacit knowledge is not equally important for every firm or industry (Asheim and Gertler, 2005). This is because the innovation process in every sector is different since it requires different types of knowledge. In particular, Asheim et al. (2006) categorise knowledge into analytical, synthetic and symbolic. Analytical knowledge refers to scientific principles which entail to a large degree codified knowledge. Therefore, the

meaning of analytic knowledge remains relatively constant across geographic locations. On the other hand, synthetic knowledge indicates applied knowledge (i.e. engineering) which is dominated by tacit knowledge. Consequently, the meaning of synthetic knowledge varies according to the specific context. Finally, symbolic knowledge refers to creative (imaginative or artistic) knowledge which is highly tacit. Thus, the meaning of symbolic knowledge depends heavily on the specific location. In light of these insights then, it is clear that spatial proximity, which is central for the transmission of tacit knowledge, is not necessarily important for every sector. This implies that creative industries as well as small and medium engineering firms rely more on tacit knowledge and thus geographic proximity than science-based sectors.

Some philosophers argue that knowledge cannot be measured and thus cannot be assigned a price (Gorz, 2003). According to Gorz, tacit knowledge has a social/public character and its social value/use is reduced when it is privatised. Lundvall (1992) agrees that important elements of tacit knowledge are collective rather than individual. The social character of knowledge derives from the fact that the value of tacit knowledge increases when it is shared. During this process, tacit knowledge becomes explicit and contributes to innovation and the generation of new knowledge (Nonaka, 1994).

It is impossible, then, not to raise questions regarding the implications that the Intellectual Property Rights system (IPR) has for knowledge creation and thus, innovation. When knowledge is privatised (through patents), there is secrecy regarding its 'ingredients'; in order to observe its contents, a fee has to be paid. Therefore, the rate of experimentation (trial and error), which is a key activity for the stimulation of innovation, may be significantly reduced (Bell and Pavitt, 1993). However, a valid counterargument with regard to this issue states that free knowledge can also lead to less innovation, since innovators cannot fully appropriate the returns to their own effort. In particular, it is often argued that strong IPR enforcement may induce more foreign direct investment (FDI) and more importantly may encourage multinational corporations (MNC) to transfer R&D to LDCs (Fink and Maskus, 2005). In contrast, Stiglitz (2004) claims that strong IPRs generate static inefficiencies. More importantly, he argues that excessive protection can even lower the dynamic gains of the IPR.

Innovation calls for two things: knowledge and learning. What has been analysed up to this point in the literature is the fact that both knowledge and learning entail particular features with bounded mobility, demonstrating in turn the local nature of innovation (Jaffe, Trajtenberg and Henderson, 1993; Audretsch and Feldman, 1996B). The fact that knowledge could possibly be shared more easily within a region or cluster has important implications for the debate concerning its social character. Firms located in the same region share common characteristics such as culture, language, social codes of behaviour and I would add, formal political and institutional setting. Consequently, regions could be comprehended as a social space characterised by the same informal institutions where people share knowledge rapidly and easily. Such a familiarity gives regions the ability to learn and accumulate knowledge and thus innovate.

Learning by interacting

While knowledge is a vital ingredient of innovation, learning is the necessary process in the acquisition of knowledge. There are many ways of learning, the most common of which is reading. However, not everything can be learned by reading a book or a blue print. Learning by doing is another method that usually facilitates the acquisition of technical skills. Imitation and repetition enable actors to perform and, ultimately, to master a task.

The 'neo-Schumpeterian[1]' School of thought emphasises that innovation is an interactive process[2] that is embedded in routines and social conventions. The shift from the *linear* model of innovation to an interactive and non-linear model was an innovation in itself. It is now acknowledged (Lundvall, 1992) that innovation is influenced by the interaction between firms, between functions within the firm, between producers and users and between firms and research institutes as well as the wider institutional infrastructure.

Nowadays, knowledge has rapidly advanced and has become highly complex. Generally, scientists or engineers are specialised in a small field of research or production. The model of the encyclopaedic scholar of the seventeenth century has been replaced by the model of the expert scientist of the twenty-first century. Therefore, learning-by-doing does not serve as the only mode of knowledge acquisition, since knowledge is complex and people cannot understand all its pieces: only a limited fraction of an entire knowledge field can be understood. In order to obtain new knowledge, firms seek to interact with organisations which have the specific 'know-how'. Learning by interaction permits actors to access accumulated experiences and tacit knowledge of other specialists in a direct manner. Thus, learning is social in nature since comprehending the *how* involves interaction, and the result of this interaction is the sharing of tacit knowledge.

But how does this relate to geographical distance? Do firms in a cluster[3] interact more than firms outside of it? Most of the territorial theories claim that firms interact more often when they are close to each other. Moreover, it is not only the frequency but also the quality of communication that increases as a result of face-to-face contact. Face-to-face interaction thus facilitates the sharing of the tacit knowledge which is a crucial step in the process of knowledge creation. In general, learning from an expert constitutes a more efficient way of transferring tacit knowledge (Polanyi, 1966). Learning through observation (i.e. imitation) may also allow for the diffusion of tacit knowledge (though less efficiently). It is important to examine the implications of learning for the firm and most importantly for the cluster. Do firms within a cluster learn faster and at lower cost than firms outside the cluster and if so, why? The following section will address this question.

2.2.2 Theoretical Insights into Localised Knowledge Spillovers

2.2.2.1 Theories of Regional Agglomeration

One of the first to address the significance of clustering was Alfred Marshall (1920). Marshall argued that the congregation of companies in the same industry is due to the function of three mechanisms:

1) The cluster acts as a magnet, which attracts specialised suppliers that promote and sell their products to a large market and thus achieve economies of scale as well as economies of scope.
2) There is a constellation of specialised labour within the cluster. The presence of a labour market decreases the costs (financial and time related) of the acquisition of new employees for local firms.
3) The cluster facilitates the diffusion of knowledge through the concentration and the mobility of specialised labour.

The first two cluster mechanisms generate cost advantages for the local firms, which are also called static externalities. The final cluster mechanism engenders knowledge gains for local firms, which are known as dynamic externalities.

Marshallian externalities have been the cornerstone for economic, geographical, sociological and managerial/organisational explanations of localised production. In the literature, there is a consensus that firms within a cluster[4] enjoy advantages compared to firms outside it. Currently, there are two contending views of cluster dynamism. Those who adhere to the New Economic Geography argue that firms cluster because they benefit from cost advantages (Krugman, 1995; Krugman & Venables, 1995). Others, following the Economic Geography and the Regional Systems of Innovation approaches, consider that clusters generate more than cost advantages for firms (Jaffe, 1993; Audretsch & Feldman, 1996A; Cooke, 2001; Morgan, 1997). Their arguments are based on knowledge and learning, and on the fact that knowledge is transferred or circulated easier within a cluster.

All of the above studies focus on the advantageous effects of geographical proximity upon regional economic performance. Their unit of analysis is the region or cluster, and the questions they raise concern the forms of analysing and explaining the growth of industrial clusters. As Table 2.1 shows, each theory emphasises different mechanisms (or different combinations of mechanisms) through which agglomeration promotes the innovative and/or economic performance of firms.

Table 2.1: Leading Theories of Regional Agglomeration

Territorial Theories	Main Question	Cost Advantages	Knowledge Spillovers[5]	Formal Institutions	Competition or Cooperation?
New Economic Geography (Krugman, 1995; Krugman & Venables, 1995)	Why is economic activity concentrated?	Advantages derive from low cost in the exchange of products/ labour/ servicesamong firms within the cluster.	Knowledge Spillovers and Institutions are not considered as important reasons of clustering.		They claim (implicitly) that competition is the mechanism through which cluster affects firms. The model assumes imperfect competition.
Economic Geography (Jaffe, 1993; Audretsch & Feldman, 1996B)	Why is innovative activity concentrated?	Not important.	This is the main reason for clustering especially for firms in high-tech sectors.	They are not considered.	The role of firms' market relations is not considered.
New Industrial Spaces (Porter, 1990; Storper & Scott, 1988; Saxenian, 1994)	Why are firms within clusters more competitive and innovative than spatially dispersed firms?	Moderately important according to Porter (1990).	Knowledge spillovers boost innovation and competitiveness.	Institutions strengthen inter-firm relations.	Cooperation between suppliers and users boosts innovation and competitiveness.
Industrial Districts (Piore & Sabel, 1984; Becattini, 1990; Schmitz, 1999)	Why are firms within clusters more competitive than spatially dispersed firms?	Flexible production systems arise from the co-existence of high specialised SMEs. The latter are connected vertically and thus gain from the exchange of products and from their fast reaction to market demand.	The role of knowledge spillovers is not explicitly discussed. However, Schmitz (1999) emphasises gain from the interaction of actors in the form of new ideas.	Social embeddednes s is more important than formal institutions	Firms have cooperative relations based on trust and reciprocity (informal institutions).
Innovative Milieu (Aydalot, 1986; Camagni, 1992)	Why are firms within clusters more innovative than spatially dispersed firms?	Less important. More emphasis is placed on local non-market relations.	They position learning at the centre of their analysis. Yet they do not state explicitly how knowledge diffuses within the milieu.	Local institutional endogeneity generates innovative dynamic firms. This is based on interactions among actors and between firms and formal institutions.	Their position on competition is not clear. They are keener on trust and reciprocity which implies a cooperative relation and not a competitive one.
Regional Systems of Innovation & Learning Region (Morgan, 1997; Keeble & Wilkinson, 1998; Lawson & Lorenz, 1999; Cooke, 2001)	Why are firms within clusters more innovative than spatially dispersed firms?	Less important. More emphasis on innovation	They emphasise the tacitness of knowledge as the main reason of clustering. Face-to-face interaction facilitates the diffusion of tacit knowledge.	Formal institutions are the centrepiece of their analysis.	The same principles as the 'Innovative Milieu' but more emphasis on the role of the social/cultural environment.

New Economic Geography

The *New Economic Geography* School attempts to elucidate cluster existence with reference to cost factors. The pioneer of this approach, Paul Krugman (1995), explains localised industrial production by considering transportation cost and economies of scale as the two most important determinants of economic agglomeration. The core model of geographical economics as developed by Krugman (1991) and as modified later by Krugman and Venables (1995) suggests that manufacturing firms tend to locate in regions with the largest demand because they can realise scale economies while minimising transport costs. Thus, transportation cost and economies of scale are the main factors for the emergence of an industrial developed centre and an underdeveloped periphery.

Researchers in the field of New Economic Geography focus on cost advantages related to transactions and claim that these are the reasons that lead firms to cluster. Krugman (1991) criticised knowledge spillovers in claiming that "...by focusing on pecuniary externalities, we are able to make the analysis much more concrete than if we allowed external economies to arise in some invisible form.... how far does a technological spillover spill?" (Krugman, 1991, p. 485).

The theory of new geographical economics explains complete agglomeration in one area while overlooking the usual pattern of agglomeration in more than one place. In addition, firms concentrated in a cluster frequently do not exchange goods (Cooke, 2001; Morgan, 1997). This means that they are not vertically but horizontally connected. New Economic Geography has nothing to say about this. If firms do not exchange goods or services, why do they concentrate in the same area? In conclusion, this model does not consider innovation: thus its usefulness for the purpose of this thesis is limited.

Economic Geography and New Industrial Spaces

The importance of local knowledge spillovers has been raised within the field of *Economic Geography* (Jaffe, 1993). In particular, Audretsch and Feldman (1996B) suggest that innovative activities tend to cluster in order to take advantage of knowledge spillovers, since innovation is knowledge-dependent. They control for the pre-existing concentration of production and find that innovative activity tends to cluster in industries where new knowledge plays an especially important role. What they suggest is that within a cluster, there are knowledge spillovers and knowledge-intensive firms tend to cluster in order to make the most of these advantages. However, they do not analyse the specific mechanisms by which knowledge spillovers operate and affect a firm's innovative activity.

Porter (1990) approaches the cluster issue from another perspective. While exploring the determinants of competitiveness (of firms, industries and nations), he concludes that firms within a cluster may be more competitive than isolated ones. Competition, specialised suppliers/buyers, and institutions are the main reasons behind the good performance of some clusters. The local environment is the coordinator of these forces and the one who adds the highest value: "differences in national economic structures, values, cultures, institutions, and histories contribute profoundly to competitive success" (Porter, 1990, p. 19). As a consequence, policy makers should promote clusters in order to strengthen the competitiveness of firms. Although very influential, the cluster concept of Porter has been criticised for being "highly generic in character", "deliberately vague", and "sufficiently indeterminate" (Martin and Sunley, 2003, p. 9), and has been charged with a "...lack of clear boundaries, both industrial and geographical" (Martin and Sunley, 2003, p. 10).

The work of Storper and Scott (1989) constituted a major contribution to the theorisation of clusters and to the opening up of a new line of research, known as the *New Industrial Spaces* (Storper, 1995, 1997; Scott, 2001, 2004). Initially they placed emphasis on the transaction costs advantages that firms utilise within the cluster while later they stressed that *New Industrial Spaces* involve not only agglomerate production systems, but also 'untraded interdependencies'. Untraded interdependencies go beyond market transactions and involve conventions, social rules and languages which enable the flow of knowledge. Later, the work of Saxenian (1994) on the Silicon Valley provided empirical support for the notion that a cluster draws advantages from the flexible organisation of the production of firms. In addition, she emphasised that local firms are not only economically connected, but that cultural factors and local institutions strengthen their relationship. These ideas build upon two older lines of research, those of the Industrial District and the Innovative Milieu.

Industrial District and Innovative Milieu

The *Industrial District* (ID) theory attempts to explain the economic success of clusters of Small and Medium Enterprises (SMEs). The term industrial district is used to define "...a geographically localised productive system, based on a strong local division of work between small firms specialised in different steps in the production and distribution cycle of an industrial sector.." (Moulaert and Sekia, 2003, p. 291). New technologies introduced greater production flexibility or 'flexible specialization' (Piore and Sabel, 1984). As a result of vertical disintegration the division of labour has changed. This change brought benefits for firms: it reduced transactions costs and generated external economies. The introduction of *just in time* practices, common in the Japanese model of production not only changed production and organisation standards, but also the terms of competition. Thus, small firms could be competitive and efficient, since they could specialise and respond quickly to the demands of the market. The theory of Industrial Districts has been further strengthened theoretically and empirically by the Italian experience of the so-called "Third Italy" regions and by the academic research that it has stimulated.[6] (Becattini, 1990)

An important contribution to the research into clusters comes from the *Innovative Milieu* approach, which has focused on the relationship between innovation and space. This approach has been developed by the GREMI[7], Aydalot (1986) and further elaborated by Camagni (1991). The notion of institutions is at the centre of their analysis. The similarities between the Innovative Milieu and the Industrial District approach are found in the role of the local socio-economic community – milieu or district – the space where specialised agents cooperate and complement each other. However, they place less emphasis on transaction cost advantages than does ID theory. The non-market relationship among agents is the mechanism that facilitates collective learning and reduces the degree of uncertainty for firms (Camagni, 1991). These ideas coincide with others adopted by the proponents of the Regional Systems of Innovation.

Regional Systems of Innovation and the Learning Region

The theory of *Regional Systems of Innovation* and that of the *Learning Region* (Cooke, 2001; Morgan, 1997) is based on the same ideas of cooperation and complementarities. Cooperation between institutions and enterprises constitutes the basis for innovative activity. The concept of institution is extensively used in the literature but does not always refer to the same thing. The term is commonly used to describe a research institute/university that supplies clustered firms with knowledge in the form of information or human capital (skilled labour). For example, the groundbreaking research conducted by Stanford University on radar, solid-state electronics, and computing created a local pool of technical knowledge and suppliers that

attracted reputable corporations and encouraged the formation of new enterprises in the highly innovative cluster of Silicon Valley (Saxenian, 1994). From time to time the firm is also treated as an institution. In the evolutionary literature, institution refers to 'recurrent patterns of behaviour-habits, conventions and routines' (Morgan, 1997, p. 493). Thus, a business firm could be considered as an institution. In such a case, 'institution' is a production routine that constitutes 'a habitual pattern of behaviour embodying knowledge that is often tacit and skill-like' (Langlois and Robertson, 1995: cited in Morgan, 1997, p. 493). The notion of 'routines' is at the centre of the evolutionary analysis of firms' behaviour. "Routines are persistent features of the organism and determine its possible behaviour; they are heritable and selectable" (Nelson and Winter, 1982, p.14).

If we accept the notion of the firm as an institution and the notion that its functions are based on routines, then innovation could be pursued more efficiently when firms are located close to each other. This allows firms to observe and compare routines and processes that cannot be easily traded in the form of a product. The work of Malmberg and Maskell (2002) is along these lines. They emphasise the horizontal dimensions of a cluster and the way in which rivalry between firms encourages variation, observability and comparability. As a consequence, different types of knowledge are exchanged, and the possibilities to innovate are enhanced.

While many studies in Regional Systems of Innovation and Economic Geography address local or regional advantages, few pay attention to the global dimension of clusters. Recently, however, Simmie (2003), Bathelt et al (2004) and Owen-Smith and Powell (2004) argued that a region cannot be self-sufficient [not even a country] and raised the importance of external linkages or the so-called 'trans-local pipelines'. Non-local linkages, namely the 'pipelines', constitute channels for the entry into the cluster of new information regarding new markets and technologies (Bathelt et al., 2004). The new knowledge is transmitted rapidly through the function of knowledge spillovers to the firms within the cluster. For example, Simmie (2003) considered the interface of local and global and found that in the United Kingdom, innovative firms are concentrated in a few locations (thus confirming the importance of regions/clusters) but at the same time, innovative regions have more linkages with international actors than less innovative regions. In his interpretation international linkages [with customers and clients] are important for obtaining leading edge knowledge concerning market trends rather than technological information. While technological knowledge is tacit and circulates at local level, knowledge about markets is less tacit and is located in international centres of excellence that firms need to contact. In other words, Simmie raises the importance of 'demand-pulls ...in understanding the drivers of innovation' and stresses the significance of international linkages for regions or clusters in advanced economies (Simmie, 2003, p. 616). Therefore, according to these new insights, clusters need to establish and maintain external relations in order to sustain their innovativeness and competitiveness in the long run.

To conclude, the review of the leading theories of regional agglomeration proved to be useful for the comprehension of local knowledge spillovers. In particular, the Economic Geography and the Regional Systems of Innovation and the Learning Region approaches view LKS as the driving force behind the agglomeration of firms in clusters and/or regions.

2.2.2.2 Technological externalities

Knowledge spillovers or technological externalities arise from the production of knowledge, when knowledge retains some characteristics of a public good. Public goods have two properties: they are non-rival and non-excludable in consumption. Non-rivalry means that the consumption of a public good by one actor does not prevent others from enjoying the benefits of its use. Non-excludability signifies that it is difficult to retain the exclusive use of a public good. As a result, the production of a public good generates externalities which the market fails to take into account (i.e. by maximising the social returns of knowledge production).

Both the theory of Regional Systems of Innovation and the theory of Economic Geography identify the presence of localised knowledge spillovers as the main reason for the clustering of economic activity. While studies in the former research stream have focused upon theorising and upon qualitative case studies, research in the latter has attempted to verify the local nature of knowledge spillovers by following a quantitative methodology. However, in both streams of research, KS are treated implicitly. So far it is not obvious what KS refer to and, more importantly, how they take place (with few exceptions, i.e. Saxenian, 1994). In this section I will draw attention to the rather overlooked matter of knowledge spillovers and their mechanisms.

The first author to state that clusters facilitate the diffusion of knowledge through the concentration and the mobility of specialised labour was Alfred Marshall (1920). Inspired by the cotton mills of nineteenth century Manchester, he noted the existence of production systems that are geographically concentrated. One of the ingredients of Marshall's Industrial Districts theory can be interpreted to refer to knowledge spillovers "the mysteries of the trade become no mysteries, but are as it were in the air"[8] (Marshall, 1920, p. 225).

The concept of knowledge spillovers reappeared decades later in the work of Scitovsky (1954). His notion of real externalities resemble what Marshall referred to as 'something in the air', though Scitovsky did not explicitly consider the spatial attributes of knowledge spillovers. According to his predecessor (Meade, 1952), real external economies are the results of the interdependence between the decisions and actions of various firms. In particular, Meade argued in 1952 that real external economies arise in situations in which the output (X_1) of a firm may depend not only on its own inputs (L_1, C_1,...) of productive resources but also on the output (X_2) and inputs (L_1, C_1,...) used by other firms. This is the case of direct or non-market interdependence among producers, or so-called 'real externalities'.

$$X_1 = F\ (L_1, C_1, ...;\quad X_2, L_2, C_2, ...)$$

Scitovsky (1954) paid attention to another type of externality which included the interdependence among firms through market mechanisms. This is the case of the so-called 'pecuniary external economies'. As the following equation shows, the profit of a firm depends on its own input and output and also on the price of inputs and outputs of other firms (Scitovsky, 1954).

$$P_1 = G\ (X_1, L_1, C_1, ...;\quad X_2, L_2, C_2, ...)$$

In this same work Scitovsky states that pecuniary external economies could have significant implications for the economic development of underdeveloped countries. Simply put, when investment decisions are coordinated between firms, the social benefit is higher than when individual firms take them. Underdeveloped countries can take advantage of pecuniary externalities and achieve high rates of growth. In a similar way Rosenstein-Rodan (1943)

argued that pecuniary externalities call for industrial planning, coordination of investment and market intervention (Hirschman, 1958; Chenery, 1959).

In the late 1970s, attention turned once again to knowledge spillovers. Grilliches (1979) was interested in understanding the impact of public research and development upon economic growth and he acknowledged that R&D generates knowledge spillovers. He distinguishes two types of spillovers: rent spillovers and real spillovers. While real spillovers resemble that which was previously known as real or technology externalities, the term rent spillovers is a new one. The latter appear when a firm from industry A purchases inputs from a firm from industry B and the price of these inputs does not reflect quality improvements. Grilliches tends to underestimate the significance of these spillovers because, in his view, they "...are related to issues in the [unsuccessful] measurement of capital equipment and materials and their prices and is not really a case of pure knowledge spillover" (Grilliches, 1979, p.104). On the other hand, "...the ideas borrowed by the research teams of industry i from the results of industry j" are, according to Grilliches, the 'true spillovers' (Grilliches, 1979, p.104).

Caniëls and Romijn (2003, 2005) summarise the above literature by looking at the difference between pecuniary externalities and technological (or real) externalities and by making the distinction between static and dynamic externalities. Table 2.2 presents their classification (Caniëls and Romijn, 2006), which is enriched by the addition of examples. They stress that pecuniary externalities affect the production function of the firm indirectly through prices, whereas technological (or real) externalities affect the production function of the firm directly. Furthermore, they underline that the main difference between static and dynamic externalities lies in the fact that dynamic externalities are the result of technological change whereas static externalities occur with constant technology.

Static pecuniary externalities refer to the first two Marshallian externalities; that is to economies of scale, scope and transaction that accrue to firms within clusters (see examples in Table 2.2). On the other hand, static real externalities refer to cases of environmental pollution which are not relevant for the examination of local knowledge spillovers and thus are not further mentioned in this thesis.

We take a look now at the dynamic externalities and the case of real knowledge externalities or pure knowledge spillovers. These refer to free knowledge inputs that affect directly the production function of a firm. On the contrary, pecuniary dynamic externalities or rent spillovers (Griliches, 1979, 1992) denote pecuniary gains or rents that accrue to firms when the price of inputs does not reflect quality improvements.

Table 2.2: Types of Externalities

	Pecuniary	**Real**
Static	*External economies of scale, scope and transaction*	*Unpriced external effects unrelated to technological change*
Examples	-Presence of specialised suppliers within the cluster that induce economies of scale and scope (Marshall, 1920; Krugman, 1991) -Coordination of investments in order to create backward and forward linkages (Hirschman, 1958) -Presence of a labour market with specialised skills within a cluster (Marshall, 1920)	-Environmental externalities
Dynamic	*Rent Spillovers*	*Pure knowledge spillovers* (intellectual gains)
Examples	-When the price of inputs does not reflect quality improvements achieved by the supplier-firm, then gains or rents accrue to user-firm (Griliches, 1979, 1992; Jacob, 2006)	-Informal interaction among employees of similar firms may lead to knowledge spillovers (Saxenian, 1994) -Labour mobility may diffuse knowledge (Zucker et al. 1998; Almeida and Kogut, 1999)

Source: Caniëls and Romijn (2006)

Dynamic externalities are the result of technological change and thus of the creation of new knowledge. Therefore, they are particularly important for the innovative performance of firms. The focus of this thesis is on real knowledge spillovers and not on rent spillovers. This is because I expect to find that the former are more important than the latter at the local level in the context of developing countries. Usually, rent spillovers are relevant for developing countries when they occur at the international level (Jacob, 2006).

Developing countries acquire technology from developed countries and during this process rent spillovers may occur. Consequently, while rent spillovers function at the international level, pure knowledge spillovers may be the vehicle for the diffusion of knowledge at the local level in developing countries.

The Local and Social character of Knowledge Spillovers

Knowledge spillovers are to some extent locally bounded because the creation of new knowledge is a cumulative process. In addition, both knowledge creation and innovation require tacit knowledge, which is not easy to communicate and transfer. A discussion of how the process of knowledge creation takes place at the firm level is crucial for the understanding knowledge creation at the regional level.

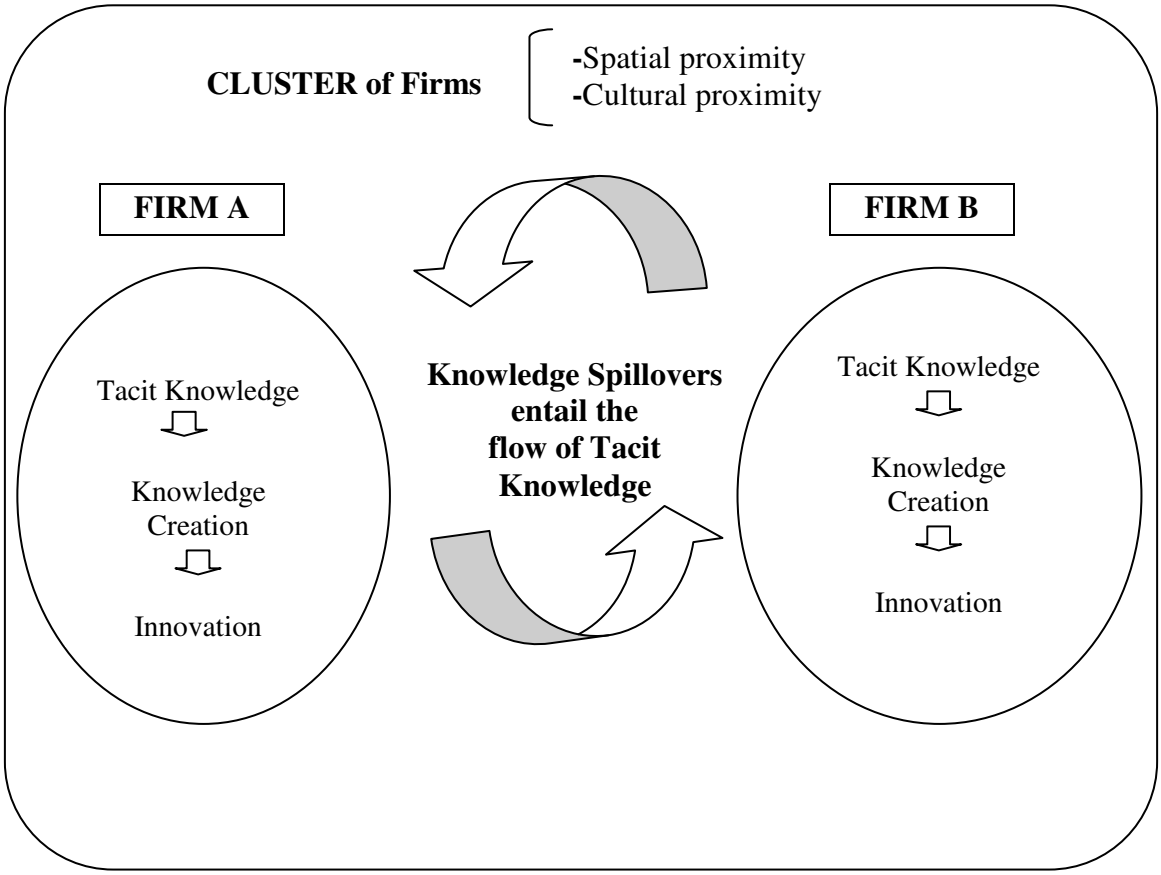
The theory of organisational learning (Nonaka and Takeuchi, 1995) emphasises the creation of knowledge out of the interaction of tacit and explicit knowledge. This interaction takes place at different levels, namely at the individual, group and organisational level. In sum, knowledge creation is a spiral process and in particular it is "a conversion process –from outside to inside and back outside again in the form of new products, services, or systems'' (Nonaka and Takeuchi, 1995, p. 6). Also of great interest, and related to the theory of clusters, is the first conversion process, from tacit knowledge, which resides outside the firm, to tacit knowledge within the firm. According to Nonaka et al (1995), this is a process of socialisation, which takes place first and foremost by sharing knowledge. However, in order to share knowledge, especially in its tacit form, people should be able to communicate and understand each other. This understanding is achieved through the sharing of a common culture (organisational culture) that is formed by the views, beliefs and knowledge shared among the people of an organisation based on mutual trust. "To effect that sharing, we need a 'field' in which individuals can interact with each other through face-to-face dialogues" (Nonaka and Takeuchi, 1995, p. 85).

The theory of knowledge creation at the level of the organisation has important implications for the process of knowledge creation at regional level. Two focal points may be highlighted from the aforementioned analysis: space and culture. In order to communicate tacit knowledge, it is necessary to share a common culture and to be engaged in a face-to-face contact.

Similarly, Enright (1999) argues that firms can find vital resources within the region. He links the strategy of the firm to regional advantages. Enright focuses upon cost advantages as well as knowledge resources. He introduces an activity-based view of the firm and argues that regional agglomeration will persist as long as firms can coordinate and share their activities within clusters.

Both the Regional Systems of Innovation and the Learning Region advocates claim that learning serves to incorporate new information into the knowledge base of the firm and combine diverse and tacit knowledge (Keeble and Wilkinson, 1998; Lawson and Lorenz, 1999). They further argue that learning is better achieved within a cluster, since in a region or cluster the exchange of different kinds of knowledge can take place in a more effective manner. The concentration of intelligent agents such as skilled labour, specialist suppliers and firms creates the capability that a region needs to renew and augment a firm's knowledge. In addition, the region provides a social context – common language and culture – that facilitates the exchange of tacit knowledge (Helmsing, 2001). Figure 2.1 depicts the cycle of knowledge sharing that takes place among firms (or actors) within a cluster. In sum, the cluster encompasses two features: spatial and cultural proximity. A prerequisite for learning and knowledge creation, then, is the sharing of tacit knowledge. The latter circulates more easily when the actors are engaged in face-to-face contact and retain a common culture, which in turn facilitates the communication of tacit knowledge.

Figure 2.1: Knowledge Diffusion Cycle within Clusters



Source: Adapted from Nonaka and Takeuchi (1995)

Regional Systems of Innovation and the Innovative Milieu approaches underline the systemic view of the cluster, that innovation is the outcome of the interaction among firms and between them and local institutions. Thus, firms are embedded in their social context and this in turn, influences their behaviour and economic performance. Those ideas are based on the Social Network theory and the pioneering work of Granovetter (1985), who linked the micro and macro level of sociological analysis by introducing the idea of embeddedness. Embeddedness signifies that the structure of a network of social relations influences the behaviour of a firm concerning the formation of its relationships or ties (Gulati, 1998). Actors or firms that collaborate often build trust, a common understanding of reality, of values and social rules that smoothens their collaboration. Burt (1992) argued that these relations constitute the social capital of the firm. The 'regional systems of innovation' approach has incorporated the notion of embeddedness in order to explain the social feature of knowledge exchange amongst the actors within the cluster (Cooke et al., 1998).

But what does this imply for a firm and its competitive strategy? Is it easier to build social capital within clusters? The Social Network theory does not explicitly elaborate on the spatial aspects of embeddedness or social capital. Either directly or indirectly, most of the territorial theories claim that firms interact more and build up trust when they are located in close proximity. This in turn facilitates the formation of social networks. Another issue that arises from this debate is whether the interaction of firms within a cluster is more formal or more informal. Formal interaction supports the economists' view and their arguments of cost advantages for clustered firms (formal interaction may also produce rent spillovers). On the

other hand, informal interaction tends to support sociologically-based notions of trust and culture that facilitate communication and exchange of knowledge among clustered firms (informal interaction may give rise to knowledge spillovers).

Recently the importance of geographic proximity for the transmission of tacit knowledge has been challenged by Amin and Cohendet (2003), who highlight the key role of organizational or relational proximity for the transfer of tacit knowledge. In particular, their work postulates that spatial proximity is not a sufficient condition for the exchange of tacit knowledge. It is cognitive proximity that is necessary for the successful transmission of tacit knowledge (Amin and Cohendet, 1999, 2000). This type of proximity is present among individuals that belong to the same professional communities the so-called 'knowing communities' such as communities of practice or epistemic communities (Cohendet, 2005).

Both, communities of practice and epistemic communities refer to groups of people which are joined together [usually informally] because of similar professional interests (Lave and Wenger, 1991; Amin, 2000). People that participate in communities of practice communicate often in order to solve practical problems. It is applied knowledge (engineering) or the so-called synthetic that is important in communities of practice (Asheim, Coenen, Vang-Lauridsen, 2006). On the other hand, epistemic communities, interact in order to create new knowledge. It is theoretical knowledge (scientific) or the so-called analytical knowledge that plays the central role in epistemic communities (Asheim, Coenen, Vang-Lauridsen, 2006). In sum, the common interest of professionals or scientists which motivates their participation to the 'knowing communities' (characterised by small cognitive distance) is the necessary condition for the exchange of tacit knowledge (Haas, 1992; Hakanson, 2003). These communities can be either local or global (Amin and Cohendet, 1999, 2000).

In light of these criticisms many scholars aligned with the Economic Geography and the Regional Innovation Systems approach started to raise different questions. In particular, Gertler asked "what forces shape or define this 'relational proximity', enabling it to transcend physical, cultural, and institutional divides?" (Gertler, 2003, p. 87). In Gertler's view the main problem arises from the misconception of space by the proponents of relational proximity, who assume that space is a separate entity. Proponents of Economic Geography such as Bathelt and Glucker (2003) argued that there is a two ways relationship between space and economy. In particular, Gertler (2003), based on the examination of the work of Karl Polanyi (1944), claims that economic activities are embedded in social relations and that institutions shape economic processes. In other words, geography is important because entails specific socio-economic and institutional relations which influence the production and sharing of tacit knowledge, which is context dependent (Polanyi, 1966; Gertler, 2003; Morgan, 2004). Context is defined not only as an abstract geographic space but instead as an organic space in which social, economic, institutional, and cultural relations take place. In sum, geographic proximity still matters, because space entails socio-economic relations, which are a prerequisite for relational proximity to arise.

As we have seen, KS are not a new issue. They have been examined in different periods and within different contexts. But there has been little systematic exploration regarding *how* LKS take place (see section 2.2.3 for detail studies on LKS). According to developments in innovation literature with regard to the importance of tacit knowledge, it can be deduced that tacit knowledge is to a great extent embodied in humans and thus can be transferred only by them.

The Spontaneous and Intentional Character of Knowledge Spillovers

Economists generally interpret knowledge spillovers as spontaneous or unintended flows of knowledge (Griliches, 1979). Recently, however, scholars in the field of innovation management have suggested that knowledge spillovers may also "occur intentionally; hence, they can be called voluntary information spillovers" (Harhoff et al., 2003, p. 1767). These authors show several case studies in which user firms prefer to reveal their innovations to the world rather than to keep them secret in order to benefit from improvements in equipment and software. The main idea is that "in a world of self-interested agents with complementary capabilities, free revealing can be profitable" (Harhoff et al., 2003, p. 1767).

Informal knowledge sharing among competitive firms has also been discussed in the literature by Robert Allen (1983) and von Hippel (1987). First, Allen (1983) wrote about a process he called "collective invention". During the nineteenth century in the district of Cleveland in England, firms in the steel and iron industry carried out incremental innovations[9] which resulted in a more efficient production process. What is more interesting is the way in which this incremental innovation took place. Firms in the Cleveland district would share information about new techniques and designs in an informal manner without financial transactions. The channels for the diffusion of information were mainly informal disclosure of information, publications, and conferences. Alessandro Nuvolari (2004) identifies a parallel case of 'collective invention' in the Cornish mining district from 1813 until 1852. For a later period, von Hippel (1987) ascertains a similar phenomenon in the steel mini-mill industry in United States. Informal know-how trading was taking place among competitive firms on the basis of reciprocity. The main idea of these findings is that enterprises frequently choose to exchange knowledge freely on the basis of reciprocity and not through a market mechanism (such as a formal contract or financial compensations). This phenomenon occurs because the actors involved enjoy mutual benefit through the act of sharing or exchanging knowledge. The most notable contemporary example of the intentional free sharing of knowledge is found in the case of open source software. In this system, the development of a software product is a collective work of several professionals who are not financially compensated for their contribution.

A difference between the cases of Allen and von Hippel is that in the first case, knowledge is shared multilaterally (between all firms), while in the second case knowledge is shared bilaterally (between the trading parties). However, in both cases, knowledge is exchanged in a direct way, and not through a market mechanism. As a result, despite the attention given to patents which represent a financial incentive for innovation, 'collective invention' or 'informal know-how trading' are institutions which may induce innovation as well (von Hippel, 1987). In the latter case, the main motivation for innovation is innovation itself and the subsequent benefits it brings for individuals (reputation, professional success), firms (profit, image) and regions (economic development).

In sum, the analysis of the literature on LKS shows that there is a range of different forms of LKS that could refer to unintentional leakages of knowledge and to intentional free sharing of knowledge as well. Therefore, in order to shed light on LKS it is necessary to examine the whole variety of forms through which knowledge spills over from one actor to another.

2.2.3 Methodological and Empirical Approaches on the relation between Local Knowledge Spillovers and Innovation

Although, knowledge spillovers are by nature difficult to measure because they do not have a market value, some attempts have been made to assign them an indirect value. For instance, Stewart and Ghani (1991) propose a way to measure externalities that derive from technological change and technology transfer due to labour mobility, firms' networking, and interaction between firms (input and user industries).[10]

Furthermore, a number of economic geographers and economists of innovation have incorporated knowledge spillovers into their empirical analysis of clustering. Jaffe (1989) examined whether KS are localised by studying the impact of university research on corporate innovation at a State level in the USA. He relies on a knowledge production function based on the earlier work of Griliches (1979, 1984) in order to model spillovers from university R&D upon the production of patents at the local firm. The main conclusion of Jaffe's study is that university research within states plays an important role in increasing corporate patents, especially in sectors such as drugs, medical technology, electronics, optics and nuclear technology. However, this exercise constitutes only indirect evidence for existence of LKS since, as Jaffe admits, spillover mechanisms have not been modelled.

Table 2.3: Leading Empirical Studies on Localised Knowledge Spillovers

Sources	Methodology	Results	Limitations
Jaffe (1989)	Knowledge Production Function	Knowledge spillovers from the university research to corporate innovative output at the level of U.S. state.	Knowledge spillover mechanisms are not modelled.
Jaffe, Trajtenberg & Henderson (1993)	Patent citations	Patent citations are the trail of knowledge transfer and they are highly localised.	Not all patent citations represent knowledge spillovers.
Saxenian (1994)	Longitudinal (qualitative) comparative case study	Knowledge spillovers arise through informal exchange of knowledge in social events, labour mobility and spin-off firm formation in the semiconductor industry in Silicon Valley in U.S.	Sector specificities could influence the result. In addition, the fact that it is a case study raises the problem of this being the exception rather than the rule.
Audretsch & Feldman (1996B)	Corporate new product innovations and R&D intensity of industry.	Innovative activity tends to cluster in knowledge intensives industries, even after controlling for concentration of productive activity.	Knowledge spillover mechanisms are not modelled.
Zucker, Darby & Brewer (1998)	Labour market and spin-off firms.	Knowledge localisation explained by the presence of star scientist in biotechnology industry in U.S.	They consider one sector in which knowledge could be highly protected and less prone to KS.
Breschi & Lissoni (2003)	Patent citations and social network	KS embedded in social networks primarily and then to local networks.	Small data set derived from a single country
Almeida & Kogut (1999)	Patent citations and labour mobility	Inter-firm labour mobility explains the localization of knowledge spillovers.	Labour mobility may not diffuse knowledge but simply transfer it from one firm to another.

Research on LKS has been developed further by the seminal work of Jaffe, Trajtenberg and Henderson (1993), who have examined the geographic distribution of patents and the citations of these patents. They conclude that patent citations are highly localised, indicating that knowledge spillovers are spatially bounded. Jaffe et al. (1993) followed a new methodology in order to approach LKS, namely the use of patent citations. The novelty of their approach rests on the fact that they have examined the effects of LKS independently of rent spillovers by taking into account the pre-existing agglomeration of related research activity. Patent citations can offer an indication of LKS, but cannot be used to validate a theory of LKS. One problem with this methodology is that only a fraction of patent citations are added by the applicant, while the rest are added by the examiner. It is obvious that the latter does not measure any flow of knowledge. An even more important problem is that a considerable amount of new knowledge is never patented in the fist place.

Qualitative case studies of clusters in different sectors and locations constitute another line of research. One of the most influential works in this field of research has been carried out in the high-tech cluster of Silicon Valley (Saxenian, 1994). In particular, Saxenian (1994) attempted to explain, in a comparative and longitudinal study, the superior performance of the semiconductor industry in Silicon Valley *vis-à-vis* another located on Route 128. This study empirically supported the idea that the former cluster draws its advantages from the strong interdependence of firms, which allows for the exchange of ideas and knowledge to occur. In turn, the flow of knowledge [mostly through the formation of informal linkages among local firms] facilitates the learning process and consequently increases the innovative activity of these firms. In particular, Saxenian (1994) stressed three main mechanisms through which knowledge spills over locally in Silicon Valley: the informal exchange of knowledge among employees or managers of local firms in social conventions, the vibrant local labour mobility, and finally the high rate of spin-offs.

Audretsch and Feldman (1996B) examined the spatial distribution of innovation at State level for the USA. They used new products introduced to the American market as a proxy of innovative activity, while they measured the knowledge intensity of an industry by considering the R&D-sales ratio, the percentage of skilled labour (human capital) and university research. They control for the geographic concentration of production and they find that the spatial concentration of innovation is significantly greater in specific industries than for manufacturing as a whole. These are industries where new knowledge plays a more important role. Their findings support the idea that innovation is spatially concentrated due to the tacit nature of technological knowledge, indicating that personal interaction is necessary for the knowledge to spill over (Baptista and Swann, 1998; Audretsch, 1998; Audretsch and Feldman, 1996A; Verspagen and Schoenmakers, 2000; Caniëls, 2000).

Zucker, Darby and Brewer (1998) relate the location of new U.S. biotechnological firms to the presence of star scientists. They first identify a leading scientist by considering his research productivity and then calculate the number of new biotechnology firms in every region in the USA. Using a panel data set with observations from 183 regions for the period 1976-1989 they found that "localities with outstanding scientists having the tacit knowledge to practice recombinant DNA, were much more likely to see new firms founded" (Zucker et al. 1998, p. 300). One of the main contributions of this study is that it finds that "the quadratic term for stars is negative, suggesting diminishing returns rather than the increasing returns suggested by standard views of knowledge spillovers which posit uninternalized, positive external effects from university scientist" (Zucker et al. 1998, p. 300). This study poses questions about the nature of LKS. If knowledge is not a public good but rather a private

good, this implies that the producer of knowledge can fully appropriate the benefits of his/hers innovations. As a result, the phenomenon of LKS would have limited applications in practice. Still, knowledge would be localised, not because of the function of LKS, but rather because of the presence of a local labour market.

However, it cannot be concluded from this study that LKS do not play a role in innovative activity. Firstly, Zucker et al. (1998) have tested the presence of LKS by considering the spin-off growth of firms, and the location of star scientists. To begin with, this is only one channel through which LKS may take place. The study did not test for other possible channels of LKS as found for example by Saxenian (1994), namely informal exchange of knowledge and labour mobility. Secondly, tacit knowledge is not only diffused thanks to star scientists but also through less experienced scientists. Even though the latter cannot easily translate their scientific knowledge into a commercial idea, it does not mean that these scientists cannot be a source of LKS. Finally, this evidence comes from a specific industry in a particular context. It could be that the biotech sector shows particularly high appropriability, since it has a strongly regulated IPR regime.

Almeida and Kogut (1999) attempted to explain the reasons behind the localisation of knowledge spillovers. They argue that the local labour network plays a major role in the bounded mobility of knowledge spillovers. The originality of this study rests on the fact that it examines the career paths of patent holders and looks for the impact of inter-firm mobility upon the pattern of patent citations. The authors find that regional labour mobility influences the probability that a patent will be built upon a key patent from the same region in a significant and positive way. However, labour mobility does not necessarily give rise to knowledge spillovers. If the mobile worker does not share his tacit knowledge with his co-workers every time he changes a working place, he does not actually spread knowledge but he shifts it from one firm to another (Breschi and Lissoni, 2001).

Seeking to explain the motivation for information sharing amongst inventors, Breschi and Lissoni (2003) introduced a new explanatory variable: that of social proximity. They argued that inventors who have worked together in the past develop a social relation, which prompts them to share knowledge even from a distance. Thus, the question here is whether scientists are committed to their social network more than they are committed to their organisation or cluster. Breschi and Lissoni use information from an Italian patent data set to trace the collaborative patents of inventors. Their empirical findings support the hypothesis that social proximity among inventors significantly affects the spatial proximity of knowledge. They further examine the properties of social proximity by separating a social link due to mobility of inventors from those generated by indirect links between the groups of inventors. They noticed that the mobility of inventors plays a more important role than indirect linkages in the localisation of knowledge. However, their study is based on a small country data set. As they admit, the theory of LKS would be more reliable if tested in a more detailed and larger data set (such as the US patents data set).

The review of empirical studies has given us an idea on how LKS take place. Presumably, LKS could be transferred through many different manners, i.e. mobility of star scientists or engineers, industrial espionage, sharing of information at conferences or trade fairs, imitation of products thanks to reverse engineering, spin-offs and finally via patents and scientific literature. A number of methodologies have been used to examine LKS in advanced economies. While quantitative studies are rigorous, they rely on proxies in order to measure

LKS. Thus, these studies may confirm or reject the alleged relation between LKS and innovation, but they have few things to say about LKS and how they take place. In contrast, qualitative studies tend to look thoroughly at LKS. However, these studies are few, and their results may be biased on the selection of the specific cluster.

2.3 A REVIEW OF THE LITERATURE IN DEVELOPING COUNTRIES

2.3.1 Theoretical Insights on Technological Learning in Firms in Developing Countries

Development economists first introduced the concept of technological learning in the late 1970s, when they encountered difficulties in explaining the failure of technology transfer processes in several LDCs (Stewart and James, 1982; Dahlman, Ross-Larson and Westphal, 1987; Lall, 1987). The next decade was characterised by stagnation, especially in Latin America and Africa, where the 1980s was nicknamed 'the lost decade'. During the 1980s and 1990s, most of the LDCs followed the recommendations of the 'Washington Consensus', which limited State intervention and introduced economic liberalisation. However, these reforms did not manage to drive many developing countries, especially the Latin American and African economies, out of the crisis. Therefore, international organisations (World Bank and IMF) were heavily criticised even by their previous supporters (Stiglitz, 2001).

This discord partly stems from the discrepancy between neo-classical and neo-structural economics in their views of knowledge and in particular technological knowledge. Neo-classical economists[11] argue that technology is exogenously determined and is available to anyone interested in using it within the public domain. According to this school of thought, technology comes like 'manna from heaven' (see Nelson and Winter, 1982; Metcalfe, 2002). In particular, neo-classical economists see technology as a public good that can be used simultaneously by many firms. State intervention distorts resource allocation, which happens automatically in competitive markets; prices provide the signals that the firms need for choosing the right quantity of factors and products, and in turn firms select the appropriate technology and absorb it without cost.

On the other hand, neo-structuralist economists claim that technological change or alternatively, innovation is the outcome of intentional investments in technological learning and R&D (Dahlman and Westphal, 1981; Lall, 1987; Katz, 1987). Later neo-structuralist development economists adopted many of the views of evolutionary economics. Evolutionary theory argues that firms are not homogeneous in their behaviour because they have developed different technological and organisational routines (Nelson and Winter, 1982). Emphasis is given to the fact that technological learning is a cumulative process because "the routines of today are based on those of yesterday as much as those of tomorrow are related to those of today" (Nelson and Winter, 1982, p. 124).

The 'technological capability' approach has been built on the basis of the aforementioned notion of technological change. According to one of the founding fathers of this approach "technology cannot simply be transferred to a developing country like a physical product: its effective implantation has to include important elements of capability building" (Lall, 2004, p.5). In particular, it is argued that the non-rival property of knowledge and thus technology does not necessarily mean that it is freely available to all firms (Metcalfe, 2002). In order for firms to capture technology and utilise it successfully they first need to build the capabilities to absorb it, comprehend it, and then modify it (Stewart and James, 1982; Fransman, 1985; Katz, 1987).

As a result, it is now acknowledged that firms in developing countries should follow the 'high road of competition', of innovation and technological change (Humphrey and Schmitz, 2002). The alternative option of squeezing costs and profits (prices and labour costs), only leads to short term advantages [in an optimistic scenario]. These benefits will vanish as soon as other firms [regions or countries; depending of the level of analysis] reduce prices and reap the short-term competitive advantages. Long-run competitiveness is achieved when firms are involved in a process of technological change. It is through learning and innovation that firms reach a stage of dynamic competitiveness in which they continuously attempt to acquire and apply new knowledge in response to changing circumstances (Dahlman and Westphal, 1981).

Technological Learning

Technological learning is relevant in many LDCs, since the majority of the technologies are produced in developed countries and require specific abilities to operate them, and even more sophisticated skills to emulate them. Furthermore, new technologies need to be adapted in response to local specificities (Evenson and Westphal, 1995).

Learning refers to the process by which individuals and organisations acquire skills and knowledge (Bell, 1984). In particular, technological learning refers to the application of scientific knowledge and skills to the setting up, operating, and improving of productive facilities (Lall, 1992). This line of research is focused on learning processes and the factors driving these processes.

Neo-classical economists claimed that learning-by-doing is the process through which firms may accumulate experience without cost (Arrow, 1962). Simply put, more production activity deepens the skills and knowledge of individuals or firms (the notion of the learning curve). Consequently, learning is the by-product of the production process. However, empirical studies have shown that learning-by-using is another process through which the efficiency of a firm is increased as much as it uses a given technology (Rosenberg, 1982). Furthermore, empirical studies in LDCs have shown that unintended learning is not a sufficient condition for upgrading to more complex technologies (Bell, 1984). A striking example is the divergence in the growth performance of Latin American countries in comparison with the so-called Asian Tigers. While both groups of countries initially based their industrial development on imported technology, the first group did not accompany the use of technology with additional efforts of research and development (Katz, 2000). On the contrary, many of the East Asian countries went through a process of assimilation of the foreign technology which involved consistent efforts to improve and eventually change it (Amsden, 1989, 2001; Kim and Dahlman, 1992; Lall, 1996; Kim, 1997, 1999). Even more striking is the contrast between the Asian Tigers and African countries. Technological stagnation and deindustrialisation characterises many Sub-Saharan African countries and one of the main explanations for this is the lack of technological learning which left most countries with weak capabilities (Ogbu, Oyeyinka and Mlawa, 1995).

Complex technology is to some extent tacit and difficult to communicate. Consequently, learning is an essential phase during which firms acquire the capabilities that enable them to choose the appropriate technology, adapt it to local conditions and then upgrade it. Thus, emphasis is given to learning-by-interacting and learning-by-searching (Bell, 1984). The last decade a number of empirical studies in East and Southeast Asia and Latin America confirm these views and underline the importance of technological learning for the competitive performance of firms in LDCs (Hobday, 1995, 2000; Figueiredo, 2001).

Technological Capability

Technological learning may lead not only to the adaptation of technology to local conditions, but also to the design of new technology. Both manners of innovation require technological effort since adoption does not imply adaptation and the creation of a new design does not emerge from nothing but it is often the result of a previous cumulative knowledge recombined with new knowledge. "Firm-level technological change is determined by: external inputs and by past accumulation of skills and knowledge" (Lall, 1992, p. 166). Technological effort contains all the activities that firms carry out intentionally in order to acquire, absorb, apply and modify technological knowledge (Dahlman and Westphal, 1981).

During the process of technological learning, firms can acquire and expand their technological capabilities, which in turn allow them to manage technical change. Technological capabilities do not only apply to production but also encompass the full range of firm activities. According to Lall (1992), there are three types of technological capabilities: investment capabilities, production capabilities, and innovation capabilities. Bell and Pavitt (1993) made the distinction between production capacity and technological capability. The first refers to the ability of the firm to undertake standard productive and investment activities (i.e. build production facilities and procure standard machinery), while the second denotes the ability of the firm to generate and manage technical change (i.e. search for, compare and select a new technology, install it, adapt it, modify it, etc.).

Technological capabilities may be acquired both through internal activities and from external sources. The mechanisms of acquisition of technological capabilities have been classified by Romijn (1999) in her extensive review of earlier literature about technological learning in LDCs:

- Technological capabilities may be acquired through various internal technological activities. These may include the observation of routine production activities; the acquisition of knowledge from undertaking repair and maintenance; more systematic reverse engineering; or more formally organised technology development or applied research.
- Knowledge may be acquired from external resources, either relatively passively as a by-product of various kinds of interaction with the outside world, or from a range of more deliberate and active search efforts.
- Capabilities may be augmented through various kinds of human capital formation at the firm level, either via formal and informal training activities, or simply by hiring people who already have the knowledge being sought.

To conclude, the review of the technological learning and capability literature in developing countries has shown us that these studies focus on the examination of the sources of technological learning. They do not, however, address the issue of whether geographic proximity to these sources plays a role in the learning process. The latter is ultimately linked to regional agglomeration theory in the sense that firms may acquire their knowledge from within the cluster but also from outside of it. In the next section I examine how this problem has been tackled in the literature of regional agglomeration in developing countries.

2.3.2 Theoretical Insights on Regional Agglomeration in Developing Countries From the International Context…

The broader debate regarding technological change and innovation in developing countries has placed emphasis on accessing and absorbing international knowledge (Evenson and Westphal, 1995). The literature on technology transfer (Enos, 1989) and the new trade theory literature (Coe at al, 1997) underline the fact that the main sources of technological progress originate in the external domain.

Firms may overcome many of the barriers found in developing countries through the creation of informal and formal collaborative relations with sophisticated customers, suppliers, competitors, universities, and research institutes in advanced economies. Many of the impediments to the economic growth and the occurrence of innovation for firms in developing economies derive from four main factors in the local/national environment: first, the lack of well-functioning financial markets and the subsequent difficulty in acquiring funds; second, the thin institutional context which does not favour the development of a national system of innovation and thus the advancement of scientific knowledge and technological applications; third, the inadequate incentives for innovation and entrepreneurship given by the State to firms and, at the same time, the absence of sophisticated customers/users who demand innovative products; finally, and most importantly, the lack of public and private investments in formal R&D and informal searching, which result in the persistence of low levels of capabilities in a number of developing countries (Lall, 1996).

Technology transfer refers to the formal agreement (through contracts) between two parties for the exchange of technological (usually embodied) knowledge (Lall, 2001). The most common modes for the transfer of technology from advanced to developing countries include: foreign direct investments by multinationals, joint ventures, franchising, capital goods sales, licensing agreements, management contracts, marketing and technical service contracts, turnkey contracts, subcontracting, and finally original equipment manufacturing arrangements (Enos, 1989).

Finally, *new trade theories* underline the importance of trade and suggest that it is a mode through which technological knowledge may be diffused to developing countries. In particular, Coe et al. (1997) argue that R&D carried out in advanced economies may spill over into developing countries, if the latter establish a trade relationship with the former (see Jacob, 2006). Based on these findings, old arguments regarding trade liberalisation policies become relevant again. In particular, the view of Balassa (1985) and Al-Yousif (1997) on this matter claimed that countries which are open to trade and well connected to the global economy managed to catch up, whereas those imposing countless trade restrictions were left behind.

However, other writers have pointed out that openness on its own is not a sufficient condition for the economic development of less developed countries. A prerequisite for the successful adoption and adaptation of foreign knowledge and technology, as it is put forward in the technological capabilities literature, is the enhancement of local skills and capabilities of firms in developing countries through purposeful investments in informal learning and formal R&D (Bell, 1984; Lall, 1992; Romijn, 1999).

One explanation for the limited number of studies focusing on local knowledge and its circulation could be due to an unintentional tendency to think that not much is to be found at the local level beyond cost advantages. However, this view is not shared by all. In a nascent theoretical framework, Srinivas and Sutz (2005) try to understand why many skills and knowledge that are generated in developing countries during the process of 'problem-solving

in scarcity conditions' remain unrecognised. One of the main problems regarding the reasons for local knowledge and innovations not often 'scaling-up' and instead remaining 'encapsulated' innovations [isolated from the international technological and market context] is due to the difficulties posed by the local context itself, such as the cognitive, structural and institutional backwardness (Srinivas and Sutz, 2005, p.17).

…to Regional Agglomeration

Theoretical contributions to regional agglomeration in developing countries are built upon the traditional Marshallian theory as it has been re-shaped within the Industrial Districts paradigm (see table 2.1). The novel work of Schmitz (1995) enriched cluster theory by introducing the notion of 'collective efficiency', which refers to the advantages derived from clustering[12]. This approach presumes that firms in a cluster should collaborate. In this way they would gain advantages of 'active collective efficiency'. The main characteristic of this approach is that trust is assumed to facilitate the cooperation of small and medium-sized enterprises. The creation of common institutions and trade practices on the basis of common cultural norms brings additional advantages for clustered firms. This could provide us with an answer to the question raised in the discussion of geographical economists. Similar/horizontally connected firms gain from co-location even if this is not directly translated in exchange of goods and services. A common culture of trust and norms of communication provide the ground for collective action.

Humphrey and Schmitz (1998) analysed the role of trust in inter-firm relations within clusters in developing countries and suggested that extended trust facilitates cooperation of firms within clusters, which in turn increases their competitiveness in global markets. They argue that trust is initially based on socio-cultural ties, but the influence of such ties decreases over time. Ultimately, trust lies in "demonstrated economic and technical performance" and new ties are based on "conscious investments in inter-firm relationships" (Humphrey and Schmitz, 1998, p.54).

However, cluster researchers in developing countries have recently become uneasy in considering the development of clusters or regions in LDCs in isolation from their international environment. Hence, they attempted to link the cluster research to the theory of global value chain[13] (i.e. Gereffi, 1999). The global value chain argument is based upon the view that the insertion of local firms into global business networks can be a channel of technological upgrading[14] (Gereffi and Kaplinsky, 2001). Nevertheless, upgrading is contingent upon the governance of the relations and in particular the specific type of value chain they are inserted into. Humphrey and Schmitz (2002) identified four types of governance that characterise relations between clusters in the developing countries and external actors:

- Arm's length market relations[15]
- Hierarchy[16]
- Networks[17]
- Quasi hierarchy[18]

The first two types of governance entail only market relations, while the last two involve non-market co-ordination of activities as well. These activities attempt to organise, first the product (i.e. design), second the process (i.e. choice of technology, quality systems), and third the logistic specifications of the production process. This happens for a number of reasons, such as the creation of integral products consisting of customised components; knowledge of the market needs held by the external buyer; high risk related with tight delivery times and

quality standards. What is more interesting is that the informal interactions between international and local firms are claimed to assist the latter in upgrading. However, the level of technological capabilities of local actors determines the type of relations they create. Networks consist of partners with complementary capabilities, while *quasi*-hierarchical relations involve external agents with higher capabilities than those of their local counterparts. This last case is usually most commonly found in LDCs (i.e. in food processing or garment manufacturing). These relations are precisely those that are governed by the buyer who, while reinforcing product and process upgrading, can limit the functional upgrading and market diversification of local firms[19].

The aforementioned studies are focused upon the production structure of the cluster and are not linked to the literature about technological learning in the firm discussed earlier. Bell and Albu (1999) explored the relationship between clustering and technological dynamism of firms within clusters focusing on knowledge systems instead of production systems.[20] Moreover, they distinguish intra-firm, intra-cluster and outside-the-cluster sources of knowledge that increase the technological capabilities of the firms. Then they investigated how key organisational characteristics of knowledge systems in clusters affect the sources of knowledge. An important insight that can be used in further research is that the effectiveness of a knowledge system in developing countries depends on the complexity of the technology of the particular industry and also the cluster's distance from the international technological frontier.[21] For instance, a cluster of firms that supplies components and services to the software industry requires a knowledge system that is much more organisationally structured and active than a cluster of a traditional industry. However, Bell and Albu (1999) did not spell out how regional agglomeration advantages affect intra-firm learning. Rather, they concentrate their analysis on the requirements that the industrial organisation raises for firms' networking.

Similarly, there is a growing emphasis on the importance of Regional Systems of Innovation (RSI) for the economic development of LDCs (see table 2.1). The main building blocs of RSI are the close cooperation between university, industry and the regional government (or the State at the level of National Systems of Innovation) (Cassiolato and Lastres, 1999). However, in general, these institutions do not function very well in LDCs. Arocena and Sutz (2001) examine the potential of the university to produce knowledge that will eventually deepen the capabilities of Latin American countries and reinforce economic development. They stress the weakness of all actors that are involved in the RSI (university, industry, government) in the context of Latin American countries. To begin with, despite the efforts of the universities in Latin America to re-define their role[22], low funding raises problems in establishing the new institutional framework for the management of the relation between university and industry. The main problem arises from the fact that, in the past, University-industry cooperation was absent. Currently, despite the willingness of universities to increase interaction with the industry, the management of the relationship lacks flexibility and efficiency. Moreover, public as well as private sector spending in R&D in most Latin American countries is very low. Thus, the tradition of Latin American countries persists; being specialised in technologically low value-added products.

The review of the literature on technological learning and regional agglomeration in developing countries has shown that whilst at first these theories were disconnected, they are currently starting to link up with each other. However, these efforts have been limited and, as a consequence, LKS continue to remain invisible in these approaches.

2.3.3 Methodological and Empirical Approaches to Clusters and Technological Progress in Developing Countries

Empirical studies have been carried out by several academic institutions, universities and international organisations (World Bank, Inter-American Development Bank, UNIDO, UNCTAD) in many developing countries regarding the importance of industrial clusters for development. Table 2.4 depicts some major academic contributions.

One of the pioneers in this field of research, Schmitz (1995), tested his 'collective efficiency' approach in the shoe industry of the Sinos Valley, Rio Grande do Sul, Brazil. In line with his theoretical contribution, Schmitz claimed that the presence of external economies is not a sufficient condition for increasing the competitiveness of local firms and that it is only through 'active collective efficiency' sustained competitive advantage can be achieved.[23] For example, he argued that the upgrading of footwear manufacturers in the Sinos Valley (i.e. improvement in quality and delivery standards) was realised only when local firms cooperated deliberately to this end. However, the analysis remains descriptive and the operationalisation of the concept of 'collective efficiency' is weak.

Firstly, Schmitz (1995) does not distinguish static from dynamic advantages. His empirical findings seem to suggest that it is static advantages that counted for the expansion of exports of local manufacturers during the 1970s and 1980s.[24] Secondly, he is neither systematic nor persuasive in showing how spontaneous external economies fail to increase the competitiveness of the clustered firms while 'joint action' would be the necessary condition for achieving competitiveness in a global economy. In other words, it is not clear whether the advantages that derived from specialised suppliers, trade agents and local institutions were the result of unintended externalities or purposeful collaboration. Finally, the advantages that originate from clustering are not linked to an increase in innovation by the local firms. Rather, the argument remains within the boundaries of the traditional approach based solely on economic gains[25].

Also Rabellotti (1995) has examined two footwear clusters in Mexico, in the districts of Guadalajara and Leon. A sample of fifty-one firms was investigated by means of a structured questionnaire. Besides the static advantages that most of the research in the developing countries is focused upon, Rabellotti examines the dynamic advantages that derive from the presence of what she calls an "industrial atmosphere" effect. She analyses two mechanisms through which dynamic advantages arise: collaboration with suppliers and labour mobility. She notes that cooperation with suppliers is weak because of the lack of local machine suppliers. However, she overlooks the reverse case in which "the innovation constraints might lie with the footwear manufacturers' limited capability to manage technical change, and the lack of a domestic capital goods industry supplying the sector might be a symptom of this, rather than a cause" (Albu, 1997, p. 35). Moreover, even though she notes that labour mobility is present and facilitates collective learning, she does not discuss the profile of the labour force that circulates. Are these high or low skilled workers? Finally, she does not provide empirical evidence for the idea that labour circulation might increase the innovative capability of the cluster (as a whole) or at least of the firms within it.

Khalid Nadvi (1996) examined a cluster specialised in surgical instruments in the city of Sialkot in Pakistan. By means of a survey of fifty-seven firms and a close examination of six firms, Nadvi supported the findings of Schmitz (1995), namely that it is active collective efficiency that reinforces the competitiveness of a cluster. Furthermore, Nadvi (1996) argued that the common social identity of the local community increases the rate of informal

interactions and joint action. The work of Nadvi (1996) has been criticised by Albu (1997), who noticed that foreign buyers and external consultants are the two most important sources of technological knowledge for the cluster. Thus, according to him, the importance of external linkages contradicts the claims of Nadvi about local active collective efficiency. External linkages are crucial for clusters in LDCs because the frontier of technological knowledge is located in advanced economies. Therefore, the competitive advantage of a cluster in a LDC could derive from the diffusion of knowledge, which is acquired from sources external to the cluster, and this can be facilitated through local joint action.

Table 2.4: Leading Empirical Studies[26] on Regional Clusters in LDCs

Sources	Clusters	Methodology	Results	Limitations
Schmitz (1995)	Footwear cluster in Sinos Valley, Brazil.	Survey of 50 firms and in-depth interviews with representatives of local institutions. Qualitative study.	Passive cluster advantages are not enough for firms to compete in international markets.	The operationalisation of the concept of 'collective efficiency' is weak. No focus on innovation processes and capabilities.
Rabellotti (1995)	Footwear districts in Guadalajara and Leon, Mexico	Survey of 51 firms and selective interviews. Qualitative analysis.	Strong informal inter-firm collaboration but weak backward and forward linkages and institutions.	Weak empirical support for the association between dynamic advantages and collective learning.
Nadvi (1996)	Surgical instrument in Sialkot, Pakistan	Survey of 57 firms and case-study of 6 firms. Qualitative analysis.	Social capital reinforces joint action	Poor evidence of the relation between local collective efficiency and technological capabilities.
Visser (1999)	Clothing industry in Lima, Peru	Comparison of clustered firms with 3 control groups of dispersed firms. Quantitative analysis.	Superior performance of the cluster firms based on cost advantages and information spillovers (passive collective efficiency); no sustainable over the long run.	Not clear distinction between pecuniary agglomeration advantages and real knowledge spillovers.
Cassiolato and Lastres, (1999)	Agro industrial clusters: Tobacco in Rio Grade do Sul; Cocoa in Bahia; Wine in Uruguay. High-tech SME clusters: Biotechnology in Minas Gerais; Software in Rio de Janeiro; Telecom & IT in Campinas. Other Clusters: Ceramics in Santa Catarina; Steel in Espírito Santo.	Survey. Qualitative analysis.	Fragmented networks and weak institutions constrain innovation, and deteriorate the performance of the cluster.	External economies are not examined.

Another important study is that of Visser (1999), who compared the performance of small clustered firms in Lima with a control group of dispersed firms in the garment industry. He identified two types of advantages that derive from the cluster, passive advantages and active

ones that are the result of the deliberate efforts of the entrepreneur to cooperate with other actors within the cluster. His results show that the performance of clustered firms, especially small ones, was superior to the three control groups. However, his empirical findings show that this higher performance was based on passive advantages (cost advantages and information spillovers), not actively induced. His analysis is in line with the study of Schmitz. The main weakness of his study possibly relates to the ambiguous distinction between agglomeration advantages. In particular, it is assumed that spontaneous cluster advantages (*passive collective efficiency*), that is according to Visser (1999), cost reductions and information spillovers, are not conducive to innovation. It is purposeful collaboration (*active collective efficiency*) that has learning and innovation effects. In other words, not clear distinction is drawn between pecuniary agglomeration advantages and real knowledge spillovers (see Table 2.2).

Finally, Cassiolato et al. (1999) have analysed a number of different sectoral clusters in MERCOSUR (agro industrial, high-tech, traditional manufacturing). They adopt the Regional Systems of Innovation approach in order to consider the interaction of firms not only amongst themselves, but also between them and the local knowledge institutions. In addition, Cassiolato at al. (2003) take into account the impact of public policy. They draw attention to the external macroeconomic conditions that could affect the technological performance of a cluster. For example, they find that economic liberalisation had a diverse impact upon sectoral clusters in MERCOSUR. In the aftermath of liberalisation, clusters that consisted of local firms (such as the cluster of ceramics firms in Santa Catarina, Brazil and the cluster of wine processing firms in Uruguay) continued to base their dynamism on cooperation and innovation. In contrast, in clusters formed by both local firms and MNCs, the MNCs decreased the level of the local content after liberalisation. Accordingly, cooperation was limited. The result of low collaboration with MNCs was that local firms were more focused on surviving rather than making long-term investments in innovation as they used to do. Implicitly, Cassiolato et al. (1999) address the same issue as raised in the 'global value chain' approach; namely the issue of governance. In sum, at the level of LDCs, it is important to comprehend local dynamism in the sense of inter-actor networking and innovation, and place clusters in the context of the global economy.

Finally, the work of Pietrobelli and Rabellotti (2004) is remarkable because they attempt to fill the gap found at the interface of the global and the local, by merging the cluster approach to the global value chain theory. In particular, they make a conceptual distinction between cost advantages and knowledge spillovers. However, in their empirical study in several sectors in Latin America, the difference between cost advantages and knowledge gains in not explored in-depth.

Overall it can be concluded that most of the empirical research in developing countries is based on surveys. However, the information is processed in a qualitative way, while quantitative analysis is rarely pursued. The main theoretical novelty was the notion of 'collective efficiency', which was applied in diverse ways, since there is no agreement on a common methodology. In addition, agglomeration advantages are examined as homogeneous phenomenon. No distinction is made between the different types of agglomeration advantages and little attention is paid to knowledge spillovers. Finally, the main weakness of the aforementioned studies relates to their failure to systematically connect empirically the different advantages that derive from the cluster to the technological performance of the firms within it. The two debates – relating to the regional or meso-level and the firm or micro level approaches - need to be linked in order to dicover the answers to the question *what are the*

mechanisms through which regional agglomeration and in particular LKS affects the technological performance of the firm?

2.4 CONCLUSIONS

The review of the most important theories of regional agglomeration offers new insights on crucial issues related to local knowledge spillovers. In particular, the approaches of Economic Geography, Regional Systems of Innovation, and Learning Region on advanced economies underline the fact that local knowledge spillovers are the main drivers for the agglomeration of firms in clusters and/or regions. Local knowledge spillovers are the vehicle for the diffusion of tacit knowledge, which in turn is vital for the creation of new knowledge and innovation.

In contrast, the literature on industrial development in LDCs is replete with theories encouraging firms to absorb international knowledge and pays scant attention to local knowledge and its place in the global economy. Although some consequences for knowledge sharing appear to be implied in cluster studies (Schmitz, 1999; Rabellotti, 1995; Nadvi, 1996), they do not make a clear distinction between cost and knowledge advantages.

Thus, an important gap in the literature remains due to the fact that research on local knowledge spillovers has been limited to high-tech clusters in the advanced economies. Although clustering is a phenomenon that has been identified and researched in developing countries, mostly in traditional sectors, little is known about the nature and the function of knowledge spillovers in clusters in LDCs.

The literature in advanced economies focuses on the relation of LKS and innovation while less attention is drawn, with some exceptions (see Saxenian, 1994), to how LKS take place. For instance, it is not clear yet, whether LKS consist only of spontaneous knowledge spillovers or if they include intentional knowledge spillovers as well. This thesis aims to disentangle this issue and to examine how knowledge spillovers occur at the local context.

So far, empirical studies in advanced economies have used indirect proxies of LKS, such as patent citations or R&D, in order to justify their importance for the localised nature of knowledge and innovation. However, such indirect data has apparent shortcomings. For instance, patents do not cover all the outcomes of innovative activity. While this is true even for advanced economies, it would certainly be a more severe problem for developing countries, where only a fraction of innovation is ever patented. Thus, using patents as proxies in this research would pose a great risk of misrepresenting innovative activity. The same applies for R&D proxies. Many firms in LDCs are not involved in formal R&D. Much of firms' innovation is informal, and does not feature in any statistical database (Bell, 1984). Consequently, studies focusing on official statistics based on R&D investments may underestimate what firms actually do. Besides, in developing countries adequate patent and R&D data of this type are hardly available. This explains the lack of similar exercises in the developing country literature.

Both approaches (as developed in advanced and LDCs) fail to fully conceptualise a link between clustering and learning within the firm. The main question addressed in this literature review concerns the nature of LKS and their impact upon firm's capabilities to learn and innovate. Clustering may generate static advantages (that affect the efficiency of the system) and dynamic advantages (that affect the capability of the system to adapt to change, innovate

and grow). While the former advantages are the result of cost benefits that derive from the presence of specialised suppliers and labour market, the latter are the result of knowledge accumulation and sharing among the members of the cluster. Many studies have been carried out on static advantages of clustering, while few in the case of developing countries have focused explicitly on the dynamic advantages. Thus, the main weakness of the literature regarding LDCs is the failure to disentangle these different types of agglomeration advantages and examine their distinct impact upon the innovative performance of the firms. On the other hand, research dealing with advanced economies has limited applicability within the context of LDCs, due to the shortcomings of the methodology and, more importantly, because of the lack of relevant data about the indicators utilised. Therefore, this study explicitly intends to identify the sources of the dynamic capabilities of firms within clusters in LDCs, and in particular, the extent to which LKS play a role in the learning processes that give rise to these capabilities.

CHAPTER 3

THE RESEARCH DESIGN

3.1 INTRODUCTION

The review of the literature regarding advanced economies suggests that LKS are important for firms' innovation. However, LKS have not been distinctively examined in the literature regarding developing countries. Thus, it is essential for the economic development of LDCs to investigate whether LKS stimulate technological upgrading and increase the economic competitiveness of firms in clusters within developing countries. If LKS play a prominent role in clusters in LDCs, this would suggest that there are similarities in innovation processes between advanced economies and developing countries. Policies such as R&D subsidies, investments in education, de-centralization and reinforcement of regional and cluster policies could be adopted and slightly adjusted to the different environment of LDCs.

On the contrary, if it is shown that LKS play a minor role in increasing the technological competitiveness of firms in clusters in developing countries, this might indicate that international knowledge flows could be more important than local channels of knowledge diffusion. It could also be the case that other advantages related to geographical distance rather than LKS drive technological progress in developing countries (i.e. cost advantages). This outcome would suggest that distinct policies, other than the ones implemented in developed countries, should be applied in LDCs. For instance, if international knowledge transfer plays the dominant role for the innovation of firms in developing countries, emphasis will need to shift towards policies that support international education and training of the local labour force, insertion of local firms into global value chains and building of international alliances.

In order to assess the importance of LKS for firms' innovativeness, it is first crucial to find out if LKS do exist in the context of LDCs. Thus, the mechanisms of knowledge flows need to be identified and analysed. The following section presents the conceptual framework upon which this study has been developed.

3.2 THE CONCEPTUAL FRAMEWORK

This thesis will attempt to shed light on local knowledge spillovers, understand how they take place and examine their importance for the innovative and economic performance of firms within clusters in LDCs. The review of the methods that have been used to examine this issue in advanced economies has shown that many studies have been criticised for using proxies that do not represent solely pure knowledge spillovers but also encompass the outcome of market transactions (Breschi and Lissoni, 2001, 2003). In order to overcome these problems

in disentangling knowledge spillovers from transaction-based knowledge flows, I intend to capture both by trying to measure them, and then differentiate between them.

For this purpose I introduce the concept of 'knowledge flows', which includes both market-based knowledge transactions resulting from formal cooperation between actors, as well as free and direct knowledge flows arising from purely informal contacts, i.e. knowledge spillovers proper (see also Kesidou and Romijn, 2006). Furthermore, in order to be able to single out the importance of LKS from among other knowledge-contributing factors for firms' innovative and economic performance, data was not only collected about local knowledge flows, but also about non-local ones. Consequently, knowledge flows are classified into the following four types (see also Table 3.1):

a. **Localised Knowledge Spillovers** (Griliches, 1979; Saxenian, 1994; Audretsch and Feldman, 1996B)

LKS are local positive technological externalities that derive from the inability of firm A to fully appropriate the economic returns of its innovation activity (Griliches, 1979). As a consequence, firm B can take advantage of the new product or knowledge directly and without compensating firm A. Moreover, LKS may also occur intentionally as a result of the informal sharing of knowledge amongst actors (von Hippel, 1987; Harhoff et al., 2003). They can be caused by: mobility of key scientists or engineers; information available from patents and scientific literature; leakage and sharing of information at conferences or trade fairs; imitation of products through reverse engineering; spin-offs; informal know-how trading; and finally industrial espionage (Saxenian, 1994; von Hippel, 1987).

b. **Local Knowledge Transactions** (Rosenberg, 1982; Dahlman et al., 1987).

Local knowledge transactions indicate knowledge that circulates in a cluster as a result of firms' formal interactions and indirect interdependence through the market transactions. This knowledge does not flow freely; only the firms that actually cooperate or are involved in a type of transaction may take advantage of the knowledge flow. Firms interact through the market.

c. **Non-local Knowledge Spillovers** (Haas, 1992; Hakanson, 2003; Amin and Cohendet, 1999, 2000, 2003; Cohendet, 2005):

Non-local knowledge spillovers point to a free flow of information over a longer distance. Firms imitate each other through reverse engineering, attending trade fairs, following scientific or technical journals and, of course, through patent disclosures. Finally, scientists or researchers that belong to the so called 'epistemic communities' may share knowledge over long distances since they already have a common understanding of the codes and principles of the particular field of study.

d. **Non-local Knowledge Transactions** (Gereffi, 1999; Gereffi and Kaplinsky, 2001).

Non-local knowledge transactions specify knowledge that flows between local clustered firms and national/international actors outside the cluster. The exchange or transfer of knowledge is the result of formal cooperation or transaction. The literature of LDCs has stressed the importance of the insertion of local firms in global value chains, which, in turn may facilitate their technological upgrading (Gereffi, 1999; Gereffi and Kaplinsky, 2001). In addition, the literature on technology transfer (Enos, 1989; Lall, 2001) highlights the possibility that formal agreements (i.e. foreign direct investments and licensing agreements by multinationals, and

joint ventures) between foreign actors and local firms in developing countries can be important conduits for the transfer of technological knowledge.

Table 3.1: Classification of Knowledge Flows

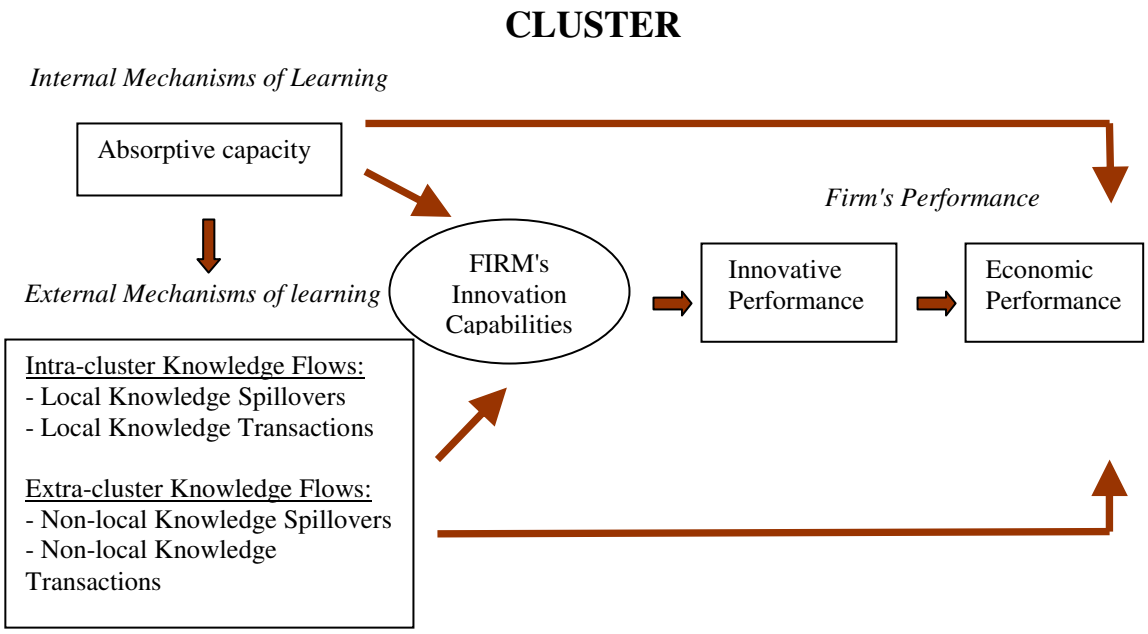
Knowledge Flows				
	Local Knowledge Spillovers	**Local Knowledge Transactions**	**Non-local Knowledge Spillovers**	**Non-local Knowledge Transactions**
	Griliches, 1979; Saxenian, 1994; Audretsch and Feldman, 1996B.	Dahlman et al., 1987; Rosenberg, 1982.	Haas, 1992; Hakanson, 2003; Amin and Cohendet, 1999, 2000, 2003; Cohendet, 2005.	Gereffi, 1999; Gereffi and Kaplinsky, 2001; Enos, 1989; Lall, 2001.
Type and Place of knowledge flow	Free and local flow of knowledge	Pecuniary and local transfer of knowledge	Free and non-local flow of knowledge	Pecuniary and non-local transfer of knowledge
Mechanisms of acquisition of external knowledge	-Informal interaction between university's employees and local firm's employees -Informal interaction among employees of local firms -Labour mobility -Spin-offs	-Contract agreements with local actors -Consultancy by local actors -R&D co-operation with local actors -License or selling of proprietary technological knowledge -Joint investments in training. -Exchange of knowledge with supplier as a by-product of formal cooperation	-Reverse engineering -Journals -Trade fairs -Patent disclosures -Conferences	-Contract agreements with international actors -Consultancy R&D co-operation -License or selling of proprietary technological knowledge -Joint investments in training -Exchange of knowledge with supplier as a by-product of formal co-operation

Source: Author.

Figure 3.1 presents the conceptual model upon which this study is based. In general, firms can increase their innovative performance [and eventually their economic performance] by investing in internal and/or external learning activities. Internal learning is contingent upon with the absorptive capacity[27] that the firm has developed. A number of studies suggest that purposeful investments in internal learning tend to increase the capabilities of the firm (see Chapter 2 on technological capability literature).

Firms may use a variety of mechanisms in order to learn from external sources. These sources can be located within the cluster or outside of it. When a firm acquires knowledge locally in an informal and direct way, it makes use of local knowledge spillovers. Furthermore, a firm may acquire knowledge locally, but through formal market mechanisms, stimulating local knowledge transactions. Knowledge may also be transferred from non-local sources in an informal way, which induces non-local knowledge spillovers. Finally, non-local knowledge transactions occur when clustered firms acquire knowledge in a formal way from national/international actors.

Figure 3.1: Conceptual Framework - Local Knowledge Spillovers and Innovation



Source: Author

The choice and utilisation of a particular external mechanism of flow might be influenced by the firms' internal mechanisms of learning. The latter is determined by the absorptive capacity of a firm, which in turn influences the quantity and quality of information that a firm can absorb (Cohen and Levinthal, 1990). Similarly, Lall (1992) refers to the so-called 'linkage capabilities', or skills required to "transmit information, skills and technology to, and receive them from, component or raw material suppliers, subcontractors, consultants, service firms, and technology institutions" (Lall, 1992, p. 168). For example, a firm that has a well-organised system of performance feedback may have a higher capability to absorb external knowledge than a firm that does not keep a record of the problems that it has confronted, and the ways in which those problems were surmounted. Consequently, firms with a higher absorptive capacity may be able to grasp more knowledge that flows freely or not in the cluster than firms with lower absorptive capacity.

3.2.1 Research Questions

A prerequisite towards operationalising this model is the comprehension of firms' mechanisms of learning in LDCs. In other words, it is important not only to understand how

firms process knowledge internally (intra-firm learning) but also to understand how they acquire knowledge from external sources (extra-firm learning). Local knowledge spillovers occur when a firm attempts to learn from other local actors in an informal and direct way. However, as I have already mentioned in the previous section, LKS are not the only mechanisms of knowledge flow identified in the literature. Understanding the role of the different mechanisms of knowledge flow within a cluster is crucial for two main reasons: firstly, the empirical identification and analysis of the different types of knowledge flow within a cluster will help us to identify the presence and understand the functioning of local knowledge spillovers. Secondly, thanks to this analysis, we will be in a favourable position to assess the relative impact of LKS upon the innovative and economic performance of the clustered firms in comparison to other types of knowledge flow. Therefore, the most important research questions I will address throughout this study are:

RQ 1: What is the quantitative distribution of the different mechanisms of knowledge flow used by the firms within the chosen cluster in Uruguay? In particular, do LKS play a significant role among these mechanisms?

The literature on technological learning in the firm suggests that the choice of a particular mechanism of flow might be influenced by the firms' internal mechanisms of learning. Assuming that the intra-firm learning mechanisms represent the firm's absorptive capacity, it is important to see whether firms with heterogeneous absorptive capacities utilise their external environment in differing ways.
This lead us to a second research question:

RQ 2: How strong is the correlation between the internal (to the firm) mechanisms of learning and the use of a particular type of external knowledge flow? Do firms with different absorptive capacities use different types of external knowledge flows?

The next set of questions deals with the impact of LKS on firms' performance. Are knowledge advantages in clusters, in particular LKS, important as sources of innovative and economic dynamism, in the context of developing countries, specifically in the case of the software cluster in Uruguay? In other words:

RQ 3: How important are LKS versus other mechanisms of knowledge flow for firms' (a) innovative and (b) economic performance?

RQ 4: How important are intra-cluster versus extra-cluster mechanisms of knowledge flow for the (a) innovative and (b) economic performance of firms?

RQ 5: Is the role played by LKS in developing country clusters, and in particular in the Uruguayan software cluster, in any way different from the function of LKS in high tech clusters in economically advanced countries?

Another set of questions focuses on the sources of knowledge that give rise to LKS, and their relation with the mechanisms through which LKS may occur.

RQ 6: What are the most important sources of knowledge for software firms within the Uruguayan high-tech cluster?

RQ 7: What are the mechanisms by which knowledge spills over among the Uruguayan software firms, their suppliers and customers, and public and private institutions? Does it happen through (a) inter-firm interactions, (b) labour mobility, and/or (c) spin-offs?

RQ 8: Is there a relation between the mechanisms of LKS and the sources from which the knowledge comes?

Finally, I will examine whether the performance of a firm is related to its position in the local knowledge network within the cluster. I will test whether the level of integration [or embeddedness] of the firm in its social network has an impact on its innovative and economic performance.

RQ 9: How cohesive is the local knowledge network within the Uruguayan software cluster?

RQ 10: Do firms with central positions in the local knowledge network exhibit a higher innovative and economic performance than firms that are located in peripheral positions?

RQ 11: Do firms with relatively high absorptive capacity occupy the key positions in the local knowledge network?

3.3 METHODOLOGY

A common approach to the study of knowledge spillovers requires the use of secondary data at a high level of aggregation and the analysis of this data with the use of statistical methods. Innovative output (patents or new products) and innovative effort (R&D) are used as proxies of innovative activity and their spatial distribution is analysed. If we want to find out whether local knowledge spillovers are important drivers of technological advance and competitiveness in a less developed country setting, we should explore new methodological avenues. An alternative approach should be used for the following reasons:

Firstly, aggregate data related to innovation is scarce in most developing countries. Secondly, many problems derive from the method of aggregation itself. To begin with, patents, which usually are considered as a proxy for innovation, do not cover all the outcomes of innovative activity. Moreover, patents are mainly the outcome of formal research activity. In addition, by considering R&D activity as a proxy of the innovative effort of the firm, we disregard a large fraction of activities and efforts, which contribute to technological accumulation. On many occasions, these efforts do not entail formal R&D, which is an activity mainly undertaken by large firms usually in developed countries. Technological upgrading in firms in LDCs and in particular in small and medium enterprises is rather demonstrated by efforts to adapt, improve and develop technologies as well as by problem solving activities (Bell, 1984).

Even if we could apply similar methodologies to those used in advanced economies, the inherent problems of these approaches would give rise to strong criticisms. In particular, Breschi and Lissoni (2001) have argued that the local concentration of patent citations constitutes only indirect evidence of the presence of local knowledge spillovers. The fact that patents and patents' citations are locally distributed does suggest that knowledge flows more frequently among local firms than among firms situated at long distances from each other. However, there is no indication that knowledge circulates freely and without compensation

among the firms within a region. Zucker et al. (1998) provided empirical evidence showing that the knowledge that is exchanged between local firms and universities results from market transactions rather than spillovers. In other words, collaboration among local actors may cause increased innovative activity in a region. However, in order to claim that this is the result of localised knowledge spillovers, one must first verify (rather than assume) that knowledge exchange is the outcome of informal interaction outside the market (not formal cooperation).

Qualitative methods have also frequently been used in the analysis of clusters and in the analysis of knowledge spillovers (Saxenian, 1994; Schmitz 1995; Nadvi, 1996). However, a qualitative case study will not serve the purpose of this research: the assessment and measurement of the importance of LKS. This is not to say that qualitative research is not useful. On the contrary, qualitative research will complement my quantitative analysis by providing more in-depth information and consequently conveying a complete picture of the problem. It is argued that the trustworthiness of the information acquired by research would be greater if the two methodologies are combined (Marsland et al. 1998).

Finally, innovation surveys have been undertaken in many developed and developing countries. The Statistical Office of the European Communities (Eurostat) has conducted the Community Innovation Survey (CIS) in order to collect firm-level data on the innovation process and its effect upon the economy[28]. The first CIS took place in 1992 and then followed the CIS2 in 1996 and CIS3 in 2001. CIS is methodologically based upon the "Oslo Manual" (OECD/EC/Eurostat, 1996), which is a joint publication of Eurostat and the OECD. Several innovation surveys have been conducted in LDCs as well using the CIS methodology (Rooks et al., 2005). Particularly noteworthy is the attempt carried out by the Network on Science and Technology Indicators (RICYT) to develop adequate instruments for the measurement of science and technology (input) and innovation (output) among Ibero-American countries. However, the main problem with these surveys is that the sample coverage is thin, and they do not include questions about physical proximity of firms' knowledge sources (Kesidou and Romijn, 2006).

It is thus necessary to develop a new methodological approach in which the importance of LKS (in relation to other mechanisms of knowledge flow) will be measured and statistically analysed on the basis of new firm level data collected through fieldwork. A quantitative study among firms will explore the phenomenon of knowledge spillovers in a cluster in a developing country by overcoming two important problems that derive from existing studies: first, the lack of relevant data in LDCs and second, the risk of misrepresenting innovative activity by considering indicators related to patents or R&D in a developing country setting. For that aim, I rely on collecting appropriate firm-level data by using a survey based on a structured questionnaire, specifically designed to capture LKS and other types of knowledge flow in a developing country setting. The survey will be enriched by qualitative information from face-to-face interviews.

3.4 CRITERIA FOR SELECTING THE CASE STUDY

3.4.1 Knowledge Intensive Sector

Audretsch and Feldman (1996B) have claimed that knowledge spillovers are important, especially for knowledge intensive sectors, since they involve a great degree of tacit knowledge. Therefore, to be able to empirically assess the significance of LKS and to explore in detail their functions, a knowledge intensive sector needs to be selected for this study.

Knowledge-based or high-tech sectors are characterised by a high proportion of investments in disembodied knowledge and skills (UNCTAD, 1996). In fact, these are the investments that constitute potential sources of locally driven knowledge spillovers. In particular, a knowledge-based sector should possess at least one of the following attributes:

(a) A high proportion of the expenditure in this sector should be devoted to R&D (Frascati Manual, 2002).
(b) A high number of patents, new products, or copyrights (Oslo Manual, 1996; Patent Manual, 1994)
(c) High levels of human capital measured by education levels and/or years of experience (Canberra Manual, 1995)

Sectoral Classifications

Industrial sectors are classified by taking into account one or all of the aforementioned indicators. For example, Pavitt (1984) classifies industrial sectors by taking into account the innovation patterns of the firms and their industrial organisation[29].

1. Supplier-dominated firms: agriculture, housing, traditional manufacture.
2. Scale intensive firms: bulk materials (steel, glass), assembly (consumer durables & autos).
3. Science-based firms: electronics, electrical, chemicals.
4. Specialised suppliers: machinery, instruments, software.

However, this classification derives from UK data on firms' patenting behaviour and thus may not adequately reflect conditions in developing countries (Bell and Pavitt, 1993).

Despite the fact that the service sector accounts for a large percentage of total value added[30] in developed and less developed countries, not all that attention has been given to its innovative performance. The following are important service sectors: transport, wholesale, telecommunications, financial, computer, and technical services. The more innovative sectors among these are telecommunications, computer and technical services as well as electricity, gas and water distribution utilities (CIS-2, 2001). Soete and Miozzo (1989) classify service sectors according to their processes of technological innovation. They distinguish three categories:

1. Supplier dominated sectors: Public services such as education, health care and personal services such as food and drink, repair businesses as well as retail trade. These are sectors that mainly adopt technologies developed by manufacturers.
2. Production-intensive, scale intensive and network services: Network services such as banks, insurance and telecommunications services rely upon IT networks. Scale-intensive services such as transport and travel services, wholesale trade and distribution rely upon physical networks. In sum, these are more complicated services than those of the first category. Their main source of technology is IT and technologies developed in manufacturing.
3. Specialised technology suppliers and science-based sectors: These include services such as software, specialised business services, laboratory and design services. The internal innovative activities of the firm are considered as the main source of technology.

In a recent taxonomy, Lall (2000) categorises economic activities, according to their technological intensity. This is measured by R&D inputs into production and author's judgment[31]:

1. Resource-based: food, leather processing, petroleum refining.
2. Low technology: textiles, garments, footwear.
3. Medium technology: automotive products, chemicals, basic metals, engineering products.
4. Engineering and high technology sectors: electronics, electrical products, generating equipments, aircraft, pharmaceuticals.

However, Lall's classification does not specifically reflect the industrial structure of developing countries. The study of Pietrobelli and Rabellotti (2004), which focuses on Latin America, addresses this issue in detail. They classify industrial sectors by taking into account the specificities of Latin America and by also considering a dynamic service sector, namely software. In particular, they emphasise the low in-house R&D activities of the firms, the specialisation of the LA countries in resource-based industry and the backward position of the region regarding high-tech/science based industries. They propose the following categorisation:

1. Traditional Manufacturing: textiles, footwear, tiles and furniture.
2. Natural Resource-based Industries: copper, marble, fruit, and wine.
3. Complex Products' Industries: automobiles, aeronautics, ICT, electronics.
4. Specialised Suppliers: software.

Traditional Manufacturing refers to industries that are mainly labour intensive. The principal sources of technical change for these firms are suppliers of capital equipment (Pavitt, 1984; Pietrobelli and Rabellotti, 2004). Therefore, investments in capital goods are crucial for the upgrading of the firms. Technological learning takes place during the production process, wherein new inputs are used to modify and improve the production processes (in terms of lower cost of production or higher output performance). At the same time, firms in this category may undertake improvements in the design of products. However, the degree of their involvement in product design varies from case to case. Most commonly, large buyers provide a full or partial design; only production is left to firms (Humphrey and Schmitz, 2002). Firms in this category cannot be characterised as knowledge intensive. Certainly, firms need to invest in human capital too; they need *know-how* in order to operate the machines and *know-why* in order to repair them. However, the major part of the investments of the firms and their main source of technology derives from the acquisition of capital goods. Thus, this category is not particularly relevant for the purpose of this study.

Resource-based Industries consist of sectors that are largely labour and capital intensive. To a lesser extent, this encompasses industries that employ skill-intensive technologies. The main sources of technical change are input suppliers and public research institutes (Pavitt, 1984). Similar to traditional manufacturing, innovation comes from investments in capital goods. Consequently, the suppliers, the main sources of technical change, are the ones who drive innovation. At the same time, basic and applied research plays a crucial role for the upgrading of some sectors. In this respect, there is potential knowledge that can spill over from public research centres towards firms. Suppliers (chemical, machinery) are often the mediators between research institutes and user firms. Their role lies in the commercialisation of the innovations of the research institutes, through patenting, and the provision of new products to the user firms (Pietrobelli and Rabellotti, 2004). This mediation, consequently, diminishes the role of knowledge spillovers.

Complex Products Industries include two main types of sectors: industries that are scale intensive and use standardised technology, and industries that are R&D intensive and use rapidly changing technologies. A representative example of large standardised production is the automobile industry. Assembly firms in this industry undertake large in-house investments in R&D that are aimed at incremental changes in the production process (i.e. design, building and operation of large scale processes) (Pietrobelli and Rabellotti, 2004). Standardisation implies that, to a large extent, knowledge in this industry is codified and embodied in complex capital goods. The importance of external knowledge flows is very limited in this sector, with the exception of knowledge flows occurring through formal cooperation[32].

R&D intensive industries, such as electronics and biotechnology, have been considered the most important actors fostering LKS. In rapidly changing industries such as these, external knowledge flows appear to play a crucial role in the survival and growth of firms. Interactions have been observed between research institutes/universities and bio-tech firms, as have spin-off activities deriving from large bio-firms (Pietrobelli and Rabellotti, 2004). Thus, knowledge spillovers could play an important role in these industries. However, the presence and dynamism of these industries in LDCs is limited, with some exceptions (i.e. the biotech cluster in Campinas, Brazil). Studying a phenomenon like local knowledge spillovers in a context which is rather in the periphery of developing countries' economy would not be relevant for the whole economy, and more importantly, for other developing countries as well.

Specialised Suppliers are industries that are derived from the vertical disintegration of large complex industries. Sectors such as electronics and ICT are grouped under this term (Rosenberg, 1976). They encompass small-scale equipment, instruments and software suppliers. They deliver sophisticated inputs into large and complex systems of production. In particular, Latin American and many Asian countries are experiencing a surge in the software industry. An important source of learning for software firms are sophisticated users (Pavitt, 1984; Malerba, 2005). User-producer relations are of particular importance since specialised suppliers develop products (instruments, equipments, software programs) for specific production processes. In addition, cooperation among software firms has been observed in several developing countries (i.e. in Mexico and Brazil) (Pietrobelli and Rabellotti, 2004). Software is a rapidly changing technology and external sources of knowledge play an important role in enhancing the innovative capabilities of the software firms. At the same time, the absorptive capacity of firms (human capital capable of developing products and solutions for users) and the intra-firm learning efforts (in-house R&D) are crucial factors for innovation. A survey of several Latin American clusters has shown that the software clusters exhibit a high degree of externalities. In particular, Pietrobelli et al. (2004) have claimed that these externalities greatly influence entrepreneurs' strategies of product, process and functional upgrading.

In sum, the main condition for the investigation of LKS in clusters in LDCs is the selection of a knowledge intensive sector. The analysis of the industrial sectors in accordance with a classification adapted to industrial structure in Latin America has shown that knowledge intensive sectors are mainly of two types, science-based industries that produce complex products and specialised suppliers that provide inputs to these industries. The same appears to be the case in other LDCs. Although, theoretically, science-based industries constitute a potential candidate for an investigation of LKS, their presence in LDCs is rather limited. On the other hand, the category of specialised-suppliers and in particular the software sector is well developed in many Latin American and Asian developing countries. Therefore, I conclude that the software industry is a suitable sector for analysing the mechanisms of LKS

and their relation to firms' innovative and economic performance. The study of Pietrobelli and Rabellotti (2004) provided the majority of the information for the selection of the appropriate cluster. Therefore, I will focus on the Latin American region for the selection of the case study.

3.4.2 Export Intensive Cluster

In order to assess the importance of local knowledge flows versus non-local ones, the prospective cluster should also have an outward orientation. A cluster, which exports a large part of its production, would be particularly suitable for studying this aspect. The software clusters that have been studied so far in Latin America are local-market oriented. For example, the software clusters of Blumenau (Brazil), Mexico D.F., Guadalajara, Aguascalientes and Monterrey (Mexico) address the needs of the local market. Hence, it is not surprising why Pietrobelli et al. (2004) identified some agglomeration effects in these clusters. The concentration of productive activities which feeds local demand may generate agglomeration advantages. Firms have more incentives to integrate into the local environment when their demand is solely local. On the contrary, firms that export face the opportunity to collaborate with external customers and even to find alternative suppliers. These firms have the opportunity to use international channels, besides the local ones, in order to acquire external knowledge. If firms located in an export intensive cluster still take advantage of local knowledge spillovers, this would indicate that LKS add something unique to their innovation processes. Consequently, an export intensive cluster would serve the purpose of this research.

3.4.3 Economically and Technologically Dynamic Cluster

In terms of development strategy, the chosen sector should be large and economically dynamic. In other words, it should make a significant contribution to the country's growth, productivity and employment. Another consideration in choosing the sector will be its role, if any, in the national plans of industrial or technological development. The selected sector should be experiencing technological upgrading and innovation, demonstrated by the growth of high-value products or introduction of new improved products. If firms do not innovate no significant spillovers can occur either. Therefore, it is vital that this research is carried out in a cluster where technological upgrading is taking place.

3.4.4 The Selected Cluster

In sum, an appropriate sector case study for this research should comply with the following criteria:

- Knowledge intensiveness
- Export intensiveness
- Economic and technological dynamism

The software cluster of Montevideo in Uruguay fulfils the above criteria. In particular:

- Software is a knowledge intensive sector which has flourished in many Latin American regions. It is classified in the so-called Specialised Suppliers group.
- This software cluster is export intensive. Stolovich (2003) reports that the majority of the local software firms are export oriented (43 per cent of the total output was directed to foreign markets in 2004).
- The software cluster in Montevideo became innovative in order to compete in foreign markets with other international players (often with multinationals). A report conducted for the Inter-American Development Bank shows that this is a competitive

sector which has been placed on the agenda of local government and international organisations (Failache et al., 2004).

3.5 DATA COLLECTION

3.5.1 Description of the Sample

Primary data were collected by means of a field study in Uruguay. The research took place in the technologically dynamic cluster of software firms in Montevideo, which has been successfully integrated into the global market by providing innovative products. The software sector in Uruguay is part of the information technology industry, which consists of four large sections: (1) software development, (2) consultancy and services, (3) internet and data transmission and (4) hardware and sales. In total there are 2,216 companies registered with the Uruguayan Chamber of Information Technologies (CUTI). CUTI is an institution that assists firms in the development of business capabilities and reinforces common action for the promotion of the Uruguayan software products in foreign markets.

Since LKS are predominantly present in knowledge intensive sectors (Audretsch and Feldman, 1996B), my research initially concentrated on the sub-sector of software developers, which is the most knowledge intensive of the four sections. During the fieldwork, local researchers and software firms suggested that it would be very useful to also include the section of consultancy services. So these were included as well. In total this left me with about 149 firms (Stolovich, 2003)[33]. I obtained an accurate list of these firms from CUTI. However, after the first contacts with these firms it became clear that some were not carrying out any kind of software development. Therefore, some firms were left out of the population.

I enlarged the population with firms found in the local telephone guide. During the initial interview rounds firms also mentioned names of other unlisted firms in the sector that could be included in the research. This led to a second enlargement of the population, which brought the total population of firms that develop software and provide consultancy in the Montevideo area to approximately 150. The full population of 150 firms was approached and asked to take part in the survey. 98 firms were willing to participate in the survey (representing a 65 per cent response rate). All the large, medium and small firms participated in the survey. The non-responding firms were mainly micro firms (<10 employees). Nevertheless, they were quite well represented in the sample; from the total of 103 micro firms, I interviewed 50 (48.5 per cent). Therefore, I consider that my results will adequately reflect the spillovers of knowledge among firms within the Uruguayan software cluster.

Key characteristics of the firms that were interviewed are presented Table 3.2. Panel (a) shows that almost half of the firms specialise in developing software products, while 20 per cent specialise in providing consultancy services. Another 25 per cent of the firms offer both software products and consultancy services. The third column shows that the average number of employees is approximately 20 in every class of firms, except in consultancy services, where firms have on average more employees than the other groups. This happens because this segment of software sector cannot profit from economies of scale; the more services they provide the more employees they need. The fourth column, displays large variations in the average sales among the different software segments. Consultancy firms display the highest absolute sales among the four groups. However, if we take into account the fact that consultancy firms are larger than the rest of the software firms, the average productivity[34] of

the software development firms is higher (115US$) than that of the consultancy firms (68US$). Finally, firms that do not have a clear business model but are involved in both software development and consultancy present the lowest sales and productivity scores (24US$). The last column shows that the segment of consultancy and services firms has the highest average exports in comparison to the other segments of the software industry.

Panel (b) illustrates that the majority of the firms are privately owned Uruguayan national companies. A few are owned by foreign multinationals (3 per cent). Note that there is a relatively large number of firms (20 per cent) which have established at least one subsidiary in a foreign market. On average, foreign multinationals have many more employees than the firms in the other categories. In addition, foreign multinationals exhibit the highest average sales, productivity (96US$) and exports.

Panel (c) shows that the majority of the firms are quite young; more than 40 per cent of them were established in the 1990s. However, this group of firms is characterised by very low levels of sales, market shares and exports. Firms that emerged during the 1980s and, thus, managed to take advantage of the software boom of that decade, exhibit the highest market share (55%). Finally, Panel (d) indicates that most of the firms are very small (52 per cent) or small (36 per cent) enterprises. Only 12 firms have more than 50 employees. However, these 12 firms account for the 45 per cent of the sales and the 73 per cent of the exports in my sample of the Uruguayan software sector.

Table 3.2: Characteristics of the Sample

Characteristic	Firms	Number of Employees		Sales		Exports	
	n=97	Average	Percentages	Average sales in Thousands US dollars	Percentages	Average sales in thousands US dollars	Percentages
(a) Principal activity of the firm							
Software Development	47	19	38.3%	2186.0	58%	785.0	47%
Consultancy and Services	19	45	37%	3070.0	33%	1939.0	47.5%
Both (Soft. Dev. & Consult.)	26	18	20.2%	435.0	6.3%	74.0	2.5%
Other business activity	5	21	4.5%	967.0	2.7%	640.0	4%
(b) Type of firm							
Private national	73	15	47%	1155.0	60.5%	355.0	33%
Domestic multinational	20	44	38%	1852.0	21%	1059.0	27%
Foreign multinational	3	113	14.5%	10900.0	18.5%	10580.0	40%
Other	1	7	0.5%	N.A.	N.A.	0.0	0%
(c) Year firm started							
Before 1970	4	40	7%	3517.0	8%	975.0	5%
1971-1980	6	77	20%	2691.0	9%	2032.0	15%
1981-1990	28	24	28%	3475.0	55%	971.0	35%
1991-1999	41	15	27%	428.0	10%	95.0	5%
2000-2004	18	23	18%	1784.0	18%	1759.0	40%
(d) Size of the firm							
1-10 employees	50	6	11.5%	115.0	3.2%	15.0	1%
11-49 employees	35	25	37.5%	2629.0	52%	578.0	26%
50-250 employees	10	67	29%	4140.0	23.3%	2290.0	28%
> 251 employees	2	256	22%	19000.0	21.5%	17800.0	45%
Total	**97**	**2321**	**100%**	**177217.0**	**100%**	**78867.0**	**100%**

Source: Author's survey.

3.5.2 Innovation Survey

The fieldwork in Uruguay was conducted in two separate rounds: (a) an innovation survey, and (b) a survey based on the Social Network approach. Primary data for the innovation survey (see Appendix A) was collected during the first field study in Uruguay (October-December 2004). The research population was the Uruguayan software cluster. The unit of analysis consisted of the individual firms within the cluster. The questionnaire is based to a certain degree on the Community Innovation Survey and has been adjusted to reflect the peculiarities of the software sector in a developing country. Once in the field, at the suggestion of the initial participants (managers of the software firms) the questionnaire was adapted further. A semi-structured format was adopted. This questionnaire was administered by means of face-to-face interviews with the director or/and the chief engineer of the R&D department of the companies.

3.5.3 Network Survey

Network data were collected from the software cluster in Uruguay during a second field study (November-December 2005). I targeted the same firms as in first survey in order to be able to link the responses. Besides gathering information from firms, I collected information from local institutions and universities. The unit of analysis in a network survey entails the ties of the actors within the cluster. In contrast to conventional data, network data are relational. This means that network data provide information related not only to the actors and their attributes but also to the actors and their relations (Hanneman, and Riddle, 2005). The network survey used a short questionnaire aimed at gathering information about the relations between local actors and the intensity of these relations.

The following actors are relevant for a network study of the software cluster in Uruguay:

- Software firms (N=94).
- Multinational software/hardware companies: Tata, Solusiona, Trintech, Microsoft, Oracle, IBM (N=6).
- Local universities: The University of the Republic, University ORT, The Catholic University (N=3).
- Institutes:
  (a) Support institutes: CUTI, Integro (N=2).
  (b) Research/Support institutes: Software Testing Centre (CESS), Incubator program (LATU/Ingenio) (N=2).

The entire population of 160 actors was approached and asked to take part in the network questionnaire. 107 organisations were willing to participate in the survey (representing a 67 per cent participation rate)[35]. In particular, all the large/medium and small software firms participated. Micro firms also responded, but here non-response was higher. In total 94 software firms responded. The rest of the organisations, such as local universities, multinationals and support institutes were all willing to participate in the research.

Approximately half of the interviews (55) were held face-to-face while the others were conducted via internet (34) or by telephone (18). The respondents were provided with a list of all of the 107 organisations and were asked: 'with whom among these actors do you communicate in order to solve technical or functional problems'? The respondents were asked to indicate the frequency of the interaction with these actors, according to the following scale:

'Never', 'Rarely' (once per year), 'Sometimes' (2-5 times per year), 'Often' (every month), 'Very often' (every week).

3.5.4 Interviews

In both rounds of my survey the structured interviews were followed by more qualitative discussion with the respondents (see Appendix C). On many occasions, a single person was not able to answer every one of the questions. Thus, another person from the same firm would be interviewed. Other times a second visit was made to the firm in order to acquire the qualitative information. Thus, in addition to the responses to the questionnaires I also have 107 transcript interviews with all the sample actors involved in the Uruguayan software industry.

3.6 OPERATIONALISATIONS

3.6.1 Dependent variables[36]

3.6.1.1 Innovative Performance

As the conceptual framework in figure 3.1 indicates, the innovative performance of the firm is the outcome of a latent variable that denotes the innovation capability of the firm. Innovation capability refers to the skills and knowledge which are necessary for a firm to be able to improve and change products and/or processes (Lall, 1992). In general, innovation embraces all the efforts of the firm which aim to "improve technological mastery, to adapt technology to new conditions, to improve it slightly or to improve it very significantly" (Lall, 1992, p.166). Although investment and production capability are also relevant in the context of the software sector, I focused upon innovation capability in the survey, since the main characteristic of the software sector is a continuous effort towards product innovation. In particular, Pavitt (1984) classified software firms as specialised suppliers. He argued that this type of firm is characterised by a high rate of product innovations.

Therefore, the indicators that have been used in this study to denote the innovative performance of the firm put emphasis upon product and service innovation, while paying less attention to process innovation. Prior to the field research, I tested the questionnaire with one European software firm (based in the Netherlands) and one American firm (based in the Silicon Valley). The test confirmed the tendency of software firms to undertake predominantly product innovations. Moreover, in the initial interviews in Uruguay and discussions with local experts, I verified the use of measures of product and service innovation as appropriate indicators for the innovative performance of the software firms in that context. The following variables for innovative performance were used in the analysis:

Product/Service - New to the Market

This is a yes/no answer to the question: 'Did your firm introduce new product and/or service innovations to the market during the period 1999-2004?' In other words, this question identifies products which were new to the market (they were not an imitation). The innovation usually addresses new functionalities to existing technologies or addresses the same functionality through a new technology. The important feature of this indicator is that it refers to a product/service new to the market. This implies that the firm had the capability to create a substantially new product (registered package or standard system) and to introduce it to the market. This variable is denoted as:

NEW_PS: This is a dummy variable that takes the value of 1, if the firm had introduced a new product and/or service innovation to the market during 1999-2004, and 0, otherwise.

Product/Service - Changed Substantially

For firms that have never had a unique, innovative product, I created another indicator to address the degree of change undertaken with respect to an already existing product or service. This was a yes/no answer to the question: 'Did your firm change products/services in a substantial manner during the period 1999-2004?' Such changes usually come about in response to the requirement to satisfy the needs of a customer. In other words, it mainly takes the form of the creation of new services or customised software. The difference in comparison with the *New to the Market* indicator is that the firms which introduced a new to the market product not only created a new functionality but also had the capability to do so on a generalised scale. They had gone from offering a personal solution (customisation or service) to providing a general solution with many applications (product). This means that while the NEW_PS variable denotes innovations that are completely new to the market, the CHANGE_PS variable indicates innovations that are new for the firm. The symbol for this variable is:

CHANGE_PS: This is a dummy variable that takes the value 1, if the firm has changed substantially a product and/or service during the period 1999-2004, and 0, otherwise.

Sales of Innovation Output

This variable refers to the percentage of sales of a firm that derived from product and/or service innovations in 2004[37]. The most important feature of this variable is that it identifies the firms that manage to commercialise their innovations successfully. When a high percentage of the sales of a firm consists of innovative products/services it signifies that this is an innovative firm. This variable is indicated as:

SALES_INNOV: This variable refers to the percentage of sales that derived from product and/or service innovations in 2004.

Number of Innovations

This indicator takes into account the number of innovative products and/or services[38] the firm has created during the period 1999-2004. In general, software firms develop just a few products and then adjust these to the current technological and market trends by developing new versions. This variable, then, may capture the changes that a firm has undertaken in terms of product design, user-friendly functionalities, and up-to-date technology adjustments, through the creation of new versions of older products.

NO_INNOV: This is a continuous variable that considers the number of product/service innovations of each firm during 1999-2004.

Quality of Products and/or Services

This indicator captures the quality of the products and/or services that a firm has developed. Firms were asked to report whether they hold any of the internationally recognised quality certifications such as ISO 9000 and CMM (related to software). While the process for obtaining a quality certification might represent a period of learning for a firm which could improve the quality of its processes, most of the firms tend to hold such certificates in order to access international markets. This suggests that the acquisition of a quality certificate reflects a change in the business practice of the software firms with the aim of improving their image in international markets. The acquisition of a quality certificate, then, constitutes a form of an organisational innovation and not so much a technological one.

QUAL_PS: This is a dummy variable that takes the value of 1 if the firm has a quality certification, and 0 otherwise.

3.6.1.2 Economic Performance

Economic indicators are considered in order to have a more complete view of the performance of the firms. A firm may not score high on innovation indicators but may still demonstrate a high economic performance. Such a discrepancy between these two types of variables might appear in a cross-section analysis. One reason for this is that firms could have invested in learning in the past and may be currently enjoying the benefits of their investment. In such a case, innovative indicators might appear low, while the economic indicators are high. The opposite may also occur.

Sales Performance

The absolute value [in US dollars] of sales of each firm in 2004 is considered. Additionally, I take into account the growth of sales from 1999 till 2004. Finally, the sales value per worker is calculated. The variables are denoted as follows:

SALES: This is a continuous variable, which denotes the sales of software products and/or services of the firms in US dollars in 2004.

SALES_GR: This is a continuous variable, which denotes the growth of the firms' sales of software products and/or services during the period 1999-2004.

SALES_EMPL: This is a continuous variable, which denotes the sales value per employee for each firm in US$ in 2004.

Export Performance

The exports of the firm in 2004 are considered. In addition, the growth of exports from 1999 to 2004 is taken into account. Finally, the export intensity of the firms' sales is calculated.

EXPORTS: This is a continuous variable, which denotes the exports of software products and/or services of the firms in US dollars in 2004.

EXPORTS_GR: This is a continuous variable, which denotes the growth of the exports of software products and/or services of the firms during the period 1999-2004.

EXPORTS_INTENS: This is a continuous variable, which indicates the percentage of sales directed to foreign markets in 2004.

Growth of employment

EMPL_GR: This is a continuous variable, which represents the growth of the number of employees for each firm during the period 1999-2004.

3.6.2 Independent Variables

3.6.2.1 External Mechanisms of Learning

Firms use different mechanisms to acquire external knowledge. According to the Oslo Manual (OECD/EC/Eurostat, 1996) knowledge circulates among various actors in different ways. The most important are the following:

- Formal and informal linkages between firms

These are networks of small firms, user-producers relationships, relationships between competitors and, finally, relationships of firms with universities or research institutes. These interactions can produce information flows, which can stimulate innovation explicitly or implicitly.

- International links

Networks of international experts (epistemic communities, a-spatial, 'invisible colleges, conferences) are important channels through which frontier knowledge may be transferred across country boundaries.

- Reverse engineering

Knowledge embodied in machinery can give rise to knowledge flows. When machinery is dismantled by an engineer, the latter becomes familiar with the knowledge that was used to build the relevant artifact.

- Mobility of experts

An important part of knowledge is embodied in people. Labour mobility is often used to measure knowledge flows, as a person who moves to work with another employer brings along the cumulated knowledge (human capital) he has acquired in the past. High labour inflow may be a sign that new knowledge/information is brought into the firm.

- Spin-off company formation

The generation of new firms by previous employees of an existing organisation as a university, a MNC and/or a firm involves the transfer of knowledge to the newly established firm. This is a way by which new product developments are commercialised.

- Codified knowledge in patents, the specialised press and scientific journals

Repositories of knowledge are often patents, the press and scientific or professional journals.

- Access to public R&D capabilities

- The presence of expert technological 'gatekeepers' or receptors

These are individuals that continue to be aware of new developments and maintain personal networks, which facilitate flows of information.

The advocates of Economic Geography (Audretsch and Feldman, 1996B; Baptista and Swann, 1998; Audretsch, 1998; Verspagen and Schoenmakers 2000) claim that a particular type of knowledge flow, namely local knowledge spillovers, plays a predominant role in increasing firms' innovative capability. In general, LKS arise when a firm can take advantage of the innovative output of firms located in the vicinity without paying any compensation. I apply this definition to the various categories of knowledge flows that are identified in the literature. A knowledge flow, thus, is a LKS only when satisfies two conditions:

- It is knowledge that flows locally, and
- It is knowledge for which no pecuniary compensation is given.

In the second section of this chapter, I classified external knowledge flows into four categories: local knowledge spillovers, local knowledge transactions, non-local knowledge spillovers and non-local knowledge transactions. I will now examine to what extent the previous list of external mechanisms of learning constitute local knowledge spillovers. Taking into account the aforementioned definition of LKS, only some of the previously referred mechanisms of knowledge flow can be considered as local knowledge spillovers:

- Formal and informal linkages between firms

By definition a formal relationship such as a contract agreement, R&D cooperation, or licensing does not constitute LKS. This is because a formal relationship presupposes a form of compensation for the acquisition of the knowledge.[39] I will consider local formal relations as local knowledge transactions (LKT). On the other hand, an informal relationship between actors (on the basis of reciprocity, trust, belonging to the same epistemic community etc.) located within a close geographical distance can potentially give rise to local knowledge spillovers (LKS).

- International links

If an international link works through market mechanisms then it may give rise to international knowledge transactions (IKT). On the other hand, if an international link works through informal channels (non-market mechanisms) then it may stimulates international knowledge spillovers (IKS).

- Reverse engineering

Reverse engineering is not a mechanism of local knowledge spillovers because a product is not restricted to one location. It can be bought and consequently imitated in any R&D laboratory. Usually reverse engineering may stimulate international knowledge spillovers, especially in cases when developing countries buy foreign technology and then attempt to imitate it. Reverse engineering, then, frequently stimulates international knowledge spillovers (IKS).

- Mobility of experts

Insofar as skilled employees move within a cluster, we can consider them to act as channels of local knowledge spillovers (LKS).

- Spin-off company formation

As far as the spin-offs occur in the same area as the parent organisation this can be considered a channel of local knowledge spillovers (LKS).

- Codified knowledge in patents, the specialised press and scientific journals

Knowledge within patents does not generally constitute local knowledge spillovers since this information can travel anywhere and is not restricted to a particular geographic space. Usually, codified knowledge in patents and scientific publications stimulate international knowledge spillovers (IKS).

- Access to public R&D capabilities

If the cooperation of the firm with the public research institute is formal this does not give rise to local knowledge spillovers but rather to local knowledge transactions (LKT). On the contrary, if the cooperation is informal it could be a potential channel for local knowledge spillovers (LKS).

- The presence of expert technological ‘gatekeepers’ or receptors

Networking (informally) with key agents may give rise to local knowledge spillovers (LKS).

Consequently, there are three main mechanisms through which LKS can arise:

- Spin-off firm formation[40]

When a firm is a spin-off from a local actor (university, MNC, large firm) this frequently implies, that crucial know-how and problem solving skills are circulated within the cluster. A person learns this knowledge within an organisation and then he creates his/her own firm. The

identification of a firm that was a (local) spin-off indicates that knowledge has (at one point in time) spilled over from a university/MNC/large firm to a new firm.

- Labour mobility[41]

When a firm is characterised by high labour inflow, this implies that employees represent a channel for the acquisition of knowledge. When the new employees originate from the cluster, it means that knowledge spills over locally through the mobility of labour.

- Interaction of local actors

When important sources of knowledge for a firm are local actors (university, supplier/user, competitor) these may constitute significant channels of LKS. A prerequisite for this would be that the interaction between the actors is informal.

Accordingly, the independent variables pertaining to the mechanisms of knowledge flow for the acquisition of external knowledge (to the firm) are defined as follows:

Intra-cluster Knowledge Flows:

Local Knowledge Spillovers:

LKS_S: This is a dummy variable that takes the value of 1 if a firm is a spin off from a university/MNC/large firm that is located within the cluster, and the value of 0 otherwise.

LKS_L: This variable denotes the percentage of employees that joined the firm from within the cluster during the last five years (1999-2004). It is measured by the Inflow Rate[42]: $R(in)_t = \Sigma\, im_{t-1} / N_t$.

LKS_I: This is a constructed variable that indicates the importance of intra-cluster flows of knowledge that arise from informal interactions among local actors (see Box 3.1 for further information).

LKS_I2: This is a constructed variable that indicates the existence of intra-cluster flows of knowledge that arise from informal interactions among local actors (see Box 3.2 for further information).

Local Knowledge Transactions:

LKT: This is a constructed variable that indicates the importance of intra-cluster flows of knowledge that arise from market transactions among local actors (see Box 3.1).

LKT2: This is a constructed variable that indicates the existence of intra-cluster flows of knowledge that arise from market transactions among local actors (see Box 3.2).

Extra-cluster Knowledge Flows[43]:

International Knowledge Spillovers:

IKS: This is a constructed variable that indicates the importance of extra-cluster flows of knowledge that arise from informal interactions among local and foreign actors (see Box 3.1).

IKS2: This is a constructed variable that indicates the existence of extra-cluster flows of knowledge that arise from informal interaction among local and foreign actors (see Box 3.2).

International Knowledge Transactions:

IKT: This is a constructed variable that indicates the importance of extra-cluster flows of knowledge that arise from market transactions between local firms and foreign actors (see Box 3.1).

IKT2: This is a constructed variable that indicates the existence of extra-cluster flows of knowledge that arise from market transactions between local firms and foreign actors (see Box 3.2).

Box 3.1: Construction of the Variables – Importance of Knowledge Flows through Interaction (1)

Firms were asked in the survey to *assess the importance of various sources of information/advice or assistance for their upgrading or innovation efforts* on a Likert scale (0=unimportant, 1=less important, 2=important, 3=very important, 4=crucial). I provided them with thirteen different potential sources of knowledge (Group, New Personnel, Customers, Suppliers, Competitors, Vertically connected firms, Consultants, Research Institutes, Universities, Innovation Centres, Sector Institutes, Exhibitions, and Electronic Information). Moreover, firms were requested to report *where the sources of knowledge that they use were geographically located* (Local or International). Finally, firms were asked to *clarify the type of relationship between their firm and each source of knowledge that they use* (Formal transaction-based or Informal not involving transactions).

Using the three attributes (Importance, Location and Type of the relationship) I constructed the variables that denote the importance of the knowledge arising from interactions. For instance, the *international knowledge transactions* (IKT) variable was constructed in the following way: for every case (firm) I added up the scores of importance assigned to the various sources of knowledge that are acquired internationally through transactions. All the relations between firms and Group, New Personnel, Customers and Suppliers were classified as formal. Even though user-producer interaction is not a strictly transaction-based relation, still the knowledge flow between a firm and its supplier or customer is the result of a formal market transaction and thus it is treated as a pecuniary knowledge flow. In contrast, all the relations between firms with Competitors are informal and thus considered to give rise to knowledge spillovers. Likewise acquisition of Electronic Information is generally for free and thus considered as a spillover of knowledge. Finally, the relation of firms with other Vertically connected firms, Consultants, Research Institutes, Universities, Innovation Centres, Sector Institutes, Exhibitions, is ambiguous. For example, some firms form alliances in a formal way (i.e. by sharing R&D outcomes) while others keep them informal (i.e. by sharing information regarding problem solving activities). Knowledge that flows between these sources of knowledge and the firms can be either transaction-based or free. Therefore, the type of knowledge flow between these sources of knowledge and the firm varies for each case. Thus I classified them on a case by case basis.

Each variable has a range from 0 to 52. The maximum value of the IKT variable for instance, would be 52, if a respondent would give the value of 4 to all thirteen sources of knowledge, all of which are acquired through market transactions from abroad.

:

Source: Author

Box 3.2: Construction of the Variables – Existence of Knowledge Flows through Interaction (2)

The same question as in Box 3.1 was used to determine whether a knowledge flow existed or not. Those sources of knowledge that were considered by the respondent as having an impact upon their efforts to innovate were given the score of 1. A score of 0 was given to the sources that were considered to be unimportant. Using the three attributes (Existence of the relationship, Location and Type of the relationship) I constructed the variables that denote the presence of the knowledge flow. For instance, the i*nternational knowledge transactions* (IKT2) variable was constructed in the following way: for every case (firm) I added up the scores of the sources of knowledge that are acquired internationally through market transactions.

Each variable has a range from 0 to 13. The maximum value of the IKT2 variable for instance, would be 13, if a respondent would give the value of 1 to all thirteen sources of knowledge, which are all acquired through market transactions from abroad.

Source: Author

3.6.2.2 Internal Mechanisms of Learning

Research and Development

I consider the R&D activity of the software firms as a proxy for their internal capability (or absorptive capacity). Two indicators are used to denote the R&D effort of the firm. The first proxy reflects the cumulative R&D effort of the firm between 1999 and 2004. In particular, this indicator measures the time that a firm has spent on research and development during this period in man-years. The second proxy reflects the R&D intensity of the firm, as measured by the percentage of the firm's employees that have conducted R&D, out of the total number of employees during 2004.

R&D_MY: This is a continuous variable which denotes the time that a firm has spent on R&D during the period 1999-2004 in man-years [44].

R&D_INTENS: This variable denotes the percentage of firm's labour force that was carrying out R&D in 2004.

Education of employees

The first group of education variables refers to the level of formal education.

EDU_Voc: This variable denotes the percentage of employees whose highest level of education is vocational training related to computer programming.

EDU_BSc: This variable denotes the percentage of employees whose highest level of education is a Bachelor degree in software engineering.

EDU_MSc: This variable denotes the percentage of employees whose highest level of education is a Master Science degree.

EDU_PhD: This variable denotes the percentage of employees whose highest level of education is a PhD degree.

An education index[45] has been constructed, based on the above information, which indicates the educational level of the employees of every firm. For each firm, the percentage of the employees with vocational education is multiplied by 3. The percentage of employees with BSc is multiplied by 5. Then, the percentage of employees with MSc is multiplied by 7 and finally, the percentage of employees with PhD is multiplied by 11. The aggregate of all these scores denotes the weighted average educational level of the employees of the firm.

EDU: Education Index.

An additional variable was constructed in order to denote the variation of education levels of employees within a firm. When for example 100 percent of the employees of a firm have a BSc, a score of 1 is assigned to this firm. If, on the other hand, a firm consists of 50 percent of employees with BSc and 50 percent with MSc, a score of 2 is assigned to that firm. Finally, if a firm consists of 30 percent of employees with vocational education, 40 percent with BSc, 20 percent with MSc and 10 percent with PhD, a score of 4 is assigned to that firm.

EDU_VAR: This is an ordinal variable which reflects the variation of educational levels found in a firm

Moreover, a dummy variable has been created which takes the value of one when the highest level of education of the employees within a firm is a completed MSc or PhD degree. On the contrary, when the highest level of education found in a firm is Vocational or BSc we assign the value of zero. This variable reflects firms with advanced human capital, which is the result of postgraduate studies of the employees.

EDU_DUM: This is a dummy variable which takes the value of 1 if a firm has employees with MSc or PhD degrees, and 0 otherwise.

Finally, the percentage of the labour force that has higher foreign education is considered.

EDU_F: This variable denotes the percentage of the employees in a firm who have acquired a university degree abroad.

Experience of employees

The years of experience of the employees working in the software sector are considered.

Exper_<6months: This variable denotes the percentage of employees who have less than 6 months experience in the software sector.

Exper_6-12months: This variable denotes the percentage of employees who have approximately 6 to 12 months experience in the software sector.

Exper_1-2years: This variable denotes the percentage of employees who have approximately 1 to 2 years experience in the software sector.

Exper_2-4years: This variable denotes the percentage of employees who have approximately 2 to 4 years experience in the software sector.

Exper_>4years: This variable denotes the percentage of employees who have more than 4 years experience in the software sector.

An experience index has been also constructed, based on the aforementioned information, which indicates the weighed average years of experience of the employees of every firm. For each firm, the percentage of the employees with less than 6 months experience is multiplied by 0.25. The percentage of employees with 6 to 12 months of experience is multiplied by 0.75. The percentage of employees with 1 to 2 years of experience is multiplied by 1.5. The percentage of employees with 2 to 4 years of experience is multiplied by 3 and finally, the percentage of employees with more than 4 years of experience is multiplied by a figure in a range of 6 to 12[46]. The aggregate of all these scores denotes the weighted average experience level of the employees of each firm.

EXPER_Y: Years of Experience Index.

An additional variable has been constructed[47] in order to denote the variation in years of experience of employees within a firm.

EXPER_VAR_Y: This is an ordinal variable that reflects the variation of experience levels of employees found within a firm

Additionally, I have taken into account the number of occupations related to software that the employees had held in the past.

Exper_0 firms: This variable denotes the percentage of employees that did not have prior work experience (the current employment is their first job).

Exper_1-2 firms: This variable denotes the percentage of employees that had worked in 1 or 2 other firms in the past.

Exper_3-4 firms: This variable denotes the percentage of employees that had worked in 3 or 4 other firms in the past.

Exper_5-6 firms: This variable denotes the percentage of employees that had worked in 5 or 6 other firms in the past.

Exper_>6 firms: This variable denotes the percentage of employees that had worked in more than 6 other firms in the past.

A second experience index has been constructed, based on the above information, which indicates the weighted average number of firms in which the employees had worked in the past. The percentage of the employees with no previous experience is multiplied by 0. The percentage of employees with previous experience in 1 or 2 firms is multiplied by 1.5. The

percentage of employees with experience in 3 or 4 firms is multiplied by 3.5. The percentage of employees with experience in 5 or 6 firms is multiplied by 5.5, and finally, the percentage of employees with experience in more than 6 firms is multiplied by 6. The aggregate of all these scores denotes the weighted average experience level of the employees of the firm in terms of the number of previous occupations held by them.

EXPER_FIRMS: Experience in Firms Index.

An additional variable has been constructed[48] in order to denote the variation of experience levels of employees within a firm, in terms of number of firms in which they had worked prior to joining the present firm.

EXPER_VAR_F: This is an ordinal variable that denotes the variation of the experience of the employees (in terms of number of firms in which they had worked) within a firm.

Finally, the accumulated experience by the firm as a whole is taken into account, by considering the age of the firm.

AGE: This is a continuous variable which measures the age of the firm with reference year 2004.

5.6.3 Control Variables

I control for the size of the firm.

SIZE: This is a continuous variable which captures of the firm measured by the number of employees in 2004**.**

CHAPTER 4

THE EMERGENCE AND EVOLUTION OF THE SOFTWARE CLUSTER IN URUGUAY

4.1 INTRODUCTION

Software refers to a list of instructions in the form of code that directs a computer to execute specific tasks. Software is stored electronically in devices, or hardware. A software program is a collection of instructions and is usually distinguished between systems software and application software (Steinmueller, 1996).

Table 4.1: Types of Software Products (A)

A. Package Software			
System Software	**Programming Languages**	**Application Tools**	**Application Solutions**
Operating systems & utilities	BASIC, C, C++, COBOL, Ada FORTRAN, and Pascal.	Computer-aided software engineering tools (CASE).	Financial sector, health sector etc.

Sources: IDC (1990); Malerba and Torrisi (1996).

Table 4.2: Types of Software Products (B)

B. Custom Software & Services				
Turnkey systems	**System Integration**	**Professional Services**	**Facilities Management**	**EDP Services**
Custom-made software that can be easily set up and operated.	The progressive linking and testing of system components to merge their functional and technical characteristics into a comprehensive, interoperable system.	Customised software, consulting, training, maintenance	Electronic data processing	Problem solving, transaction processing, on-line information services.

Sources: IDC (1990); Malerba and Torrisi (1996).

Table 4.1 and 4.2 classify software products into two main categories, package software and custom software services. Package software refers to software that is standardised and sold to many customers; in this case, the software firm provides a product. Custom software and

services refer to software that is tailor-made to fit the requirements of the customer; in this case, the software firm offers a service.

With respect to the first category, systems software consists of basic programs that interact with the computer such as operating systems, compilers and utilities. Applications software consists of solutions that allow end-users to perform specific tasks such as database formation, word processing, and industrial automation. Application tools and solutions are usually demanding and sophisticated products. In contrast, system software is easier to develop. In the case of custom-made software and related services, the level of sophistication differs and depends on how challenging the specifications of the customers are. Usually, electronic data processing, system integration, maintenance and training, and EDP services are not complex activities. Again, custom-made software can be very complex or simple, depending on the type of customer and his requirements.

Research on the software industry, especially international comparisons, is limited because the statistics of the sector are rather ambiguous. The main official sources of information for the software industry are firstly, national accounts [in the form of surveys of economic activity] carried out by national statistical agencies and secondly, industry studies usually undertaken by industry associations and market research companies.

The main advantage of national accounts is that they provide longitudinal data that allows for analysis of the evolution of the software industry. However, their main drawback is that they do not provide disaggregated data which permits to observe the distinct contribution of software to GDP. For example, the category 72 'Computer and Related Activities[49]' of the ISIC Rev 3[50] provides information about the software industry (Tether *et al*. 2001, p.101). However, this category does not consider intermediate goods; namely embedded software in hardware or in telecommunications equipment (Hawkins and Puissochet, 2005). Moreover, the supply of software services by other industries (e.g. engineering and scientific services) is not taken into account in category 72 (Lequiller *et al*, 2003). On the other hand, industry studies provide an in-depth view of the sector. Nevertheless, their main disadvantage is that they take place at one point in time [which does not permit the examination of the evolution of the industry] and often they are not freely available to the public (e.g. IDC studies of the software market are highly priced).

Software products are intangible. This implies that the capital costs for their production and reproduction are very low. The most important resource for a software firm is human capital. Highly skilled professionals such as programmers and system architects are the fundamental requirements in order to set up a software business; software is considered to be [partly] a knowledge intensive industry. The emergence of software sectors in a number of developing countries throughout the 1990s was unexpected. India, China and Brazil are the best known examples, with India standing out due to the astonishing growth of its exports.

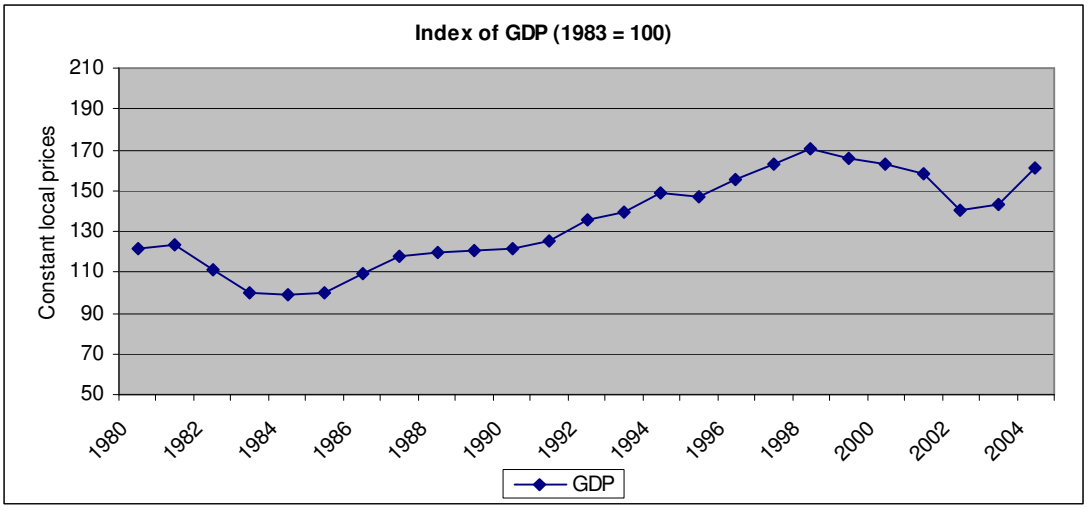
A less well known case is the Uruguayan software industry, which developed – without public support – in the 1990s. Uruguay is a traditional agricultural economy, as is demonstrated by its main exports, meat, leather, wool and rice. Therefore, it came as a surprise to many local and international observers that the Uruguayan software industry blossomed and that its exports of software products and services reached approximately 80 million U.S. dollars in 2004 (CUTI, 2004). The most interesting feature of the Uruguayan software sector is that it has emerged by itself without the support of the State and that it has managed to create sophisticated products, which satisfy the demands of both the domestic and the international market.

In this chapter, I introduce and discuss the Uruguayan software sector within the context of its national economy. In section two, I review the macro features of the Uruguayan economy and examine its main productive sectors. In section three, I look at the development of the software industry in advanced economies, mainly in the United States. Finally in sections four and five, I analyse the evolution of the Uruguayan software industry and compare it to similar software industries in other developing countries.

4.2 THE URUGUAYAN ECONOMY

Over the past twenty-five years, the Uruguayan economy has expanded at a rate of 1.2 per cent per year[51]. Figure 4.1 exhibits the growth of GDP during this period. From 1980 till 1984 the economy contracted at a rate of 5 per cent, while during the period 1984-1998 GDP grew at a steady pace of 3.97 per cent per year. However, this growth was disrupted by a deep crisis that began in 1998 and lasted until the end of 2002. During this period GDP declined by 4.75 per cent per year. Between 2002 and 2004 the Uruguayan economy seemed to recover from the crisis, showing a growth of 7.10 per cent per year.

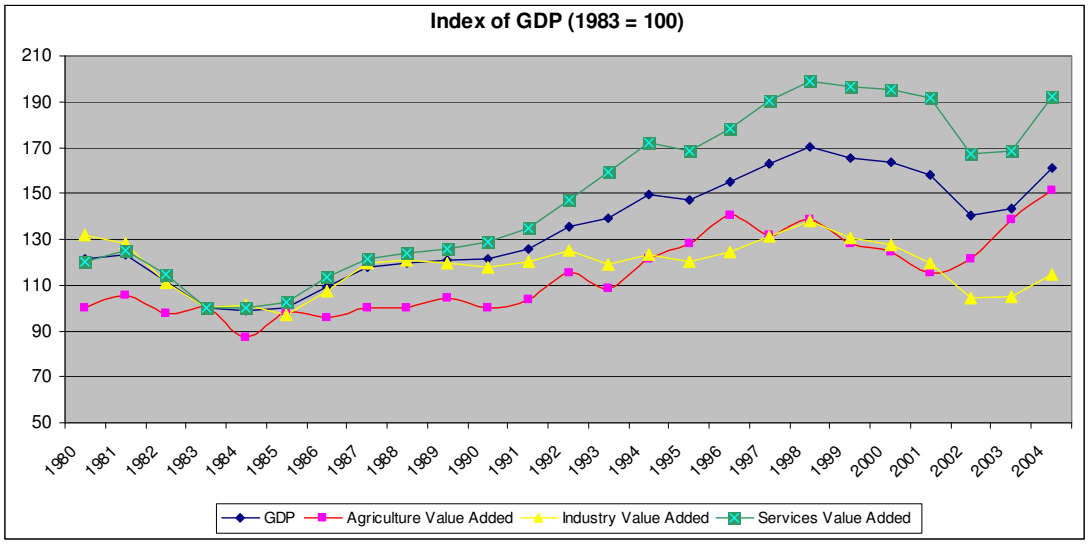
Figure 4.1: The Growth of the Uruguayan Economy (1980-2004)



Source: Own calculation based on data from the Central Bank of Uruguay (data base 1988-2004), and World Bank (2005) (data base 1980-1988).

At the sectoral level, services expanded most rapidly, at 1.97 per cent per annum over the past twenty-four years (compared to 1.73 per cent growth of agriculture and 0.59 per cent growth of the industrial sector). Figure 4.2 depicts the growth of the different sectors from 1980 until 2004. During the period of the economic expansion (1984-1998), services grew at 5.03 per cent p.a., agriculture at 3.37 per cent p.a. and industry at 2.20 per cent p.a. The contribution of services to total value added increased from 54 to 63 per cent. Figure 4.3 shows the sector shares during the period 1980-2004. The share of agriculture to the total value added stayed at approximately 10 per cent. The share of the industrial sector declined from 34 to 27 per cent.

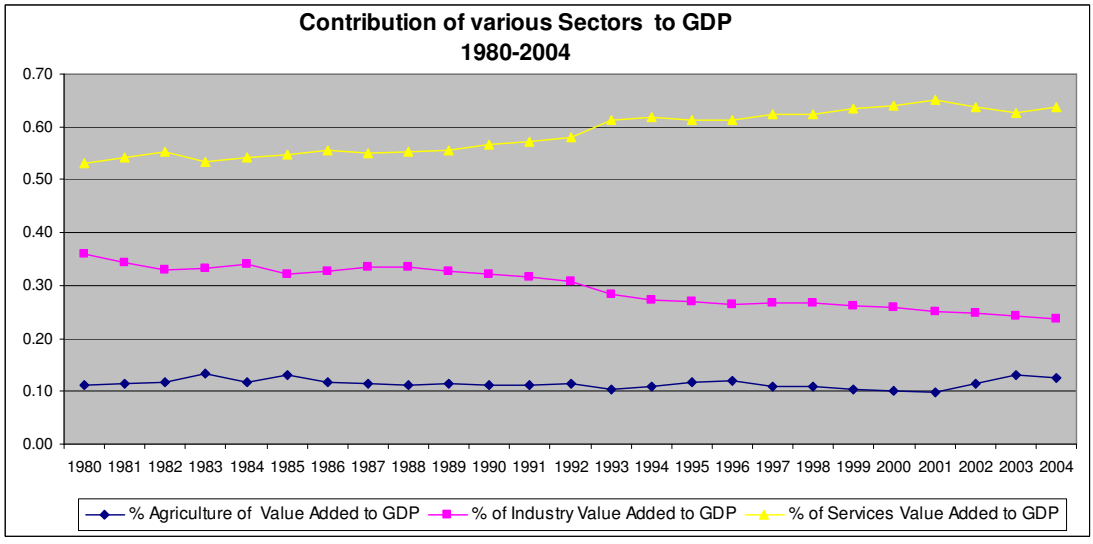
Figure 4.2: Sectoral GDP (1980-2004)



Source: Own calculation based on data from the Central Bank of Uruguay (data base 1988-2004), and World Bank (2005) (data base 1980-1988).

During the period of the crisis (1998-2002), the industrial sector experienced the deepest decline, at a rate of 6.65 per cent p.a. (compared to 3.28 per cent p.a. for agriculture and 4.23 per cent p.a. for services). Moreover, while the other sectors seemed to recover rapidly after 2002 (agricultural value added increased at 11.64 per cent p.a. and services at 7.17 per cent p.a.), the industrial sector expanded at a slower pace (4.74 per cent p.a.).

Figure 4.3: Sector Share in GDP (1980-2004)



Source: Own calculation based on information from the Central Bank of Uruguay (data base 1988-2004), and World Bank (2005) (data base 1980-1988).

The main reasons for the crisis of 1999-2002 were threefold: First, the devaluation of the Brazilian Real in January 1999; second, the foot-and-mouth disease that occurred in Uruguay in 2001; and finally, the economic and financial crisis of Argentina in late 2001 (Perry and Servén, 2003; Santo, 2005).

It is clear that two of the three causes of the crisis are related to external factors. The tied trade relation of Uruguay with the two neighbouring countries (Argentina and Brazil) makes her vulnerable to economic fluctuations.[52] Thus, when Brazil devaluated its currency in 1999, Uruguayan exports were considerably affected. As figure 4.2 shows, in 1999 all sectors of the Uruguayan economy were in decline.

Uruguayan exports are predominantly agricultural. Primary products accounted for 58.4 per cent of the country's exports in 2001, while manufactured goods constituted the remaining 41.6 per cent (Eclac/Cepal, 2002). Meat, wool, leather, rice and milk are the main products produced in Uruguay. Livestock is the most important sub-sector of agriculture. Value added of the livestock sector accounted for 69.4 per cent of agricultural output in 2000 (Osimani and Paolino, 2005). In addition, the agro-industrial sector is important within the manufacturing sector. For example, value added of meat processing and preserving accounted for 7 per cent of manufacturing value-added in 2000 (UNIDO, 2005). In that same year dairy products contributed 4.2 per cent to the total manufacturing VA (UNIDO, 2005). The foot-and-mouth disease had a very destructive impact upon the economy of the country and affected both its agricultural and manufacturing industries. As Figure 4.2 shows, in 2001 the agricultural sector was at its lowest level in the last decade. A year later, both the manufacturing and the services sector were affected by the profound crisis that the foot-and-mouth disease had caused.

In 2001, the Argentinean crisis deepened the recession in Uruguay. This was the worst crisis in the history of the Uruguayan economy and affected the real economy (productive sectors) as well as the monetary economy (financial and banking sectors) of the country. The majority of Uruguayan exports were directed to Argentina. As a result of the Argentinean crisis, these exports decreased by 74 per cent (Osimani and Paolino, 2005). In addition, the negative economic climate created pessimism among investors who perceived Uruguay as a high-risk investment location. The exodus of foreign and then of local capital provoked a banking crisis. Finally, the State let the currency float freely, which further aggravated its depreciation.

The Uruguayan economy seems to have overcome the crisis since and grew at a rate of 12 per cent in 2004. In that year, industry contributed 24 per cent to GDP, agriculture 12 per cent, and services 64 per cent (Central Bank of Uruguay, 2004). Consequently, the Uruguayan economy has recovered but has not reached pre-crisis levels.

Currently the most important manufacturing activities are textiles and clothing, and pharmaceuticals. 6 per cent of VA in manufacturing was attributed to textiles and clothing in 2000, while the contribution of pharmaceuticals to MVA at the same period was 4 per cent (UNIDO, 2005). The most significant agricultural products are livestock (beef meat, leather and wool), milk and its by-products (butter, cheese, fresh cream) and finally forestry (Osimani and Paolino, 2005; Berretta and Paolino, 2005; Laens and Paolino, 2005). The service sector mainly consists of the following activities: transport and logistics, which accounted for 6.5 per cent of GDP in 2002; tourism, which accounted for 15 per cent of country's exports during the last decade (National Institute of Statistics, 2001); and the software sector, which represented 5.3 per cent of total exports in 2004 (Author's survey).

In summary, Uruguay is a small and open economy. During the period 1984-1998 Uruguay experienced a steady growth of around 4 per cent, due to the growth of agriculture and agro-industrial sectors that constituted the main export activities of the country. From being the 'Switzerland of Latin America,' the country fell into a deep economic crisis that lasted from 1998 until 2002, and affected the agricultural, financial and banking sectors.

During the period 2002-2004, Uruguay redefined its economic policy and placed emphasis on sectors other than agriculture. In particular, the Government's attention has at last turned to the information technology sector. The software sector, although small by international standards, could be important for the economic development of the country. Official statistics referring to the software sector are ambiguous because of its newness and intangible nature[53]. According to the National Institute of Statistics in Uruguay Computer and Related Activities section 72 of the 3rd ISIC division accounted for 1.5 per cent of the value added of all economic activities in 2001 (excluding agriculture). The institute of the software sector reported that in 2001 software exports amounted to 83 million US dollars (Stolovich, 2003).

The slow economic growth of the country clearly does not encourage the development of a high-tech industry. In addition, Uruguay is a country with a limited productive base. This could be a disadvantage for the development of a sector which is mainly driven by sophisticated customers (Pavitt, 1984; Malerba, 2005). In this respect, the software industry in Uruguay has limited opportunities to learn from local actors. However, government policy could stimulate the capabilities of the local firms through procurement projects. Section 4.4 will discuss in detail the emergence of the software sector in Uruguay and the factors that reinforce and hinder its development.

4.3 THE GLOBAL SOFTWARE INDUSTRY

Although the software industry emerged in mid-1960s and took off only from the mid-1980s onwards, software activity has existed since the 1950s in the United States. The U.S software industry is used as an example of the development of the software sector in advanced economies. There are two main reasons why the U.S. has become such a central paradigm. First, U.S. firms were the first to develop software products and dominated the international market for a long period (approximately until 1990). Second, despite the entrance of other countries such as U.K., Germany and Japan, U.S. firms are still leading in some segments of the industry. In a historical study, Campbell-Kelly (2003) categorises the emergence of the software industry in the U.S. in terms of three main sub-sectors (see Table 4.3):

- Software Contractors

Software contractors emerged in the mid 1950s in order to satisfy the needs of custom-made software programs for mainframe computers. These firms developed computer programs for the defence industry, computer manufacturers and private corporations. These products were unique (developed and sold to one customer) and very expensive[54]. The main business model of software contractors was that of services providers. The services of an engineer or construction contractor (Campbell-Kelly; 2003) would reflect the business model that the custom-made software programmers adopted. To succeed in such a business, the most important capability that these firms developed was the ability to take advantage of economies of scope by specialising on a sub-market area. Such a specialisation gave the firms the opportunity to modify programs slightly and sell them to another client. Finally, project management was an important process for the business model of software contractors that would enable them to complete the project within the pre-decided time and cost.

- Corporate Software Products

Corporate software products had their breakthrough in the mid 1960s and provided software products for the first family computer (IBM-360). The main clients of these firms were enterprises that wanted to computerise business functions such as payroll systems. Corporate

software products could be applied as such, or adapted to the requirements of several (hundreds) clients. The business model of the corporate software firms resembles the business model of the production of capital goods (Campbell-Kelly, 2003). These firms were confronted with the high costs of development of generalised software, high marketing cost and the need for sales support. Hence, corporate software firms relied on economies of scale, producing a large volume of products. Quality was an important parameter for the success of this type of software because it addressed the core business of financial or insurance companies. Errors would have critical consequences. Although these products were packaged, the software was complex and required some type of customisation (adaptation to the needs of customer), user training and upgrading (new versions).

- Mass Software Products

Mass software products developed after the introduction of the first personal computer in the mid 1970s (MITS Altair). The markets for these firms were users of personal computers that needed software such as operating system and entertainment software. Software for PCs was sold in very large volumes (hundred thousands). The mass-market software resembles the characteristics of the music business (Campbell-Kelly, 2003). High R&D expenses, low production cost and significant marketing costs are the main characteristics of this business model. Hence, firms that decided to sell mass market software realised economies of scale by producing high volumes and by focusing on low cost marketing (retail or order by mail) directed toward the end-user. Finally, software products were simple and easy to use.

Table 4.3: Taxonomy of the Software Industry and its main Attributes

	Software Contractors	**Corporate Software Products**	**Mass-market software products**
Types of Software	Custom-made software	Package software (generalized)	Package software
Target market (Frick and Nunes, 1996)	Vertical market: Government contracts, Computer manufacturers	Vertical market: Corporations	Horizontal market: End-users
Business model	Services (for the development of large software systems)	Products and Services (Customization, User training,Upgrading)	Products
Capabilities (Campbell-Kelly; 2003)	Economies of scope, Cost estimation, Project management.	Economies of scale, Corporate marketing, Quality guarantee, Pre-and-after sales support.	Economies of scale, Mass marketing, Ease of use.
Examples of software output (Steinmueller, 1996)	Large software systems e.g. Military systems	Software tools, Applications such as ERP (enterprise resource management)	Operating systems, Applications such as databases, spreadsheets, word processors.
Examples of software firms (Campbell-Kelly; 2003)	SDC (1956) CUC (1955) CSC (1959) Informatics (1962)	ADR (1959) Informatics (1962) SAP (1972) Computer Associates (1976) Oracle (1977)	Microsoft (1975) MicroPro (1978) Software Arts (1979) Lotus (1982) Activision (1980) Broderbund (1980)

Source: Adapted from Campbell-Kelly (2003).

The American software industry has dominated the world software market for a long period. Its revenues in 1982 were 10.3 billion dollars, which represented 70 per cent of the world's

total (Campbell-Kelly, 2003). However, U.S. software industry share of revenues has declined in the last decade. In 1990 the revenues of the U.S. software industry were 62.7 billion dollars, which accounted for only 57 per cent of the world market revenues in software (Brandt, 1991). Western Europe accounted for 21 per cent of the world revenues in the software industry, followed by Japan with 13 per cent, while the remaining 9 per cent goes to other countries (Brandt, 1991). The global share of the U.S. software industry had diminished further to 53 per cent in 2002 (Botelho, Stefanuto and Veloso, 2005). This suggests that software has increasingly become a globalised industry. New players have emerged, and surprisingly enough, some developing countries are among them. India represents the most prominent example of a less developed country that has managed to enter international software markets and export more than 70 per cent of its sales.

Although the American share in the software industry has diminished, U.S. firms still hold a large share of the world market (53 per cent). Table 4.4, shows the market share of U.S. and non-U.S. firms in the sales of package software. While U.S. firms lead the world market in software tools and systems, their share is quite small in software applications. The main reason for this poor performance in application software is the close relation with the client that this type of product requires. Customisation, maintenance and training are usually services that accompany the sale of application software. Consequently, application software is context specific. This is the main reason why the US industry has not expanded its world operations in this segment.

Table 4.4: Market shares (%) of U.S. and non-U.S. Firms in Sales of Packaged Software (1993)

Consuming region	Product categories		
	Tools	Applications	System-level software
	U.S. firms		
United States	83.5	87.9	94.3
Western Europe	74.6	41.3	88.7
Japan	64.7	35.3	73.7
	Non-U.S. firms		
United States	16.5	12.1	5.7
Western Europe	25.3	58.7	11.3
Japan	35.3	64.7	26.3

Source: Mowery (1996) data attributed to IDC1994.

4.4 THE EMERGENCE AND EVOLUTION OF THE SOFTWARE INDUSTRY IN URUGUAY

The majority of the Uruguayan software firms are located in Montevideo and started their operations during the 1990s. In Latin America, this period was characterised by excess demand for software services and/or products. Nevertheless, demand cannot be considered a strong enough factor to justify the development of the software sector in Uruguay.

Public Policy

The main rationale behind the development of the software cluster in Montevideo was the presence of a group of well-qualified professionals. Education constituted a priority for the Uruguayan State, which succeeded in achieving one of the lowest illiteracy levels in Latin America (World Development Indicators, 2002)[55]. This group of professionals possessed a hybrid type of knowledge; they held technological knowledge, and also knowledge of a

specific market (i.e. financial, health, construction etc.). Not surprisingly, then, they managed to respond to the increasing demand for software products in Latin American markets.

A direct policy encouraging the emergence of the software sector was not in place in Uruguay. The impact of the State on the emergence of the software industry was indirect and entailed the building of human capital through investments in education. There are public as well as private university programs in Computer Engineering and Informatics in Uruguay. The majority of the graduates come from the Universidad de la República (47 per cent), while 45 per cent have studied in the University ORT. The Catholic University provides 5 per cent of the graduates and the remaining 3 per cent comes from the Instituto Universitario Autónomo del Sur and the Taller de Informática (Mejía and Rieiro, 2002). The number of graduates from computer study programs in Uruguay is somehow ambiguous. The main problem arises from the fact that at the Universidad de la República, Computer Engineering students also take an Analyst Programmers Licenciado degree as a part of their curriculum. Thus, they are counted twice when graduate statistics are reported (first as engineers and then as analysts/programmers). Although Mejía and Rieiro (2002) recognise the pitfalls of the statistics, they overestimate the numbers of graduates, reporting 2601 graduates from 1990 until 1999, a figure that represents 289 graduates per year. This picture clearly does not reflect reality. A better way to calculate the number of graduates would be to consider only the Analyst and Programmer graduates, since in the case of Universidad de la República, the aforementioned double counting problem occurs. Following this method, I found that an average of 230 graduates in Computer Studies received their degree every year in the same period[56].

As mentioned before governmental policy in Uruguay has not played an active role in the emergence of the software sector. The State was possibly even discouraging the strengthening of the capabilities of the software industry by offering the main government procurement projects to foreign firms (author's interview). Fiscal incentives were limited and started only in 1999, when the State finally expressed its interest in the software industry. Ever since software products have been exempted from taxes imposed on the revenues of industry and commerce (IRIC; Impuesto a la Renta de Industria y Comercio)[57]. In addition, the exports of software services are exempt from the value-added tax[58] (Pérez, 2004; Failache et al., 2004).

Most recently, in 2001, the LATU[59] in collaboration with the University ORT created an incubation program: the Ingenio. This initiative was financed by the Inter-American Development Bank (IDB). It hosted approximately 30 firms and offered infrastructure and training in order to strengthen the business and/or technical capabilities for firms. However, the participation was limited to firms that had their own resources; usually professionals with previous experience who took the decision to start a software business. In this respect, the program did not succeed in attracting a large participation, because it did not offer grants or other types of financing to participants. Software development requires approximately two years of R&D before product commercialisation. Although the President of LATU acknowledged the shortcomings of the incubation program with regards to the lack of grants, he also stated that, overall, the incubation program was a good experience for Uruguay.[60] From December 2005 the incubation program has given small grants to the participants in the form of a salary.

Simultaneously, the Uruguayan government initiated the PDT, Program for Technological Development (Programa de Desarrollo Tecnológico). The Ministry of Education and Culture was in charge of executing the project, which was 80 per cent financed by the IDB and 20 per

cent by the Uruguayan government itself. The main objective of the program was to stimulate innovation in SMEs in Uruguay and to encourage the mobility of domestic researchers. As far as the first objective is concerned, firms were asked to submit innovative projects to be financed. However, this program addressed all fields of research and not solely the software sector. Competition for financing was fierce and grants were difficult to obtain.

Another endeavour was the Program for the Support of the Software Sector, PASS (Programa de Apoyo al Sector del Software), which was implemented in 2002. This program was administered by CUTI and was 55% per cent financed by the IDB and 45 per cent by CUTI. The main objective of this program was to stimulate the export capability of firms. The campaign was geographically aimed at the Ibero-American[61] markets. According to one participant in this export program, the main strategy in entering a foreign market involved a series of calculated steps. 'Usually a local consultant, with an extended network of contacts and knowledge of the local market, is hired. In addition, we inform the potential customers, previous to our visit, about the software industry of Uruguay'[62]. The simplest strategy for exports is the search for distributors in the foreign market. A more advanced strategy which involves more transfer of knowledge is the creation of technology alliances with local software firms, which would assimilate and then commercialise the technology. Larger and dynamic firms would also open a branch in the foreign market, from which they would be able to offer the necessary services.

Finally, Zonamérica Business and Technology Park is a key location for a number of the most important software enterprises in Uruguay. This is a privately owned, tax-free zone that was founded in 2002 and is located in the outskirts of Montevideo. Zonamérica created a technological park, the so-called Silicon Plaza, using the most advanced specifications[63]. Besides software firms, other high-tech firms such as biotechnology firms are located in Zonamérica. Other firms are usually financial business, logistic and distribution centres. Firms located in Zonamérica are exempt from custom duties and taxes (Whitelaw, 2004). These are unique conditions, since in most free trade zones in the world only custom benefits are granted, while tax exemptions are only partially given. Consequently, Zonamérica Business and Technology Park offers many advantages to foreign firms wishing to enter the Latin American market. One of the largest Indian software firms, Tata Consultancy Services, decided to settle in Zonamérica. According to the Vice-President of TCS-Iberoamérica, the decision to invest in Uruguay and in particular in Zonamérica, was taken after careful examination of other alternative locations such as Costa Rica, Chile, Brazil and Argentina.[64] Among other reasons, the VP of Tata stressed that 'Zonamérica is considered to be the most advanced technology park in the Latin American region and in combination with the qualified personnel available at a reasonable price, combined with the political stability of Uruguay, it constitutes the best location for the objective of our business'.[65]

The small domestic market – driving force of exports

The literature on the software industry (Correa, 1996) suggests that the domestic market is the initial learning ground for software firms. It has been argued that the fragmented European market was one of the reasons for the European countries' failure to create a dynamic software industry (Malerba and Torrisi, 1996). Additionally, more than a decade ago, Schware (1992) compared the development of the Indian and Brazilian software industry, and favoured the Brazilian case when he clearly stated that "India has entered the software business with a short-sighted idea of merely earning foreign exchange rather than creating capabilities in strategic domestic segments for the formation of skills and diffusion of knowledge" (Schware, 1992, p. 160). The case of Uruguay challenges these views and offers an alternative scenario

for the development of the software industry (the further development of the Indian industry also disputes further the aforementioned views).

The key incentive for the Uruguayan software firms to export was the small size of the internal market. The Uruguayan software sector is a case of an industry that attempted to compete in international markets since its birth. The pressure of competition forced Uruguayan entrepreneurs to improve the quality of their products/services and to learn from sophisticated customers. Although the majority of the exports are directed towards the Latin American region (73.5 per cent), a small portion of exports is directed to advanced economies (23.5 per cent) (CUTI, 2004).

Type of Products

The section of Software Developers and Consultancies in Montevideo provide a range of products and services, which are usually software applications in the form of a standard or customised product (Stolovich, 2003; Mejía and Rieiro, 2002; Failache et al., 2004). Appendix E presents a classification of the software products produced in Uruguay. The degree of standardisation of the product is the main factor that differentiates custom-made products from registered packages (Bitzer, 1997). The sale of a customised product is in the form of services; implementation or adaptation of products, *ad hoc* solutions provided at one point in time in the form of consultancy, maintenance and training. The sale of a registered package has the form of a product similar to manufacturing products. In particular, software firms in Montevideo develop products to cover the needs of the financial market (banking, credit cards), the vertical market such as health, education, transport, and the horizontal market such as the management solutions for SMEs. Additionally, software firms develop tools that are used by other firms in the sector for their applications.

In summary, software firms in Montevideo offer vertical software products. At the beginning of the 1990s, software firms in Uruguay received the requirements for specific products and, in turn, fulfilled the needs of the customers. The managing director of a local firm said that "the business model resembled the duties of a scrivener[66]". At the same time, customers were considered as the 'sponsor godfather' of the company, financing the development of their first product. Once the product was ready, it could be sold to another customer through the recommendation of the previous customer. Consequently, during the first stage of the development of the software industry in Montevideo, most of the firms were developing custom-made software products for the vertical market (low degree of standardisation). The business model that was adopted was that of the software contractor (see Table 4.3).

Nowadays, reality has changed dramatically; demand has been met and competition among software firms is fierce. Despite the effects of the Argentinean crisis, the software cluster in Montevideo continues to be a vibrant industry and to compete in foreign markets. What changes have occurred in the business model of the firms that managed to survive despite the adverse economic climate? There are two dominant business models in Uruguay: firms that develop software products and firms that provide software services. During the second stage of the development of the software industry in Montevideo, a large number of firms created standard products (with many applications-high degree of standardisation); this more closely resembles the business model of the corporate software products (see Table 4.3). Another group of firms focused on consultancy services (they focus on a core area of specialised services); they continued to be software contractors, but with a higher degree of sophistication. As a result, firms in both models could realise economies of scale and scope respectively, and capture high profits. However, another group of firms did not manage to

pass to this second stage successfully. This group of firms still provide custom-made products while at the same time attempting to standardise and commercialise their products.

Official Sources of Information

As already mentioned in the introduction, the statistics relating to the software sector in Uruguay, as in the case of other countries, are ambiguous. The official statistics offer information that is gathered from the annual survey of economic activity of Uruguay, carried out by the National Institute of Statistics since 1997. Bizarrely, the National Economic Census (IV CEN1997) considers only firms with more than 50 employees and firms with 5-19 employees. The Annual Survey of Economic Activity (EAE) of 1998 and afterwards consider all firms with more that 5 employees. Table 4.5 shows the information that is provided by the National Institute of Statistics.

Table 4.5: INE Survey (economic activity – category 72)

72 ISIC R.3 (current US dollars)	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Production	72,774,263	66,511,879	84,906,672	92,903,476	91,787,784	84,157,036	74,719,357
Value Added	37,765,591	41,086,623	46,593,543	53,602,717	45,116,333	40,639,519	34,495,329
Employment	1,398	1,088	1,095	1,487	1,771	2,072	2,009
Remunerations	23,137,906	25,522,141	24,689,281	23,956,133	25,107,327	17,162,631	13,048,705
Total Sales	n.a	80,715,694	99,457,669	106,825,259	107,194,400	n.a.	n.a.
Domestic Sales	n.a.	79,854,453	95,790,564	101,700,004	100,407,852	n.a.	n.a.
Total Exports+	n.a.	861,241	3,667,106	5,125,654	6,786,548	n.a.	n.a.
Share of Exports	n.a.	1%	3.7%	4.7%	6.3%	n.a.	n.a.

Source: Authors calculation from original data on current pesos from the National Institute of Statistics –Uruguay-2005; Exchange rates (peso/dollar) for every year from IMF.
[+] Export figures do not include exports from tax-free zones.

The other source of information on the software sector in Uruguay comes from the Business Association of the software firms, CUTI. It carries out an annual survey and collects information on a sample of 149 firms with more than one employee and 1600 individual Software Development and Consultancy Service firms. However, the results of the survey are not available to the public. CUTI published two reports about a survey in 2002 and another one in 2004. A fraction of the results of the 2002 survey are shown in Table 4.6, while parts of the results of the 2004 survey are shown in Table 4.7. The years in which the information provided by the two surveys conducted by CUTI coincide (2000, 2001 and 2002) show different figures for the total sales. This difference is caused in particular by discrepancies in the domestic sales figures. While exports are the same in both surveys (approximately 80 million US dollars), domestic sales are about 30 per cent higher in the second survey. One explanation for the discrepancy between the two surveys by CUTI could be the expansion of the survey to include more firms (which are mainly oriented towards the local market).

Table 4.6: CUTI Survey (category Software Development and Consultancy Services)
(Survey 2002)

Software Development & Consultancy Services (current US dollars)	**1999**	**2000**	**2001**	**2002**
Total Sales	180,030,000	174,900,000	181,800,000	145,800,000
Domestic Sales	104,930,000	97,200,000	99,600,000	66,700,000
Total Exports	75,100,000	77,700,000	82,200,000	79,100,000
Share of Exports	41%	44%	45%	54%

Source: CUTI (2002)

Table 4.7: CUTI Survey (category Software Development and Consultancy Services) (Survey 2004)

Software Development & Consultancy Services (current US dollars)	**2000**	**2001**	**2002**	**2003**	**2004**
Total Sales	203,500,000	212,800,000	170,500,000	157,700,000	168,000,000
Domestic Sales	124,702,650	130,205,420	91,103,900	84,394,900	88,399,350
Total Exports	78,797,350	82,594,580	79,396,100	73,305,100	79,600,650
Share of Exports	38%	39%	46%	46%	47%

Source: CUTI (2004)

The results of my survey are reported in table 4.8. I have based my survey on information concerning a sample of 98 firms of Software Development and Software Consultancy Services with more than one employee (single-person firms were not considered).

Table 4.8: Author's Survey (category Software Development and Consultancy Services) (Survey 2004)

Software Development &Consultancy Services (current US dollars)	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Total Sales	151,070,143	163,417,361	169,681,220	159,664,090	149,864,090	182,244,417
Domestic Sales	114,438,031	118,122,144	110,209,478	107,422,431	104,350,110	103,376,707
Exports	36,632,112	45,295,217	59,471,742	52,241,659	45,513,980	78,867,710
Share of Exports	24%	28%	35%	33%	30%	43%

Sources: Author's Survey

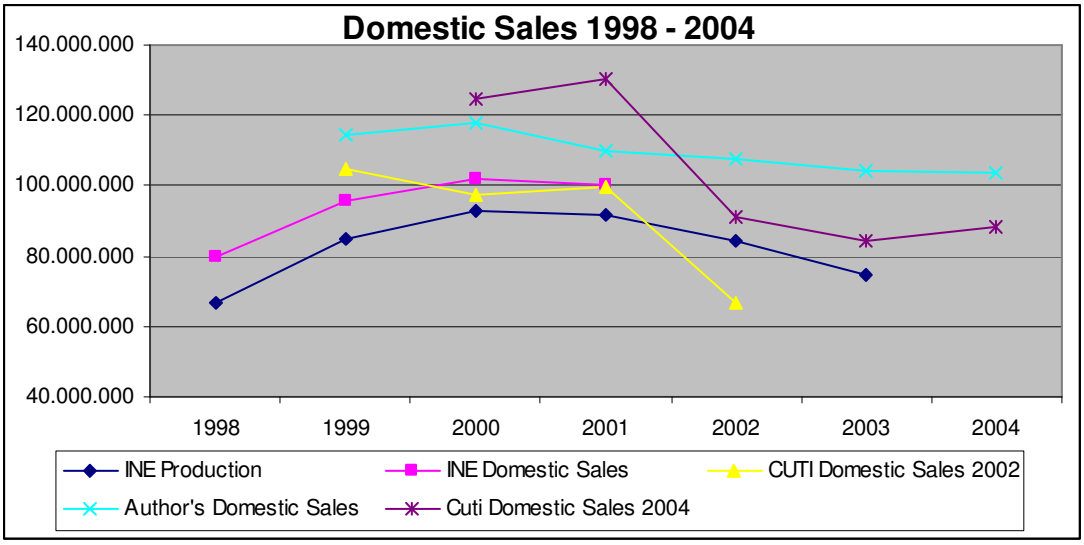
We notice that the results provided by the three different sources (INE, CUTI and author) do not match. First, the total sales of INE (106 million in 2000) are much lower than the total sales reported by CUTI (approximately 174 million in the same year according to the Survey 2002; approximately 203 million in 2000 according to the Survey 2004) and also much lower than the results of the author's survey (approximately 163 million for the same year).

The figures for the domestic sales reported by the three different sources are much closer. For example, INE reports 101 million US dollars in domestic sales in 2000, CUTI claims that domestic sales were 97 (Survey 2002) and 124 (Survey 2004) million US dollars in the same year, and the author's survey shows that domestic sales were 118 million US dollars in 2000. Consequently, the main difference among the diverse sources of information is caused by the figures relating to the exports of the software firms.

INE reports that exports of the firms were 5 million US dollars in 2000. In contrast, the CUTI survey indicates that exports were 78 million US dollars, while the author's survey indicates exports worth 45 million US dollars. The main explanation for the big discrepancy between the figures of INE on one hand, and the CUTI and author's survey on the other, may be found in the peculiar method of registering exports used by INE. INE does not take into account exports carried out from the free-export zones in the country. These exports are tax-free and do not contribute to the public income. Thus, they are not considered as relevant by the INE survey. Overall, the CUTI survey is a more reliable source of information relative to INE.

Figure 4.4 exhibits the evolution of the domestic sales of the Uruguayan software sector. From 1998 to 2001, sales grew steadily, while in the subsequent years they started to diminish. A further discrepancy between the various survey sources is noticeable while assessing domestic sales. According to INE and the author's survey, domestic sales diminished gradually, while CUTI affirms that they dropped rapidly. One explanation for this disagreement could be due to the fact that the CUTI survey also includes single-person firms, which mainly sell their consultancy services to the domestic market. These firms have been affected enormously by the crisis of 2001.

Figure 4.4: Domestic Sales of the Uruguayan Software Sector (Constant prices)



Source: INE, CUTI, author's survey.

As I mentioned in section 3.6.1 of Chapter 3, the full population of the software firms was identified and asked to participate to the survey. All the large, medium and small firms were included in the sample. The non-responding firms were micro firms (<10 employees). Table 3.1 presented the main characteristics of the sample firms. We notice that micro firms were quite well represented in the sample; from the total of 103 micro firms, I interviewed 50 (48.5 per cent). Thus, I will attempt to estimate the sales and exports of the full population of the Uruguayan software sector assuming that the 51.5 per cent non-responding micro firms are similar to the 48.5 per cent of the micro firms in the sample.

Table 4.9: Projection of Sales and Exports for the full Population of the Uruguayan Software Sector

Software Development & Consultancy Services (current US dollars)	**2004** (sample data)	**2004** (full population estimates)
Total Sales	177,217,000	183,312,000
Domestic Sales	98,350,000	103,650,000
Exports	78,867,000	79,662,000
Share of Exports	44.5%	43.5%

Sources: Author's calculations based on author's survey.

The average sales of a micro firm in the sample were 115,000 US dollars in 2004. Thus, the total sales of the 53 non-responding firms are estimated at 6,095,000 US dollars. 15,000 US

dollars was the average export of micro firms. For 53 firms, total exports would be 79,000 US dollars. Table 4.9 shows the estimates of sales and exports for the total population of software firms in Uruguay.

If we compare our results (Table 4.9) with the figures of CUTI (Table 4.7) in 2004, we find that they coincide to a large degree. In particular, both sources estimate that the exports of the Uruguayan software sector are approximately 79,600,000 US dollars. However, CUTI's survey underestimates the total sales of the sector because it does not include the whole population. In doing so, it overestimates the export share of the sector (47 per cent). The inclusion of the micro firms in our sample lower the export share of the sector (43.5 per cent). Overall, one can say positively that the software sector in Uruguay exhibits a high share of exports, although this derives from only a few (12 large and medium) firms. Although the other firms are less export intensive, they are well connected to the local market and may facilitate the local diffusion of knowledge not only among software firms themselves, but also to other sectors.

4.5 COMPARISON OF THE URUGUAYAN SOFTWARE INDUSTRY WITH THE BRASILIAN, CHINESE AND INDIAN CASES.

Brazil, China and India are among the few developing countries that have created a significant software industry. What are the reasons behind the development of a high-tech sector, such as the software sector, in these developing countries? The statistics on the growth of the sales of software, as shown in Table 4.12, indicate the rapid development of the software industry in these countries. In particular, Brazilian software sales were 7.7 billions U.S. dollars, while the sales of China and India were approximately 9 billions in 2001. The growth rate, during the decade 1991-2001, was 38 per cent p.a. in Brazil, 65 per cent p.a. in China and 43 per cent p.a. in India. The share of exports in India (79 per cent) is noteworthy. I will compare these cases to the Uruguayan software industry, identify their similarities and differences and illustrate why Uruguay is an important case for the creation of local software industries.

Table 4.10 exhibits the macroeconomic features of Uruguay, the three aforementioned developing countries and three advanced economies, which are all used as references due to the fact that they are among the leading players in the software industry. In particular, Israel and Ireland are examples of latecomers to the software business which have managed to establish an internationally competitive software industry. In this respect, their examples could be easier to replicate in developing countries than that of the U.S., which has the advantage of early entry and thus, the exploration of unique conditions.

Economic growth has been sluggish in some countries and faster in others. Economic growth was remarkable in China between 1990 and 2002, a period in which the Indian economy also grew very fast. Comparatively, Latin American countries seem to have grown modestly. However, they seemed to recover fast in 2004 and Uruguay led the way with a remarkable jump into a double digit growth. Developed countries grew slowly, as anticipated. However, in the last decade the Irish economy has experienced a significant growth of 7 per cent. This means that Ireland joined the club of the advanced economies only recently.

Table 4.10: Macroeconomic data 1990-2003

	Uruguay	Brazil	China	India	Ireland	Israel	United States
GDP growth							
1990-2002	1.2	2.5	9.7	5.3	7.1	4.4	2.9
2003/2004	12.2	5.1	9.5	6.9	4.9	4.3	4.4
Current Account Balance (% of GDP)							
1990	2.0	-0.8	3.3	-2.2	-0.7	0.3	-1.3
2000	-2.8	-4.0	1.8	-1.0	-0.3	-1.3	-4.2
2003	0.4	0.8	3.2	1.1	-1.3	0.5	-4.8
Inflation (annual %)							
1990	106.8	2509.4	5.6	10.5	-0.7	15.8	3.8
2000	3.9	9.7	0.9	3.7	4.2	1.8	2.1
2003	18.3	14.9	2.0	3.1	1.5	0.3	1.8
Foreign direct investment (% of gross capital formation)							
1990	0.0	1.1	2.8	0.3	6.3	1.1	4.7
2000	9.7	25.3	9.7	2.4	107.5	20.3	16.0
2003	18.8	11.6	8.5	3.0	-	20.8	-

Source: Authors calculations based on information from the World Bank (2005)

Almost all of the countries exhibit current account deficits with the exception of China. Among the reasons that set China apart from the rest of the developing countries were her sharp rise in FDI during the 1990s and the robust export growth of manufacturing goods (Szirmai, 2005). As a result, China exhibited current-account surplus.

Inflation has been a recurrent problem for the Latin American countries over the past four decades. Table 4.10 shows how Uruguay and Brazil were faced with very high inflation in the 1990s. Why did Uruguay and Brazil suffer from a chronic inflation while the Asian countries did not? Although there is no agreement with regard to what might have provoked inflation in Latin America, one of its most important causes may be related to the fact that during the import-substitution period, government expenditures in many Latin American countries, including Uruguay and Brazil, were high.[67] However, these expenditures were not adequately financed by increased tax revenues, which resulted in large deficits and accelerated inflation (Fishlow, 1990). Furthermore, exchange-rate overvaluation imposed barriers to local exporters and caused shortages of foreign exchange (Shatz and Tarr, 2000; Amann and Werner, 2003). These deficits were financed with external borrowing, which slowed down after the oil crisis in 1979, and triggered an even greater increase in the public expenditures. The global recession (OECD countries) that followed found Latin American countries extremely indebted and disconnected from the global economy[68]. Unsurprisingly, Latin American countries entered a deep crisis and inflation became the crucial concern of public policy.

With regard to the importance of foreign direct investment (FDI), scholars such as Markusen and Venables (1999) have stressed that FDI may generate benefits to developing countries. In particular, it is stressed that FDI improves the productivity of the economy by creating

linkages with other productive sectors (Rivera-Batiz and Rivera-Batiz, 1990). In his case study of FDI in East Africa, Portelli (2006) offers some evidence regarding the creation of backward linkages between MNCs and local suppliers in Tanzania, and underlines the strengthening of capabilities of local suppliers. Finally, FDI can open markets for exports by local producers (Markusen and Venables, 1999). Table 4.10 indicates that the share of FDI in gross capital formation has, for Brazil and Uruguay, grown considerably. This is the outcome of liberalisation policies which took place after 1990 and attracted FDI. In particular, Uruguay exhibits an astonishing increase in the inflow of FDI, which accounts for approximately 19 percent of its gross capital formation.

Table 4.11: Human Capital and Communications Infrastructure in 2000

	Uruguay	Brazil	China	India	Ireland	Israel	United States
Income							
GDP per capita in 2000 (PPP$)	8,831	7,366	3,821	2,416	30,283	23,800	33,989
Education							
School Enrolment tertiary (% gross)	36.1	16.5	9.7	10.8	47.3	52.6	70.6
Research							
R&D expenditure (% of GDP)	0.2	1.0	1.0	0.8	1.2	3.3	2.6
Patent applications, non residents	572	64,645	96,714	60,852	119,569	39,742	121,445
Patent applications, residents	44	41	25,592	90	1,226	2,529	141,342
Personal computers and Internet							
Personal computers (per 1000 people)	105	50	16	4	359	253	572
ICT expenditure (% of GDP)	6.1	5.5	4	3.6	5.6	8.1	9.5
Internet users (per 1000 people)	111	29	17	5	179	202	440
Internet total monthly price ($)[69]	26.5	28	10	8.7	28.3	29.7	15
Secure Internet servers[70]	39	1580	182	281	784	562	138514
Telecommunications							
Telephone mainlines (per 1000 people)	278	182	112	32	483	474	664
Mobile Phones (per 1000 people)	123	136	66	3	650	701	389
Telephones cost of local call ($ per 3 minutes)	0.1	0.03	0.02	0.01	0.1	0.01	0.09
Telephone cost of call to US ($ per 3 minutes)	4.8	1.7	6.7	3.3	0.7	3.3	N.A.

Source: World Bank (2005)

Table 4.11 presents the income levels and the developments in human capital and communication infrastructure of the examined countries. The software industry requires qualified personnel and a suitable infrastructure in order to flourish. The development of software is a knowledge intensive and in particular skill-intensive activity. Qualified

personnel are crucial for the success of a software firm. Although capital investments are important because they improve the productivity of software firms[71], they do not constitute an entry barrier for software firms compared to other high-tech industries such as microelectronics (Correa, 1996).

With respect to the income levels, Uruguay and Brazil have a similar income per capita; they both represent countries with a medium level of development. On the other hand China and India show very low income per capita. Human capital indicators suggest that Uruguay is closer to developed countries' standards. This is mainly due to the model of social policy that the government has followed throughout the history of Uruguay, which was based on social services and in particular, on the provision of free education at all levels. 36 per cent of the respective age population in Uruguay follows a tertiary education. This sets Uruguay apart from other developing countries. Precisely the opposite can be said about Brazil, China and India, all of which show very low enrolment ratios in tertiary education.

Uruguay also shows the lowest figures in research activity (expenditure and output) among the developing countries listed in the table. The expenditure of the Uruguayan government on R&D is a meagre 0.2 per cent of GDP. Accordingly, patent applications during the same period were only 616. In contrast, Brazil, China, India and, Ireland, spent more on R&D than Uruguay (around 1 per cent of their GDP). The majority of the patent applications in the aforementioned countries, including Uruguay, are from non-residents. China, with approximately the 80 per cent of the patent applications made by residents, is the only exception.

The communication infrastructure in Uruguay is considerably better than that in the other LDCs listed in the table. As already mentioned in section 4.4, Uruguay has one of the most advanced technology parks in the world. Additionally, Table 4.11 shows that the country has a nationwide network of telecommunications and computer/internet infrastructure. Such an infrastructure is crucial for the development of the software industry and for the diffusion of its products to the domestic market. However, the communication infrastructure seems to be more expensive in Uruguay than in the other developing countries (in particular when compared to Brazil and India). High expenses for the use of communication infrastructure could erect a barrier to the further development of the software industry in Uruguay.

Table 4.12 shows the main characteristics of the software industry of a group of developing countries (the first 5) and two advanced economies. It is clear that all of the developing countries included here provide mainly software services. In contrast, developed countries offer software products. As I discussed in section 4.3, entry barriers for the business model of software services are lower than those of software products. Software products require high initial investments in R&D. In contrast, software services rely more on the capabilities of their personnel than on accumulated R&D. Therefore, any developing country is expected to have easier access to the business of software services. In this sense, Uruguay follows the trajectory of the other developing countries.

Table 4.12: The Software Industry in Different Countries

	Uruguay	**Mexico**	**Brazil**	**China**	**India**	**Ireland**	**Israel**
Type of Software	Mainly Customized Software Services	Mainly Customized Software Services	Mainly Customized Software Services	Mainly Customized Software Services	Mainly Customized Software Services	Mainly Software Products	Mainly Software Products
Market Orientation	Exports	Local	Local	Local	Exports	Exports	Exports
Ownership of firms	Mainly Indigenous	Mainly Indigenous	Mainly Indigenous	Mainly Indigenous	Mainly Indigenous	Mainly Foreign	Mainly Indigenous
Government Support	Absent	State Coordination	Strong State support	Strong State support	State Coordination	State Coordination	Strong State support
Agglomeration tendencies	Complete agglomeration	Agglomeration in 4 locations	Agglomeration in 4 locations	Agglomeration in 3 locations	Agglomeration in 5 locations	Complete agglomeration	Scatter
Total Software Sales ($) 1991 2001	 8 million [a] 212 million	 n.a. 196 million	 300 million 7,7 billion	 60 million 9,1 billion	 560 million [b] 9 billion	 2,2 billion 13 billion	 650 million 7,1 billion
Growth rate 1991-2001	31% [c]	9 % [d]	38.1%	65%	43.1% [d]	19.5%	29.9%
Growth rate 2000-2001	4.5%	n.a.	6.9%	26.4%	23%	29%	12.7%
Sales/GDP	1.01%	0.03%	1.26%	0.78%	1.96%	12.91%	6.17%
(Sales/GPD)/ (GDP per Capita)	 1.14%	 0.03%	 1.71%	 2.04%	 8.14%	 4.26%	 2.59%
Export share 1991	3% [a]	n.a.	n.a.	n.a.	58.9%	92%	42.3%
Export share 2001	39%	n.a.	2%	8.9%	79%	93%	42.3%

[a] In 1989.
[b] In 1993.
[c] Growth rate 1989-2001
[d] Growth rate 1993-2001

Sources: Uruguay (Snoeck, Sutz and Vigorito, 1992; The Uruguayan Chamber of Information Technologies, 2004; www.cuti.org.uy). Mexico (Duran, 2003). Brazil, China, India, Israel (Commander, S., 2005). Ireland (National Software Directorate, 2006; www.nsd.ie).

Developed and developing countries make use of different commercialisation strategies. Developed countries sell their products mainly to international markets, while developing countries follow a variety of strategies. Brazil and China provide software products mainly for their local markets, while India is export-oriented. Uruguay, remarkably, follows a different path. Uruguayan exports constitute approximately the 40 per cent of the total software sales. This implies that the local market absorbs a large part of the software products, while another substantial part is exported.

It is important to consider the nature of the ownership of the software industry in the aforementioned countries in order to comprehend whether the knowledge and capabilities, which characterise a high-tech industry such as software, reside in indigenous or foreign firms. Table 4.12 illustrates that most of the countries, with the exception of Ireland, have developed indigenous capabilities.[72]

Government policy was the main driving force for the generation and development of the software industry in Brazil, China, and Israel[73]. In the case of Ireland, India and Mexico[74] the role of the State was rather that of coordinator. Government policy attempted to strengthen and facilitate the development of the sector. Finally, in Uruguay, the government has only recently taken a more active role in supporting the software sector; government policy was absent throughout the creation and the initial development of the sector.[75]

The location patterns of the software industry in the examined countries differ. Uruguayan firms are agglomerated in the capital city, like Irish firms[76]. One reason for the complete agglomeration of the software industry in one location could be that firms enjoy the advantages of knowledge spillovers due to firms' interaction, labour mobility and university-industry contacts. In the other featured developing countries, the software industry is clustered in approximately three to five locations. One explanation for the more dispersed pattern found in these countries could be the fact that these are large countries that can sustain more than one cluster. Finally, Israel shows a more scattered pattern of location. Despite the fact that 21 per cent of the Israeli software firms are concentrated in Tel Aviv, the rest of the firms are dispersed over more than five locations.

The sales of the software industry in the respective countries are an indication of the size of the industry. However, interpretations should be cautious, because these statistics do not include value added data and thus overestimate the value of the output. The sales of Ireland are well above those of the other countries, followed by India, China, Brazil, Israel, Uruguay and finally Mexico. Some of the countries in Table 4.12 are very large, while others are small. Thus, it is important to consider the size of the country. Hence, I have also shown software sales as a percentage of GDP. We see that the relative importance of the software sector in Uruguay is higher than the respective sector in the context of the Chinese economy but it is still far behind countries like Ireland or Israel. The software industry is very significant in Ireland where it represents the 13 per cent of GDP and in Israel where it represents 6 per cent of GDP. Another problem arises when countries with different levels of development are compared. The GDP of advanced economies is predominately characterised by a larger share of high-tech industries than that of the developing economies. Consequently, it is wise to control for the level of economic development by dividing the share of software sales in GDP by GDP per capita (Botelho et al., 2005). This indicator exhibits the importance of the software industry in India. In the case of Uruguay, is apparent that a sizeable software industry has developed. Finally, if we compare Uruguay with Mexico, the contrast could not

be more striking. Mexico, like many other Latin American countries, has built a software industry to serve the needs of the local market. Although Mexico is located next to U.S. and the NAFTA agreement facilitates trade relations with North America, the software sector remains very small (Botelho et al., 2005).

I will now examine the software sector in Brazil, China and India in more detail. These are the three developing countries that stand out because they have managed to create a large software industry quite rapidly.

Brazil

The pre[77]-and post[78]-liberalisation State policy and the increasing local demand for software products were the main reasons for the emergence of the Brazilian software industry. As Table 4.12 demonstrates, the software industry in Brazil is an inward-oriented industry (the export share of the software sector in 2001 was 2 per cent of total sales). The main products that firms offer are custom-made software products.

Botelho, Stefanuto and Veloso (2005) view the future success of the Brazilian software industry as conditioned by the presence of sophisticated local clients and the presence of competition which acts as a selection mechanism. Until now, local demand derived from two main sources in Brazil: the public sector and the private sector. The financial and telecommunications sectors especially are highly advanced in Brazil, and have contributed to the enhancement of the capabilities of local software firms. Local competition after liberalisation was vigorous and forced indigenous firms to compete with MNCs. However, Botelho et al. (2005) are sceptical about whether the local market will be a sufficient force to induce the new industry to learn and grow, and not to become a barrier to its further development.

Behrens (2005) is more critical of the reasons that lie behind Brazil's low export performance. Although SOFTEX set a target of 2 billion U.S. dollars of exports by 2000, only 100 million were actually realised. This failure, according to Behrens (2005), was due to wrong policies of SOFTEX and weak capabilities of local firms. In particular, SOFTEX promoted local software products which were not successful in international markets. The main reason for this failure was the fact that Brazilian software was a response to local business problems and/or imitation of foreign software; it was not original enough to address the needs of international customers.

China

As anybody would expect, in China the software industry is strongly influenced by the government. This is not surprising because the Chinese economy in general is still coordinated and managed by the State. Numerous Chinese software firms were supported by government research (University, Research Institutes, State Enterprises) and funding. Additionally, many of the founders of Chinese firms are ex-government officials or university professors. For example, Tschang and Xue (2005) interviewed a sample of thirty firms, half of which trace their origins to government, university and the CAS[79]. As in the case of Brazil, state intervention accounts for the emergence of the software sector in China.

The Chinese software industry is inward looking; it mainly addresses the needs of the local market. This inward orientation contrasts with the cases of India and Uruguay, and resembles the case of Brazil. The Chinese software industry is extremely fragmented and formed from many small firms with low level of specialisation and weak capabilities (Tschang and Xue,

2005). The main products that the Chinese software industry provides are low added value services such as system integration and accounting systems, and finally products allowing for Chinese language adaptation.

A threat similar to that in Brazil engenders industries that are inward-looking and strongly supported by the State. Despite the impetus in the emergence of the software sector, continuous support of governmental policies may generate inefficiencies. For example, Tschang and Xue (2005) are concerned with the outcome of government procurements and the favoured position of many local firms. If local software firms rely too heavily upon large governmental contracts, they run the risk of not increasing their capabilities to international standards.

Saxenian and Quan (2005) stress that the regulatory and legal institutions that manage the open economy have not yet replaced the old Chinese structures of bureaucracy and corruption. In this respect, social networks and trust emerge as substitutes of law and the formal system of regulations.

There is evidence of the preferential treatment of software along with other high-tech industries by the Chinese government. In this respect, the Chinese case recalls the 'picking winners' strategy of South Korea, with the objective to create 'national champions'. Compared to the sophisticated customers that exist in Brazil, Saxenian and Quan (2005) claim that the domestic market is immature and not sophisticated enough. The latter is mainly formed by the government and State-owned enterprises. Chinese software firms lack managerial experience and continuous support by the government will not help them to build such capabilities.

India

The Indian software industry is well known for its ability to ‘deliver a working team of software professionals to any part of the world to do any software engineering job’ (Athreye, 2005. p.27). In other words, the main capability of the Indian firms resides in establishing a business model based on outsourcing software services to international customers, mainly to the United States.

Desai (2005) downplays the common belief that the success of the Indian software industry was due to its low wages, the wide use of the English language and the abundance of human capital. Additionally, he argues that factors such as the 6 hours difference with U.S. that enabled U.S. firms to work 24 hours and the presence of the Indian engineers in U.S. who facilitated the entrance of Indian firms into the U.S. market played some role in the development of the Indian software sector. He claims that the most important reasons for the emergence and further success of the Indian software industry relate to historical accidents and advancements in technology (by advanced economies). Among the most important factors for the emergence of the Indian software industry are the following (Desai, 2005):

- The exit of IBM from India in 1978 which left behind qualified personnel;
- The presence of Indian engineers in U.S. which facilitated the recruitment of Indian programmers by U.S. firms during the 1980s, the so-called body-shopping.
- The development of wireless satellite links making possible the emergence and sophistication of a business model of offshore software development.

In my opinion the emergence of the Indian software industry was due to the low wages, English language and the presence of qualified employees. However, the success of the Indian

software was neither based only upon the aforementioned reasons, nor was a historical accident as Desai (2005) suggests. According to Athreye (2005) the business models of Indian firms became increasingly sophisticated during the 1990s. They adopted the offshore model. They managed to address the needs of MNCs by increasing their organisational efficiency, and were among the first to acquire quality certifications, such as the CMM. In addition, many of these firms managed to specialise in domains such as financial services, thus becoming experts in their field. Finally, these firms cemented their credibility by going public, something that offers a wide contrast to the Chinese case.

India's main difference when compared to Brazil and China is that its software industry has focused on exporting rather than on domestic production. As in the case of Uruguay, Indian firms were exposed to international competition (Mani, 2006). Even more than in the Uruguayan case, they addressed the needs of a demanding market, namely the U.S. market. The Indian government responded with policies to help the software industry to develop further.[80] Quite the opposite happened in the cases of Brazil and China, where the government was one of the main reasons for the emergence of the local software industry (see Veloso, Botelho, Tschang, and Amsden, 2003).

The lesson that can be learned from the comparison between Uruguay and Brazil, China and India is that the Uruguayan case shares some similar features with the development of the software industries in other countries, but at the same time, it is a unique case. As with the other latecomers to the software industry, Uruguay offers customised products and services to the vertical market (and not packaged products to the horizontal market which are mainly offered by U.S. firms). Uruguay like India is an export-oriented software industry that managed to learn from international customers and find its place in the global software industry. Similarly to other developing countries, the majority of the firms in Uruguay are owned by local entrepreneurs. This implies that Uruguay has developed the capabilities and skills for building an indigenous software industry. In contrast to all the other examined cases, the Uruguayan software industry has emerged without public support and has developed advanced skills and capabilities. The success of the software industry in Uruguay cannot be attributed to State policy, like in the case in most of the other countries (and partially in India, Ireland and Mexico). Finally, the software industry in Uruguay is clustered in one location. Agglomeration advantages could be one of the reasons for the development of the Uruguayan software sector.

4.6 CONCLUSIONS

In this chapter I have presented the development of the software industry in Uruguay with reference to three important issues: a) the structure of the economy of Uruguay; b) the U.S. paradigm in the software sector; and c) the path that other developing countries have followed in creating a software industry.

In sum, we have seen that Uruguay is predominately an agricultural economy with a weak industrial base. Additionally, government policy has not triggered the emergence of the software industry as has happened in the cases of China, Brazil and Israel. Even now the State does not support the development of the Uruguayan software sector with specific policies, as in the case of India.

I have stressed that developed countries mainly provide software products, while developing countries focus on providing software services. However, among the developing countries,

the level of product sophistication differs. China offers low value software, mainly system integration products. Brazil and Uruguay offer more sophisticated products such as software applications. Finally, although until recently offering low value services, India has managed to create a profitable export-oriented business model and to benefit from it. Among the benefits besides profits and foreign exchange, are the increase in reputation and credibility which serve as sources of impetus for new Indian firms offering more advanced software products.

While China and Brazil address mainly the domestic market, the growth of the Indian software industry has been based on exports. In comparison, Uruguay has a more mixed market, within almost half sales being export-oriented while the rest address the local market. This is a unique case because clearly the Uruguayan software sector has developed not only international linkages but also local ones. Export-oriented versus inward-oriented development constitutes a significantly different learning and development path. A predominant view is that export-led growth exposes firms to dynamic international competition, which reinforces the capabilities of strong firms at the expense of weak firms.[81] In addition, firms in an export scenario have the possibility to learn from sophisticated customers. In the case of the inward-looking industry, firms could very well learn from domestic customers, focus on R&D and specialise in a specific domain. However, the inward looking industry may suffer from inefficiency and from not providing incentives to local industry for upgrading its capabilities. Uruguay might learn from competition from abroad and these lessons could circulate locally and benefit firms that are focused on the domestic market. Hence, the Uruguayan software sector is in an excellent position to avoid suffering from the disadvantages of a one-sided orientation

Finally, Uruguay exhibits a pattern of complete agglomeration similar to that of Ireland. Clustering can generate knowledge spillovers and other advantages which enhance the innovative capabilities of firms. This is an advantage that could reinforce the development of the Uruguayan software industry.

CHAPTER 5

THE IMPORTANCE OF LOCAL KNOWLEDGE S SPILLOVERS FOR THE INNOVATIVE AND ECONOMIC PERFORMANCE OF FIRMS: A QUANTITATIVE ANALYSIS

5.1 INTRODUCTION

The purpose of this chapter is to examine empirically whether local knowledge spillovers in clusters are important drivers of innovation and learning within the context of developing countries. Using new firm-level data, I test whether LKS affect the innovative and economic performance of the firms within the Uruguayan software cluster. The outcome of this analysis will contribute to a better understanding of the significance of LKS in high-tech clusters in developing countries. It will indicate whether LKS can contribute to innovation and economic development through a cluster-driven trajectory.

The remainder of this chapter is structured as follows. In section 2, I present the conceptual model and the research questions. In section 3, I conduct an empirical analysis and then I discuss the results. Section 5, summarises the conclusions.

5.2 CONCEPTUAL MODEL AND RESEARCH QUESTIONS

Figure 5.1 presents the conceptual model that was introduced in Chapter 3. The present model includes the variables that will be used to measure the respective concepts. This chapter will address the first five questions that were posed in Chapter 3 (see Appendix D for the presentation of all the variables):

RQ 1: What is the quantitative distribution of the different mechanisms of knowledge flow over the firms within the cluster? In particular, do LKS play a significant role among these mechanisms?

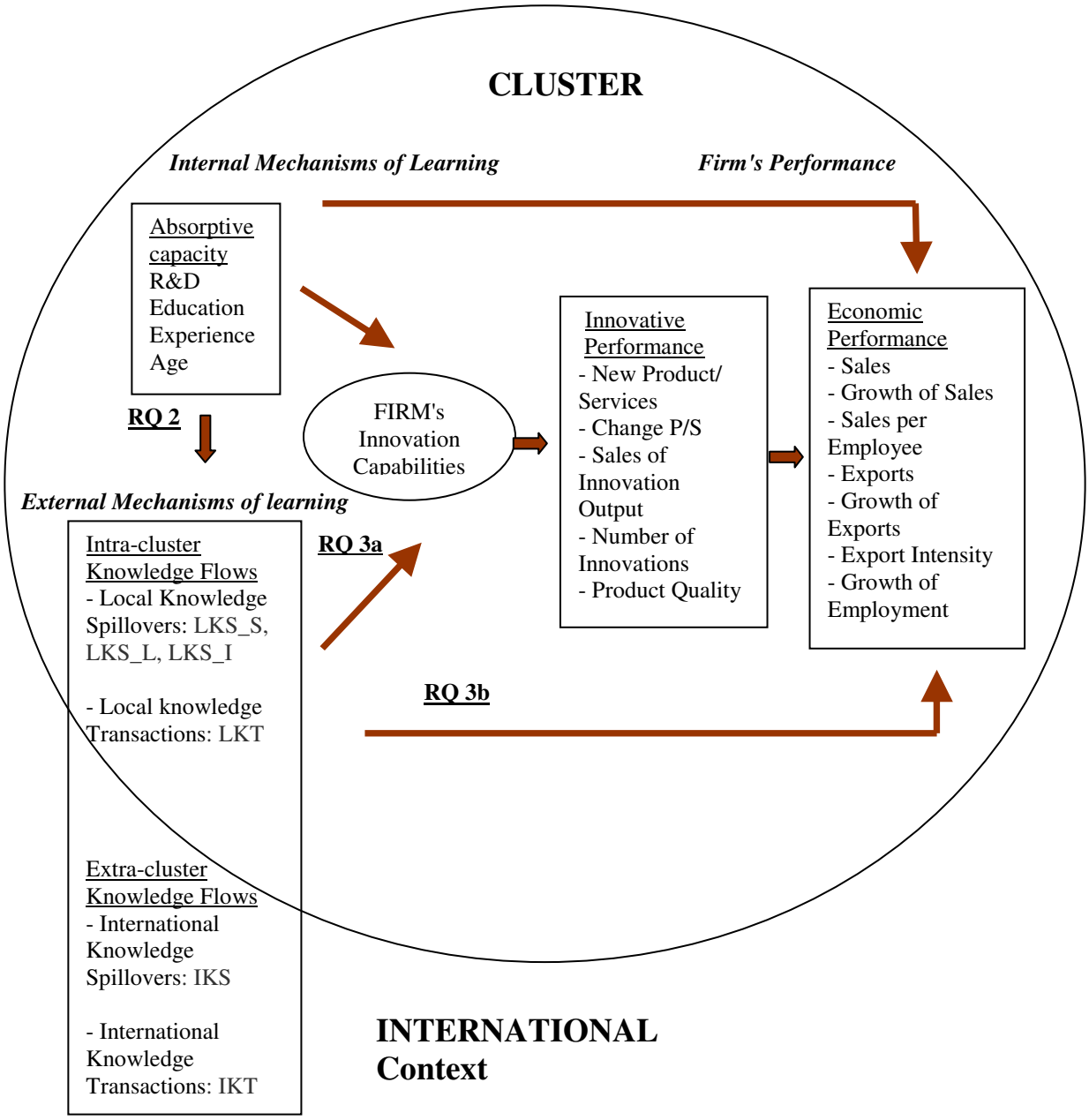
RQ 2: How strong is the correlation between the internal (to the firm) mechanisms of learning and the use of a particular type of external knowledge flow? Do firms with different absorptive capacities use different types of external knowledge flows?

RQ 3: How important are LKS and other mechanisms of knowledge flow for firms' (a) innovative and (b) economic performance?

RQ 4: How important are intra-cluster and extra-cluster mechanisms of knowledge flow for the (a) innovative and (b) economic performance of firms?

RQ 5: Is the role played by LKS in developing country clusters, and in particular in the Uruguayan software cluster, in any way different from the function of LKS in high tech clusters in economically advanced countries?

Figure 5.1: Conceptual Framework - Local Knowledge Spillovers and Innovation[82]



Source: Author

5.3 EMPIRICAL ANALYSIS AND RESULTS

5.3.1 Descriptive statistics

Appendix F presents the descriptive statistics for all the variables that are used in this analysis. I pay particular attention to the variables that indicate the innovative performance of the firms and the ones that denote the mechanisms of knowledge flow.

Innovative performance

First, I examine the frequency of the distribution of the variables that denote the innovative performance of the firm. Almost half of the firms have developed a software solution that is new to the market (NEW_PS) (Table 5.1). In addition, approximately 70 per cent of the firms have substantially changed the product or service they offer (Table 5.1). Less than 40 per cent of the firms have an international certification, which endorses the quality of their processes (Table 5.1).

Table 5.1: Frequency of Innovation Indicators–Product/Service New in the Market (NEW_PS), Product/Service Changed Substantially (CHANGE_PS) and Quality of Product and/or Services (QUAL_PS)

	NEW_PS		CHANGE_PS		QUAL_PS	
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
No = 0	47	48.5	29	29.9	60	61.9
Yes = 1	50	51.5	68	70.1	37	38.1
Missing	1		1		1	
Total	98	100.00	98	100.00	98	100.00

Source: Own computations based on author's survey.

Table 5.2 shows that a subset of 32 percent of firms has more than 80 percent of its sales due to innovative products and/or services.

Table 5.2: Frequency of Innovation Indicators–Sales of Innovation Output SALES_INNOV)

Percentage of Sales due to Innovation	SALES_INNOV	
	Frequency	**Valid Percent**
0	1	1.0
0< - <10	22	22.3
10≤ - <20	9	9.1
20≤ - <30	9	9.1
30≤ - <40	6	6.1
40≤ - <50	5	5.1
50≤ - <60	8	8.2
60≤ - <70	6	6.1
70≤ - <80	1	1.0
80≤ - <90	10	10.2
90≤ - <100	21	21.4
Total	98	100.00
Descriptive Statistics		
Mean	0.44	
Std. Deviation	0.369	

Source: Own computations based on author's survey.

Similar results exhibit the NO_INNOV indicator (Table 5.3). More than 20 percent of the firms have produced more than 4 innovations during the period 1999-2004.

Table 5.3: Frequency of Innovation Indicators-Number of Innovations (NO_INNOV)

Number of Innovations	NO_INNOV	
	Frequency	**Valid Percent**
0	1	1.0
1	15	15.5
2	17	17.5
3	14	14.4
4	20	20.6
5	12	12.4
6	6	6.2
7	3	3.1
8	2	2.1
9	0	0
10	3	3.1
11	1	1.0
12	0	0
13	1	1.0
14	0	0
15	2	2.1
Total	97	100.00
Missing data	1	
Mean	4.00	
Std. Deviation	2.901	

Source: Own computations based on author's survey.

Overall, these results show that firms within the software cluster of Montevideo are quite innovative. They are able to introduce new products in the market and they also have the capability to substantially change the products or services they offer. A large percentage of the sales of these firms are due to innovation. On the other hand, less than 40 per cent of the software firms in the cluster of Montevideo hold quality certifications. This suggests that not all of the firms have the capability to meet international quality standards and compete in global markets.

External Learning – Mechanisms of Knowledge Flow

Table 5.4 indicates that almost half of the firms are spin-offs. This implies that a given point in time, employees in existing firms and/or lecturers at universities, within the cluster of Montevideo, made the decision to start their own businesses. Thus, knowledge has been circulating through a high rate of new firm formation.

Table 5.4: Frequency of Local Knowledge Spillovers through Spin-offs (LKS_S)

0 = No, Spin-off **1 = Yes, Spin-off**	**LKS_S**	
	Frequency	Valid Percent
0	51	52.0
1	47	48.0
Total	98	100.0

Source: Own computations based on author's survey.

With respect to the variable that indicates labour mobility we notice in Table 5.5 that approximately 30 per cent of the firms have a score of zero. This implies that almost one third of the firms have not attracted any labour from other firms in the cluster during the last 5 years. 43 per cent of the firms exhibit moderate (40-60%) to high levels of labour inflow (60-130%). This implies that half of the firms in the sample have acquired new employees during the period 1999-2004 (more than 40 per cent of their employees are new).

Table 5.5: Frequency of Local Knowledge Spillovers through Labour Mobility (LKS_L)

Percentage of Labour Inflow	**SALES_INNOV**	
	Frequency	**Valid Percent**
0	29	29.6
0< - <10	2	2.0
10≤ - <20	8	8.1
20≤ - <30	9	9.1
30≤ - <40	8	8.1
40≤ - <50	9	9.1
50≤ - <60	8	8.1
60≤ - <70	10	10.2
70≤ - <80	3	3.0
80≤ - <90	10	10.2
90≤ - <100	0	0
100≤ - <110	0	0
110≤ - <120	0	0
120≤ - <130	2	2.0
Total	98	100.00
Descriptive Statistics		
Mean	0.35	
Std. Deviation	0.315	

Source: Own computations based on author's survey.

A. Importance of Mechanisms of Knowledge Flow through Interaction

As described in Box 3.1, the first group of indicators, which reflects knowledge flows through interaction, was constructed on the basis of questions about the perceived importance of the knowledge flows by the entrepreneurs. They assessed the significance of the knowledge flows for their innovation process on a Likert scale from 0 to 4. This implies that the variables concerning the importance of the sources of information for innovation reflect the subjective opinions of the entrepreneurs. However, it is assumed that, while subjective, the opinion of the manager of the enterprise reflects the strategy of the specific firm in using external knowledge. I interpret this variable as signifying the search of the entrepreneurs for information (from a variety of sources) for their innovative processes. The 3rd Community

Innovation Survey (CIS3) formulates the questions[83] regarding the sources of information for innovation (CIS3, 2004) in a similar way. Research based on the CIS data interprets the question regarding the importance of the sources of information for innovation as revealing the intensity of information sourcing (Mohnen and Hoareau, 2003).

In addition to the question from the CIS3, I have collected information regarding the mechanisms of knowledge transfer (i.e. LKS) and the location of the sources of knowledge (see Box 3.1 for further elaboration). Information can be transferred locally in a direct and informal manner (giving rise to LKS) or through market transactions (giving rise to LKT). The constructed variable, then, measures the intensity of the various knowledge flows used by the enterprises. It will be interesting to see, in the next section, whether the judgments of the entrepreneurs will be validated when the innovative and economic performance of the firms will be regressed on the knowledge flows.

Table 5.6 presents the frequency distribution of the LKS_I (importance of local knowledge spillovers through interaction) variable across firms. 10 per cent of the firms do not think that LKS_I are relevant for their innovative efforts. On the contrary, only a negligible percentage of the firms (3 per cent) do not use local knowledge transactions (LKT). Regarding international knowledge spillovers (IKS), 14 per cent of the firms do not use them, while an even larger group (approximately 20 per cent) do not use international knowledge transactions (IKT).

Table 5.6: The Importance of Knowledge Flows – Frequency Distributions

Intensity	LKS_I		LKT		IKS		IKT	
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
0	10	10.3	3	3.1	14	14.1	19	19.6
1 – 2	6	6.2	2	2.1	4	4.1	0	0
3 – 4	22	22.6	9	9.3	25	25.7	29	29.9
5 – 6	14	14.4	13	13.4	13	13.4	17	17.5
7 – 8	21	21.7	20	20.6	18	18.5	14	14.4
9 – 10	13	13.4	20	20.6	11	11.3	5	5.2
11 – 12	5	5.2	10	10.4	5	5.2	4	4.2
13 – 14	2	2.1	6	6.2	6	6.2	6	6.2
15 – 16	4	4.2	8	8.2	1	1.0	0	0
17 – 18	0	0	2	2.1	0	0	3	3.1
19 – 20	0	0	3	3.1	0	0	0	0
21 – 22	0	0	1	1.0	0	0	0	0
23 – 52	0	0	0	0	0	0	0	0
Total	97	100.00	97	100.00	97	100.00	97	100.00
Descriptive Statistics								
Mean	6.09		9.10		5.82		5.40	
Std.D.	3.903		4.513		3.953		4.363	

Source: Own computations based on author's survey.
Note: LKS_I = Importance of Local Knowledge Spillovers
LKT = Importance of Local Knowledge Transactions
IKS = Importance of International Knowledge Spillovers
IKT = Importance of International Knowledge Transactions

The distribution of the variables is skewed to the left (on a scale from 0 to 52; see Box 3.1). The majority of the firms make modest use (i.e. intensity 3-4) of the LKS_I, IKS and IKT. The intensity with which the entrepreneurs search for LKT is higher than the rest of the knowledge flows. For instance, 51.6 per cent of the firms perceive the importance of LKT to be at a level of 9-10 or more. In contrast, 24.9 per cent of the firms use LKS_I in an equal intensity. An even smaller percentage of firms (23.7 and 18.7 per cent respectively) uses IKS

and IKT in the same intensity. This suggests that a large percentage of the software firms in Montevideo uses local knowledge transactions rather intensively as inputs into their process of innovation.

B. Existence of Mechanisms of Knowledge Flow through Interaction

The second group of indicators that denote knowledge flows through interaction were constructed in a different way from the indicators discussed in section A. The main difference between the two constructs is the fact that the second one is based on whether or not a knowledge flow is relevant for innovation according to the respondent (see Box 3.2). It indicates whether a knowledge flow exists. This means that this indicator is somewhat less subjective than the previous one, which reflected the degree of importance assigned by the entrepreneur to the various knowledge flows.

Table 5.7: The Existence of Knowledge Flows – Frequency Distributions

Number of sources of Knowledge	LKS_I2		LKT2		IKS2		IKT2	
	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent	Frequency	Valid Percent
0	10	10.3	3	3.1	14	14.4	19	19.6
1	28	28.9	13	13.4	34	35.1	37	38.1
2	25	25.8	35	36.1	26	26.8	26	26.8
3	28	28.9	21	21.6	17	17.5	7	7.2
4	5	5.2	14	14.4	6	6.2	5	5.2
5	1	1.0	10	10.3	0	0	3	3.1
6	0	0	0	0	0	0	0	0
7	0	0	1	1.0	0	0	0	0
8 – 13	0	0	0	0	0	0	0	0
Total	97	100.0	97	100.0	97	100.0	97	100.0
Descriptive Statistics								
Mean	1.93		2.67		1.66		1.49	
Std. D.	1.139		1.344		1.117		1.217	

Source: Own computations based on author's survey.
Note: LKS_I2 = Existence of Local Knowledge Spillovers
LKT2 = Existence of Local Knowledge Transactions
IKS2 = Existence of International Knowledge Spillovers
IKT2 = Existence of International Knowledge Transactions

While the zero categories (knowledge flows not relevant for innovation) give identical results as in the previous construct, the rest of the scale has a different connotation. The scale in Table 5.7 reveals the variety of sources from which the firms access external knowledge. For instance, approximately 30 percent of the firms use only one source to access LKS_I2, 13 percent of the firms use only one source to access LKT2, 35 percent of the firms use only one source to access IKS2, and, 38 percent of the firms use only one source to access IKT2.

This table implies that firms in the software cluster in Montevideo manage to obtain international knowledge through contacts with few specific sources of knowledge. IKT2 exhibits the highest percentage of firms (approximately 40 percent) that use only one source of knowledge to access international knowledge through market transactions. In contrast, at the local level, firms use a greater variety of sources in order to access external knowledge. For instance, approximately 30 percent of the firms use 3 sources in order to obtain knowledge through LKS_12. This suggests that firms in the software cluster in Montevideo are primarily locally oriented. They use a greater variety of local sources in order to acquire knowledge.

Based on the above analysis I will attempt to answer the first research question (RQ 1) regarding the quantitative distribution of the different mechanisms of knowledge flow. With regard to local knowledge spillovers I have examined four indicators –LKS_S, LKS_L, LKS_I and LKS_I2. The main conclusions that can be derived from the analysis of these indicators are as follows:

- Approximately 50 per cent of the software firms in the cluster of Montevideo are spin-offs.
- Approximately 40 per cent of the software firms exhibit medium (40-60%) to high (60-130%) levels of labour inflow.
- A small percentage (24.9%) of the software firms makes intense use (9-10 or more) of local knowledge spillovers through interaction (LKS_I), while the majority of the firms (58.7%) make a moderate use of LKS_I (3-8).
- Approximately 30 per cent of the software firms in the cluster of Montevideo acquire knowledge in a direct way from a variety (i.e. 3) of local sources through the mechanism of local knowledge spillovers through interaction (LKS_I2).

These results demonstrate that local knowledge spillovers are present in the Montevideo software cluster and take place through a number of different mechanisms. Knowledge has been circulating intensively in the Montevideo software cluster through the formation of many new firms and through the mobility of labour. The flow of knowledge through informal and direct interactions among firms has been less intensive.

Concerning local knowledge transactions, two indicators have been examined – LKT and LKT2. The software firms in the Montevideo cluster use local knowledge transactions with high intensity. In addition, roughly 10 per cent of the local firms use five sources in order to acquire knowledge locally based on market transactions. These results show that local knowledge transactions are used with greater intensity than the rest of the knowledge flows.

Turning our attention to international knowledge spillovers (IKS and IKS2), we notice that a small percentage of firms (23.7) make intense (9-10 or more) use of IKS. Similarly, a small percentage of the firms (17) acquire IKS2 from three sources. This implies that international knowledge spillovers are not used very intensively by the large majority of the software firms in Montevideo.

Regarding international knowledge transactions (IKT and IKT2), it has been shown that they are used intensively (9-10 or more) only by 18.7 per cent of local firms. Moreover, a small fraction (7%) of the firms acquire IKT2 from three sources. Consequently, international knowledge transactions are the least used mechanism among the firms in the Montevideo cluster.

A last finding is the existence of a number of isolated firms; 10 per cent of firms do not make any use of local knowledge spillovers through interaction; 30 per cent of firms have not renewed their stock of employees during the period 1999-2004; and finally, 20 per cent of firms do not access any international knowledge transactions.

5.3.2 Factor Analysis: Innovative and Economic Performance Indicators

Innovative Performance

At this point, it is important to examine whether the innovative performance of the firm can be measured using less than five variables[84]. For this reason, principal factor analysis is used. Two factors explain approximately 60 per cent of the cumulative variance (see Appendix G). Table 5.8 exhibits the loads of each innovation variable on the two factors. The first factor is explained mainly by the variables NEW_PS and CHANGE_PS. The first variable NEW_PS is an indicator of the uniqueness of the product in the market. The second variable CHANGE_PS represents a product/service that has undergone a significant change. In the first case, the product is new to the market, whereas in the second the product is new to the firm. This means that the firm has created and/or substantially changed a product or service. These are technological changes: firms applied new scientific or technological knowledge into their products or adapted their products to the needs of the customer.

Table 5.8: Innovation Components

	Components	
	1 Technological Innovation	**2 Marketing/Organisational Innovation**
NEW_PS	**0.895**	0.009
CHANGE_PS	**0.919**	0.028
QUAL_PS	0.011	**0.798**
SALES_INNOV	0.200	**0.277**
NO_INNOV	-0.077	**0.766**

Source: Own computations based on author's survey.

The second factor is explained by the variables QUAL_PS, SALES_INNOV and NO_INNOV. The QUAL_PS variable indicates those firms that hold an international recognised quality certification. A quality certification is supposed to improve the productivity of the firm and the quality of its products. Usually, it is a necessary step for many firms in developing countries that try to enter foreign markets and gain the trust of demanding customers. However, the acquisition of a quality certificate is a long and costly process and consequently more likely to be undertaken by large firms. What aspect of the firm's innovative capabilities does QUAL_PS represent? In brief, a quality certification reassures the customer less about the technological/scientific level of the product than it constitutes a guarantee of the functionality of the product. The firm has to organise its [development] process better and minimise the errors committed at every stage. Thus, quality certification has to do with the organisational capabilities of the firm.

The SALES_INNOV variable denotes the percentage of sales of a firm due to innovative products/services (P/S). On one hand, this demonstrates that the specific firm is innovative, because a large number of its sales are innovative products and services. On the other hand, this indicator shows that the specific firm is able to commercialise its innovative products and services and to profit from them. In other words, this variable expresses the capability of the firm to use marketing knowledge and to sell its products and services in the market.

Finally, the variable NO_INNOV denotes the number of innovations that a firm produces. In the software industry, a firm commonly holds few products and then produces numerous versions of them. Again, these versions represent the capability of the firm to react to market needs and to sell its product in diverse forms. To a large degree, this variable represents the

commercial success of the firm and its capabilities in selling its original products by satisfying the needs of the current customers.

I use the two components of the factor analysis in order to express the innovative performance of the firms. The first factor denotes the technological innovation of the firm while the second factor denotes the firm's marketing and organisational innovation capabilities with regard to products and services.

TECH_INN: Technological innovation factor indicates the capability of the firm to create or change products and services based on technological and/or scientific advancements.

MARK_INN: Marketing/Organisational innovation factor indicates the capability of the firm to follow the market requirements (quality), trends and strategies and successfully commercialise its products and services.

Economic Performance

I will examine whether the economic performance of the firm can be measured using less than seven variables. For that reason, I again apply principal factor analysis. Three factors explain approximately 80 per cent of the cumulative variance (see Appendix H). Table 5.9 presents the three components and the variables that explain them. The first factor is explained by exports and the export intensity of the firm. This factor is called export intensity. The second factor is explained mainly by the sales, and the sales per employee. This factor refers to those firms that are commercially successful (Sales) and at the same time are characterised by a high productivity (Sales_Empl). This factor is called level of performance. Finally, the third factor is explained by the growth of sales, exports and employment. This variable is named economic growth since it represents those firms that grow rapidly.

EXP_INTES: Export intensity factor denotes the size of the exports and the export intensity of a firm.

L_PERFORM: Level of performance factor indicates the volume of the sales and the sales per employee.

EC_GROWTH: Economic growth factor indicates the growth of the sales, exports and employment.

Table 5.9: Economic Performance Components

	Component		
	1 Export Intensity	**2 Level of Performance**	**3 Economic Growth**
Exports	**0.679**	0.530	0.213
Exports_Intens	**0.858**	-0.054	0.055
Sales	0.191	**0.976**	0.061
Sales_Empl	-0.096	**0.955**	-0.028
Sales_Gr	0.179	0.000	**0.911**
Exports_Gr	-0.140	0.061	**0.689**
Empl_Gr	0.293	0.012	**0.761**

Source: Own computations based on author's survey.

I proceed to the empirical analysis with the new variables that are presented in Table 5.10. Finally, Appendix J exhibits the correlation of the main variables that will be used in the analysis.

Table 5.10: Presentation of the Variables

Variables	Variable Name	Definition/Measurement
Dependent Variables		
Innovative Performance		
Technological Innovation	TECHN_INN	Indicates the capability of the firm to create or change a P/S based on technological or scientific advancements.
Marketing/Organisational Innovation	MARK_INN	Indicates the capability of the firm to follow the requirements of the market in terms of quality, trends and commercialisation strategies.
Economic Performance		
Export Intensity	EXP_INTENS	Denotes the size of the exports and the export intensity of the firm.
Level of Performance	L_PERFORM	Indicates the size of the sales and the productivity of the firm.
Economic Growth	EC_GROWTH	Indicates the growth of the sales, exports and employment of the firm.
Independent Variables		
External Learning		
Local Knowledge Spillovers through Spin-off	LKS_S	This is a dummy variable that takes the value of 1 if a firm is a spin-off of a university/MNC that is located within the cluster and the value of 0 in other case.
Local Knowledge Spillovers through Labour Mobility	LKS_L	This variable denotes the percentage of employees (inflow) of a firm that came from within the cluster during the last five years (1999-2004). This is measured by the Inflow Rate[85]: $R(in)_t = \Sigma\, im_{t-1} / N_{t.}$.
Local Knowledge Spillovers through Interaction –Importance	LKS_I	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from the non-pecuniary interaction of local actors.
Local Knowledge Spillovers through Interaction -Existence	LKS_I2	This is a constructed variable that indicates the existence of intra-cluster flow of knowledge that arises from the non-pecuniary interaction of local actors.
Local Knowledge Transactions - Importance	LKT	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from transactions.
Local Knowledge Transactions - Existence	LKT2	This is a constructed variable that indicates the existence of intra-cluster flow of knowledge that arises from transactions.
International Knowledge Spillovers - Importance	IKS	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from the non-pecuniary interaction among local and international actors.
International Knowledge Spillovers- Existence	IKS2	This is a constructed variable that indicates the existence of extra-cluster flow of knowledge that arises from the non-pecuniary interaction among local and international actors.

International Knowledge Transactions -Importance	IKT	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from transactions.
International Knowledge Transactions-Existence	IKT2	This is a constructed variable that indicates the existence of extra-cluster flow of knowledge that arises from transactions.
Internal Learning		
Research and Development man-years	R&D_MY	R&D effort measured in man-years. It measures the cumulative R&D effort of the firm for innovative products during the period 1999-2004.
Research and Development intensity	R&D_INTENS	This variable denotes the percentage of firm's labour force that carried out R&D in 2004.
Level of Education Index	EDU	Indicates the level of education of the employees of the firm.
Variation of Education	EDU_VAR	Ordinal variable that denotes the variation of the education levels of the employees of a firm
Postgraduate education	EDU_DUM	This is a dummy variable which takes the value of =1 if a firm has employees with MSc or PhD degrees, and the value of =0 in other case.
Foreign Education	EDU_F	This variable denotes the percentage of the employees in a firm that have acquired foreign education.
Years of Experience Index	EXPER_Y	Indicates the average years of experience in the software sector of the employees of a firm.
Variation of Experience	EXPER_VAR_Y	Ordinal variable that denotes the variation of the experience of the employees within a firm.
Experience in Firms Index	EXPER_FIRMS	Indicates the average No. of firms that the employees of the company have worked in the past.
Variation of Experience in Firms	EXPER_VAR_F	Ordinal variable which denotes the variation of the experience in No. firms of the employees within a firm.
Age	AGE	Firm's age (reference year 2004).
Control Variables		
Size	SIZE	Size of the firm measured by number of employees at year 2004.

Note: See full list of the variables in Appendix D.

5.3.3 Regression Analysis: Local Knowledge Spillovers versus other Mechanisms of Knowledge Flows and the Innovative Performance of the Firm

The aim of this section is to examine the relative contributions of various mechanisms of external learning to the innovative performance of the firm. For this, it is necessary to control first for the level of the internal learning activities of the firm. Thus, this section will estimate the following relationship:

$$IP = f(EL_1, EL_2, \dots, EL_n; IL_1, IL_2, \dots, IL_n)$$

IP denotes the innovative performance of the firm, EL_n indicates the different mechanisms of external learning, and finally, IL_n denotes the various internal learning mechanisms.

Principal factor analysis produced two indicators for the innovative performance of the firm; namely technological innovation and marketing/organisational innovation. Section A will use technological innovation as the dependent variable, whereas section B will use the marketing/organisational innovation as the dependent variable.

A. Technological Innovation

The first objective of this analysis is to find the relative contribution of LKS to the innovative performance of the firm, controlling for the internal learning mechanisms. Additionally, the second objective is to find out the relative impact of local versus international mechanisms of learning upon the technological performance of the firm.

The two variables that denote knowledge flows (i.e. LKS_I and LKS_I2) are derived from the same survey questions (see Box 3.1 and Box 3.2) and are highly correlated. Therefore they entered into different regressions. I have found that the first group of knowledge flows through interaction (i.e. LKS_I) are better predictors of the technological performance of the firms compared to the second group (LKS_I2). Therefore, the following analysis only includes the first group of knowledge flow variables.

Table 5.11 reports the results of the regression analysis. Regression A includes all the variables. Those mechanisms of learning (external and internal) that had a very low significance level in the bivariate correlation[86] or that were causing multicollinearity were not included in models B and C. This leads us to the best-fit model B. So far, regression B satisfies the requirements of Ordinary Least Squares (OLS) analysis[87]. Various interaction effects such as LKS_L x IKT and LKS_I x IKT were tested in a number of regressions, but they did not generate any significant effects nor did they increase the adjusted R square. Thus, they were not included in the current regressions.

Model B depicts a higher adjusted R square than model A. This suggests that model B is the best-fit model, which will be further discussed. The main predictors of technological innovation are the following: LKS_I, LKS_L, IKT and EXPER_Y.

$$TECHN\_INN_i = b_o + b_1 LKS\_L_i + b_2 LKS\_I_i + b_3 IKT_i + b_4 EXPER\_Y_i + u$$

Table 5.11: Determinants of Technological Innovation

Independent Variables	***Regression A***	***Regression B***	***Regression C***
	Standardized beta Coefficients	*Standardized beta Coefficients*	*Standardized beta Coefficients*
LKS_S	0.134 (1.121)		
LKS_L	0.161 (1.443)	0.223 (2.234) **	0.272 (2.784)***
LKS_I	0.309 (2.939)***	0.303 (3.271) ***	0.300 (3.217)***
LKT	-0.048 (-0.451)		
IKS	0.221 (1.931)*		
IKT	0.197 (1.619)	1.177 (1.812) *	0.187 (1.882)*
RD_MY	0.123 (1.046)		
RD_INTENS	-0.077 (-0.752)		
EDU_VAR	-0.033 (-0.211)		
EDU	0.063 (0.504)		
EDU_DUM	-0.051 (-0.288)		
EDU_F	-0.189 (-1.652)		
EXPER_VAR_Y	0.023 (0.167)		
EXPER_Y	-0.289 (-1.568)	-0.265 (-2.805)***	
EXPER_VAR_F	-0.098 (-0.858)		
EXPER_FIRMS	0.183 (1.438)		
AGE	0.001 (0.006)		-0.231 (-2.475)**
SIZE	-0.035 (-0.294)		
Intercept			
N	97	97	97
Adj. R^2	0.168	0.212	0.198

Note: - OLS estimation; t-values in parenthesis; ***p<.01, **p<.05, *p<.10
Source: Own computations based on author's survey.

Next, the effect of each independent variable upon technological innovation will be examined. First, LKS_L affect TECHN_INN in a positive and significant way. This implies that those firms that profit from high labour mobility by attracting workers from within the cluster have higher innovative performance than those that do not.

Second, LKS_I demonstrate a positive and significant impact upon TECHN_INN. This suggests that local knowledge spillovers are significant determinants of the technological innovation of the software firms in the Montevideo cluster. In particular, those firms that use, with higher intensity, local knowledge spillovers through interaction demonstrate higher technological performance.

Third, IKT exhibit a positive and significant effect upon TECHN_INN. This means that international knowledge transactions make an important contribution to the technological innovation of the firms in the Montevideo cluster. Specifically, those firms that manage to use international knowledge through market mechanisms with higher intensity exhibit a higher technological performance.

Fourth, EXPER_Y has a negative impact upon TECHN_INN. This means that firms which have employees with many years of experience exhibit lower technological innovation than those firms which have employees with few years of experience. This comes as a surprise because we would expect that the accumulation of experience augments the technological innovation of the firms. Model C throws more light on this issue. It shows that the age of the firm (AGE) has a negative and significant impact upon TECHN_INN. This suggests that the

older a firm is the lower its technological innovation. In other words, the years of experience of the employees and the age of the firm produce similar results; they affect the technological innovation of the firm in a negative way.

Innovation literature in the advanced economies supports the above results concerning the negative relationship between age and innovation (Hansen, 1992; Huergo and Jaumandreu, 2004). In particular, Hansen (1992) examined the proportion of innovative sales of American firms and found that it is inversely related to the firms' age. Huergo and Jaumandreu (2004) examined Spanish firms and claimed that entrant firms exhibit a higher probability of innovation in comparison to older firms. In sum, the innovation literature shows that new firms tend to innovate more than old firms. My results confirm these findings, in the context of a developing country.

Local Knowledge Spillovers versus other mechanisms of knowledge flow

The standardised[88] beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the technological innovation of the firms within the Montevideo cluster. Model B shows that local knowledge spillovers are stronger predictors of technological innovation than the other knowledge flows. In particular, LKS_I and LKS_L, which are both indicators of local knowledge spillovers, have a stronger impact upon technological innovation (together but also individually) than IKT. Based on these results, we can answer RQ 3a and assert that local knowledge spillovers are the most important mechanism of knowledge flow for the technological innovation of the firms within the software cluster in Montevideo. In addition, we notice that LKS_I is a stronger predictor compared to LKS_L. This means that local knowledge spillovers through interaction play a more important role than local knowledge spillovers through labour mobility for the technological innovation of the firms in the Montevideo software cluster.

These results answer RQ 4a regarding the importance of local versus international knowledge flows for the technological innovation of the firms. The mechanisms of local knowledge flows (LKS_I and LKS_L) are stronger predictors than the mechanism of international knowledge flows (IKT). This suggests that local knowledge flows play a critical and more important role than international knowledge flows for the technological innovation of the software firms in the Montevideo cluster.

B. Marketing/Organisational Innovation

In this section I assess the relative contribution of local knowledge spillovers to the marketing/organisational innovation of the software firms within the Montevideo cluster. First, I control for the internal learning or the absorptive capacity of the firm and I then estimate a multiple OLS regression.

Table 5.12 reports the results of the regression analysis. Regression A includes all the variables. Those mechanisms of learning (external and internal) that had a very low significance level in the bivariate correlation or that were causing multicollinearity were not included in the model. This leads us to the best fit model which is the one of regression B. Regression B meets the requirements of Ordinary Least Squares Regression (OLS) analysis in terms of normality and homoscedasticity. Various interaction effects such as LKS_L x IKT and LKS_I x IKT were tested in a number of regressions, but neither they had any significant effect nor they increased the adjusted R square. Thus they were not included in the regressions.

Table 5.12: Determinants of Marketing/Organisational Innovation

Independent Variables	***Regression A*** *Standardized beta Coefficients*	***Regression B*** *Standardized beta Coefficients*
LKS_S	0.227 (2.240)**	0.260 (3.055)***
LKS_L	-0.097 (-1.023)	
LKS_I	0.023 (0.261)	
LKT	0.107 (1.183)	
IKS	0.008 (0.078)	
IKT	0.211 (2.042)**	0.173 (1.963)*
RD_MY	0.266 (2.662)***	0.271 (3.175)***
RD_INTENS	0.031 (0.358)	
EDU_VAR	-0.182 (-1.347)	
EDU	-0.086 (-0.811)	
EDU_DUM	0.338 (2.252)**	0.203 (2.466)**
EDU_F	-0.054 (-0.552)	
EXPER_VAR_Y	0.071 (0.612)	
EXPER_Y	0.124 (0.790)	
EXPER_VAR_F	0.236 (2.423)**	0.197 (2.347)**
EXPER_FIRMS	-0.057 (-0.527)	
AGE	0.221 (1.346)	0.343 (4.094)***
SIZE	-0.038 (-0.369)	
Intercept		
N	97	97
Adj. R^2	0.396	0.431

Note: - OLS estimation; t-values in parenthesis; ***p<.01, **p<.05, *p<.10
Source: Own computations based on author's survey.

Model B shows that LKS_S, IKT, RD_MY, EDU_DUM, EXPER_VAR_F and AGE are important factors that explain the variation found in the marketing/organisational innovation of the firms.

$$MARK\_INN_i = b_o + b_1 LKS\_S_i + b_2 IKT_i + b_3 RD\_MY_i + b_4 EDU\_DUM_i + b_5 EXPER\_VAR\_F_i + b_6 AGE_i + u$$

First, LKS_S affect MARK_INN in a positive and significant way. This implies that those firms that were spin-offs of local organisations demonstrate the highest marketing/organisational innovation. Second, IKT exhibit a positive and significant effect upon MARK_INN. This means that international knowledge transactions play an important role for the marketing/organisational innovation of the firms in the cluster of Montevideo. Specifically, those firms that manage to use international knowledge flows through market mechanisms with higher intensity, exhibit a higher marketing/organisational performance. Third, RD_MY has a positive impact upon MARK_INN. This suggests that firms that invest more in R&D exhibit higher marketing/organisational innovation than those firms that are weak in R&D. Fourth, EDU_DUM affects MARK_INN positively and significantly. Firms which have employees with postgraduate education (MSc and/or PhD) have a higher marketing/organisational performance that those firms which do not have employees with postgraduate degrees. Fifth, EXPER_VAR_F has a positive and significant impact upon MARK_INN. This means that firms which are characterised by a large variation in the

experience of their employees[89] are more innovative in terms of marketing /organisational innovation than those firms which exhibit a low variation in the experience of their employees[90]. Finally, AGE affects MARK_INN in a positive and significant way. This means that older firms exhibit higher marketing/organisational innovation than younger firms. This suggests that over time firms accumulate marketing and organisational capabilities which enhance their performance. However, in the previous section we found that age had a negative effect upon the technological innovation of the firm. This means that while young firms produce more technological innovations they fall behind old firms in marketing/organisational innovations.

Local Knowledge Spillovers versus other mechanisms of knowledge flow

The beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the marketing/organisational innovation of the firms within the Montevideo cluster. Model B is the best-fit model and shows that local knowledge spillovers are stronger predictors of marketing/organisational innovation than the rest of the knowledge flows. In particular, LKS_S, which is an indicator of local knowledge spillovers, has a stronger impact upon marketing/organisational innovation than IKT. Consequently, local knowledge spillovers are the most important mechanism of knowledge flow for the marketing/organisational innovation of the software firms within the Montevideo cluster (RQ 3a). This suggests that local knowledge spillovers through spin-offs play a more important role than international knowledge transactions for the marketing/organisational innovation of the firms in the Montevideo software cluster.

These results answer RQ 4a concerning the importance of local versus international knowledge flows for the marketing/organisational innovation of the firms. The mechanisms of local knowledge flows (LKS_S) are stronger predictors than the mechanism of international knowledge flows (IKT). This suggests that local knowledge flows play a more important role than international knowledge flows; not only for technological but also for marketing/organisational innovation of the software firms in the Montevideo cluster.

5.3.4 Systems Method Estimation: Local Knowledge Spillovers versus other Mechanisms of Knowledge Flows and the Economic Performance of the Firm

The aim of this section is to examine the relative importance of local knowledge spillovers compared to the other mechanisms of knowledge flow for the economic performance of the clustered firms after controlling for the absorptive capacity of the firm. Thus I will analyse the following relationship:

$$EP = f(IP_1, IP_2, ..., IP_n; EL_1, EL_2, ..., EL_n; IL_1, IL_2, ..., IL_n)$$

However, as we have seen in the previous section, innovative performance also depends on external and internal learning. Additionally, literature analysis[91] suggests that external learning may also be contingent upon the internal learning activities of the firm (we test for this relation in Table 5.13). Thus, if the above equation is to be estimated, some of the indicators that denote the predictor variables – the innovative performance of the firm and the external learning of the firm- would be endogenous[92]. When one or more of the predictor variables are endogenous, we encounter the problem of that variable being correlated with the error term. This suggests that the innovative performance and the external learning variables may be correlated with the error term. We may examine whether such a problem occurs in the

current case. Under these conditions, the results of the previous section come into question as well.

I use R&D man-years, variation in education and previous experience in other firms as indicators of the internal learning of the firm and I examine whether they affect the external learning of the firm. Moreover, I control for the size of the firm and I save the residuals of the model. Next, I test whether the OLS estimates of the model of innovation performance (exhibited in the previous section) and of the current model of economic performance are consistent.

Table 5.13: Testing for the Endogeneity of International Knowledge Transactions

Model 1 OLS	***Dependent Variable***	***IKT***	***Standardized beta Coefficients***	
	Predictors	R&D_MY	0.126	(0.041)***
		EDU_VAR	0.476	(0.585)
		EXPER_F	-0.327	(-0.339)
		SIZE	0.024	(0.010)**
		Constant	3.196	(0.010)
		Adj R^2	0.21	
Model 2 OLS	**Dependent Variable**	**TECHN_INN**		
	Predictors	LKS_L	0.718	(0.263)***
		LKS_I	0.077	(0.024)***
		IKT	0.057	(0.045)
		AGE	-0.025	(-0.010)**
		Residual IKT	-0.019	(-0.050)
		Constant	-0.731	(-0.309)**
		R2	0.19	
Model 3 OLS	**Dependent Variable**	**EXP_INTENS**		
	Predictors	TECHN_INN	0.230	(0.104)**
		LKT	-0.062	(-0.021)***
		IKT	0.216	(0.021)***
		Residual IKT	-0.168	(-0.051)***
		Constant	-0.499	(-0.338)
		Adj R^2	0.36	

Note: - OLS estimation; Standard Errors in parentheses; ***p<.01, **p<.05, *p<.10
Source: Own computations based on author's survey.

Table 5.13 shows that the coefficient of residual IKT (the residual of international knowledge transactions) in Model 3 is significant. This means that there is a problem in using IKT as a predictor of the economic performance. In other words, these results indicate that ordinary least squares estimates of the 3rd regression model are not consistent because the variable IKT is endogenously determined. On the other hand, we do not encounter this problem in the second model. These results suggest that I do not have to discard the results of the previous section.

Based on this test and on literature studies, we acknowledge the problem that some indicators of innovative performance of the firm and of external learning are endogenous (as indicated in Table 5.13). In a traditional linear regression model, the OLS estimates might not be consistent; in such a case the assumption of OLS –the independent variables are distributed independently of the disturbances- would be violated as it happened in the third model. This calls for a system of equations in which, besides economic performance, innovative performance and external learning are endogenous.

Principal factor analysis produced three indicators for the economic performance of the firm; namely export intensity, level of performance and economic growth. The following section will use export intensity as the dependent variable, whereas the next section will use level of performance as the dependent variable[93].

A. Export Intensity

The following structural model makes it possible to test the three research questions[94] simultaneously. In particular, export intensity (EXP_INTENS) is used as an indicator of the economic performance of the firm. The first objective of this analysis is to find out whether local knowledge spillovers have a direct impact upon the export intensity of the firm or whether they just affect it indirectly (through innovation). In addition, the second objective is to find out the relative importance of local versus international (external to the firm) mechanisms of learning for the economic performance of the firm.

$$\left.\begin{aligned} EXP\_INTENS &= a_1 + a_2 TECHN\_INN + a_3 LKT + a_4 IKT + a_5 EDU\_VAR + a_6 SIZE + e \\ TECHN\_INN &= b_1 + b_2 LKS\_I + b_3 LKS\_L + b_4 IKT + b_6 EXPER\_Y + u \\ IKT &= c_1 + c_2 R\&D\_MY + c_3 EXPER\_VAR\_F + c_4 SIZE + w \end{aligned}\right\}$$

Three-stage least squares (3SLS) technique is used, which permits the parameters of all three equations to be estimated simultaneously. This is a system method of estimation which is also called full information method, because it takes into account information from all equations at the same time. On the contrary, limited information methods such as OLS or 2SLS estimate one equation at a time and do not permit the disturbances of the different equations to correlate (Greene, 2000).

In this system, export intensity (EXP_INTENS), technological innovation (TECHN_INN) and international knowledge transactions (IKT) are endogenous variables. We apply the 3SLS method in three subsequent steps:

The first step is to replace the endogenous variables TECHN_INN and IKT with instrumental variables. The instrumental variable for TECHN_INN should be highly correlated with TECHN_INN but not caused by EXP_INTENS. The variables LKS_I, LKS_L and EXPER_Y are used as instrumental variables for TECHN_INN. The variable R&D_MY and EXPER_VAR_F are used as instrumental variables for IKT.

The second step regresses TECHN_INN and IKT on their instrumental variables respectively. Then we save the predictions pre_TECHN_INN of the first regression and the predictions, pre_IKT of the second regression.

During the third step, we use these predictions (pre_TECHN_INN and pre_IKT) to estimate the economic performance of the firm by using the Generalised Least Squares (GLS) technique. While OLS minimises the sum of squares of the disturbances, the GLS method minimises a different quadratic form of the residuals, that of the covariance matrix of the equation disturbances (those are the residuals obtained during the second step) (Greene, 2000).

Table 5.14: Simultaneous Estimates of Export Intensity, Technological Innovation and International Knowledge Transactions

	beta-Coefficients †		***beta-Coefficients*** ‡	
EXP_INTENS				
TECHN_INN	0.399	(0.177)**	0.377	(2.26)**
LKT	-0.053	(-0.017)***	-0.226	(-3.00)***
IKT	0.100	(0.041)**	0.411	(2.39)**
EDU_VAR	-0.446	(-0.127)***	-0.314	(-3.50)***
SIZE	0.012	(0.002)***	0.454	(5.11)***
Constant	0.555	(0.287)*		
"R^2"	0.51		0.51	
N	67		67	
TECHN_INN				
LKS _I	0.077	(0.026)***	0.302	(2.91)***
LKS_L	0.643	(0.318)**	0.241	(2.02)**
IKT	0.040	(0.046)	0.177	(0.87)
EXPER_Y	-0.121	(-0.041)***	-0.292	(-2.93)***
Constant	-0.335	(-0.335)		
"R^2"	0.26		0.26	
N	67		67	
IKT				
RD_MY	0.148	(0.042)***	0.349	(3.49)***
EXPER_VAR_F	0.255	(0.605)	0.049	(0.42)
SIZE	0.028	(0.010)***	0.261	(2.63)***
Constant	2.463	(1.456)*		
"R^2"	0.27		0.27	
N	67		67	

†Unstadardised regression coefficients (beta); Standard Errors in parentheses; ***p<.01, **p<.05, *p<.10
‡ Standardised coefficients (beta); t-values in parenthesis.
-3-stage least squares:
Endogenous Variables: EXP_INTENS, TECHN_INN, IKT.
Exogenous Variables: LKT, EDU_VAR, SIZE, LKS_I, LKS_L, EXPER_Y, RD_MY, EXPER_VAR_F.
Source: Own computations based on author's survey.

There are 67 observations for the previous model of system equations (Table 5.14). Not all firms were willing to give information regarding their economic performance. However, for the rest of the variables, we do have 97 observations. We may, at this point, test[95] the sub-system of TECHN_INN and IKT and see whether the results are similar to those of the full model.

Table 5.15: Simultaneous Estimates of Technological Innovation and International Knowledge Transactions

	beta-Coefficients	
TECHN_INN		
LKS _I	0.077	(0.023)***
LKS_L	0.597	(0.316)*
IKT	0.039	(0.048)
EXPER_Y	-0.109	(-0.039)***
Constant	-0.332	(-0.333)
"R^2"	0.24	
N	97	
IKT		
RD_MY	0.144	(0.038)***
EXPER_VAR_F	0.694	(0.473)
SIZE	0.026	(0.010)***
Constant	1.770	(1.140)
"R^2"	0.24	
N	97	

-Standard Errors in parentheses; ***p<.01, **p<.05, *p<.10
-3-stage least squares:
Endogenous Variables: TECHN_INN, IKT.
Exogenous Variables: LKS_I, LKS_L, EXPER_Y, RD_MY, EXPER_VAR_F, SIZE.
Source: Own computations based on author's survey.

A comparison of the full model with the 3 equations (Table 5.14) with the model which consists of the 2 equations (Table 5.15) produces similar results. This suggests that the observations that are missing from the small sample would not produce different results.

Table 5.14 reports the results of the system method estimation analysis. Several models were tested using different indicators for the independent variables. The best-fit model in Table 5.14 shows that the R-square of the EXP_INTENS sub-system is 0.51. This means that 51 per cent of the variation of the export intensity is explained by the independent variables. Moreover, the R-square of the TECHN_INN sub-system is 0.26. Finally, the R-square of the IKT sub-system is 0.27. Overall, the model seems to explain a fair amount of the variation of the endogenous variables. Based on this model we may draw the following conclusions:

Concerning the EXP_INTENS sub-system, I notice that, first, TECHN_INN affects EXP_INTENS in a positive and significant way. This means that technologically innovative firms export more than less innovative firms. Second, LKT exert a negative and significant impact upon EXP_INTENS. This implies that those firms that use local knowledge transactions intensively export less than those firms which use local knowledge transactions less intensively. Third, IKT has a positive and significant impact upon EXP_INTENS. In other words, those firms that use international knowledge transactions intensively export more than those firms that use international knowledge transactions less intensively. Fourth, EDU_VAR affects EXP_INTENS negatively. This implies that firms which exhibit a large variation in the educational level of their employees export less than firms which are comprised of employees with similar educational level. Fifth, SIZE has a positive impact upon EXP_INTENS. Large firms export more than small firms.

With regard to the TECHN_INN sub-system, Table 5.14 shows similar results to the OLS regression of Table 5.11 with the exception of IKT. The latter variable affects TECHN_INN in a positive way. However, its effect is not statistically significant. One explanation for this discrepancy (3SLS in Table 5.14 and OLS in Table 5.11) is the fact that IKT, as shown earlier, is endogenously determined; IKT depend on RD_MY and SIZE. After we control for the effect of these variables in the system equation model, IKT does not influence TECHN_INN significantly.

This is a very important finding because it shows the OLS method may not always produce consistent estimates, especially when it manages complex problems, such as the current one. This is due to the endogeneity of some variables. In the current case, the sub-system of IKT shows that the intensity with which a firm uses international knowledge transactions is contingent upon RD_MY and SIZE. This suggests that firms that invest strongly in R&D build the capabilities to use international knowledge transactions. On the contrary, those firms that are weak in R&D do not have the capabilities to use IKT. Moreover I notice that large firms use international knowledge transactions more intensively than small firms.

Local Knowledge Spillovers versus other mechanisms of knowledge flow

The beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the export intensity of firms within the Montevideo cluster. As I have mentioned already, local knowledge spillovers do not have a direct impact upon EXP_INTENS, but an indirect effect through TECHN_INN. Consequently, among the various mechanisms of external (to the firm) knowledge flows, it is IKT which exhibits the strongest positive effect on EXP_INTENS. With regard to RQ 3b I conclude that LKS play a less important role than international knowledge transactions for the export intensity of the firms in the software cluster in Montevideo.

These results answer RQ 4b concerning the importance of local versus international knowledge flows for the export intensity of the firms. The mechanism of international knowledge transactions (IKT) is a stronger predictor than the mechanism of local pecuniary knowledge flows (LKT). This suggests that international knowledge flows play a more important role than local knowledge flows for the economic performance (as indicated by export intensity) of the software firms in the Montevideo cluster.

B. Level of Performance

A similar methodology is applied using different indicators for the performance of the firms. In particular, level of performance (L_PERFORM) is used as an indicator of the economic performance of the firm, while marketing/organisational innovation (MARK_INN) denotes the innovative performance of the firm. The first objective of this analysis is to find out whether local knowledge spillovers have a direct impact upon the level of performance of the firm or whether they just affect economic performance indirectly (through innovation). In addition, the second objective is to find out the relative importance of local versus international mechanisms of learning for the economic performance of the firm.

The following structural model uses once again the three-stage least squares (3SLS) technique.

$$L\_PERFORM = \alpha_1 + \alpha_2 MARK\_INN + \alpha_3 LKT + \alpha_4 RD\_INTENS + \alpha_5 EXPER\_FIRMS + \alpha_6 SIZE + q$$

$$MARK\_INN = \beta_1 + \beta_2 LKS\_S + \beta_3 IKT + \beta_4 RD\_MY + \beta_5 EDU\_DUM + \beta_6 EXPER\_VAR\_F + \beta_7 AGE + v$$

$$IKT = \gamma_1 + \gamma_2 RD\_MY + \gamma_3 EXPER\_VAR\_F + \gamma_4 SIZE + z$$

Table 5.16 presents the results of the 3-stage least squares estimation method. A number of alternative models were tested using different indicators for the independent variables. The best-fit model in Table 5.16 shows that the R-square of the L_PERFORM sub-system is 0.22. Moreover, the R-square of the MARK_INN sub-system is 0.49. Finally, the R-square of the IKT sub-system is 0.27. Overall, the model seems to explain a fair amount of the variation of the dependent variables. Based on this model we may draw the following conclusions:

Concerning the L_PERFORM sub-system, I first notice that RD_INTENS affects L_PERFORM in a positive and significant way. This means that R&D intensive firms perform better than firms that invest less on R&D. Second, SIZE has a positive impact upon L_PERFORM. Large firms exhibit a higher level of performance than small firms.

With regard to the MARK_INN sub-system, Table 5.16 shows similar results as the OLS regression of Table 5.12 with the exception of IKT and RD_MY. Both variables affect MARK_INN in a positive way. However, their effect is not statistically significant. One explanation for this discrepancy (3SLS in Table 5.12 and OLS in Table 5.16) is the fact that IKT is endogenously determined; IKT depends on RD_MY and SIZE. After we control for the effect of these variables in the system equation model, neither IKT nor RD_MY affect MARK_INN significantly.

Finally, the sub-system of IKT shows that the intensity with which a firm may use international knowledge transactions is contingent upon RD_MY and SIZE. This suggests that firms that invest strongly in R&D build the capabilities to use international knowledge transactions. On the contrary, those firms that are weak in R&D do not have the capabilities to use IKT. Moreover, I notice that large firms use international knowledge transactions more intensively than small firms.

Table 5.16: Simultaneous Estimates of Level of Performance, Marketing/Organisational Innovation and International Knowledge Transactions

	beta-Coefficients *		*beta-Coefficients* **	
L_PERFORM				
MARK_ INN	0.162	(0.206)	0.151	(0.79)
LKT	0.040	(0.027)	0.167	(1.43)
RD_INTENS	1.396	(0.455)***	0.465	(3.04)***
EXPER_FIRMS	-0.147	(-0.104)	-0.176	(-1.42)
SIZE	0.005	(0.002)**	0.218	(1.98)**
Constant	-0.814	(-0.358)*		
"R^2"	0.22		0.22	
N	67		67	
MARK_INN				
LKS_S	0.487	(0.192)**	0.244	(2.53)**
IKT	0.009	(0.091)	0.045	(0.12)
RD_MY	0.027	(0.016)	0.279	(1.63)
EDU_DUM	0.712	(0.260)***	0.316	(2.74)***
EXPER_VAR_F	0.298	(0.124)**	0.248	(2.39)**
AGE	0.029	(0.009)***	0.274	(3.02)***
Constant	-1.780	(-0.365)***		
"R^2"	0.49		0.49	
N	67		67	
IKT				
RD_MY	0.143	(0.043)***	0.337	(3.33)***
EXPER_VAR_F	0.122	(0.620)	0.023	(0.20)
SIZE	0.030	(0.010)***	0.275	(2.26)***
Constant	2.761	(1.485)		
"R^2"	0.27		0.27	
N	67		67	

*Unstandardised regression coefficients (beta); Standard Errors in parentheses; ***p<.01, **p<.05, *p<.10.
** Standardised coefficients (beta); t-values in parenthesis.
-3-stage least squares:
Endogenous Variables: L_PERFORM, MARK_INN, IKT.
Exogenous Variables: RD_INTENS, EXPER_FIRMS, SIZE, LKS_S, LKT, EDU_DUM, AGE, RD_MY, EXPER_VAR_F.
Source: Own computations based on author's survey.

Local Knowledge Spillovers versus other mechanisms of knowledge flow

The beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the level of performance of the firms within the cluster of Montevideo. It turns out that local knowledge spillovers have neither a direct impact upon L_PERFORM, nor an indirect effect through MARK_INN. The level of performance of the software firms in the cluster of Montevideo depends on their internal learning mechanisms and in particular of the percentage of employees dedicated to R&D. RD_Intens is the variable which exhibits the strongest effect upon L_Perform.

Discussion of the Results

Regarding the second research question (RQ 2), I have found evidence indicating that firms with high absorptive capacity are able to access external knowledge. However, considering that the variables used in this study are only indicators of the internal and external mechanisms that firms use to access knowledge, generalisations are hard to make. Therefore,

I will draw conclusions only based on the meaning assigned to the specific indicators. In particular, the analysis in Table 5.14 and Table 5.16 has shown that firms with high levels of R&D (measured in man-years) are able to use international knowledge transactions (IKT) intensively. In addition, these firms are large. This implies that firms in developing countries which are small and weak in R&D are in some way disconnected from the international economy.

This evidence suggests that firms in developing countries need to invest in R&D and to become large enough in order to access international knowledge through market mechanisms. On the other hand, the fact that the rest of the mechanisms of knowledge flow such as LKS, LKT and IKS do not depend on the internal capabilities of the firm is remarkable. Once again, this might be the outcome of the limitation of the indicators used in a study to reflect a wider concept. In sum, the results of this study show that firms may absorb local knowledge as well as international knowledge spillovers without being very large or particularly strong in R&D. However, for a firm to be able to establish a formal relationship with international actors, it needs to be large and R&D oriented.

Regarding the first part of the third research question (RQ 3a), the results of the empirical analysis support the presence of local knowledge spillovers and their positive influence upon the innovation of firms within the cluster. In particular, local knowledge spillovers through interaction and labour mobility affect the technological innovation of the firms positively, whereas local knowledge spillovers through spin-offs have a positive effect on the organisational/marketing innovation of the firms. Although, international pecuniary knowledge affects the innovative performance of firms positively, its effect is not statistically significant. This suggests that local knowledge spillovers matter more than the other knowledge flows. The rest of the explained variation is due to learning carried out internally in the firm.

On the other hand, local knowledge spillovers do not affect the economic performance of the firms. Concerning the second part of the third research question (RQ 3b), then, we see that it is international knowledge transactions which have the strongest impact upon the economic performance of the firms. Even if we assume that local knowledge spillovers affect the economic performance of the firms indirectly, through innovation, Table 5.14 shows that the beta coefficients of IKT are higher than the beta coefficients of TECHN_INN. This means that local knowledge spillovers are less important for the economic performance of the firms in the Montevideo cluster. It is primarily international knowledge transactions and then technological innovation which influence the economic performance of the firms. It is important to clarify that the indicator of the economic performance is the export intensity (EXP_INTENS) of the firms. This means that those firms that are well connected in the international economy and acquire knowledge through market mechanisms are those which are export intensive. A prerequisite for this is that these firms are technologically innovative.

Regarding the fourth research question (RQ 4a), this analysis has shown that clustering matters in developing countries. I found that intra cluster knowledge flows contribute considerably to the innovative performance of the firm. In particular, regarding the relative importance of local knowledge flows versus the international ones for the innovative performance of the firms, I have found that local knowledge flows have a stronger impact upon the innovative performance of the firm than the international knowledge flows.

The results of the analysis are different with respect to the relative significance of local knowledge flows for the economic performance of the firms (RQ 4b). While LKS affect the innovative performance of the firms directly in a positive manner, they do not influence their economic performance directly. One reason for this could be the fact that LKS are usually the conduits of tacit knowledge, which needs first to be translated within the firm into explicit knowledge in order to have an economic significance. Nevertheless, LKS are connected indirectly to the economic performance of the firm. This chapter has shown that innovation affects the economic performance of the firm in a positive and direct way, while innovation depends on LKS.

International knowledge transactions (IKT) play a more important role in the economic success of the software firms. This outcome is all the more pronounced if we consider that one indicator of local knowledge transactions (LKT) even affects the economic performance of the firms negatively. As mentioned above, local knowledge flows do affect the economic performance of the firms indirectly through innovation. But the effect of international knowledge flows was stronger than that of technological innovation. This means that extra-cluster knowledge flows are more important than intra-cluster knowledge flows for the economic success of the software firms in the Montevideo cluster.

It is difficult to draw general conclusions concerning the role played by local knowledge spillovers in a developing country (RQ 5) based on the examination of a single sector in a single country. By investigating the Uruguayan software cluster, we may draw the following conclusions: To begin with, local knowledge spillovers play a crucial role for the innovative performance of the software firms in the cluster of Uruguay. At the same time, the outcome of this study suggests that international knowledge transactions are important for the economic performance of the firms. LKS are important for the innovation of the firms, but not sufficient for their economic success. To be innovative is not the same as being economically successful: rather, it is a prerequisite. To achieve economic success according to the results of this study, it is important that a firm is connected to the international economy. The latter is contingent upon the internal capabilities of the firm.

The main hypothesis in the literature of LKS in the advanced economies stresses that LKS are the main reason for the increased innovative and economic performance of the firms within clusters and/or regions (Saxenian, 1994). The results of this study confirm the above hypothesis partially at the context of developing countries. The importance of international linkages has been overlooked in the literature of LKS in developed countries, which is focused on the advantages of LKS. In contrast, in the literature on clustering in developing countries, LKS were overlooked. This study provides evidence which suggests that LKS *do* matter for the innovation of firms within clusters in developing countries. However, it is IKT which allow firms in developing countries to achieve economic success. Firms in developing countries need to be connected with the international economy. This is why international knowledge flows through market mechanisms are so important.

5.5 CONCLUSIONS

Throughout this chapter, I have examined the relative significance of a particular mechanism of knowledge diffusion - namely local knowledge spillovers- in the context of a developing country. Using new firm-level data from software firms clustered in Montevideo, I tested the hypothesis of whether LKS occur and if they affect the innovative and economic performance of these firms.

The results of the econometric analysis show that local knowledge spillovers do indeed occur and also matter for innovation in the context of the software cluster in Uruguay. Local knowledge spillovers take place through the spin-off formation of firms, the informal interaction of actors and the mobility of labour. The econometric analysis underlines that different mechanisms of local knowledge spillovers influence different aspects of the innovative performance of the firm. In particular, labour mobility and informal interactions affect the technological innovation of the firms, while spin-offs affect the marketing organisational innovation of the firms.

Moreover, the evidence suggests that international knowledge transactions are very important for the economic performance of the sample firms. In particular, international knowledge transactions are crucial for the export performance of the firms. IKT are the conduit for the transfer of knowledge related to market trends and customer needs. Finally, the use of international knowledge through market mechanisms by the firms depends on their investments in R&D, which contribute to a firm's absorptive capacity.

CHAPTER 6

HOW DO LOCAL KNOWLEDGE SPILLOVERS TAKE PLACE? A QUALITATIVE ANALYSIS

6.1 INTRODUCTION

Research on local knowledge spillovers has mainly concentrated on verifying the relationship between local knowledge spillovers and innovation in technologically advanced economies. However, not much is known about how localised knowledge spillovers take place in less developed countries. In the previous chapter, I concluded that local knowledge spillovers matter for the Uruguayan software cluster and that they play a significant role in the innovation of the firms. The objective of this chapter is to open the 'black box' of local knowledge spillovers. I will provide an in-depth analysis of the mechanisms by which knowledge spillovers take place at the geographic level. Case studies in advanced (Saxenian, 1994) and developing countries (Schmitz, 1999) point out that the informal interaction of local firms is one of the most important mechanisms through which knowledge spills over within a cluster. Hence, this chapter will focus mostly upon knowledge spillovers which are based on interactions between firms, but it will also pay some attention to spillovers that arise through the channels of labour mobility and spin-off firm formation[96].

In order to analyse knowledge spillovers, I place them in the broader context of knowledge flows, which is also discussed in this chapter. A mechanism of knowledge flow refers to the manner in which knowledge is transferred from a source to a recipient of knowledge (see section 3.2 on knowledge flows). This transfer may take the form of knowledge spillovers or market transactions. Knowledge resides in individuals and organisations (firms and institutions) that constitute the so-called sources of knowledge. Different sources embrace diverse types of knowledge. For example, firms usually hold applied knowledge whereas universities contain scientific and technical knowledge. Scientific and [partly] technical knowledge have a public character while applied knowledge has a more private character. One of the main reasons for the occurrence of knowledge spillovers is the public character of knowledge (Meade, 1952); namely knowledge is non-rival and non-excludable in consumption. Hence, knowledge spillovers arise because it is difficult (some times impossible) to prevent others from enjoying the benefits of certain knowledge. In contrast, private knowledge can be used exclusively by one actor who can impose restrictions to the rest. Some types of knowledge (i.e. tacit) are close to the private pool of knowledge. Sources that control private knowledge would reinforce knowledge flows that have to be paid for, i.e. market transactions. Thus, I expect to find a relation between the source of knowledge and the mechanisms of knowledge flow; sources that hold public knowledge would give rise to

knowledge spillovers while sources that control private knowledge would reinforce market transactions. The previous assumptions about different sources of new knowledge and different mechanisms of knowledge flow call for an appropriate applied study on the basis of systematic field work. Hence, the research questions addressed in this chapter are:

RQ 6: What are the most important sources of knowledge for software firms within the Uruguayan high-tech cluster?

RQ 7: What are the mechanisms by which knowledge spills over among software firms, their suppliers and customers, and public and private institutions? Does it happen through (a) inter-firm interactions, (b) labour mobility, and/or (c) spin-offs?

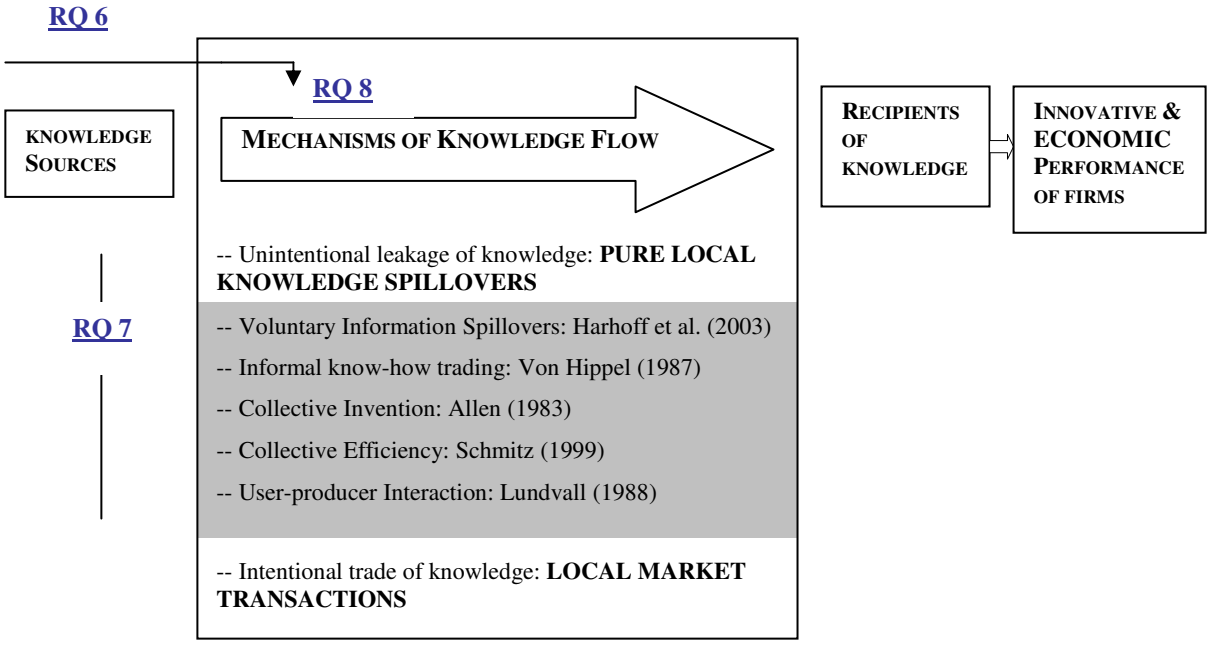
RQ 8: Is there a relation between the mechanisms of local knowledge spillovers and the sources from which the knowledge originates?

This chapter is structured as follows: in the following section, I address the conceptual framework used for this analysis. In section three, I identify the actors that constitute the sources of knowledge for innovation. Section four attempts to shed light on the inter-firm mechanisms of knowledge spillovers and stresses the motivation of the firms for participating intentionally and unintentionally in the process of knowledge diffusion. Labour mobility and spin-off channels of knowledge spillovers are discussed in section five. Finally, in section six, I seek to understand whether the mechanisms of knowledge spillovers are related with specific sources of knowledge.

6.2 CONCEPTUAL FRAMEWORK OF ANALYSIS

The analysis of the literature on LKS (see section 2.2.2.2) shows that there is a range of different forms of LKS that may refer to both unintentional leakages of knowledge and to intentional free sharing of knowledge. Figure 6.1 shows the relation between the research questions that will be addressed in this chapter.

Figure 6.1: Conceptual Framework of Analysis



Source: Kesidou and Caniëls (2006)

Therefore, in order to understand LKS, it is necessary to examine the whole variety of forms through which knowledge spills over from one actor to another. The concept of 'knowledge flows' was introduced in chapter 3 to denote the entire range of forms of knowledge transfer. At one extreme, market transactions refer to the intentional and pecuniary (formal) flow of knowledge and at the other extreme, knowledge spillovers indicate unintentional leakage of knowledge without cost (informal). As Figure 6.1 demonstrates, besides the two extremes ideas of knowledge flow, the literature indicates that there are in-between categories (grey areas) that fall in between one or the other group. Thus, in order to shed light on LKS, I need to examine in detail those grey areas between the two extreme types of knowledge flow.

An extensive analysis of the literature has led me to a classification of the mechanisms of knowledge flow in (1) knowledge spillovers that flow freely and informally between agents (in a direct way and not through the market), and (2) knowledge flows that work through the market, i.e. are pecuniary and formally organised. In the literature, I find that certain mechanisms of knowledge flow are associated with certain sources. Table 6.1 gives an overview of the literature.

The first distinction is between local knowledge spillovers and local knowledge transactions. Storper (1995, 1997) suggested that the region or cluster generates traded and untraded interdependencies. Tödtling and Trippl (2005) applied this approach to the biotech sector later on. Traded relations refer to those streams of knowledge that emerge from formal relations or market transactions. For instance, the purchase of a capital good or a service is a transaction-based relation. Storper (1995) stressed that it is the untraded interdependencies, namely the informal relations, which count mostly towards the innovation of firms within regions. In this section I argue that these informal and direct relations among actors generate knowledge spillovers. For example, in the case of the Montevideo software cluster, informal relations occurred among ex-colleagues or ex-classmates (at a personal level) and among firms that are using the same technology by the formation of user-networks of communication (at the level of the firm). Moreover, I make a distinction between those mechanisms of knowledge flow that take place through interaction and other mechanisms, such as labour mobility and spin-offs.

Local knowledge spillovers can be further subdivided into pure knowledge spillovers and *quasi* knowledge spillovers. To begin with, *pure knowledge spillovers* arise out of the informal and direct interaction of the actors (non-intentional[97]). At times, knowledge sharing among firms is based on reciprocity (Allen, 1983; von Hippel, 1987). For instance, the informal exchange of knowledge among competitors that use the same technology is usually motivated by their need to understand new technologies and to solve problems rapidly. Additionally, within a cluster, *quasi knowledge spillovers* of an intentional[98] character may arise (Humphrey and Schmitz, 1998). Social capital may be vibrant in certain clusters or regions and can thus provide the context (of sharing values and beliefs) upon which trust can be built (Burt, 1997; Coleman, 1988, 1990). Backward linkages, for instance, may be informal, with the absence of contract or monetary compensation, and based on trust. Knowledge is shared is such a way between, for example, a supplier of a technology and a user through the formation of a nascent (informal) collaboration.

Table 6.1: Mechanisms of Local Knowledge Flows and Associated Sources

	Local Knowledge Spillovers		**Local Knowledge Transactions**	
	Informal and Direct relations – Untraded interdependencies		Formal Market Transactions – Traded interdependencies	
	(Storper, 1995, 1997; Tödtling and Trippl, 2005)			
A. Through Interaction	**Pure Knowledge Spillovers**	**Quasi knowledge Spillovers**	**Quasi knowledge Transactions**	**Pure Knowledge Transactions**
	(Griliches, 1979; Harhoff et al., 2003; von Hippel, 1987; Allen, 1983)	(Schmitz, 1999; Humphrey and Schmitz, 1998; Saxenian, 1994)	(Lundvall, 1988)	(Dahlman et al., 1987; Rosenberg, 1982)
	Interactions among competitive **software firms** Interactions with **University** & **Research Institutes** Interactions in **Exhibitions** & **Conferences**	Vertical interactions: **backward linkages** Vertical interactions: **forward linkages** Interactions with **Support institutes**	Interactions with **customers**	Purchase of knowledge services from **consultants** Purchase of knowledge products from **suppliers**
B. Other Mechanisms	**Labour Mobility**		**Labour Mobility**	
	(Zucker et al. 1998; Almeida and Kogut, 1999) Labour mobility is seen as a mechanism of knowledge spillover.		Breschi and Lissoni (2001, 2003) Labour mobility is seen as an outcome of well functioning labour markets.	
	Spin-offs			
	(Saxenian, 1994; Zucker *et al.* 1998) Spin-off firm formation is seen as a mechanism of knowledge spillover.			

Source: Author.

Local knowledge transactions can be subdivided into pure knowledge transactions and *quasi* knowledge transactions. *Quasi knowledge transactions* refer to those situations in which a market relationship might not be restricted by the confines of the transaction but can be also extended and take the form of an informal and direct relationship among the actors involved. For instance, the intense user-producer interaction that may accompany the sale of a capital good is not restricted to the business/market transaction, but involves the creation of network relations (Lundvall, 1988). *Pure knowledge transactions* refer to relations that terminate after the purchase of a good or service. For example, technology transfer through the purchase of a capital good could be a case of pure knowledge transaction. Thus, the main difference between pure knowledge transactions and *quasi* knowledge transactions is that in the former case, the flow of knowledge is the result of a [formal] market based relation. In contrast, in the latter case, while the relationship begins as a formal one, further collaboration among the participants generates extensive knowledge flows.

Knowledge is diffused not only through the interaction of actors but also through the mobility of labour and new start-ups. In this study, I interpret these two mechanisms as channels of local knowledge spillovers. However, especially in the case of mechanism of labour mobility, there is no consensus on whether the latter induces knowledge spillovers or just shifts knowledge from one firm to another (Breschi and Lissoni 2001; 2003). Therefore, labour mobility is also located in the column of knowledge transactions. In section 6.5 I discuss the reasons why in my view labour mobility and spin-offs are considered as mechanisms of local knowledge spillovers.

6.3 SOURCES OF KNOWLEDGE

To understand the mechanisms of knowledge flow within a software cluster I need first to gain insight into the types of knowledge that are crucial for the software sector.

In the literature, a distinction is made between two types of knowledge that are needed to generate innovations. (1) *Know-why*, concerning scientific and partly technological knowledge, and (2) *know-how*, involving applied knowledge in different business contexts (Lundvall et al., 2001). "Know-how is the accumulated practical skill or expertise which allows one to do something smoothly and efficiently" (von Hippel, 1987, p. 4). Both types of knowledge are especially important in the software industry. Know-why, i.e. profound technological knowledge, is needed for the development of software products. Know-how is needed as well, since the implementation of a program in a firm requires specific, mostly tacit knowledge of how the firm's internal processes are organised. This implies that knowledge about the sector in which a firm operates is indispensable. For instance, an excellent understanding of the banking sector is crucial to create a banking software product.

My fieldwork illustrates the importance of both technological and applied knowledge for innovation. As the director of a local firm stresses, "you need to know the type of business of your customer in order to develop the software product that we offer. Therefore, even if another software firm has the code of this product but does not understand the business, it is very difficult to use it. Face to face communication is very important because you are learning from the customer"[99]. In other words, to imitate this product, a firm needs technological knowledge in order to be able to generate the code and applied knowledge for adjusting it to the specific business context.

In particular, my survey shows that 99 per cent of the firms consider technological knowledge important for innovation and only 1 per cent of the firms consider it unimportant. With respect to the relevance of applied knowledge, 82 per cent of the firms assert that it is important, while 16 per cent say that it is not important at all for innovation. Thus, both types of knowledge are considered highly important for innovation in the software cluster. While technological knowledge is significant for nearly all firms, applied knowledge is important only for a large segment of them.

I would expect to find a difference in origin (source) between these various types of knowledge. If knowledge is public, several people can share it simultaneously. The character of technological knowledge in the case of the software sector is mainly public and its sources are usually universities or research laboratories. The new technological knowledge is open to the public by means of scientific publications or patents. On the other hand, if knowledge is private, the agreement of its producer is a requirement for its successful transfer (Lundvall et

al., 2001). The character of applied knowledge in the software sector is mainly private; it is embodied in humans or organisations. Applied knowledge is usually developed in firms. In order to address research question six (RQ 6), I will analyse the sources of knowledge that are used in the Montevideo software cluster.

Table 6.2: Sources and Types of Knowledge

Sources	**Importance for innovation**[100] (% of respondents)	**Type of Knowledge** (as identified by respondents)
Customers	90% { 25%-Important, 40%-Very Important, 25%-Crucial }	Mainly applied
Exhibitions/ Conferences	66% { 39%-Important, 24%-Very Important, 3%-Crucial }	Applied/ Technological
Vertically connected firms	59% { 33%-Important, 20%-Very Important, 5%-Crucial }	Mainly applied
Competitors	57% { 36%-Important, 17%-Very Important, 2%-Crucial }	Mainly technological
Suppliers	53% { 24%-Important, 19%-Very Important, 9%-Crucial }	Mainly technological
Consultants	39% { 18%-Important, 14%-Very Important, 5%-Crucial }	Mainly applied
Support Institutes	28% { 23%-Important, 4%-Very Important, 1%-Crucial }	Mainly applied
Universities	23% { 15%-Important, 8%-Very Important, 0%-Crucial }	Mainly technological

Note: A source of knowledge for innovation was considered to be important, if the respondent had given the score of ≥2 in the following Likert scale: Unimportant = 0; Less Important = 1; Important = 2; Very Important = 3; Crucial = 4.
Source: Own computations based on author's survey.

In this study I have asked respondents to evaluate the importance of several sources of knowledge for innovation on a five-point Likert scale. I have also asked whether these sources are important for acquiring technological or applied knowledge. The results show that firms in the Uruguayan software cluster acquire technological knowledge from seminars or courses at the university, from suppliers and informal contacts with other software firms and from conferences/exhibitions (see Table 6.2). Applied knowledge is mainly acquired from customers, other vertically connected firms (with distributors and suppliers), consultants, conferences/exhibitions and support institutes.

These results indicate that customers are the principal source of knowledge for innovation. 90 percent of the firms listed customers as important sources of knowledge for innovation. Moreover, exhibitions/conferences, vertically connected firms, competitors and suppliers play an important role for innovative projects in firms as well. The university/research institutes, support institutes and consultants play the smallest role in the innovation of firms in the Montevideo cluster.

These findings are consistent with past research into the software sector. The seminal work of Keith Pavitt (1984) emphasised that software firms usually undertake product innovation in close cooperation with their clients (see also Malerba, 2005). In addition, case studies on China, India, and Brazil also suggest that sophisticated customers are the most important sources of innovative ideas for software firms (Veloso et al, 2003).

6.4 MECHANISMS OF LOCAL KNOWLEDGE FLOWS THROUGH INTERACTION

As mentioned in section 6.2, knowledge spillovers may take place in a number of different ways. They may occur spontaneously but also intentionally. Thus, in order to unravel local knowledge spillovers, it is important to examine the whole range of forms through which knowledge flows across firms, including pecuniary flows. This section will address research question seven.

On the basis of the fieldwork (interviews and survey), the mechanisms of knowledge flow that were identified in the literature (see Table 6.1) were validated. I will now discuss each of the mechanisms and show the sources of these flows.

6.4.1 Local Knowledge Spillovers

6.4.1.1 Pure Knowledge Spillovers

Firms within the software cluster in Montevideo share knowledge in an informal and direct way, which gives rise to knowledge spillovers. Partly pure knowledge spillovers take place spontaneously. Although, there is an intention[101] behind every action of a firm, the unintentional nature of pure knowledge spillovers has to do with the fact that the sharing of knowledge does not have a direct economic or business relevance to the actors involved. Thus, knowledge spills over at certain random moments, for example, when two professionals meet at a conference.

Next, I will examine the occasions in which knowledge spillovers of this nature occur in my case study. Moreover, I will try to show the factors that induce firms to use the mechanism of LKS in order to acquire knowledge. I discuss how local knowledge spillovers occur during A) horizontal interactions among software firms, B) interactions with universities and research institutes, and C) interactions at exhibitions and conferences.

A. Horizontal Interactions among Software Firms

Purely informal interactions occur among employees of different software firms within the cluster. Informal relations of this type are based partly on reciprocity and serve various purposes:

Networking

Firms' employees initiate and maintain contacts with other firms at a personal level. These relations usually develop among ex-colleagues, professional friends and ex-classmates and

lead to the exchange of information. The purpose of these contacts is to acquire information regarding the technological or commercial aspects of the software sector. The latter is a rapidly developing technology sector. This implies that information regarding new technologies needs to be acquired quickly. At the same time the commercialisation of intangible products such as software is as important as the development of the product. Therefore, through networking, firms attempt to maintain good relations and develop new contacts that eventually may facilitate their efforts to commercialise their products. For instance, the chief engineer of a local software firm states that "we communicate informally with other software firms on a permanent basis. Usually these are personal contacts with ex-colleagues, professional friends, people that have studied together, other firms that use the same technology, friends that work in the university. Through this network we exchange technological or commercial information, which is very important for problem solving and for entering new markets"[102].

In sum, informal exchanges of knowledge take place between colleagues working for various firms in Montevideo and are based on personal contacts. The director/partner of a local software firm claims "we exchange ideas constantly with colleagues and professionals whom we have a personal relation with. We share information regarding the composition of new technologies and of how to solve precise problems that occur. We consult each other for solving these problems"[103]. Finally, the president of another local software firm acknowledges "my engineers are exchanging knowledge with employees of other firms on a daily basis. Usually, they talk and share experiences with employees of friendly firms. However, I cannot stop them from sharing information with employees of competitor firms"[104].

User-communities

Firms that use the same technology often communicate informally amongst themselves. The main objective of these contacts is to exchange information in order to avoid pitfalls and make the most efficient use of the technology at their disposition. Firms create so-called 'user-communities', where they exchange, via e-mail, phone calls and direct contacts, their experiences in using any aspect of a specific technology. In the words of the director of a local software firm, "the general director has an excellent communication with firms that use the same technology; this enables us to solve problems fast"[105]. Harhoff, Henkel and von Hippel (2003) use various case studies to show that users of technology products share innovative ideas freely among themselves and with the manufactures of those products. As a result, innovation is stimulated by the need to primarily 'use' an improved product and not to sell it (von Hippel 2003).

In Montevideo, a unique case of a user-community was formed among the majority of the local software firms. The main reason for the development of this network of users was the presence of a leading technology firm, Artech, which developed a software engineering tool (Genexus). Genexus is a generating code - a platform upon which software firms are able to develop a variety of software solutions. Besides the advantage afforded by being located near to their main technology supplier, the Uruguayan firms have formed an informal network of users. Hence, knowledge spills over among software firms (users) and facilitates problem-solving and innovation.

B. Interaction with University and Research Institutes

Software firms receive technological knowledge (know-why) from universities and research institutes. Usually, knowledge which flows between universities (and/or research institutes)

and firms takes the form of knowledge spillovers. Firms in the software cluster in Montevideo have two main reasons for creating a link with a university and/or a research institute:

Testing

For software firms, it is essential to obtain in-depth knowledge of new technologies as frequently as possible. In addition, complex software products need to be tested in order to confirm their quality and functionality. Software firms tend to create contacts with knowledge centres in order to gain access to up-to-date knowledge and to test their products. For example, the engineer of a software firm in the cluster explains why they have developed a close relationship with CES,[106] "we are partners of the 'CES', which is a centre for software testing located in Montevideo. There, we received information about new technologies and we were able to test our products"[107]. Software testing is very important; it assess the functionality, robustness, and compatibility of software products. CES was created in 2004 with the support of the European Union[108], United Nations[109], the faculty of engineering of the University of the Republic, and CUTI.

Research

Software firms not only have to identify and comprehend existing technologies but also have to create new knowledge. Knowledge creation is a time-consuming research process which involves high risks. Thus, many software firms try to acquire research inputs from external sources. The mechanism of knowledge spillovers is used by local software firms in order to acquire research insights from the local universities. The director of another local software firm clarifies the reasons for the interactions of his firm with the local university.

> "We have worked together with the faculty of engineering of the University of the Republic. At one point in the development of our product, we came across a problem that we did not know how to solve. We had a contact in the university and we designed a BA thesis based on this problem. Three students undertook the challenge and I have worked as an external tutor with them. Finally, the students came up with a solution. This solution as such cannot be applied. However, they offered methodological knowledge of how to tackle the problem. This allowed us to create the new component for our product. The interactions between my firm and the university were informal and based on mutual benefit"[110].

Finally, the partner of a local software firm claims "we have an informal relation with most of the local universities. Often, we work together in research through the research projects of students. Moreover, we talk with professors in the university and exchange ideas"[111]. These statements demonstrate that in the Uruguayan software cluster knowledge flows informally and directly between the firms and the local universities.

C. Interactions in Exhibitions and Conferences

Most of the firms recognise the importance of exhibitions, which serve many purposes. Usually, they are the place where firms have the opportunity to make new contacts, become aware of new technologies and practise espionage. There are exhibitions where firms can participate for free and others for which firms have to pay a fee. However, knowledge spillovers are flourishing in these spaces, since the participation fee is a minimal payment in exchange for technological knowledge and for personal contacts. For example, the manager of a local software firm tells us "you usually pay a fee to participate in an exhibition or a conference, but then the knowledge you get is informal"[112].

The director of another local software firm explains the role of exhibitions: "We go usually to two big trade fairs in USA and Europe and three or four in Montevideo every year. There sometimes we make mysterious shopping, we go to our competitors and we take ideas from them and of course we collect all the brochures. There we identify the competitors and subsequently through Internet we check what they do regularly"[113].

6.4.1.2 *Quasi* knowledge Spillovers

In the software cluster in Uruguay, cooperation between firms is often based upon trust. In turn, trust depends upon reputation concerning the performance of the firm rather than its social status. The main reason for this is that from its genesis, the software cluster in Uruguay has been an export-oriented industry, which faced severe competition and pressure from international players. In this context, the local identity of the firm influences relations with other enterprises to a lesser extent than does its actual performance. Although some of these relations begin formally, they ultimately expose an informality that flourishes mainly on the basis of trust. Such relations take the form of informal interactions between software firms during: A) vertical interactions through backward linkages, and B) vertical interactions through forward linkages. Moreover, software firms realise C) economies of scale through interactions with other software firms, and finally achieve synergies during D) interactions with support institutes.

A. Vertical Interactions: Backward Linkages

Software firms in Montevideo develop close relations with their suppliers. The latter constitute the main providers of technological advance for software firms. The most important local suppliers are a local firm and two multinational companies. Artech, Microsoft and IBM supply the majority of the software firms with technology tools and knowledge. Informal sharing of know-how is the main mechanism by which knowledge is transferred from suppliers to local firms.

Software firms collaborate technologically with suppliers based on common trust. As a result, they share knowledge in an informal way. Suppliers share their knowledge with local software firms for two main reasons. Firstly, suppliers of technological tools such as Artech use local software firms as B-testers. Selected software firms test the technological tools, detect errors and offer ideas for further improvement. For example, the marketing manager of a software firm within the Montevideo cluster claims that the cooperation that has been established with Artech is informal and explains why: "Genexus is the most innovative technology at this moment in Uruguay and it is free for us to use it. Artech developed the Genexus tool and we were the second software firm that used it. Ever since, our firm has been the biggest B-tester of Genexus, and we have facilitated them with error detection. There is no contract or money involved in this collaboration; it is based on reciprocity and trust. On a daily basis our employees are talking and exchanging ideas with the employees of Artech, which is located next door"[114]. Finally, he asserts, "face to face informal communication with the employees of Artech constitutes one of the most important ways of acquisition of technological knowledge and learning from one of the most successful companies in the cluster".

Secondly, suppliers of application platforms such as Microsoft are interested in entering vertical markets (financial, telecommunications etc.). They achieve this through close collaboration with software firms. Thus, when a software firm sells its products (which are developed using Microsoft) then Microsoft instantly starts selling its products as well. For

instance, the director/engineer of a local firm explains that he cooperates with a multinational company on the basis of mutual benefits and trust. "The interactions with the specific MNC are not pecuniary. This means that they provide most of the licences for their products free of charge, because they want us to use their products. Oracle, IBM and Microsoft compete to gain a share in this vertical market, so they provide their products for free to the software firms"[115].

B. Vertical Interactions: Forward Linkages

'Socios de negocio', or business partners, are firms that commercialise software products. These are the firms that integrate software products into the systems of the customer and tailor them according to their needs. In other words, these firms sell, install, maintain and offer training to the final customer.

Generally, we would expect this type of relationships (between the software firms and their distributors) to work through the market, to be formalised through a contract or to be pecuniary. However, face-to-face interviews with the actors involved in the case of software in Uruguay reveal the opposite. Many of the collaborations that software firms create with distributors are informal and based on trust.

Local software firms form commercial collaborations with distributors that implement the software and offer consultancy services. This is a common strategy for software firms and it serves two purposes. Firstly, software firms can focus on a specific business strategy and leave the marketing and commercialisation to another firm. Secondly, this is a path that many software firms have followed in order to export and enter foreign markets. The strategy begins by identifying software firms specialising in services in growing markets. The second step is to demonstrate the product and its credentials and to allow the potential user firm to try it. If the potential user firm likes the product, the software firm continues to offer the new versions and training for free [in order to enable the user firm to understand the full capacity of the program]. From this point onwards, the software firm takes the role of the provider of technology (free), and the distributing firm takes the role of receiving this technology, learning how to use it, promoting it and eventually selling it.

According to the director of a local software firm, "we have commercial collaboration with a firm in Ecuador. This firm is characterised by a high level of knowledge and they use our tool in their work. They sell our tool to their customers. It is an indirect way of selling. Through this cooperation we acquire information about the specific requirements of the customers, and we proceed by adapting the product to the need of the market"[116].

In other cases, a local software firm will mainly create this type of collaboration with other local software firms. The latter are responsible for offering consultancy to the final customer. These firms (distributors) offer the know-how to the software firms and facilitate the incremental improvement of the product.

C. Economies of Scale through Interactions between Software Firms

The importance of informal communication rests on the benefits that it provides to small firms. Firms develop informal relations with other software enterprises in order to undertake big projects together and to overcome the size problems they are facing. This networking is crucial for the formation of technological alliances. The latter are frequently established among software developers. To support this argument the director of an Uruguayan software

firm states "for a small firm, the network of personal contacts with other actors of the software market is crucial and more important than the formal relations. For example, in the last project that we are working on for a medical lab, we undertook it together with another software firm. If you have an informal network of contacts, it is easier to form a formal alliance when you need it"[117]. Similarly, the partner of another local software firm explains the type of relation that they have developed with other software firms. "We undertake large projects with other software firms. There is not a written formal contract which defines these collaborations. However, there is a spoken agreement based on trust"[118].

D. Interactions with Support Institutes

Institutional relations are multilateral agreements of actors with common aims that may generate synergies. There are two main institutions that are active in the Uruguayan cluster, CUTI and Integro. The 'joint action' of firms under the umbrella of an institutional organisation serves different purposes in the Uruguayan cluster (Schmitz, 1999). CUTI functions as a link between the software firms and National and Multinational funding organisations. In addition, CUTI organises trade fairs and exhibitions in order to promote Uruguayan software abroad and to improve the image of the country as a technology centre. Integro, on the other hand, represents the effort of local firms to share the cost and acquire training in relation to quality certifications and marketing strategies for exports.

CUTI

An important source of knowledge for software firms is the sector's institute - CUTI. However, according to my survey, CUTI does not seem to be important for the majority of the firms (only 28 per cent of the firms consider that support institutes are important). The director of a local software firm that actively participates in CUTI explains its role. "CUTI is a political actor that gains its relevance above the needs of every one of the firms. CUTI is the interlocutor which searches, and connects the different political segments nationally. In addition, the CUTI puts strategic goals above the individual goals of the firms. The concept of the mission of CUTI is to take overall action that the firms cannot take. The benefits of these actions will be seen 2 or 3 years later. However most of the firms in Montevideo do not perceive the role of CUTI in the same way. Thus, they fail to foresee the importance of CUTI for the development of the software business"[119].

Integro

Integro, the other support institute, is by no means less significant for the spillover of knowledge between the software firms in the cluster. The director of a local software firm explains the reasons for their participation in the group. “Integro is an alliance which enables us to better commercialise our product abroad. In addition, we receive training in marketing, sales and negotiation all together. It is our intention to work together to achieve synergy"[120].

This opinion is supported by the directors of several other firms. For example, the director of another software firm elucidates the activities of Integro:

> "Eight companies that participate in the group Integro decided to undertake the CMMI project together. Capability Maturity Model Integration evaluates the quality of the process by which each firm produces software. However, it is difficult for a small firm to go through such a process due to financial and time constrains. Cooperation generates synergies in terms of access to credits and sharing of experiences. Firstly, firms may gain an easier access to credit because they provide guarantees to each other. Secondly, they exchange knowledge and experiences

because there are not previous experiences in CMMI in Uruguay. To have other firms that follow the same trajectory is important in order to know if there are failures in particular areas, if they are motivated by a specific organisational issue, or to be able to clarify an error in the process. In that way, we save valuable time (CMMI is a long project with duration of 1-2 years), by comparing our experiences and avoiding reappearance of mistakes, applying best practice, etcetera"[121].

6.4.2 Local Knowledge Transactions

Local knowledge transactions can be classified into two types: (1) *quasi* knowledge transactions, and (2) pure knowledge transactions. *Quasi* knowledge transactions refer to the acquisition of knowledge through the extension of relationships which are based on market transaction (i.e. informal training and advices that the supplier provides together with the sale of the machinery). Pure knowledge transactions refer to the acquisition of knowledge inputs as a result of a market transaction (i.e. the purchase of machinery from a supplier).

6.4.2.1 *Quasi* knowledge Transactions

Interactions with Customers

Customers have contributed to the emergence of software firms in the Montevideo cluster. In particular, they have provided the financial capital for the research and development of the first product of many of these firms. Capital markets are less than perfect in most developing countries. Moreover, the financial market of Uruguay has weakened as a result of the Argentinean crisis of 2001. The bulk of the software firms started out in a similar manner. A large firm would need to electronically systematise its production or distribution systems and its human resource management, etc. Thus, the project would be assigned to one of the emerging software firms. According to the director of a local software firm "the first client had the role of the godfather; he financed our first project which implies that it took the financial risk and it gave us time to learn"[122]. This customised or ad-hoc product would be the first 'learning-by-doing' path (Arrow, 1962) that most of the software firms followed.

Customers bring to the firm knowledge of the know-how type. Usually, customers are enterprises specialised in a line of business (finance, health, education etc.). Thus, they hold the software product applied knowledge. Customers transfer this know-how to the software firms initially by setting the requirements for the product and subsequently by giving a feedback concerning its performance (regarding problems and/or additional functions). Therefore, the transfer of knowledge as such is not pecuniary. There is no compensation on the part of the software firms for the knowledge they gain as a result of the interaction with the customers. However, the relationship between customer and the software firm is a market relationship. The exchange of knowledge is a by-product of this relationship. As a result, the gains that a software firm has in terms of know-how depend on the success of this association. In particular, two features of the relation are crucial: the capabilities of the customer and the type of interaction.

Sophisticated Customers

Research in the software industry shows that innovative customers are the most important sources of knowledge for software firms (Veloso et al., 2003). They are responsible for establishing the problem, calling for a solution and providing feedback. In the words of the director of a local software firm "customers are faced with practical problems; their knowledge concerns the definition of the problem. Then we proceed by searching the solution"[123]. As a result, the more innovative a customer is the more sophisticated products he demands from his suppliers. Software firms which provide products to innovative sectors

(banking, telecommunications, etc.) are stimulated more than firms which provide products to sectors that are not so technologically advanced (timber, construction industry, etc.). The director of a local software firm underlines the importance of the capabilities of the customers for their innovation process: "we created a software product for the timber industry but it was not successful. We tried to improve it and sell it to other customers without any success. The problem derives form the fact that the timber industry does not invest in information technology in general, and in particular in Uruguay. It represents a niche market that we manage to enter, but it is not an innovative sector"[124].

Learning by interacting

To a great extent know-how is tacit knowledge, which requires spatial proximity for its transmission. In other words, face-to-face interaction is important for the successful transfer of this type of knowledge. In particular, through close user-producer interaction many firms substantially improve their final product (Lundvall, 1988). The feedback coming from a customer, in the form of additional requirements or the discovery of a defect, has enabled the firms in Montevideo to 'learn-by-interacting'. The director of a local software firm claims that "face to face communication with the customer enables us to detect the problem in reality"[125]. This is very important, because it allows firms to monitor the needs of the market. Finally, problem-solving activities are more successful when a good definition of the problem is provided by a customer.

6.4.2.2 Pure Knowledge Transactions

Pure market transactions take place by purchasing *knowledge services* from specialists (i.e. consultants). Disembodied knowledge flow to another actor after the payment of a fee. Another conduit for the transfer of knowledge which represents a pure market transaction is the purchase of *knowledge products* (technology embodied in products, i.e. equipment or machinery) from suppliers. Knowledge transfer through purchase of equipment may enhance the efficiency of the user and may as well facilitate imitation through reverse engineering (Dahlman et al. 1987).

Consultants are usually carriers of know-how type of knowledge. They complement the knowledge base of the firm by providing the applied part (logistics, human resources management, etc.). This knowledge is tacit in nature and embedded in humans because it concerns the application of a specific knowledge in a local business context. Moreover, know-how is sticky and difficult to diffuse outside of the cluster; it is embedded in a local social, economic and cultural context (Lundvall et al., 2001; von Hippel, 1994). Likewise Cowan et al., (2000) have argued that knowledge is tacit because it is highly contextual and specific. Thus, not everybody is aware of the way in which this knowledge is translated into simple meanings. For instance, a multinational company attempted to enter the Uruguayan market. It initially faced many difficulties in understanding the Latin American market, despite the international experience that it had. It became compulsory for this firm, to gain a sound understanding of local know-how. The president of the Uruguayan branch explains, "10 percent of our innovative projects failed because we could not understand the local business culture. Even though this company has 35 years experience, we have not comprehended the needs of the local customers"[126]. They finally acquired this type of knowledge by using the services of local consultants. This type of knowledge is vital, especially for software firms that provide services and/or customised products to many different types of businesses.

Software firms acquire know-why type of knowledge from suppliers. The latter sell technological knowledge, usually in the form of an artifact that is based on scientific

principles. Nevertheless, the purchase of this artifact does not imply that the user-firm knows also how to operate it, repair it or improve it. This is the know-how knowledge which comes with the experience of using the artifact and learning from its use (learning-by-using). For example, in a seminal work, Rosenberg (1982 argued that efficiency in using a complex technology increases with time while firm learns. The relationship between software firms and their suppliers is formal. Software firms buy the license or sign a partner contract with the suppliers.

6.5 OTHER MECHANISMS OF LOCAL KNOWLEDGE SPILLOVERS: LABOUR MOBILITY AND SPIN-OFFS

Table 6.1 made a distinction between mechanisms of knowledge flow through interaction and other mechanisms. The latter includes labour mobility and spin-offs, which are interpreted here as mechanisms of local knowledge spillovers.

6.5.1 Labour Mobility

Labour mobility has been widely used as an indicator of localised knowledge spillovers (Zucker et al., 1998; Almeida and Kogut, 1999). A high rate of labour mobility within a cluster or region is said to induce LKS through the circulation and sharing of knowledge among firms (Marshall, 1920).

The view of labour mobility as a channel of local knowledge spillovers has been criticised for not reflecting the pecuniary nature of the transfers of knowledge via mobility. In particular, Breschi and Lissoni (2001) argued that since a fee (in the form of a salary) is paid by the firm when the latter appoints a new employee, labour mobility should not be regarded as a conduit of knowledge spillovers.

However, this is not entirely true for two main reasons: First, although at the level of the firm, a high labour inflow might not be a pure knowledge spillover, it certainly has characteristics of rent spillovers. A high rate of labour circulation brings new knowledge to the firm, which is vital for innovation. The new employee, not only contributes to the output of the firm (for which he is paid). He is also circulating and sharing his knowledge with his new colleagues and thus augmenting and enriching the knowledge base of the firm (for which he is only partly paid). In this respect, labour mobility may be viewed as a rent spillover.

Secondly, at the level of the cluster or region, labour mobility constitutes a knowledge spillover because it induces knowledge circulation without cost. The total benefit of the effect of high labour mobility, -the sharing of knowledge within the region and the potential improvement of the region as a whole through innovation, is greater than the sum of the individual gains at the level of the firm. This is the idea of positive externalities. In addition, the collective effect of labour mobility arises without cost. The firm does not pay for the high rate of labour mobility within the region. The motivation of an employee (and thus his knowledge) to move from one firm to another one located in the same area is not paid by any firm. The firm starts paying the employee from the time he begins working and thus offering his services. The firm does not pay for the actual movement of the employee and thus does not pay either for the movement of knowledge that he carries with him.

The market alone cannot induce such a phenomenon. The presence of a labour market is a necessary condition for labour mobility, but not a sufficient condition. A labour market can facilitate the process of labour recruitment by reducing the transaction costs of both

employers and employees. However, labour mobility and the subsequent knowledge spillover that creates is not only the outcome of the presence of demand and supply of employment. It is also related to labour law, allowing labour flexibility and mobility without additional costs. It is also related to the pace of technological change within a sector. When this is rapid, new knowledge is critical and thus, the acquisition of new employees is urgent. Finally, the confinement of labour mobility to a region is related to idiosyncratic and cultural factors that tie people to a locality. Whatever the reasons for spatially confined labour mobility, it can certainly be regarded as a pure knowledge spillover.

Breschi and Lissoni (2003) have also argued that an employee may simply contribute to the output of the firm without sharing his knowledge with the rest of his colleagues. In that respect, at the level of the firm, the employee does what he is paid for. In such a case, Breschi and Lissoni (2003) argued that LKS do not occur. At the level of the cluster, labour mobility shifts rather than shares knowledge from firm to firm.

Whether or not an employee shares his knowledge with his co-workers depends very much on the organisation of the firm. If the firm has formal routines through which the employees meet (for instance weekly) to share their output and ideas, then the aforementioned situation is unlikely. On the other hand, if the firm is based on a hierarchical model of communication and interaction, an employee can retain undisclosed knowledge. However, considering that ideas of knowledge sharing, communication and interaction are central in the organisational literature, I believe that the case to which Breschi and Lissoni refer is not a common one, especially among successful firms (Nonaka et al., 1995).

Labour Mobility in the Uruguayan Software Cluster

The increased rate of labour mobility that was identified in the software cluster in Montevideo (chapter 5) is due to the fact that some firms in Uruguay use flexible employment in order to adjust quickly to rapid changes in the market associated with the short life cycle of software products and the economic fluctuations of the country.

A strategy that has been adopted by the firms in order to deal with the aforementioned problems entails the appointment of self-employed professionals working under a contract to provide services to the firm for a pre-defined period. Through this process, firms do not contribute to the social welfare of the employees. It is thus cheaper and easier to recruit and dismiss labour. At the same time, these employees do not appear in the official statistics as labour occupied in the sector. Rather, they are recorded as part of the non-labour expenses of the firm and deducted from value added as intermediate inputs. This is one of the reasons why I found low value added figures for the sector in Chapter 4. Failache et al. (2005) raise the same problem in assessing the value added of the sector in the official statistics.

There are different types of employees that firms use, depending on their needs. Interviews with local firms in Uruguay have made it possible to shed some light on these issues. For example, the manager of a very successful software firm said that "during the last five years, more than 30 per cent of our employees are freelance"[127]. According to the same firm, the contracts with these professionals vary from a period of six months to a maximum period of four years. With regard to the type of skills and knowledge these professionals bring to the firm, the manager of that company said "we have acquired employees for providing services to our customer regarding the installation of our products. In addition, we have recruited one specialist on technology research, another specialist on databases, and finally, a specialist on software quality"[128].

In other words, a large percentage of employees retain some technological knowledge, but mainly hold applied knowledge; that is, the know-how allowing for the application of software to a particular business. The latter type of knowledge enables them to adapt the product to the needs of the customer. The more projects and thus customers a firm has, the more employees of this type it will need.

A smaller percentage of the freelance employees are specialists in a particular domain, which, at a given point, becomes important for the firm. The firm, especially if it is small, cannot posses all types of capabilities; it will attempt to build a strategic or 'core competence' (Prahalad and Hamel, 1990). When the need for a specific technological knowledge appears, the firm hires specialists. While working in the firm these professionals share their knowledge with their colleagues and via this process the firm captures knowledge that it would otherwise only acquire through investments in R&D.

The director of the research and development department of another very successful local firm confirmed the above observations. In particular, he argued that a large percentage of freelance employees were used for the provision of services relating to the adaptation and installation of software for new clients and a smaller number were used to start the process of quality certification of the firm and design of new products[129]. Interviews with the rest of the firms, which have exhibited a high score of labour inflow, confirm these observations.

However, not all labour mobility is due to the mobility of freelance employees. Mobility of employees based on an employment contract is also present among firms in Uruguay. Precise data on the percentage of the labour inflow relating to freelance employment and to the fraction of labour mobility hired on the basis of a contract is not available. Based on the interviews, a crude estimate would suggest that more than 60 per cent of labour mobility is due to freelance employees.

6.5.2 Spin-off Firm Formation

Spin-off firm formation is said to be one of the mechanisms through which knowledge spills over within a cluster or region[130] (Saxenian, 1994; Zucker et al, 1998). Some firms are spin-offs of other firms, while others originate in universities. In the first case, an employee of a large firm and/or a multinational company chooses to create his own business. In the latter case, a student or a university professor decides to start up an enterprise. Even though, in the aforementioned cases, the background of the new entrepreneurs differs, the decision to start-up a firm is similar and based on their vision and desire to commercialise their ideas based on the knowledge and skills acquired in their previous occupation. When a new firm is located in the same cluster as the previous firm or university, then the formation of the new firm constitutes a LKS.

Governments may initiate policies that encourage the creation of spin-offs; these are called incubator programs. Usually, under the umbrella of a local university and/or research institution, the (local or national) government provides financial support and/or technical and business training courses to the new firms. In order for a firm to participate in the incubator program, it has to submit a proposal with a business idea, which is usually based on an innovative product. Incubated firms are given time to learn and thus enhance their capabilities, especially in those domains in which they are weak (in the case of university spin-offs, the commercial or marketing capability is usually the one which needs to be strengthened).

The knowledge that resides in multinationals is transferred through spin-offs to the newly formed firm. In other words, spin-off formation spreads tacit knowledge. This is because explicit knowledge might be protected by the previous firm through contracts of confidentiality. In addition, a founder of a spin-off firm brings along the network of his/her personal relations, such as customers (market niche), suppliers or informal relations with ex-colleagues, and other professionals. At the level of the cluster, a high rate of spin-offs may induce knowledge spillovers. Knowledge that would otherwise remain within one organisation spreads within the region through spin-offs.

Spin-offs in the Uruguayan Software Cluster

In the Uruguayan case, spin-offs were encouraged by the State and the University (incubator programs). Moreover, in many cases, the founders of the new firms were previously working in a multinational company, a large firm or in a university. Table 6.3 shows the main characteristics of the spin-offs found in the software cluster in Montevideo. The majority of the spin-offs were created during the last decade. Most of these firms are very small and do not have more than 50 employees. It is interesting to notice that 18 out of 47 spin-offs in the sample derive from other national software firms. There are very few spin-offs from multinationals. This is not surprising, since there are only a handful of multinationals in Montevideo. In addition, the percentage of spin-offs from the universities and the incubator program represent a small fraction of the total spin-offs in the sample. Finally, with the exception of one firm, the rest of the spin-offs derived from organisations located in Montevideo.

Table 6.3: Characteristics of Spin-offs in the Sample

Characteristic	**Firms** (n=47)
(a) Year firm started	
Before 1990	8
1990-1994	8
1995-1999	14
2000-2004	17
(b) Size of the firm	
1-10 employees	23
11-50 employees	20
> 51 employees	4
(c) Type parent organisation of firm	
Software firm National	18
Software Multinational	7
Other firm National	10
Other Multinational	4
University	3
Incubator	5
(d) Location of parent organisation	
Local	46
National	0
International	1

Source: Own computations based on author's survey.

Incubator Spin-offs

As already mentioned in Chapter 4, the Uruguayan government, through LATU[131] and in collaboration with the ORT University, created an incubation program in 2001: the Ingenio. This initiative was financed by Inter-American Development Bank (IDB). It hosted approximately 30 firms and offered infrastructure and training in order to strengthen their business and/or technical capabilities. However, participation was limited. In this respect, the program did not succeed in creating a large number of spin-offs, because it did not offer grants or other types of financing to the participants[132]. Since December 2005, the incubation program will give small grants to the participants in the form of a salary. In sum, the outcome of the incubator program was not what it was expected to be. Although it reinforced spin-off firm formation in the software sector, it did not offer financial support, which limited the proliferation of spin-offs and their success.

Spin-offs that derive from MNCs, Large firms and the University

A number of spin-offs emerged from multinationals and large firms. These companies are either directly related to software such as Microsoft, IBM, etc., or firms that sustained internally an Information Technology department for the management of their own information systems. These spin-offs hold often applied knowledge, which enables them to commercialise their products more easily than the university spin-offs.

University professors or researchers in the department of Informatics have also founded new firms. These firms often have a scientific and/or technological basis, since their founders are

or were experts in a specific technology field. However, these spin-offs lack the application and/or commercialisation knowledge which is vital for the survival of a newly founded firm.

To conclude, within the Uruguayan software cluster knowledge spills over among software firms, their suppliers, customers, and institutions through all the alleged mechanisms. Nevertheless, inter-firm interactions and labour mobility seem to play a more important role than spin-offs.

6.6 THE RELATION BETWEEN LOCAL KNOWLEDGE SPILLOVERS AND SOURCES OF KNOWLEDGE

As I mentioned in the introduction, the mechanisms of knowledge flow are expected to be linked with specific sources of knowledge. In order to address research question eight (RQ 8), I have to place local knowledge flows in a broader context and include international knowledge flows as well. Next, I breakdown the variables local knowledge spillovers (LKS), international knowledge spillovers (IKS), local knowledge transactions (LKT), and international knowledge transactions (IKT) and identify the sources of knowledge for each mechanism.

Table 6.4: Sources and Mechanisms of Knowledge Flow[133]

	Mechanisms of Knowledge Flow			
	Knowledge Spillovers (pure knowledge spillovers and quasi knowledge spillovers)		**Pecuniary Knowledge Transactions** (pure knowledge transactions and quasi knowledge transactions)	
Sources of Knowledge	**Local**	**International**	**Local**	**International**
Parent Company	0% (0)	0% (0)	3% (7)	8.2% (12)
New Personnel	0% (0)	0% (0)	10% (25)	3% (4)
Customers	0% (0)	0% (0)	33% (85)	36.5% (53)
Suppliers	0% (0)	0% (0)	15% (39)	21.5% (31)
Competitors	29% (54)	22.5% (36)	0% (0)	0% (0)
Vertical interactions backward linkages/ forward linkages	29.5% (55)	7% (11)	3% (7)	2% (3)
Consultants	5% (9)	1% (2)	10% (25)	7.5% (11)
Universities/ Research labs	10.5% (20)	3% (5)	4% (11)	0.6% (1)
Innovation Centres	0.5% (1)	0% (0)	0% (0)	0.6% (1)
Support Institutes	9.5% (18)	0% (0)	9% (24)	0.6% (1)
Exhibitions/ Conferences	16% (30)	19.5% (31)	14% (36)	19.5% (28)
Electronic Info	0% (0)	47% (76)	0% (0)	0% (0)
Total	100% (187)	100% (161)	100% (259)	100% (145)

Note: To construct this table, we have given the value of =1 if a source of knowledge is used by a firm (that is 1=less important; 2=important; 3=very important; or 4=crucial), and the value of =0 if a source of knowledge is not used by a firm (that is 0=unimportant).
Source: Own computations based on author's survey.

Table 6.4 illustrates that local knowledge spillovers emerge out of informal cooperation between software firms and vertically linked software firms (backward linkages and forward linkages). In particular, 29.5 per cent of total local knowledge spillovers derive from backward and forward linkages. In addition, 29 per cent of local knowledge spillovers emerge

from the informal interaction amongst competitive software firms. Finally, 16 per cent of local knowledge spillovers take place in exhibitions and conferences.

International knowledge spillovers occur as a result of the use of Internet and other electronic information; 47 per cent of the total international knowledge spillovers emerge through the use of electronic information and the Internet. In addition, 22.5 per cent of international knowledge spillovers emerge from the informal interactions amongst competitive software firms. Moreover, international exhibitions and conferences seem to play a fundamental role in the occurrence of international spillovers; 19.5 per cent of international knowledge spillovers occur at exhibitions and conferences.

Both local and international knowledge transactions take place mostly as a result of interactions between software firms and their customers. In particular, 33 per cent of local knowledge transactions emerge from the interaction of software firms with local customers. 36.5 per cent of international knowledge transactions occur between local software firms and customers located abroad. Moreover, 15 per cent of local knowledge transactions arise between software firms and their suppliers, while 21.5 per cent of international knowledge transactions are between software firms and suppliers located abroad.

To conclude, this analysis suggests that the mechanisms of knowledge flows are partly associated with specific sources. Knowledge spillovers (both local and international) are mainly related to sources of technological knowledge such as competitors, and vertically linked software firms. In contrast, knowledge transactions (both local and international) are linked to sources of applied knowledge, such as customers. However, knowledge spillovers are also related to sources that retain applied knowledge, represented by the collaborations of software firms with their distributors. This indicates that knowledge spillovers diffuse not only public but also private knowledge. For the latter to arise some intentionality in the sharing of knowledge is required.

6.7 CONCLUSIONS

The analysis presented in this chapter suggests that local knowledge spillovers take place through the direct and informal interaction of actors, labour mobility, and finally spin-off firm formation. Although the economic literature on knowledge spillovers underlines the spontaneous nature of the mechanism, literature on innovation management suggests that knowledge spillovers may occur as a result of the intentional sharing of knowledge among competitors. Based on information from interviews with actors in the software cluster in Uruguay, I offer new insights into the notion of knowledge spillovers and unravel the motives of the firms for sharing knowledge with other local actors.

The survey data indicates that customers are the principal source of knowledge for innovation (RQ 6). This result is in line with findings in earlier literature regarding the key role of customers in software sector innovation (Pavitt, 1984; Veloso et al. 2003; Malerba, 2005).

Based on an extensive literature review and ascertained by the fieldwork interviews I have found that knowledge spillovers take place not only through spontaneous but also intentional interaction between local actors. In particular, firms sustain personal contacts, which enable them to be aware of new technology and market opportunities (RQ 7). These personal contacts are the grounds upon which future collaborations (formal and/or informal) are built. Moreover, user-communities create extensive knowledge spillovers that concern

technological knowledge. Informal communication with universities and research institutes regarding research and testing services were also identified in the case of the Uruguayan software industry. Finally, software firms collaborate with suppliers and distributors, which are conduits for the spillover of technological and applied knowledge respectively. On the other hand, knowledge transactions derive from market transactions such as the purchase of services and capital goods from consultants and suppliers respectively. *Quasi* knowledge transactions occur when software firms become involved in close interaction with their customers.

Finally, I have found evidence suggesting that the mechanisms of local knowledge spillovers are partly associated with specific sources of knowledge (RQ 8). In general, knowledge spillovers are associated with sources of technological knowledge, while transaction-based knowledge flows are related to sources of applied knowledge. This partly confirms the findings of neoclassical literature (Arrow, 1962) regarding the association of the public nature of knowledge and the spillover of this knowledge. Even if we assume that technological knowledge is public (which is debated by scholars of the history of technological change i.e. Rosenberg, 1982), I have shown that knowledge spillovers are also related to sources that retain applied knowledge, such as collaborations of software firms with their distributors.

These findings imply that knowledge spillovers diffuse public and private knowledge. While the diffusion of the former gives rise to pure knowledge spillovers, the diffusion of the latter stimulates *quasi* knowledge spillovers. That is, there is some intentionality that characterises the sharing of private knowledge. In the software case study, I managed to make a clear distinction between public knowledge (technological) and private knowledge (applied). In both cases, actors share knowledge in an informal and direct way. However, in the former case, the sharing of knowledge is more spontaneous than in the latter.

CHAPTER 7

THE LOCAL KNOWLEDGE NETWORK OF THE SOFTWARE CLUSTER IN MONTEVIDEO

7.1 INTRODUCTION

According to the most important contributors to the methods of Social Network analysis, "relational ties (linkages) between actors are channels for transfer or flow of resources" (Wasserman and Faust, 1994, p. 4). In this study, knowledge is the critical resource that is transferred among the actors in the Uruguayan software cluster. In this last chapter, I will examine the knowledge network within the software cluster of Montevideo. A knowledge network is a set of relationships among certain actors. I will focus upon the informal and direct relationships that lead to the sharing of knowledge, namely through local knowledge spillovers (LKS).

With this analysis, I aim to shed light upon two fundamental issues. First, from a macro perspective, the examination of the knowledge network can reveal how cohesive the local knowledge network is. A network that consists of actors that are well interconnected, potentially allows knowledge to flow rapidly within it. Second, at the micro level, I will use several network indicators reflecting the position of the firm within the local knowledge network, in order to explain the innovative and economic performance of the firm. For example, firms with many ties are expected to exhibit higher innovative performance than firms with fewer relations. Finally, I will examine the reasons behind the advantageous (or disadvantageous) position of a firm within the local knowledge network. I hypothesise that absorptive capacity explains the position of a firm in the local knowledge network. In sum, this chapter will address the following questions:

RQ 9: How cohesive is the local knowledge network within the Uruguayan software cluster?

RQ 10: Do firms with central positions in the local knowledge network exhibit a higher innovative and economic performance than firms which are located in peripheral positions?

RQ 11: Do firms with high absorptive capacity occupy the key positions in the local knowledge network?

In Chapter 5, quantitative analysis revealed that local knowledge spillovers are relatively more important for the innovation of software firms in the Uruguayan cluster than other mechanisms of knowledge flow (such as local knowledge transactions -LKT, international knowledge spillovers –IKS, and international knowledge transactions –IKT). In chapter 6, I analysed qualitatively how knowledge spillovers take place and the motivation of the actors involved in informal sharing of knowledge. Based on the insights of these two chapters, I will

now focus on the actors that are involved in LKS and assess their position within the local knowledge network.

This approach differs from the analysis developed in chapter 5, because it not only looks at the perceived importance of LKS for the innovation of the firm, but also at the frequency of interaction between actors. Moreover, this chapter takes an even closer look at LKS, by attempting to see how firms access local sources of knowledge. For example, do firms access knowledge directly (firm A contacts firm B) or in an indirect way (firm A contacts firm C, and then firm C contacts firm B)? I will analyse not only whether LKS exist or how important they are, but also how efficiently they function. If knowledge is distributed evenly among the local actors, then this means that it is rapidly diffused. If, on the other hand, knowledge is concentrated in the hands of a few actors, this implies that its diffusion is slow. Finally, I will examine whether unequal distribution of knowledge is related to differences in the innovative and economic performance of those actors.

7.2 CONCEPTUAL FRAMEWORK

According to Social Network theory, a firm is embedded on its local social context (Granovetter, 1985). In turn, the structure of the network of social relations influences the output of the firm (Gulati, 1998). One reason for the better performance of well-embedded firms is the fact that the social network facilitates the transfer of knowledge. Empirical studies regarding social networks claim that embedded relations within a network facilitate the circulation of 'thicker information' regarding strategy and production know-how (Larson, 1992; Powell, 1990). This process of knowledge sharing thus promotes learning and innovation (Uzzi, 1996).

A number of studies have used Social Network analysis for different research goals. Borgatti and Foster (2003) highlight two crucial approaches to network analysis; that is the connectionist and structuralist stream of research. According to the first approach, the network is seen as a set of connections through which resources, such as information and knowledge, can flow (Lin, 2001). In this view, the more contacts an actor has, the more successful he is (since he can access a large quantity of information through these relationships). On the other hand, the structuralist approach focuses on the topology of the social relations (Coleman, 1990; Burt, 1992). The 'structural hole' theory states that it is the critical position of an actor in the network (for instance, when he is located between two disconnected actors) what makes him more powerful than the others (Burt, 1992).

I have chosen to follow a combination of the connectionist and the structuralist paradigms because both are relevant for the informal and direct flow of knowledge. The co-location of firms within clusters facilitates the frequent interaction of actors. In turn, it is through interaction that knowledge, and in particular tacit knowledge, is transferred amongst actors. While it is not difficult to conclude that the more linkages or relations an actor has, the more knowledge he may access, network structuralist theorists stress the importance of those actors that occupy the so-called gatekeeper position. I look at structural holes from the connectionist point of view: that is, based on the argument for knowledge advantages, which asserts that "an actor can maximise the amount of non-redundant information he receives through his contacts, providing that the contacts are unconnected to each other" (Borgatti and Foster, 2003, p.1003). In other words, the actors that have a brokerage position convey the most critical knowledge, because these are the ones that are able to link disconnected actors.

Table 7.1 derives from the examination of the various types of knowledge flows in chapter 6. As I have stressed in the previous chapter, knowledge spillovers are based partly on trust, reciprocity and social capital in general. The main difference between *quasi* knowledge spillovers and pure knowledge spillovers lies in the fact that the former have an intentional character, while the latter tend to take place spontaneously.

Table 7.1: Classification of Local Knowledge Spillovers

Local Knowledge Spillovers	
Pure Knowledge Spillovers	***Quasi* knowledge Spillovers**
(Griliches, 1979; Harhoff *et al.*, 2003; von Hippel, 1987; Allen, 1983).	(Schmitz, 1999; Humphrey and Schmitz, 1998; Saxenian, 1994).
Interactions among competitive software firms **Interactions with** University **&** Research Institutes **Interactions in** Exhibitions **&** Conferences	Vertical interactions: **backward linkages** Vertical interactions: **forward linkages** Interactions with **Support institutes**

Source: Author

Table 7.1 presents only the actors that are involved in local knowledge spillovers. These actors in the Uruguayan case are as follows: software firms, support and research institutes, and universities. In the following sections, I will analyse this network as a whole, and then I will examine the position of the individual actors within it.

7.3 METHODOLOGY

7.3.1 Network Methods of Analysis

A network is a group of actors (or nodes) connected by a series of ties (or relations). A tie might be directional (i.e. resources flow only one way; from actor A to actor B), or non-directional (i.e. resources flow in both directions; actors A and B interact or are both involved in a communication process). This means that the relation is reciprocal (Wasserman and Faust, 1994). Reciprocal relationships generate symmetric data matrices. Symmetric or reciprocal data matrices are critical for the calculation of centrality measures (Ouimet, et al., 2004). My data assumes reciprocal relationships, based on mutual communication[134]. Firms share knowledge and therefore there is reciprocity. Certainly, one actor might be giving more knowledge than the other, however both of them are involved in an interactive process of knowledge sharing. From the firms' responses I have constructed a symmetric matrix. I assign the highest score for an interaction between two firms, and the lowest score for an interaction between a firm and other organisations[135]. The latter tend to overestimate the frequency of their interactions because one of their objectives is to create and sustain network relations.

The indicator of a relationship might be either dichotomous or valued. Dichotomous indicators specify whether a relation is present or absent. Valued indicators can take a range of values indicating the strength of the tie (frequency of interaction in our case) between a pair of actors. I have collected information regarding the frequency of interaction between the local actors in the software cluster of Uruguay, which allowed me to generate a valued

dataset. Additionally, I have created a binary dataset because many network measures require dichotomous data (Hanneman and Riddle, 2005).

Based on the information from the network survey (see Chapter 3) I have created two matrices: (a) A dichotomous matrix, in which the score of 0 was given to all ties that were ranked 'Never', while those ties that were ranked as 'Rarely', 'Sometimes', 'Often', and 'Very often' were given a score of 1. (b) A valued matrix, in which the value of 0 is given to those organisations that responded with 'Never', while those ties that were ranked as 'Rarely' were given a score of 1, 'Sometimes' was assigned a score of 2, 'Often' was given a score of 3, and finally, 'Very often' was given a score of 4.

7.3.2 Network Indicators

In order to answer the final research questions, I have calculated the following nine network indicators[136]. The first four indicators address research question nine (RQ 9) with regard to the macro characteristics of the knowledge network within the software cluster in Uruguay. The last five indicators are used for answering research questions ten and eleven (RQ 10 and RQ 11), concerning the relationship between the network position of the firms, and their innovative and economic performance and absorptive capacity. Among numerous possible network indicators, I have chosen the following ones because they fit the purpose of this study, in particular:

- Density: This indicator considers the ratio of the total number of reported ties to the total number of possible ties. Density measures the cohesiveness of the network. If a network has high density, this implies that knowledge flows rapidly among actors.
- Distance: The geodesic distance between two nodes is the length of the shortest path[137] between them. The average geodesic distance gives an idea of the ease access to knowledge in the network.
- Number of N-Cliques: The N-Clique is a sub-group that consists of the maximum number of nodes that have a connection to every other member of the group at a path distance of 2 (N=2). The number of N-Cliques indicates how dispersed or concentrated the knowledge network is, by examining the presence of sub-groups within the network. If a network consists of many disconnected groups, this implies that knowledge cannot flow effectively within the network.
- Lambda set: By identifying the ties with high lambda this technique classifies each of the relations in the network according to their importance. A relation is important when a large part of the flow among actors in the network goes through it. These are critical relationships for the knowledge network. If they were to be disconnected they would interrupt the flow of knowledge among all of the actors.
- Degree Centrality: This measure is the sum of the direct ties that an actor has within a network. Firms that have many direct relationships also have more opportunities to access diverse types of knowledge.
- Closeness Centrality: This indicator measures the distance of an actor from all others. First, I calculate the 'farness', which is the sum of the lengths of the shortest paths [geodesic path] from each ego [focal actor] to all other actors. The inverse of farness gives us the closeness indicator. This indicator identifies those firms that access knowledge rapidly compared to those firms that access knowledge at a slow pace. The former group may have more opportunities because of their ability to acquire knowledge (regarding technology innovations or market trends) quickly.
- Betweenness Centrality: This indicator measures the frequency with which an actor is located between other actors. It shows the extent to which an actor is in a situation of acting as an intermediary in a network. Firms that have the capacity to broker

interactions between other actors have more power than others, because they control the flow of knowledge.

- Effective Size: The effective size is an ego[138] network measure introduced by Burt (1992). To calculate effective size, I deduct from the aggregate number of alters[139] the average number of direct contacts of alters within the ego network. This indicator reflects the diversity or non-redundancy of an actor's network[140]. In other words, if a firm has many contacts which are not connected to each other, then this means that the specific firm has increased power compared to the other firms, because it plays the role of broker in the knowledge network.
- Constraint: This is an ego network measure as well (Burt, 1992). It measures the extent to which the ego's connections have alternative linkages in the neighbourhood. If alters can substitute their ties with ego with other connections, then this acts as a constraint on ego's power. This implies that even if a firm has many ties to other actors, it may still be powerless if the other actors can access knowledge from other sources.

7.4 THE KNOWLEDGE NETWORK OF THE SOFTWARE CLUSTER IN MONTEVIDEO

7.4.1 Macro Characteristics of the Knowledge Network

The first objective of this section is to assess the cohesion of the knowledge network[141] of the software cluster in Uruguay. In other words, I would like to examine how well the local firms are interconnected. The more cohesive a network, the more effective the communication among its actors.

Figure 7.1 represents the interconnections among all the actors within the knowledge network in the Uruguayan software cluster in a graphic form. Figure 7.2 displays the linkages among the subset of local software firms. Finally, figure 7.3 depicts the interactions between the rest of the actors [universities, MNCs, research and support institutes], excluding local firms. Note that figure 7.1 is denser than figure 7.2. Figure 7.1 illustrates that actors other than the local firms, are located at the centre of the graph. In particular, Universities, MNCs and Support Institutes are the actors that occupy central positions in the knowledge network within the Uruguayan software cluster. When only interactions among Universities, Institutions and MNCs are considered (figure 7.3), the density of the graph increases considerably. This is confirmed in Table 7.2.

Table 7.2 exhibits the density of the knowledge network of the software cluster in Uruguay. The first row displays the density of the dichotomous data set, which is 0.15. This means that only 15 per cent of all possible ties are present. At the same time, it is possible to observe that the density[142] of the valued data set is higher (0.34). This suggests that despite the fact that there are few linkages among actors, their quality is high (i.e. strong ties indicate high frequency of interaction). Consequently, the knowledge network of the software cluster in Uruguay is characterised by few but strong linkages.

The third row of Table 7.2 presents the density of the binary data set for the local firms only (see Figure 7.2), which is smaller (0.10) than when all links are considered (0.15). This means that there are more connections among firms and other organisations such as MNCs, universities and support institutes, while there are fewer relations among local firms themselves. The knowledge network of the non-firms in the fourth row of Table 7.2 shows that the density is quite high (0.56). This suggests that there is a substantial knowledge infrastructure in the software cluster of Uruguay. More than 50 per cent of all possible

connections among universities, support institutes and MNCs are actually present (see Figure 7.3).

Table 7.2: The Density of the Knowledge Network of the Software Cluster in Uruguay

Type of relation	Average Network Density (SD)
Dichotomous (all ties)	0.15 (0.363)
Valued (all ties) [a]	0.34 (0.904)
Valued [b] (excluding micro firms <10 employees)	0.60 (1.147)
Dichotomous (firms)	0.10 (0.304)
Dichotomous (non-firms)	0.56 (0.495)

Note: Standard deviation in parenthesis.
[a] No=107.
[b] No=59.
Source: Own computations based on author's survey.

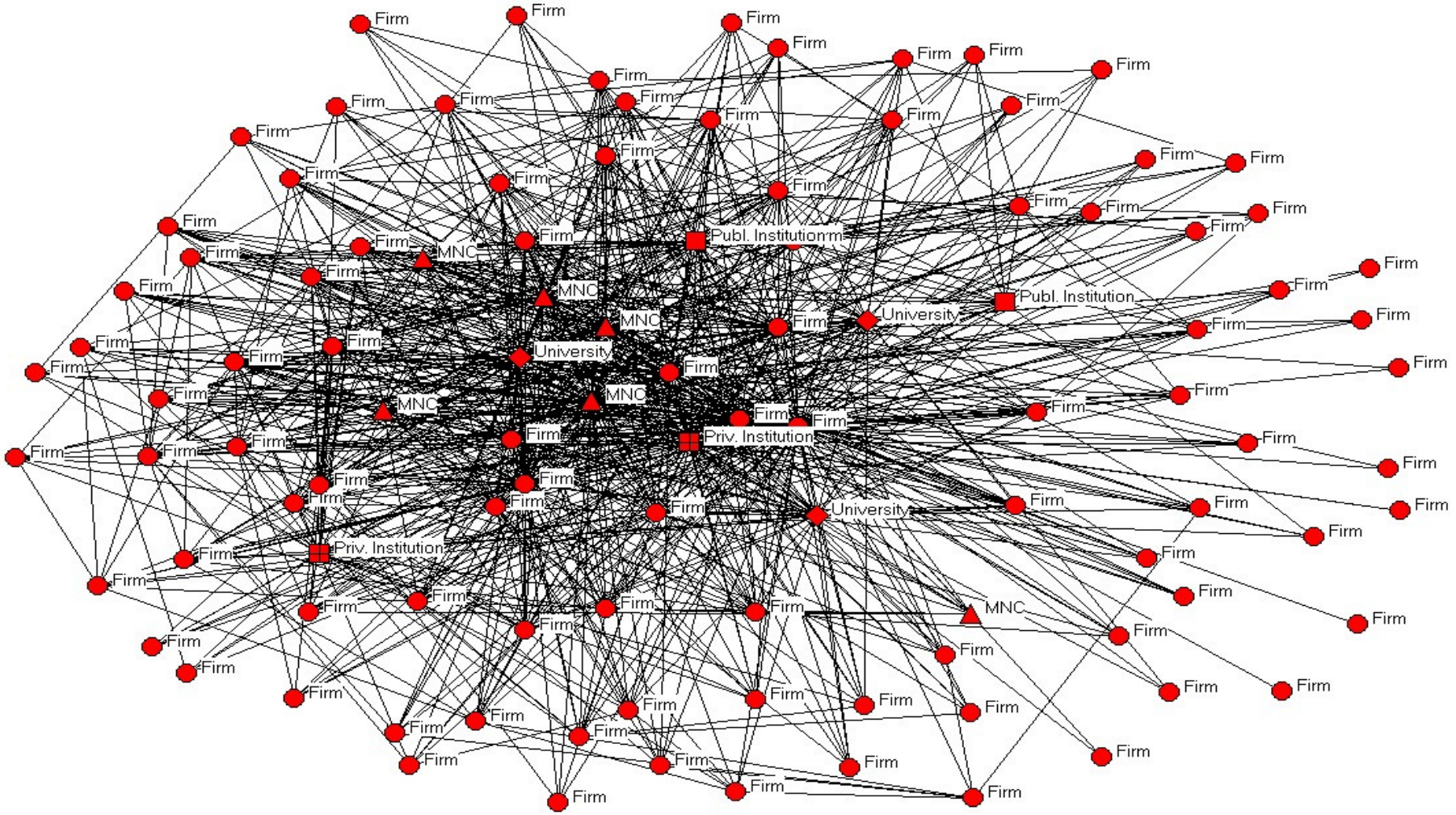
Table 7.3: Frequency Distributions of the rate of Interaction among the Actors

Rate of Interaction		Frequency of Distribution	Type of Ties	
0	Never	84 %	-	
1	Rarely *(once per year)*	5 %	Weak ties	**5%**
2	Sometimes *(2-5 times per year)*	4 %	Medium ties	4%
3	Often *(every month)*	5 %	Strong ties	**7%**
4	Very Often *(every week)*	2 %	Strong ties	

Source: Own computations based on author's survey.

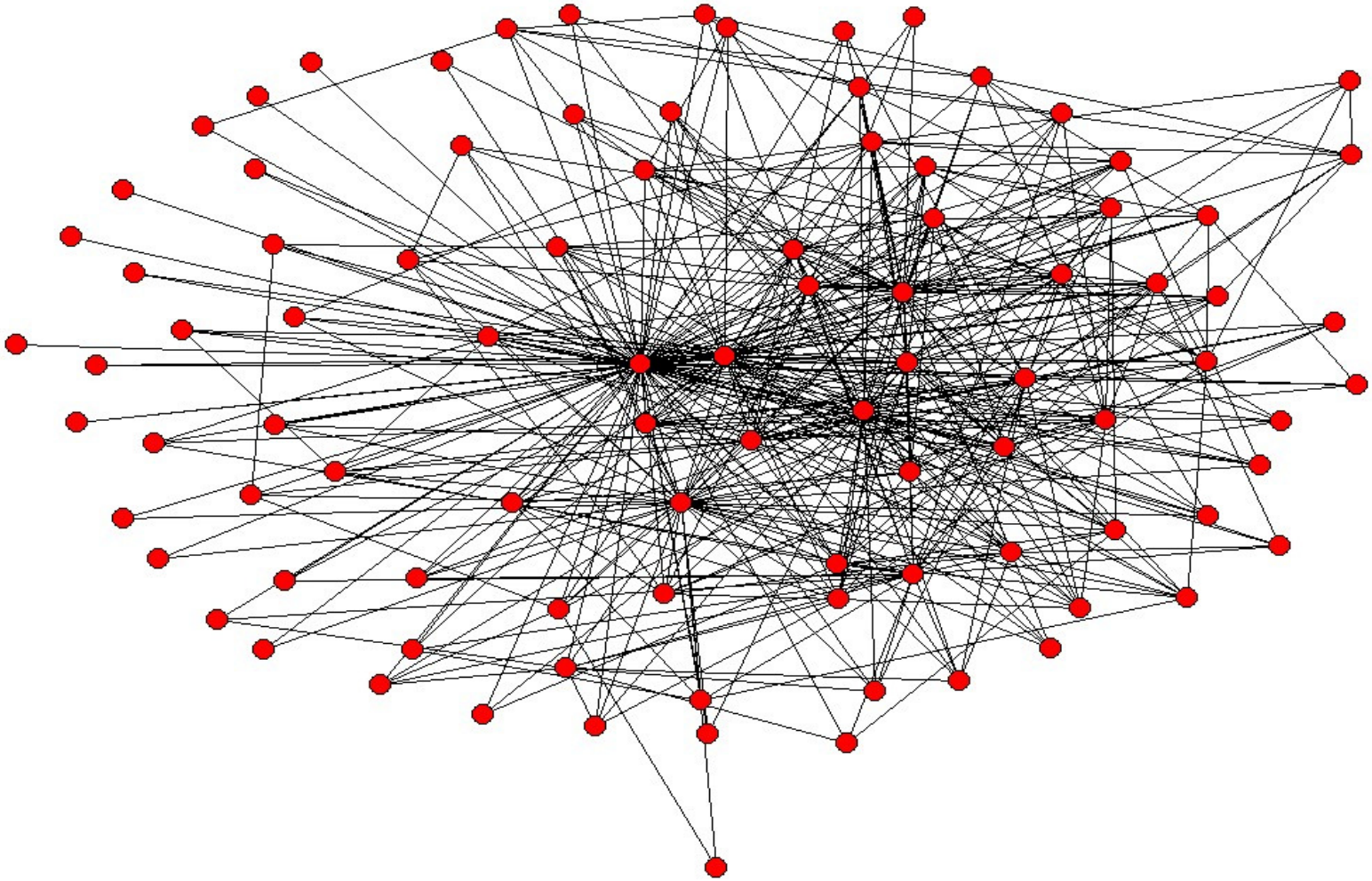
Table 7.3 illustrates the frequency of the distribution of the rate of interaction among the actors within the knowledge network of the Uruguayan software cluster. 5 per cent of the relations are characterised as weak, since they take place only once per year. Interactions that occur two to five times per year are defined as of medium strength. Those relations that occur every month and/or every week are considered to be strong ties. These represent 7 per cent of the ties. This outcome confirms the aforementioned discussion, in which I stressed the fact that although the density of relations within the knowledge network of the Uruguayan software cluster is rather low, the relations are quite strong. These results are in line with previous findings regarding research into knowledge flows within clusters. In particular, Morrison and Rabellotti (2005) compared the structure of the information network and the knowledge network within the same cluster. They concluded that while the information network was characterised by higher density than the knowledge network, the latter consisted of a larger percentage of strong relations. In other words, not all possible relations are present within a knowledge network, but among those that do exist are many strong ones.

Figure 7.1: The Knowledge Network of the Software Cluster in Uruguay (all ties)



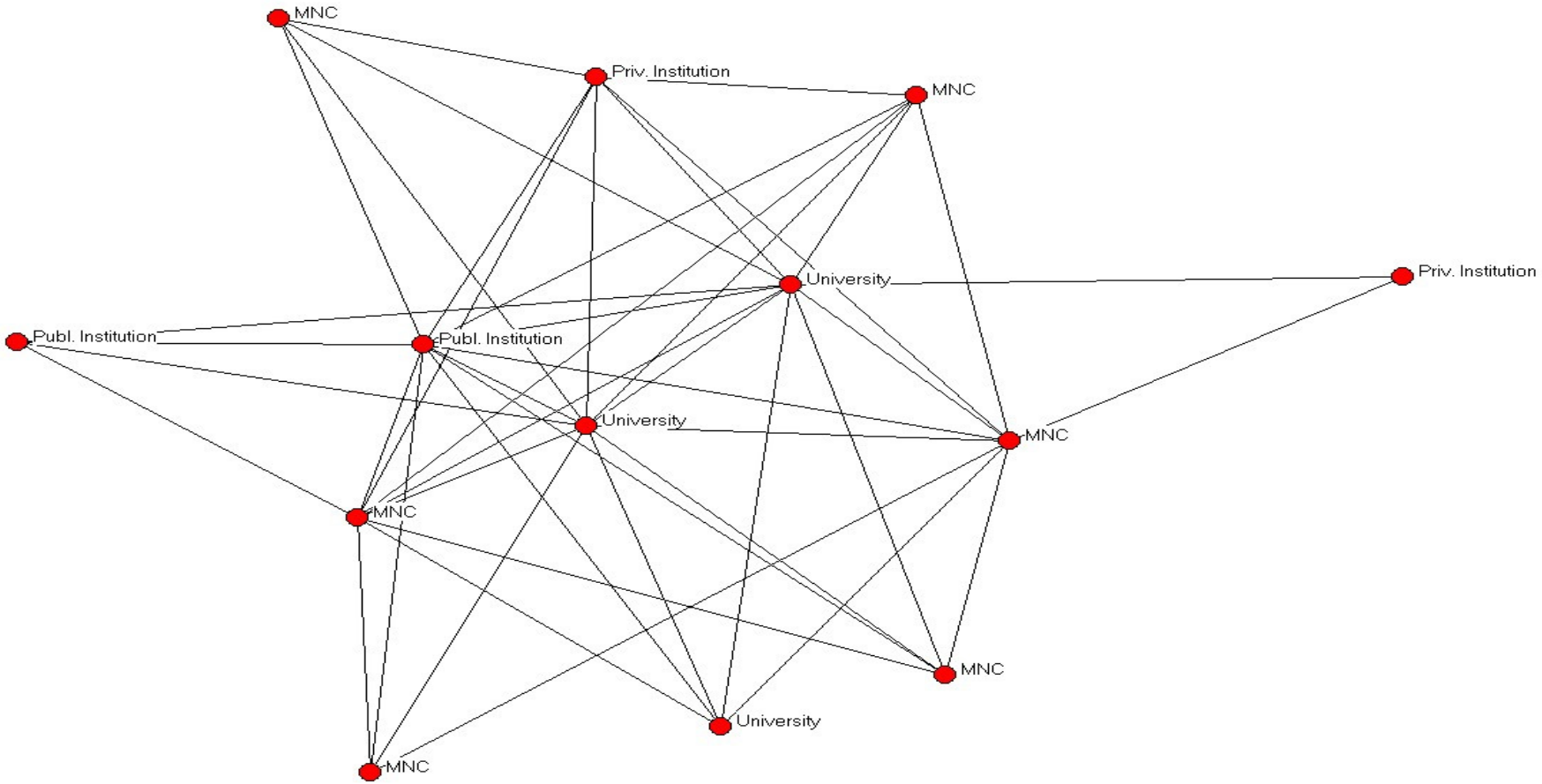
Source: Own computations based on author's survey.

Figure 7.2: The Knowledge Network of the Software Cluster in Uruguay (firms)



Source: Own computations based on author's survey.

Figure 7.3: The Knowledge Network of the Software Cluster in Uruguay (non-firms)



Source: Own computations based on author's survey.

Table 7.4 exhibits the average distance between actors within the knowledge network of the Uruguayan software cluster. On average each actor has to cover a distance of only two steps in order to access knowledge. This suggests that knowledge flows relatively effectively among the local actors in Uruguay. They can access knowledge reasonably fast by contacting no more than two other actors.

Table 7.4: The Distance among Firms within the Knowledge Network of the Software Cluster in Uruguay

Type of relation	Average Geodesic Distance
All ties [a]	1.925
Ties [b] excluding micro firms <10 employees	1.768

[a] No=107.
[b] No=59.
Source: Own computations based on author's survey

As mentioned in Chapter 3, not all firms within the software cluster in Uruguay were willing to participate in the network survey. Would the results be different if all firms had participated in the survey? Does the non-response bias my results and in what ways? We know that non-response is highest amongst small/micro firms. I therefore, remove from the sample the firms with less than 10 employees and re-examine two network indicators: density and geodesic distance.

When micro/small firms are excluded the density among the actors increases dramatically. In particular, the third row of Table 7.2 shows that the density of the network is 0.60, which implies that 60 per cent of all possible ties are present. The connectivity of this network (without micro/small firms) is twice as high as that for all actors. This suggests that the missing non-participating actors within the software cluster in Uruguay have fewer connections. Moreover, Table 7.4 suggests that when we consider the linkages of all actors with the exception of micro/small firms, their average geodesic distance is to some extent smaller (1.768) than if we consider the distance among all actors (1.925). This means that the cohesiveness of the network comprised of medium and large firms is higher than the one that consists of all firms (including micro/small firms). I conclude that if all micro/small firms would have been included in the data set, then the cohesiveness of the network would have been lower. As my sample includes approximately 50 per cent of all micro/small firms, it provides a reasonably representative picture of the knowledge network within the Uruguayan software cluster.

In the next section, I will explore the presence of sub-groups or cliques within the knowledge network of the software cluster in Uruguay. I proceed with the N-clique analysis. I have identified the presence of 21 2-Cliques[143] within the knowledge network of the software cluster in Montevideo. This suggests that there are many sub-groups within the knowledge network. This constitutes additional evidence that the knowledge network in Uruguay is rather dispersed.

I also examine whether these sub-groups overlap. I apply cluster analysis and examine how close the cliques are to each other. More than 70 per cent of the firms have 21 clique memberships in common, which suggests that there is a very high degree of common membership in the knowledge network[144]. This means that despite clique formation,

knowledge may still diffuse quickly [compared to a situation in which the cliques are disconnected from each other].

At this point, it is important to examine whether there are specific links in the knowledge network of the software cluster in Montevideo that, if removed, would destroy its structure. I use the Lambda sets approach to locate the critical bridges between pairs of actors.

I identify several connections that are critical for the knowledge network. To begin with, the three most important linkages are formed between: (1) a MNC and a local software firm (Lambda = 71); (2) the same local software firm and a support institute (Lambda = 62); and finally (3) a local software firm and a university (lambda = 56). The majority of the actors are connected to all other actors through the above linkages (or bridges). The most important feature of these linkages is that none of them is between local software firms. The first connection includes a MNC, while the second involves a support institute and the last one a university. Therefore, knowledge spillovers arise out of the direct and informal interaction of local firms with a MNC, a support institute and a university. The bulk of the local firms use these bridges in order to access critical knowledge for innovation.

The fact that the three most important bridges within the knowledge network of the software cluster in Uruguay are formed between heterogeneous actors poses the question as to whether heterogeneous relations are ranked high in general, or if only the specific relations are important for the flow of knowledge within the network. In order to answer this question, I distinguish between the homogenous and the heterogeneous relations within the knowledge network and thus I again apply the Lambda set analysis. I found, in general, that heterogeneous relations rank as the most important within the knowledge network of the software cluster in Uruguay. In light of these new findings, I re-evaluated the previous results. In particular, it becomes clear that heterogeneous relations constitute the central bridges within the knowledge network, while the importance of homogenous relations is small. This may suggest that software firms need a hybrid type of knowledge in order to innovate. Hence, heterogonous relations are the most important bridges within the knowledge network.

To conclude, the macro examination of the knowledge network has revealed that the density of the network is rather low. This means that the local actors are not very well interconnected with each other. However, when the strength of the relations is considered, the density of the network is not as low as it was expected. This suggests, despite the fact that there are few relations among the actors, that those relations are strong rather than weak. The analysis of the sub-structures has shown that the knowledge network of the software sector in Uruguay is divided into 21 groups. This indicates that the knowledge network is fragmented. However, most of these sub-groups (more than 70 per cent) overlap with each other. This implies that the sub-groups are not completely disconnected. On the contrary, there is an effective flow of knowledge among the various sub-groups of the network. This is supported by the results of the geodesic distance measure, which show that on average firms are located at a distance of 2; namely they are not directly connected but they have to contact an intermediary in order to access knowledge (the friend of a friend).

Finally, I have found evidence which suggests that the most critical connections for the knowledge network in Uruguay are formed between local firms and a MNC, a support institute and a university. The vital role of a MNC in the knowledge network demonstrates the importance of international technological and marketing/organisational knowledge for the software industry in Uruguay. It is through the relationship between a local firm and a MNC

that knowledge spills through the cluster. In addition, the critical role of the university within the knowledge network reveals that software is a high-tech industry which needs constant cooperation with educational and research institutions such as the university. Finally, a support institute occupies a central position in the knowledge network. Private initiatives bring together local actors through the setting up of meetings; trade fairs are the context in which many informal interactions and knowledge sharing take place.

7.4.2 Micro Network Analysis

The objective of this section is to use network indicators, which denote the centrality of the individual actors in the knowledge network, in order to examine whether they can explain differences in the innovative and economic performance between them.

For this analysis, I will only use information about local software firms and will not include MNCs, universities and support institutes. As I have already mentioned, I have calculated five different network indicators, namely, degree, closeness, betweenness, effective size, and constraint.

Table 7.5 depicts the descriptive statistics of the network indicators. I notice that the range of the degree centrality is large (minimum= 1, maximum= 88). It is evident that the variability across firms is considerable (coefficient of variation =120). This implies that the knowledge network within the software cluster in Uruguay is very heterogeneous (large variation across firms concerning their numbers of direct relations). Figure 7.4 exhibits the histogram of the degree indicator, which displays a skewed [to the left] distribution. This suggests that the majority of the firms have a small number of ties.

Table 7.5: Descriptive Statistics – Network Indicators

	Degree	Closeness	Betweenness	Effective size	Constraint
Mean	10.17	45.77	99.52	6.85	0.28
Std. Deviation	12.26	13.54	303.32	10.67	0.22
Minimum	1.00	1.06	0.00	1.00	0.057
Maximum	88.00	94.89	2137.73	79	1.00
Skewness	3.67	-1.34	4.79	4.34	1.92
Std. Error of Skewness	0.24	0.24	0.24	0.24	0.24
Kurtosis	18.14	5.95	25.59	24.00	3.63
Std. Error of Kurtosis	0.49	0.49	0.49	0.49	0.49
Coefficient of Variation [= (Std. Dev./Mean)*100]	120.00	29.00	304.00	155.76	58.57
N	94	94	94	94	94

Source: Own computations based on author's survey

With regard to the closeness indicator, I notice that there is less variability across firms. The majority of the firms exhibit an average score of 45, which implies that there are few firms that are located very close to all others (those with scores inclined to 100). Similarly, a small number of firms is located very far from all other firms (those with scores inclined to 0).

Table 7.5 shows how both the range and variability of the betweenness indicator are extremely large. Figure 7.6 displays the histogram of the betweenness variable in which it is evident that the distribution is skewed to the left. This suggests that only a few firms in the knowledge network of the software cluster in Montevideo are powerful, in the sense that they play the role of an intermediary for the other actors.

The effective size of the various firm's ego networks in Table 7.5 shows that there is large variability in the scores of firms. In particular, figure 7.7 illustrates that the majority of the firms are characterised by a very low effective size; that is, firms depict high redundancy. Only a handful of firms exhibit high scores in effective size. As a result these firms have achieved a particularly powerful position among the others. The rest of the actors depend upon these influential central firms for the acquisition of knowledge.

Finally, the constraint indicator demonstrates that there is less variability across actors (Table 7.5). Figure 7.8 shows that there are only few actors who are highly constrained (close to 1), while the majority of the actors are not constrained by their alters.

Figure 7.4: Histogram – Degree Centrality

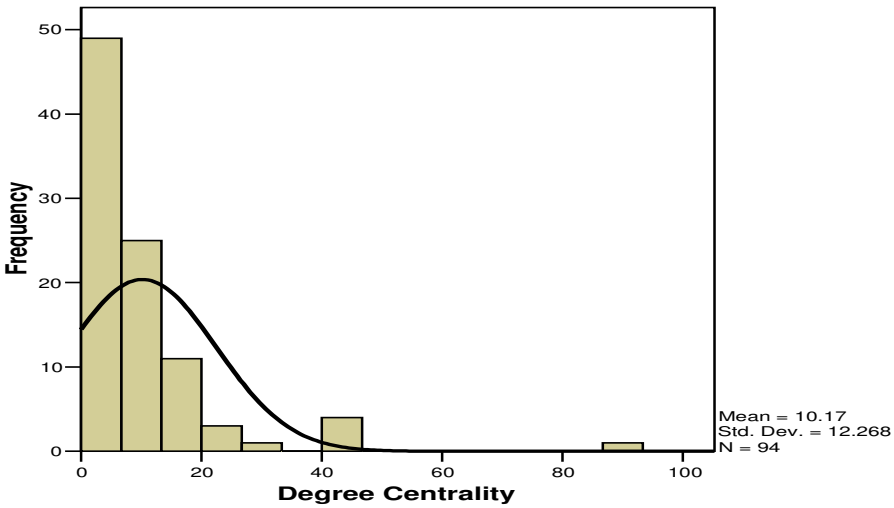


Figure 7.5: Histogram – **Closeness**

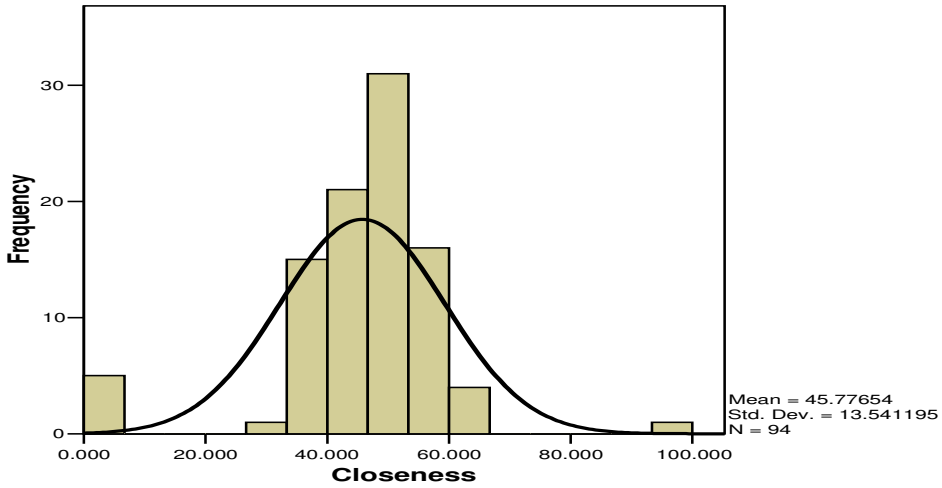


Figure 7.6: Histogram – **Betweenness**

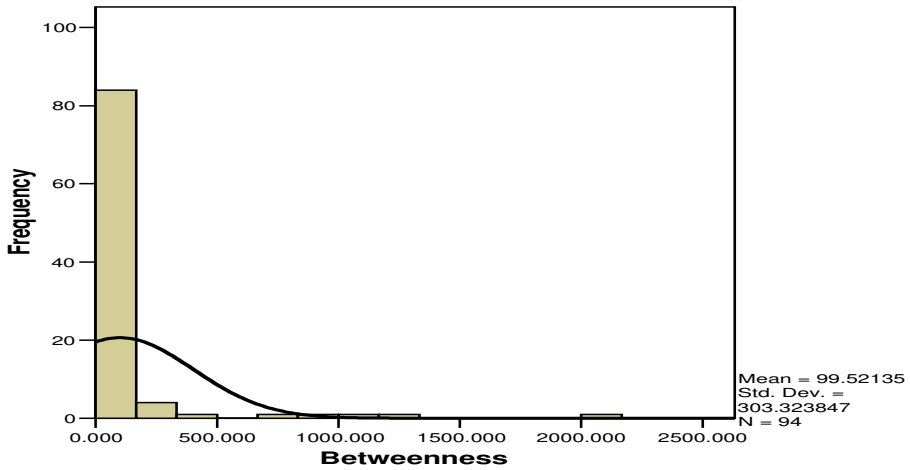


Figure 7.7: Histogram – Effective Size

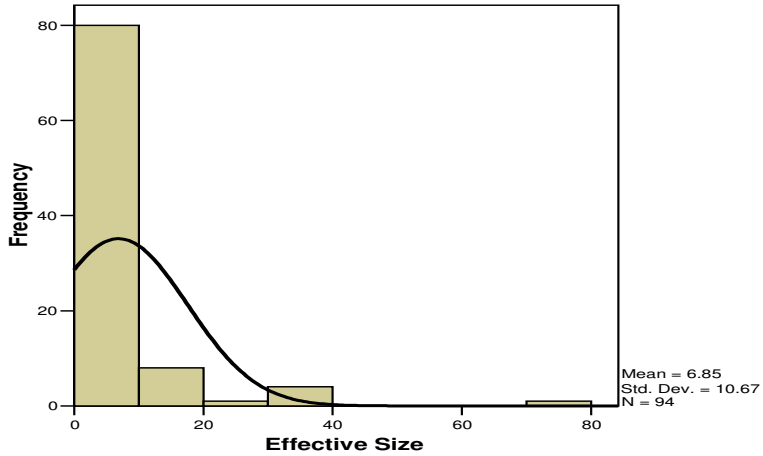
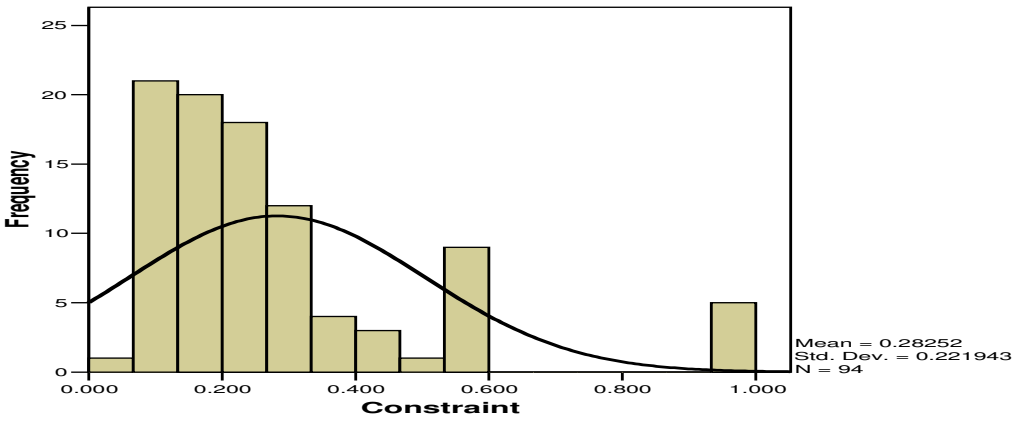


Figure 7.8: Histogram - Constraint



Source: Own computations based on author's survey

7.4.2.1 The Position of a Firm in the Local Knowledge Network and its Innovative and Economic Performance

The innovation indicators that are used in this section are those from the 1st survey on the software sector in the Uruguayan cluster. Recall that in chapter 5, factor analysis has resulted in two indicators for the innovative performance of the firm, and three indicators for the economic performance of the firm.

Table 7.6 shows that almost all of the network indicators are correlated[145] with the two indicators of innovative performance. However, when it comes to the indicators of the economic performance, two of them (level of performance and economic growth) are not related to the network indicators. Network indicators are correlated only to the export performance of the firm. Note that there is a high correlation between the network indicators, the implications of this will be discussed later.

Table 7.6: Correlation analysis – Network Indicators and Innovative and Economics Performance

	CLOSE NESS	BETWEEN NESS	EFFECT_ SIZE	CONSTRAINT	TECH_ INN	MARK_ INN	L_PERFORM	EC_ GROWTH	EXP_ INTENS
DEGREE	.837 (**)	.937 (**)	.962 (**)	-.989 (**)	.278 (**)	.278 (**)	-.024	-.111	.406 (**)
CLOSENESS	1.000	.789 (**)	.766 (**)	-.844 (**)	.229 (*)	.186	.040	-.156	.334 (**)
BETWEENNESS		1.000	.959 (**)	-936 (**)	.230 (*)	.226 (*)	.018	-.059	.307 (*)
EFFECT_ SIZE			1.000	-.963 (**)	.243 (*)	.245 (*)	.005	-.076	.348 (**)
CONSTRAINT				1.000	-.259 (*)	-.264 (*)	.015	.133	-.397 (**)
TECH_INN					1.000	.047	-.243	-.024	.298 (*)
MARK_INN						1.000	.133	-.054	.150
L_PERFORM							1.000	-.261 (*)	-.536 (**)
EC_ GROWTH								1.000	-.184
EXP_INTENS									1.000

Note: Spearman non-parametric correlation analysis; ***p<.01, **p<.05, *p<.10.
Source: Own computations based n author's survey

What this analysis tells us is that firms that are centrally located in the knowledge network of the software cluster in Uruguay exhibit both a high technological and marketing/organisational performance. In addition, firms which are well connected in the local knowledge network exhibit high economic performance (in terms of export intensity). The correlation matrix is in line with previous findings in the literature [related to informal knowledge flows in clusters], which assert that centrally located firms exhibit higher innovative and economic performance than others (Guiliani and Bell, 2005; Morrison and Rabellotti, 2005).

7.4.2.2 The Position of a Firm in the Local Knowledge Network and its Absorptive Capacity

Why are firms located in central positions? Does this depend on the absorptive capacity of the firm? Table 7.7 exhibits the correlation between the network and the absorptive capacity indicators. The network indicators show a positive and significant bivariate correlation with some indicators of the absorptive capacity, while they are correlated negatively with some others. This suggests that there is no simple and straightforward answer regarding the relationship between the network position of a firm and its absorptive capacity.

To begin with, the variables which reflect the educational level of the employees of the firm (EDU_DUM, EDU_VAR) are positively correlated with almost all the (micro) network indicators[146]. This suggests that firms with more employees holding postgraduate degrees are located in central positions within the knowledge network in the software cluster in Uruguay. In addition, firms with large variations in the educational levels of their employees are centrally located.

Concerning the experience indicators, Table 7.7 indicates that firms that are characterised by great variation in the number of years of experience of their employees are located in central positions (EXPER_VAR_Y). In addition, firms that exhibit a large variation in the number of previous occupations of their employees are well embedded in the knowledge network of the software cluster in Uruguay (EXPER_VAR_F). However, firms that consist of many employees with previous experience in many occupations are located in less central or powerful positions (EXPER_FIRMS).

All the network variables are positively and significantly correlated with the age and the size of the firm. Old and large firms are located in central positions and are the bridges of communication for the rest of the firms.

Regarding R&D, Table 7.7 shows that all the network indicators are negatively correlated with the R&D intensity (R&D_INTENS) of the firm. This implies that firms that are R&D oriented do not have many contacts in the local knowledge network. Consequently, firms that invest in R&D do not probably need to sustain many and frequent relations with other actors within the local knowledge network. On the contrary, these results underline that firms which are weak in R&D are well connected within the local knowledge network of the software cluster in Uruguay.

Based on these results, it is difficult to give a straightforward answer concerning the relationship between the network position of a firm and its absorptive capacity. What is clear is that the absorptive capacity of the firm consists of a number of distinct characteristics, such as the education level of the employees, their experience, the age of the firm and finally investments in R&D. The first three categories reflect the accumulated knowledge of the firm or, in other words, its knowledge stock. It is this stock of knowledge which will enable the firm to absorb external knowledge (Cohen and Levinthal, 1990).

However, the last category (R&D) reflects the internal learning of the firm or a flow of knowledge. It is the internal learning capabilities of the firm that can lead to technological and economic progress [without necessarily the absorption of external knowledge] (Lall, 1992; Romijn, 1999). Thus, firms, which are R&D intensive might not be centrally located within a knowledge network *not* because they lack the capabilities to absorb knowledge as some scholars have indicated (Giuliani and Bell, 2005), but because they have already accumulated within the firm the necessary knowledge resources enabling them to innovate.

Table 7.7: Correlation analysis – Network Indicators and Absorptive Capacity of the firms

	CLOSENESS	BETWEENNESS	EFFECT_SIZE	CONSTRAINT	RD_MY	RD_INTENS	VAR_EDU	EDU	EDU_DUM	EDU_F	EXPER_VAR_Y	EXPER_Y	EXPER_VAR_F	EXPER_FIRMS	AGE	SIZE
DEGREE	.837 (**)	.937 (**)	.962 (**)	-.989 (**)	.066	-.219 (*)	.218 (*)	.123	.250 (*)	.016	.330 (**)	-.077	.241 (*)	-.261 (*)	.249 (*)	.522 (**)
CLOSENESS	1.000	.789 (**)	.766 (**)	-.844 (**)	.127	-.119	.195	.093	.211 (*)	-.083	.379 (**)	-.164	.207 (*)	-.334 (**)	.302 (**)	.451 (**)
BETWEENNESS		1.000	.959 (**)	-.936 (**)	.065	-.252 (*)	.204 (*)	.170	.240 (*)	.019	.310 (**)	-.105	.271 (**)	-.258 (*)	.208 (*)	.477 (**)
EFFECT_SIZE			1.000	-963 (**)	.078	-.214 (*)	.230 (*)	.136	.255 (*)	.052	.328 (**)	-.092	.264 (**)	-.296 (**)	.248 (*)	.518 (**)
CONSTRAINT				1.000	-.088	.193	-.225 (*)	-.135	-.251 (*)	-.028	-.316 (**)	.071	-.233 (*)	.297 (**)	-.282 (**)	-.523 (**)
RD_MY					1.000	.115	.197	-.092	.144	-.091	.180	-.057	-.138	-.284 (**)	.257 (*)	.388 (**)
RD_INTENS						1.000	-.082	-.023	-.005	-.068	-.049	.053	-.118	.118	.024	-.332 (**)
EDU_ VAR							1.000	-.164	.671 (**)	.148	.379 (**)	-.127	.289 (**)	-.329 (**)	.135	.490 (**)
EDU								1.000	.458 (**)	.222 (*)	-.009	.086	.007	.078	.056	.042
EDU_DUM									1.000	.283 (**)	.323 (**)	-.054	.132	-.243 (*)	.178	.455 (**)
EDU_F										1.000	-.061	.120	.216 (*)	.074	-.095	-.010
EXPER_VAR_Y											1.000	-.570 (**)	.386 (**)	-.213 (*)	.026	.491 (**)
EXPER_Y												1.000	-.234 (*)	.181	.356 (**)	-.038
EXPER_VAR_F													1.000	.071	-.176	.257 (*)
EXPER_FIRMS														1.000	-.392 (**)	-.452 (**)
AGE															1.000	.394 (**)
SIZE																1.000

Note: Spearman non-parametric correlation analysis. ***p<.01, **p<.05, *p<.10
Source: Own computations based n author's survey. .

7.4.2.3 Systems Method Estimation

The previous section left us with some puzzling questions regarding the overall network effect and the relation between the positions of the firms within the knowledge network and their absorptive capacity and innovative and economic performance.

The fact that all five network indicators are highly correlated limits our understanding about the different network properties of the actors. This implies that the only conclusion that I am able to draw from this analysis is that the network may have an effect on the innovative and economic performance of the firms within the Uruguayan software cluster. In addition, I may also conclude that the network position of the firms is contingent upon its absorptive capacity. Consequently, I cannot give more insight regarding the distinct impact of various network properties upon firms' performance.

Furthermore, a binary correlation analysis gives rather ambiguous results. In order to answer research question ten (RQ 10) regarding the impact of network variables upon the innovative and economic performance of the firms within the knowledge network; and research question eleven (RQ 11) concerning the impact of internal learning mechanisms or absorptive capacity upon network position of the firms, a system method estimation analysis is warranted. The same model as the one in Table 5.16 is used with the addition of the network indicator. The three-stage least squares (3SLS) method is used once more for the estimation of the following structural model:

$$\left.\begin{aligned} L\_PERFORM &= \alpha_1 + \alpha_2 MARK\_INN + {}_{\alpha 3} DEGREE + \alpha_4 LKT + \alpha_5 RD\_INTENS \\ &\quad + \alpha_6 EXPER\_FIRMS + \alpha_7 SIZE + q \\ MARK\_INN &= \beta_1 + \beta_2 DEGREE + \beta_3 LKS\_S + \beta_4 IKT + \beta_5 RD\_MY + \beta_6 EDU\_DUM \\ &\quad + \beta_7 EXPER\_VAR\_F + \beta_8 AGE + v \\ DEGREE &= \gamma_1 + \gamma_2 EDU + \gamma_3 RD\_Intens + z \end{aligned}\right\}$$

Table 7.8 presents the results of the three-stage least squares estimation method. A number of alternative models were tested, using different indicators for the independent variables. The best-fit model in Table 7.8 shows that the R-square of the level of performance (L_PERFORM) sub-system is 0.22. 22 per cent of the variation of the level of performance across firms is explained by the independent variables.

The R-square of the marketing/organisational innovation (MARK_INN) sub-system is 0.43; implying that 43 per cent of the variation of the marketing/organisational innovation among firms is explained by the independent variables. Finally, the R-square of the degree (DEGREE) sub-system is 0.13. Overall, the model seems to explain a reasonable percentage of the variation of the endogenous variables. Based on this model, we may draw the following conclusions:

Table 7.8: Simultaneous estimates of Level of Performance, Marketing/Organisational Innovation and Degree Centrality

	beta-Coefficients *	
L_PERFORM		
MARK_ INN	0.205	(0.217)
DEGREE	-0.006	(-0.029)
LKT	0.044	(0.035)
RD_INTENS	1.364	(0.500)***
EXPER_FIRMS	-0.142	(-0.109)
SIZE	0.005	(0.002)*
Constant	-0.778	(-0.386)**
"R^2"	0.22	
N	65	
MARK_INN		
DEGREE	0.035	(0.020)*
LKS_S	0.526	(0.196)***
IKT	0.016	(0.028)
RD_MY	0.026	(0.008)***
EDU_DUM	0.616	(0.215)***
EXPER_VAR_F	0.271	(0.121)**
AGE	0.027	(0.009)***
Constant	-2.070	(-0.337)***
"R^2"	0.43	
N	67	
DEGREE		
EDU	5.733	(2.112)***
RD_INTENS	-4.653	(-4.365)
Constant	-15.888	(-10.432)
"R^2"	0.13	
N	67	

*Unstandardized regression coefficients (b); Standard Errors in parentheses; ***p<.01, **p<.05, *p<.10.
-3-stage least squares:
Endogenous Variables: L_PERFORM, MARK_INN, DEGREE.
Exogenous Variables: RD_INTENS, EXPER_FIRMS, SIZE, LKS_S, IKT, RD_MY, EDU_DUM, EXPER_VAR_F, AGE, EDU.
Source: Own computations based on author's survey

After the addition of the network indicator –DEGREE-, the level of performance sub-system (L_PERFORM) remains unchanged. This may suggest that firms that are characterised by many direct connections do not necessarily exhibit high economic performance.

However, the network indicator –DEGREE- has a positive and significant impact upon the innovative performance of the firms within the knowledge network. In particular, the second sub-system (MARK_INN) in Table 7.8, demonstrates that one of the predictors of the marketing/organisational innovation is degree centrality. Accordingly, firms with many direct connections exhibit superior marketing/organisational innovative performance than firms which have few linkages.

Finally, the third sub-system (DEGREE) illustrates that firms which have employees with postgraduate education are at the centre of the network. This is an indication of the fact that higher absorptive capacity is a prerequisite for the development of network relations. However, the R&D intensity indicator (R&D_INTENS) has a negative though not significant

effect upon the degree centrality variable. As I have explained in the previous section, the reason for this could be the substitution of acquisition of external knowledge through network relations with the internal investments in R&D.

7.5 CONCLUSIONS

The analysis of the density of the knowledge network of the software cluster in Uruguay has shown that firms are not very well interconnected. This implies that knowledge might not flow easily among local firms. However, despite the fact that local firms have few connections, I have found evidence to suggest that many of these linkages are strong, in the sense that they represent frequent interactions among actors. This is crucial for the sharing of knowledge that might require repeated interactions in order to be successfully transmitted. Finally, when we consider only the interactions among MNCs, universities, and support institutes, it is possible to detect that they are very well connected among themselves. In other words, we have seen that there is dense communication among key institutional players within the software cluster in Montevideo, which points to the presence of a knowledge infrastructure.

The analysis of cliques indicates that the knowledge network within the software cluster in Uruguay consists of 21 sub-groups, with a high degree of overlap. Consequently, despite the identification of a fragmented network of actors, the various sub-groups are not isolated from each other. On the contrary, more than 70 per cent of the groups overlap. Finally, I have found evidence which suggests that the most critical connections (or bridges) for the knowledge network within the software cluster of Uruguay are formed between local firms and a MNC, a support institute, and a university. This led me to conclude that the local knowledge network of the software cluster in Uruguay resembles the so-called 'small world' phenomenon in social networks; that is, actors are “connected via a chain of only a few intermediate acquaintances” (Watts, 1999, p.11). Thus, knowledge may flow effectively among the local actors within the knowledge network of the software cluster in Uruguay (RQ 9).

Correlation analysis among the network indicators and the indicators of the innovative and economic performance of the firm has shown that firms that are located in central positions within the knowledge network of the software cluster in Uruguay exhibit high innovative and economic performance. In particular, technological and marketing/organisational innovations are positively correlated with all network indicators. This suggests that firms that are innovative in any of the two ways (technological and/or marketing/organisational innovation) also exhibit high degrees of social capital. In addition, export intensive firms occupy key positions within the local knowledge network.

With regard to the absorptive capacity indicators, I have shown that while education and experience indicators correlate positively with the network variables, the R&D indicator is negatively related to them. These results offer new insights into our understanding of the motivations and capabilities of the firms for participating in the local knowledge network. Firms that are R&D intensive do not play a central role within the local knowledge network, because they are able to generate knowledge resources (through R&D) for innovation internally. In contrast, the strategy of the central actors within the network seems to rely on social capital for accessing knowledge, which can be understood as a substitute for their low investments on internal learning.

Finally, I estimated a structural model of three simultaneous equations that enables us to answer research questions ten and eleven. Regarding the relationship between the position of a firm in the local knowledge network and its innovative and economic performance (RQ 10), I have found evidence which shows that firms located in central positions in the local network exhibit a higher innovative performance than firms which occupy less central positions. Central location permits firms to access knowledge rapidly, which in turn constitutes one of the most critical inputs into the innovation process. However, firms with many contacts do not exhibit high economic performance. With regard to the impact of absorptive capacity upon the ability of firms to develop network relations (RQ 11), this study suggests that it plays an important role. In particular, firms which have postgraduate employees occupy central positions within the knowledge network of the Uruguayan software cluster.

CHAPTER 8

CONCLUSIONS AND DISCUSSION

8.1 THE SIGNIFICANCE OF LOCAL KNOWLEDGE SPILLOVERS FOR THE PERFORMANCE OF FIRMS WITHIN HIGH TECH CLUSTERS IN DEVELOPING COUNTRIES

This thesis provides evidence, which illustrates that local knowledge spillovers are very important for the innovative performance of firms within clusters in developing countries. Based on the case of the Uruguayan software cluster, my econometric analysis has provided evidence on the positive and direct effect of local knowledge spillovers upon the innovative performance of firms. However, in relation to the economic performance of the firms, the effect of LKS is more limited, since they affect economic performance indirectly (through innovation). Additionally, it can be argued that international knowledge transactions play the key role in the economic performance of firms within clusters in LDCs. The importance of international knowledge transactions for firms in developing countries has been stressed by the literature on technology transfer (Enos, 1989; Lall, 2001) and on the global value chain (Gereffi, 1999; Gereffi and Kaplinsky, 2001).

The qualitative analysis has shown that knowledge spills over through all three mechanisms discussed in a few earlier studies (see Saxenian, 1994). They take place through informal interactions of actors, who share knowledge in user-communities and via personal contacts. They also occur due to labour mobility of highly skilled professionals, who diffuse the knowledge they have accumulated every time they take a new job. Finally, they take place through spin-offs that spread knowledge from established firms, universities, and MNCs to new start-ups. Furthermore, I have provided evidence which suggests that local knowledge spillovers happen not only spontaneously but also intentionally as Von Hippel (1987) and Harhoff et al. (2003) have advocated.

Social Network analysis permits us to assess how easily knowledge spills over amongst the local actors. Although the knowledge network within the Uruguayan software cluster is quite fragmented, many firms are members of more than one sub-group, which allows knowledge to circulate effectively from one sub-group to the others. Consequently, the results of my study suggest that knowledge spills over quite effectively among the local actors in the software cluster of Montevideo. To conclude, the morphology of the Uruguayan local knowledge network is determined by central heterogeneous relations, which are formed between local firms and other organisations (MNC, university, support institute). The key role of the MNC indicates the importance of acquisition of non-local knowledge. The central position of the university within the knowledge network reveals that software is a high-tech industry which relies on collaboration with educational and research institutions. Finally, the

vital role of the relation of a local firm with a support institute shows the significance of initiatives in organising forums for social exchange, where many informal interactions and knowledge sharing take place. These findings underline the importance of social embeddedness for the performance of firms as has been stressed by Coleman (1988, 1990), Granovetter (1973, 1985), Gulati (1998), Powell (1990), and Uzzi (1996).

8.2 DISCUSSION OF RESEARCH FINDINGS

The Literature Review

The examination of the rich literature on *local knowledge spillovers* in advanced economies provides many insights into their contribution to the innovation of firms within clusters and/or regions (Chapter 2). However, important gaps still remain in this literature. In the first place, particularly problematic is the fact that studies have traditionally focused only on local knowledge advantages, while underestimating the impact of international knowledge linkages. Currently, there are studies that pay attention to the fact that innovative clusters and/or regions in advanced economies are not isolated from their international environment. For instance, sophisticated clients may be located in other countries and/or continents. They possess key knowledge about market trends and customer needs, and also remain important drivers of demand driven innovation. Accordingly, clusters of firms which have built good linkages with international actors have more chances of receiving relevant information, and being reactive or even proactive in their innovative processes than clusters isolated from the international context. One lesson that can be learned from the examination of the software cluster in Uruguay is the importance of international knowledge (Chapter 5) which is acquired by firms through market mechanisms (international knowledge transactions-IKT). Even when developed countries hold the relevant scientific or technological knowledge, they equally require knowledge about markets and customer needs which is context-specific and can be located in the international context.

A second drawback of the literature on *local knowledge spillovers* in advanced economies is the fact that most of the studies have used secondary indicators as proxies to capture local knowledge spillovers. There are very few studies (Saxenian, 1992, is one of them) that scrutinise the phenomenon of local knowledge spillovers by using primary sources. As a result, it remains unclear how local knowledge spillovers take place both in developed and developing economies.

In particular, until today scholars have not convincingly demonstrated whether knowledge spills over spontaneously or intentionally. Neither have they disentangled knowledge spillovers from transaction-based knowledge flows. For example, they have failed to reach a consensus regarding whether labour mobility constitutes a mechanism of local knowledge spillover, or if it is just a phenomenon attributed to a well functioning labour market (Breschi and Lissoni, 2001; 2003). In chapter 6, I thoroughly examined how local knowledge spillovers take place through a qualitative analysis of 107 face-to-face interviews with software firms' managers and/or R&D engineers in Montevideo. As a result, my study offers a fresh insight on matters relating to the actors and their motivations for being involved in the processes of knowledge sharing. Although I do not pretend to have the final word in this ongoing debate, I do offer a new analysis that helps us to define the types of knowledge flow that constitute knowledge spillovers, and to assess their importance for firms' performance in a more rigorous manner than what has been done so far.

The literature on *technical change* in developing countries provided the starting point for my decision to scrutinise the importance of local knowledge spillovers in contrast to that of the international knowledge linkages. First, some important works on *technology transfer* made me understand the importance of the acquisition of technology at international level through market transactions. The concept of *international knowledge transactions* that is used throughout this study derives from my reading and interpretation of these works. Secondly, through the use of the concept of *international knowledge spillovers* I addressed the occurrence of knowledge spillovers through the involvement of countries in international trade as explained in the *new trade theory* literature.

Studies on *industrial clusters* in developing countries have offered evidence on the importance of agglomeration advantages upon the technological and economic progress of firms in LDCs (Schmitz, 1999). However, this literature does not make a clear distinction between knowledge advantages and cost advantages; neither differentiates between innovative and economic performance. Based on insights derived from this literature, I have introduced a distinction between *local knowledge spillovers* and *local knowledge transactions*. Significantly, I have distinguished between the *innovative* and the *economic performance* of firms.

The literature on *absorptive capacity* and *technological capability* argues that the development of internal processes of learning within the firm is a prerequisite for the acquisition of technology [and thus external knowledge]. Technological effort is necessary: purposeful investments in learning enable firms to select, adopt, modify and improve a new technology. Consequently, this study has taken into account the absorptive capacity of the firm by considering a large number of indicators that reflect the educational level, experience, and R&D efforts of the firm.

The introduction of the concept of *knowledge flows* facilitated the measurement of local knowledge spillovers. By measuring all kinds of knowledge flows and then categorising them into different types, I was able to assess the relative importance of LKS compared to the other types of knowledge flow for the innovative and economic performance of firms within clusters. This has been a major contribution of this thesis.

In sum, based on the insights provided by the aforementioned literature, I have developed a conceptual framework which examines simultaneously: first, the relative impact of local knowledge spillovers [compared to local knowledge transactions, international knowledge spillovers, and international knowledge transactions] upon the economic performance of the firms; second, the relative impact of local knowledge spillovers upon the innovative performance of the firms; and third, the impact of the absorptive capacity upon the ability of the firm to acquire external knowledge.

The Methodology

The examination of a number of methodologies that have been used by scholars in advanced economies to analyse local knowledge spillovers led me to conclude that these methodologies could not be replicated in the context of a developing country. Among others, the most important reasons for this are the following:

First, the scarcity of data in developing countries regarding patents, R&D, and other indicators of innovative inputs and/or outputs meant that I was not able to apply the methodologies of Jaffe et al. (1993). Second, the limitations in existing innovation surveys in

many developing countries did not allow me to follow the methodologies that have been developed and applied by a number of scholars (Cassiman and Veugelers, 2002; Mohnen and Hoareau, 2003) using the datasets of the Community Innovation Survey.

Third, innovation in developing countries, as I have explained in Chapter 2, does not necessarily mean that *a product and/or process is new to the market*. Rather, it includes all the efforts of the firm to adapt or modify a product and/or process; namely *a product and/or process new to the firm*. According to this definition, indicators such as R&D would not be useful since innovation includes a number of firms' activities which are usually informal. Thus, such information could only be captured by undertaking a firm level study.

Fourth, in order to shed light upon the mechanisms of local knowledge spillovers, a combination of quantitative and qualitative study was necessary. By adopting a clear [conceptual and methodological] focus on local knowledge spillovers this research attempted to unravel the intricacies of the functioning of local knowledge spillovers in LDCs.

In view of the difficulties originating from data scarcity and from the need of detailed information regarding firms' innovative activities, I selected a specific case study of one cluster in order to examine the aforementioned research problem. After a number of criteria were set in Chapter 3 for the [unbiased] selection of the case, I chose the software cluster of Montevideo, Uruguay. Research in advanced economies has suggested that knowledge spillovers occur in knowledge intensive industries. The software sector emerged in the past 10-15 years in many developing countries, and is currently expanding steadily. In this sense, the development of the software industry was deemed to be a representative case since it constitutes a trend and not an exception in LDCs. In the specific case of Montevideo, the cluster is dynamic, both in terms of technology and economic performance. The Uruguayan software cluster was selected ahead of a number of other software clusters because it is export intensive, thus being adequate for the comparison of local versus international knowledge flows.

Two field studies were conducted in the software cluster in Montevideo. During the first research trip, I carried out an Innovation Survey through face-to-face interviews with the majority of the software firms (98). I attempted to follow the methodology of the CIS, but at the same time, I made several changes in order to adjust the questionnaire to the needs of the software sector (which includes service firms besides industrial firms) and to the peculiarities of a developing country. During the second I carried out a Network Survey which was based on the methodology of the Social Network Analysis. The sample utilised in the first survey was used again, allowing us to compare the variables of the two surveys. Finally, during both research trips, I conducted 107 interviews with the managers and/or engineers of the software firms, academics, politicians, and other professionals involved in the sector.

The Case Study

In chapter 4, I examined the emergence and evolution of the software sector in Uruguay in a comparative way. The software industry in Uruguay emerged without the support of public policy, unlike in many other developing and even advanced economies, where the emergence of the software industry was triggered by the State. This was the case in China, Brazil and Israel. Uruguay offers, like many other developing countries, mainly software services. The sophistication of the Uruguayan software is quite advanced in comparison with other developing countries, such as China.

Additionally, the Uruguayan software sector is export intensive. Almost half of the sales are directed toward foreign markets, while the other half satisfies local demand. Uruguay is unique particularly if we compare it with China and Brazil, whose software industries mainly address the domestic market, and with India's dominant export oriented software sector.

Finally and more importantly, Uruguay exhibits a pattern of complete agglomeration. Geographic proximity allows firms to interact often and provides the appropriate environment for the emergence of knowledge spillovers, which in turn enhance the capability of firms to innovate. This is a unique advantage that possibly reinforced the development of the Uruguayan software industry.

Chapter 5 contained a quantitative examination of the importance of local knowledge spillovers for the innovative and economic performance of the firms within the Uruguayan software cluster. The outcome of the econometric analysis illustrates that the acquisition of international knowledge through transactions is contingent upon firms' absorptive capacity (RQ 2). In particular, large firms that invest strongly in R&D are able to absorb international knowledge. On the contrary, small firms which are weak in R&D do not possess the capabilities to make use of international knowledge.

Additionally, the econometric analysis has shown that local knowledge spillovers are the most important drivers for the innovation of the firms within the Uruguayan software cluster compared to other types of knowledge flow (RQ 3a and RQ 4a). In particular, local knowledge spillovers through interaction and labour mobility increase the technological innovation of the cluster firms. Local knowledge spillovers through spin-offs enhance the marketing/organisational innovation of the firms within the cluster.

However, local knowledge spillovers do not directly affect the economic performance of the firms within the cluster (RQ 3b and RQ4b). It is only indirectly, through innovation, that local knowledge spillovers positively affect the economic performance of the firms. International knowledge transactions exhibit the strongest positive direct effect upon the economic performance of the firms within the cluster. In particular, international knowledge transactions are crucial for the export performance of the firms, because they are the conduits for the transfer of knowledge related to market trends and customer needs.

Based on the analysis in chapter 5, I conclude that local knowledge spillovers play an almost similar role in the context of developing countries in comparison with advanced economies (RQ 5). Local knowledge spillovers positively affect the innovation of firms within a cluster. However, it is international market transactions which allow firms in developing countries to achieve economic success. Local knowledge spillovers are not a sufficient condition for economic growth in developing countries.

Chapter 6 scrutinises the mechanisms through which local knowledge spillovers occur in a qualitative manner. The outcome of the study suggests that they take place through the direct and informal interaction of actors, labour mobility, and finally spin-off firm formation. The results of my study support the findings of earlier works, which have stressed the key role of customers for innovation in the software sector (Pavitt, 1984; Veloso et al., 2003; Malerba, 2005) (RQ 6).

Albeit the economic literature on knowledge spillovers underlines the spontaneous nature of the spillover mechanisms, literature on innovation management suggests that knowledge

spillovers may also occur as a result of the intentional sharing of knowledge among competitors (RQ 7). In the case of the Uruguayan software cluster, firms' employees sustain personal contacts, which enable them to be aware of new technology and market opportunities. These contacts provide the grounds upon which future collaborations are built. Additionally, user-communities create extensive knowledge spillovers that concern technological knowledge. Informal communications with local universities regarding training and research were also identified. Finally, software firms collaborate with suppliers and distributors, which are conduits for the spillover of technological and applied knowledge respectively.

Labour mobility and spin-offs as mechanisms of local knowledge spillovers were also examined [in a less detailed way]. The software cluster of Montevideo exhibits a high rate of labour mobility. Similarly, spin-offs are significant mechanisms that trigger local knowledge spillovers.

In general, knowledge spillovers are associated with sources of technological knowledge, while knowledge transactions are related with sources of applied knowledge (RQ 8). However, I have found evidence which shows that knowledge spillovers are also related to sources that retain applied knowledge, such as collaborations of software firms with their distributors. This evidence suggests that local knowledge spillovers diffuse not only public but also private knowledge, which in turn implies that they take place not only spontaneously but also intentionally.

In Chapter 7, I examined the knowledge network within the software cluster in Montevideo. The analysis of the macro characteristics of the knowledge network offers some key insights into the effectiveness by which knowledge circulates within the network.

The examination of a number of network indicators has shown that the knowledge network of the software cluster consists of many sub-groups, and that a large percentage of them overlap. This means that knowledge diffuses rapidly within the network when compared to a case in which the sub-groups are disconnected from each other (RQ 9).

Finally, I examined the impact of the network on the innovative and economic performance of firms (RQ 10) and analysed whether the network position of a firm is subject to its absorptive capacity (RQ 11). The outcome of the econometric analysis shows that firms that are characterised by many direct connections do not necessarily exhibit a higher economic performance. However, the network indicator exhibits a positive and significant impact upon the innovative performance of the firms within the knowledge network. Interestingly, I have also discovered that firms with more employees educated at a postgraduate level are at the core of the network. This is an indication of the fact that higher absorptive capacity is a prerequisite for the development of network relations. However, R&D intensive firms are not at the centre of the knowledge network. One reason for this could be that they substitute external knowledge [acquired through network relations] with the internal investments in R&D.

8.3 POLICY IMPLICATIONS

This study has found strong evidence that supports the presence of local knowledge spillovers within high-tech clusters in a developing country setting. Two main policy recommendations can be drawn from these results:

First, geographic proximity may generate advantages related to the fast circulation of knowledge, not only in advanced economies but also in developing countries. This suggests that knowledge advantages, as well as cost advantages, can benefit firms within clusters in LDCs (Chapter 5). A policy ingredient for state and regional agencies would be the identification and support of these geographic spaces. Besides geographic proximity, social proximity is also important. Knowledge spillovers based on social capital [and trust] are important drivers for innovation (Chapter 7). Social capital is especially important for knowledge spillovers because trust is a fundamental feature of [free] knowledge sharing activities. Thus, it is essential not to underestimate the social context when economic or technology policies are devised. More importantly, Chapter 7 has shown that the heterogeneous linkages between actors are the crucial bridges of the knowledge network within the Uruguayan software cluster. Thus, policies should attempt to reinforce linkages such as the relations between local firms, universities, MNCs, and support institutes.

Second, policies supporting LKS encompass mainly government subsidies towards universities and firms that conduct substantial R&D. However, these policies have been strongly criticised because of the past ineffectiveness of the highly interventionist policies pursued in Latin America and because of scepticism regarding the capacity of the state to allocate resources efficiently. Despite these criticisms, developmental states have played an important role in enhancing the human capital and the capabilities of their countries, negotiating with international capitalists, attracting investment, and forwarding investment into potential dynamic sectors (Amsden, 2001; Kesidou, 2004).

The software sector may generate important knowledge spillovers within and also between industries. Although developing countries should not attempt to build up a software industry from scratch, it is advisable to support an already existing ICT sector. Technology policy should not attempt to control, only to orchestrate and nurture the various economic activities. Governments in LDCs should facilitate the building and financing of IT cabling and electricity infrastructure.

In the case of the software cluster in Uruguay, labour mobility, spin-offs, and the informal interaction of agents within the cluster seem to be the most important mechanisms for the transfer of knowledge. Thus, the Uruguayan government should continue to invest in education and training of high-skilled employees, should provide more subsidies for R&D and should facilitate labour mobility by promoting more flexible and less regulated labour markets, especially for SMEs. Awareness of the importance of LKS for innovation is crucial for drawing policies that enhance accumulation and circulation of knowledge. LKS can be a potential path of learning, innovation, and thus of economic development for developing countries and in particular for small countries with many potentials.

In addition to focusing attention upon local knowledge advantages, it is also essential to keep in mind that international linkages continue to play a major role in the innovative and economic performance of firms in developing countries. Countries that are well connected to the global economy may gain through the development of formal and also informal linkages. Thus, it is crucial that these countries establish policies that lower trade barriers and open up to foreign direct investments. More importantly, a prerequisite for the absorption of external knowledge is the internal building of capabilities. For absorption to be effective, every developing country should pursue a policy of investments in education and vocational training.

8.4 LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The measurement of the variables that indicate local knowledge spillovers may involve some transaction elements. More work needs to be done in order to disentangle knowledge spillovers from transaction-based knowledge flows. Had the examination of the labour mobility within the Uruguayan software cluster been more detailed regarding the characteristics of the new employees, I could have assessed the precise role of labour mobility as a channel of local knowledge spillovers. Thus, in future research I will focus on the specific skills and knowledge that mobile workers bring into the firm.

The Social Network analysis demonstrated that the relationships of local firms with a MNC, a university, and a support institute are the key bridges that allow the effective spillover of knowledge within the network. These organisations very possibly connect local and international actors. Further research, should address the complementarities of local and global linkages for the transfer of knowledge.

It is not an easy task to draw conclusions concerning the role played by local knowledge spillovers in a developing country based on the examination of a single sector in one country. Taking into account, then, the limitations of this research with respect to the differences (in knowledge and innovation type) encountered amongst sectors and countries, I have offered only partial, though I hope pertinent conclusions.

Further research on this topic would entail the examination of software clusters in other developing countries and the detection of similarities and differences regarding the function of local knowledge spillovers. Only by adding fresh comparative studies we will be able to decipher the many puzzles that affect the world of knowledge spillovers within clusters in developing countries.

APPENDICES

Appendix A:

Innovation Survey

SOFTWARE SECTOR – URUGUAY -INNOVATION SURVEY 2004

RESNO:

Contact information

Name of contact person for your firm CONPERS .....

Telephone TELNUM .....

E-mail EMAIL.....

Definitions for the Software Sector in Uruguay-Innovation Survey 2004

- **Innovation**:

This survey defines 'innovation' as: (1) a 'new or substantially improved' service, product or process for your firm. Consequently, this definition includes new or improved services, products or processes already introduced in the market by a competitor. (2) New to the market innovations refer to those firms that were the first to introduce a 'new or substantially improved' service, product or process to the market.

- **Cluster**: Geographic concentration of small and medium enterprises.

- **New or substantially improved service, product or process:**

This means that the fundamental characteristics of the service, product or process are new or significantly improved in relation to the essential characteristics of comparable, earlier services, products or process. For example, a service/product innovation could imply a much wider range of uses while a process innovation could result in significantly lower costs and/or increased output performances.
Improved: an existing product/service, which has clearly improved technical specifications or an increased usability, compared to previous versions.
New: a product/service is usually incompatible with previous products or services of your firm and in which new technology is embodied.

Instructions for filling in this questionnaire:
Most questions are fairly easy to answer with just a YES or a NO: To answer this type of questions, just tick as is shown below:

- ❑ YES
- ❑ NO

In some questions, it is asked to fill in a figure: To answer this type of questions, just fill in as is shown below:
.....24.....%

GENERAL INFORMATION ON THE FIRMS

1. **When was your firm established?**

   .....

2. **Is your firm Independent or part of an enterprise group?**

   - ❑ Part of a National enterprise group
   - ❑ Part of a Multinational enterprise group
   - ❑ Independent →**Go to question 4**

3. **Where (Country, City) is located the head office of your enterprise?**

   .....

4. **Is your firm a spin-off of a University, Multinational enterprise, or other enterprise?**

   - ❑ YES, my firm is a spin-off of a University
   - ❑ YES, my firm is a spin-off of a National enterprise
   - ❑ YES, my firm is a spin-off of a Multinational enterprise
   - ❑ YES, my firm is a spin-off of other enterprise
   - ❑ NO → **Go to question 8**

5. **Is your parent firm located within the same region or not?**

   - ❑ The same locality (Montevideo)
   - ❑ Outside of Montevideo-National location (specify)……
   - ❑ Outside of Montevideo-International location (specify)…….

6. **Is your parent firm an important source of information or assistance in your efforts to upgrade or innovate?**

   - ❑ YES
   - ❑ NO

7. **Do you consider this interaction crucial for solving the firm's technical problems?**

   - ❑ YES
   - ❑ NO

8. **Total <u>sales</u> of your firm in 1999 and 2004?**

   On the year 1999 ……..
   On the year 2000 .....
   On the year 2001 .....
   On the year 2002 .....
   On the year 2003 .....
   On the year 2004 .....

9. **Were the profits of your firm increasing, decreasing or constant the period 1999 and 2004?**

Years	Profits		
	Increasing	**Constant**	**Decreasing**
1999			
2000			
2001			
2002			
2003			
2004			

10. **<u>Exports</u> as a percentage (%) of total sales of your firm in 1999 and 2004.**

On the year 1999 .....% of total sales
On the year 2000 .....% of total sales
On the year 2001 ..... % of total sales
On the year 2002 ..... % of total sales
On the year 2003 .....% of total sales
On the year 2004 .....% of total sales

11. **Did your firm experience any significant changes between 1999 and 2004**

- ❑ Acquisition of another firm,
- ❑ Establishment of new firm,
- ❑ Divestment
- ❑ Other.....

12. **How many <u>skilled employees</u> did your firm had in the period 1999-2004?**

On the year 1999 .....
On the year 2000 .....
On the year 2001 .....
On the year 2003 .....
On the year 2004 .....

****Skilled employees:** This refers to employees that have a type of specialization in software of any level.

13. **How many <u>new</u> skilled employees did your firm acquire during the period 1999-2004?**

❑ .....

14. **From where do your employees come from?**

- ❑ The same locality (Montevideo)
- ❑ National
- ❑ International (specify)……

15. How many of your skilled employees posses a degree and in which discipline?

Educational Background	**Discipline**		
	Mechanical engineering, Electrical engineering	**Informatics, mathematics**	**Other** (Please specify)
Vocational technical education			
BSc degree			
MSc degree			
PhD degree			

16. How many of your employees are educated in National Universities and in Universities abroad?

❑ National.....

❑ Foreign (specify).....

17. How many months of experience do your skilled employees have in the software sector?

Period	**% of employees**
≤ 6 months	
> 6 and ≤ 12 months	
>1 year and ≤ 2 years	
>2 and ≤ 4	
> 4	

18. In how many firms did your skilled employees work previously?

Type of occupation / **No. of Firms**	**% of employees**		
	ICT firm	**Other type of firm**	**University**
0			
1-2			
3-4			
5-6			
>6			

MAIN QUESTIONS

19. Which is the principle activity of your firm?

- ❑ Software development business
- ❑ Consultancy and information services
- ❑ Other (Please specify).....

20. Which types of products/services your firm provides?

- ❑ Consultancy
- ❑ Data processing
- ❑ Outsourcing or subcontracting
- ❑ 'Ad hoc' software development (customisation)
- ❑ Development of software packages (standardised systems)
- ❑ Licenses (of your products)
- ❑ Other (Please specify).....

21. Which are the most important products/services your firm provides?

Products/services	**0 Unimportant**	**1 Less important**	**2 Important**	**3 More important**	**4 Crucial**
Consultancy					
Data processing					
Outsourcing or subcontracting					
'Ad hoc' software development (customisation)					
Development of software packages (standardised systems)					
Licenses					
Other (Please specify)					

22. Between 1999-2004, has your firm introduced products/services into the market, which were technologically improved or new to your firm?

- ❑ YES
- ❑ NO → **Go to question 25**

23. Which percentage (%) of sales and which percentage (%) of profits derives from these innovative products/services?

Years	% of Sales from innovative products/services	% of Profits from innovative products/services
1999		
2000		
2001		
2002		
2003		
2004		

24. <u>How many</u> innovated products/services has your firm introduced into the market?

- ❑ ≤ 2
- ❑ > 2 and ≤ 5
- ❑ > 5 and ≤ 10
- ❑ > 10 and ≤ 20

25. Did your enterprise undertake any <u>unsuccessful</u> innovative activity between 1999 and 2004?

- ❑ YES, **Why and How** many projects.....
- ❑ NO

26. Did your enterprise undertake innovative projects that have <u>not been completed yet</u>?

- ❑ YES, **Why and How** many.....
- ❑ NO

27. Please <u>name</u> the 5 most important product/service innovations your firm developed and/or introduced and characterise them.

Innovative Product/ Service	Product / service new to the <u>firm</u>	Product / service new to the <u>market</u>	<u>Step-by-step</u> changes of product/ service	<u>Drastic</u> changes of product/ service	Time devoted in R&D (man-years)	<u>Easy</u> to be imitated (<1Year) by another competitor	<u>Difficult</u> to be imitated (>1Year) by another competitor	A market already exists for this product/ service
(1).....								
(2).....								
(3).....								
(4).....								
(5).....								

28. Has your firm acquired any of the following International Certifications, and If yes, which <u>level of capability holds</u>?

	Level
❑ SEI Process Capability Maturity Model (CMM)	.....
❑ Software Productivity Research Assessment (SPR)	.....
❑ Malcolm Baldrige National Quality Award (MBNQA)	.....
❑ ISO 9000	
❑ Other (please specify)	.....

29. Which is the software development platform (or tool) that your firm uses?

- ❑ Microsoft .NET
- ❑ Microsoft Visual Studio 6^{+} (C ++)
- ❑ Borland Builder 6^{+} (C++)
- ❑ Borland Delphi 7 (Pascal)
- ❑ Borland JZEE (Java)
- ❑ Linux
- ❑ GCC
- ❑ Other (Please specify).....

30. Have you changed the software platform that you use? If Yes, Please characterise this change:

- ❑ YES
- ❑ NO

Type of change		
1 **Less Important**	**2** **Important**	**3** **Very Important**

31. Between 1999-2004 did your firm change substantially any of the following activities?

- ❑ **Business strategy**: Change of (long term) strategic goals of your firm
- ❑ **Marketing/design**: Development of new marketing concepts and/or aesthetic change of product design
- ❑ **Reorganisation**: Implementation of radical change of the organisation of your firm
- ❑ **Management**: Implement new management tools, for example knowledge management

32. Is your firm engaged in one or more of the following innovation activities?

If yes, which <u>percentage (%) of total expenses</u> did you devote approximately to the following activities?

- ❑ **R&D within** the firm; **.....% of total costs**
- ❑ External **acquisition of R&D** services (include costs of specialists that were temporarily employed by your firm to work on an innovation); **.....% of total costs**
- ❑ The acquisition of **machinery and equipment** linked to technological innovation; **.....% of total costs**
- ❑ All activities aimed at the technical preparations to introduce new or significantly improved services or methods to produce or deliver them; **.....% of total costs**
- ❑ Cost of **Training** personnel directly linked to technological innovations (such as participation in a conference,); **.....% of total costs**
- ❑ Cost of **Marketing** activities (also done by others) directly related to the market introduction of innovated products/services (such as market research); **.....% of total costs**

33. Please, give an estimate of the R&D effort in your firm in 2004:

Number of persons engaged in research/engineering activity.

- ❑ ≤ 2
- ❑ > 2 and ≤ 5
- ❑ >5 and ≤ 10
- ❑ >10 and ≤ 20
- ❑ > 20

The above people work full time or part time on R&D?

- ❑ Full time
- ❑ Part time

34. By which ways <u>knowledge can be acquired</u> better, in your software business?

Ways of knowledge transfer	0 Unimportant	1 Less important	2 Important	3 Very important	4 Crucial
Articles, patents, reports etc.					
Face-to-face communication					
Learning-by-doing					

35. Which of the following <u>actors are sources of information/advice</u> or <u>assistance</u> in your efforts of upgrading or innovation?

	No.
❑ **Group**: From parent company	.....
❑ **New personnel**: From contracted personnel	.....
❑ **Customers**: Innovative ideas from buyers	.....
❑ **Suppliers**: Innovative ideas from suppliers	.....
❑ **Competitors**: Such as analysis of products/services of competitors	.....
❑ **Interactions with vertically connected firms**: Such as backward/ forward linkages	.....
❑ **Consultants**: Ideas from private consultancies	.....
❑ **Research labs**: From public research institutes	.....
❑ **Universities**: Including affiliated institutes	.....
❑ **Innovation Centres**: Regional centres for innovation	.....
❑ **Sector Institutes**: Ideas from trade organisations	.....
❑ **Patents**: Consult patent for ideas	.....
❑ **Electronic info/Internet**: Consult databases for ideas	.....
❑ **Exhibitions**: Including profess. Conferences	.....

Please score –between 0 (unimportant) to 4 (crucial) - among these sources of information for innovation.

Actors	0 Unimportant	1 Less important	2 Important	3 Very important	4 Crucial
Parent company					
New personnel					
Customers					
Suppliers					
Competitors					
Interactions with vertically connected firms: backward/ forward linkages (%)					
Consultants					
Research labs					
Universities					
Innovation Centres					
Support Institutes					
Electronic info/Internet					
Exhibitions/ Conferences					

36. Location of the source of information: Please, answer the following question by filling in the table below.

- Which of the aforementioned actors are located in Montevideo, Nationally or Internationally (specify)?

Actors	Location		
	Montevideo	**National location**	**International location**
Parent company			
New personnel (%)			
Buyers (%)			
Suppliers (%)			
Competitors (%)			
Interactions with vertically connected firms: backward/ forward linkages (%)			
Consultants (%)			
Research labs			
Universities			
Innovation Centres			
Sector Institutes			
Exhibitions (%)			

37. Do you compensate more (than the normal salary) the <u>new employees</u> that carry unique skills and come from <u>Montevideo</u>?

……

38. Type of relation: Please, answer the following question by filling in the table below.

- ❑ Do you compensate pecuniary the aforementioned sources of information?
- ❑ Which of them are provided for free?

Actors	**Type of relation**			
	Formal/ Market transaction	**Mixed** primarily **Formal**	**Mixed** primarily **Informal**	**Informal Free of charge**
Mother/daughter company				
New personnel (%)				
Buyers (%)				
Suppliers (%)				
Competitors (%)				
Interactions with vertically connected firms: backward/ forward linkages (%)				
Consultants (%)				
Research labs				
Universities				
Innovation Centres				
Sector Institutes				
Exhibitions (%)				

39. Has your firm received a subsidy or other innovation funds in 2004 to develop technologically new or improved products, services, or processes?

❑ YES
❑ NO

If yes, which of the following funds did your firm use for innovation in 2004?

❑ Government
❑ Venture capital (individuals, VC organ.)
❑ Development capital (Banks, IDC)
❑ Research Cooperation (Scientific Councils)
❑ Other, (please specify).....

40. Between 1999-2004 did your firm seriously delayed, abolished and/or not even started innovation activities due to factors hampering innovation.

❑ YES
❑ NO

If yes, please indicate the factors that may have hampered your innovation activities:

- ❑ Imitation of close located firms
- ❑ Economic risks
- ❑ Shortage of staff: Lack of qualified personnel
- ❑ Knowledge gap: Lack of information/familiarity with technologies
- ❑ Costs too high: Estimated costs too high/exceeding initial budget
- ❑ Shortage of finance: Lack of appropriate external financial sources
- ❑ Time to market: Could not meet required market introduction time
- ❑ Partnership: Cooperation with partners not proceeding smoothly
- ❑ Demand risks: Too many uncertainties on future product markets
- ❑ Regulations: Restrictive public or other government regulations
- ❑ Rigidities: Internal organisational rigidities hampered innovation
- ❑ Other (Please specify): .....

Please score –between 1 (unimportant) to 5 (crucial)- among these factors that hampered your innovation activities:

Factors	**0 Unimportant**	**1 Less important**	**2 Important**	**3 Very important**	**4 Crucial**
Imitation of close located firms					
Economic risks					
Shortage of staff					
Knowledge gap					
Costs too high					
Shortage of finance					
Time to market					
Partnership difficulties					
Demand risks					
Regulations					
Rigidities					
Other (Please specify)					

Source: Author.

Appendix B:
Network Survey

SOFTWARE SECTOR – URUGUAY - NETWORK SURVEY 2005

RESNO:

Contact information

Name of contact person for your firm CONPERS .....

Telephone TELNUM .....

E-mail EMAIL .....

MAIN QUESTIONS

1. **With whom among the <u>actors</u> below do you <u>communicate</u> in order to solve technical or functional problems, which occur during the development of software products/services (period 1999-2004)?**

2. **Please indicate the <u>frequency</u> of the interaction with these actors (period 1999-2004).**

To answer this type of questions, just fill in as is shown: √

<u>Actors</u>: By this we mean formal actors such as the manager or director of a firm and also informal personal contacts such as friends, ex-colleagues that work in other firms.
<u>Communication</u>: By this we mean interaction through telephone, e-mail, formal meetings and also informal social events.
<u>Frequency</u>: Rarely (once per year), **Sometimes** (2-5 times per year), **Often** (every month), **Very often** (every week).

		FREQUENCY of INTERACTION				
ACTORS	**Logo**	**Never**	**Some times**	**Rarely**	**Often**	**Very often**
OBJETOS TECNOLOGIA Y SOFTWARE	objetos					
PRANASYS S.A.	PRANASYS					
DE LARROBLA & ASOCIADOS	Bantotal					
MAGMA TOOLS	Magma					
AKROS - SOLUCIONES INFORMÁTICAS	AKROS					
URUDATA SOFTWARE	urudata					
CYBERNET	CYBERNET					

TECNOLOGÍA INFORMÁTICA							
ARNALDO C. CASTRO S.A.							
TOP SYSTEMS S.A.							
S&D SYSTEMS AND DEVELOPMENTS (ex SAND)							
DATALOGIC SOFTWARE							
CCC DEL URUGUAY SA							
SCANNTECH							
MANENTIA SOFTWARE							
NODUM SOFTWARE							
TERA INGENIEROS							
NUMINA - INFORMATICA PERSONALIZADA S.A.							
MULTITECH							
HTS LTDA.							
I.C.A. (INGENIEROS CONSULTORES ASOCIADOS)							
CONCEPTO							
PUNTOEXE CONSULTORES							
I.G.C. (INGENIERÍA EN GESTIÓN DE COSTOS)							
IMS CONSULTORES SRL							
ADVANSYS							
HEXA SISTEMAS S.R.L.							
UNGOLAZO.COM							
TOOLS TECNOLOGÍA INFORMÁTICA SRL							

COMPU SEGURIDAD						
MVD TECHNOLOGIES LTDA. (INGENIO/LATU)						
SERIEMA SYSTEMS (INGENIO)						
INTERACTIVE NETWORKS INC.						
SIG S.R.L. /OPUS						
MACROSOFT						
QUARTZ LTDA.						
IMPORTSYS LTDA.						
ASSIST LEARNING TEAM						
KALYA SOLUCIONES INFORMÁTICAS						
K&S INFORMATION TECHNOLOGY						
THOT						
SOLUR						
AT&G INFORMÁTICA						
SOHO.COM.UY SRL						
ARTECH CONSULTORES S.R.L.						
KNOW HOW						
BUXIS						
WALICXE (INGENIO)						
SOLUZIONA S.A.						
INSIS LTDA.						
CSNET CONSULTORA SUDAMERICANA						
INSIGHT S.R.L.						
ZONAURUGUAY						
TRINTECH						

GENESYS						
DATAMATIC						
EVIMED (INGENIO/LATU)						
THE DIGITAL MAP (INGENIO/LATU)						
KERNEL						
ISA LTDA.						
BCD ASOCIADOS						
SOFTWORKS						
IDEASOFT URUGUAY SRL						
BIT SISTEMAS						
Geocom Uruguay S.A.						
LITHIUM SOFTWARE						
DATASEC SRL						
MEMORY COMPUTACIÓN						
GRUPO QUANAM						
SOFTPOINT						
SIMPLE URUGUAY						
CORPORACION COMBEX LTDA.						
INGHENIA						
BRESOL / WESTEC						
SISTEMAS INFORMÁTICOS S.R.L.						
NEW AGE DATA [CGP]						
SISTEMAS CRITICOS S.A.						
MARKEL INGENIEROS						
UNIVERSAL						

INTERGROUP CONSULTORES						
RV & Asociados SRL						
BHV INFORMÁTICA (INGENIO/LATU)						
INFOCORP						
ZEN SISTEMAS						
MULTIMEDIA S.A.						
TATA CONSULTANCY SERVICES (TCS)						
LOWEND LTDA.						
APRAFUL SOFTWARE SRL.						
EXCEL						
SOFTRON						
ENRIQUE CAPPETTA						
R & B INFORMATICA						
CYC ASOCIADOS S.R.L.						
TODOSOFT URUGUAY - Martínez y Martínez Asoc.						
NORTH DATA						
DATASUR INFORMÁTICA S.R.L.						
PARADIGMA						
UNIVERSIDAD DE LA REPUBLICA						
UNIVERSIDAD CATÓLICA DEL URUGUAY						
UNIVERSIDAD ORT URUGUAY						
IBM DEL URUGUAY S.A.						
MICROSOFT URUGUAY						
ORCALE URUGUAY						
CUTI						
Integro IT group						

CES						
LATU/Ingenio						

Source: Author.

Appendix C:
Summary of Interviews

	Organisation	Name	Position	Date
1	LATU (The Uruguayan Technology Laboratory)	Eng. Miguel Brecher	President	12/12/05
2	CES (Centre for Software Testing)	Eng. Ana Asuaga	Director	10/12/05
3	Faculty of Engineering; Computer Institute; Universidad de la Republica	Eng. Maria E. Urquhart	Lecturer	11/12/05
4	Tata	Mario Tucci Meise	VP Iberoamerica	13/12/04
5	Buxis	Alvaro Vigliola	Corporate Director	01/12/04
6	HTS	Eng. Justo Miranda	Director	05/11/04
7	Thot	Eng. Gabriel Lombide	Director	22/11/04
8	Datasur	Nestor Pedemonti	Director	17/12/04
9	Insight	Roberto Talento	Director	8/12/04
10	deLarrobla	Marcelo Kosec	Marketing Manager	18/10/04
11	Solur	Gustavo de León	Director	23/11/04
12	Pranasys	Eng. Rafael Garcia Moreira	Director	18/10/04
13	Geocom	Eng. Ricardo Antúnez	Consultant	08/11/04
14	Objetos	Daniel Perez	Director	24/11/04
15	Quanam	Eng. M.Sc. MBA Graciela Pérez	Operation Manager	03/11/04
16	Magma tools	Eng. Javier Beathyate	Partner/Systems Engineer	20/10/04
17	Nodum	Eng. José María Vasquez	Director	02/11/04
18	AT&G	Jorge Abin	Director	23/11/04
19	Datasec	Eng. Reynaldo C. de la Fuente	Director	22/10/04
20	Scanntech	Econ. Benmy Szylkowski	Director	01/11/04
21	Concepto	Eng. Gustavo Ulivi	Director	09/11/04
22	Tilsor	Dr. Jorge Vidart	President	21/10/04
23	I.G.C.	Econ. Ricardo Laporta Pomi	Director	29/10/04
24	Microsoft Uruguay S.A. Mercosur Business Center	Wilson Pais	ISN Manager (Independent Software Vendor)	11/11/04
25	Akros	Alvaro Larrosa	Director	20/10/04
26	Urudata	Eng. Noela Próspero	Operations Manager	20/10/04
27	Cybernet	Eng. Jorge Moleri	Director	21/10/04
28	Arnaldo Castro	Eng. Ernesto Bianchi	Manager of Business Solutions	25/10/04
29	Top Systems	Alvaro Dominguez	Director	26/10/04
30	ex-Sand, S&D Systems & Development	Lic. Jaime Mesa	Operations Manager	27/10/04
31	Datalogic	Eng. Gustavo Charbonnier	Director	29/10/04
32	CCC	Eng. Fernando Brum	Business Development Manager	29/10/04
33	Manentia	Eng. Claudia Fernández	Director/System Analyst	02/11/04
34	TERA Ingenieros	Eng. Juan Paullier	Electrical Engineer	03/11/04
35	Numina	Eng. Carlos A. Trigo	Director/Partner	04/11/04
36	Multitech	Eng. Gustavo D'Oliveira	Director	05/11/04
37	ICA	Eng. Leonardo Loureiro	Commercial Department	09/11/04
38	PuntoExe	Juan Bustanmante	Director	04/11/04
39	IMS	Ramiro Grangel	Director	04/11/04
40	Advancys	Hugo Chiquiar	Director	10/11/04
41	HEXA	Eng. Diego Lorenzo	Director	10/11/04
42	Ungolazo	Angel Bautista	Executive director	15/11/04
43	Tools	Carlos Caetano	Director	16/11/04

44	Compuseguridad	Franklin Rivero	Software Development and Support Services	17/11/04
45	MVD	Eng. Daniel Srulevich	Director	18/11/04
46	SERIEMA	Fernando Ipar	Director	18/11/04
47	Interactive Network	Pablo Salomon	Director	18/11/04
48	SIG/OPUS	Eng. F Martinez	Director	10/11/04
49	Macrosoft	Fernando Rey	Director	19/11/04
50	Quartz	Daniel Abyon	Director	11/11/04
51	Importsys	Fernando Lopez	Director	15/11/04
52	Assist	Julio Cantera	Director	17/11/04
53	Kalya	Jorge Duclosson	Director	18/11/04
54	k&s	Ernesto Rovan	Director	16/11/04
55	SOHO	Luis Dominguez	Director	07/12/04
56	Artech	Eng. Nicolas Jodal	Vice-president	06/12/04
57	Know how	Eng. Martin Vazquez	Director	02/12/04
58	WalicXe	Bruno Buzzi Brasesco	Director	01/12/04
59	Soluziona	Gustavo Romay	Regional Manager	30/11/04
60	Insis	Guzman Etchebehere	Director	30/11/04
61	Sudamericana	Matias Perdomo	Director	30/11/04
62	ZonaUruguay	Ernesto Aramburo	Partner	06/12/04
63	ZonaUruguay	Leonardo Rodriguez	Partner	06/12/04
64	Ex-Sursoft, Trintech	Mauricio Bonifacino	CMS Development Manager	02/12/04
65	Ex-Sursoft, Trintech	Rafael Cuenca	CMS Development Manager	02/12/04
66	Genesys	Manuel Eirea	Director	14/12/04
67	X-Data	Yamandu De Leon	Director	30/11/04
68	Evimed	Eng. Antonio Lopez	Director	29/11/04
69	The Digital map	Eng. Carlos Lopez	Director	29/11/04
70	Kernel	Edgardo Pannunzio Miranda	Director	29/11/04
71	ISA	Gerardo Queirolo	Director	23/11/04
72	BCD	Carlos Larrosa	Director	23/11/04
73	Softworks	Eng. Claudia Quintero	Director	19/11/04
74	Ideasoft	Enrique Tucci	Executive director	15/11/04
75	BIT sistemas	Pablo Barros	Software Development Department	10/11/04
76	BIT sistemas	Diego Cukerman	Software Development Department	10/11/04
77	Lithium	Eng.Juan José Moreno	Information Technology Manager	16/11/04
78	Memory Computacion	Andres Topolansky	Manager of software production	28/10/04
79	Memory Computacion	Fernando Machado	Software architech	28/10/04
80	Softpoint	Eng. Pablo Oliva	Technology Manager	11/11/04
81	Simple	Marcelo Guelfi	Director/Technology Consultant	12/11/04
82	Combex	Ec. Ariel Scarone	Partner	22/11/04
83	Combex	Eng. Silvio Barbato	Partner	22/11/04
84	Inghenia	Eng. Felipe Arocena	Director	22/11/04
85	Bresol / Westec	Antonio J. Lacarte	Director	26/11/04
86	Sistemas Informaticos	Eduardo Ruiz de Olano	Director	24/11/04
87	New AGE Data	Nicola Pippolo	Director	26/11/04
88	Sistemas Criticos	Samigo Nunet	Director	13/12/04
89	Markel Ingenieros	Eng. Marcel Keschner	Director	10/12/04
90	Universal	Eng. Susana Caffarini	Manager	10/12/04
91	Intergroup	Ney Benavides	Director	03/12/04
92	R&V asociados	Alvaro Ros	Partner	07/12/04

93	BHV	Aldo Villegre	Director	07/12/04
94	Infocorp	Daniel Gómez	Partner	08/12/04
95	Infocorp	Felipe Gil	Partner	08/12/04
96	ZenSistemas	Diego Aluarez	Director	10/12/04
97	Multimedia-Negoxia	Oscar Costa de Grossi	Director	13/12/04
98	Lowend	Nelson Rodríguez	Director	16/12/04
99	Apraful	José Mareque	Director	14/12/04
100	Contawin/Excel Wais	Sergio Podesta	Director	14/12/04
101	Softron	Ricardso Augustyniak	Manager	15/12/04
102	Enrique Cappetta	Enrique Cappetta	Director	15/12/04
103	R&B Informatica	Miguel Rivero Daz	Director	15/12/04
104	CyC Asociados	Alberto Curbelo	Partner	15/12/04
105	Todosoft	Horacio Martinez	Director	16/12/04
106	North Data	Pablo Zas	Systems Manager	17/12/04
107	Paradigma	Héctor Gabriel Cor	Consultant	20/12/04

Source: Author.

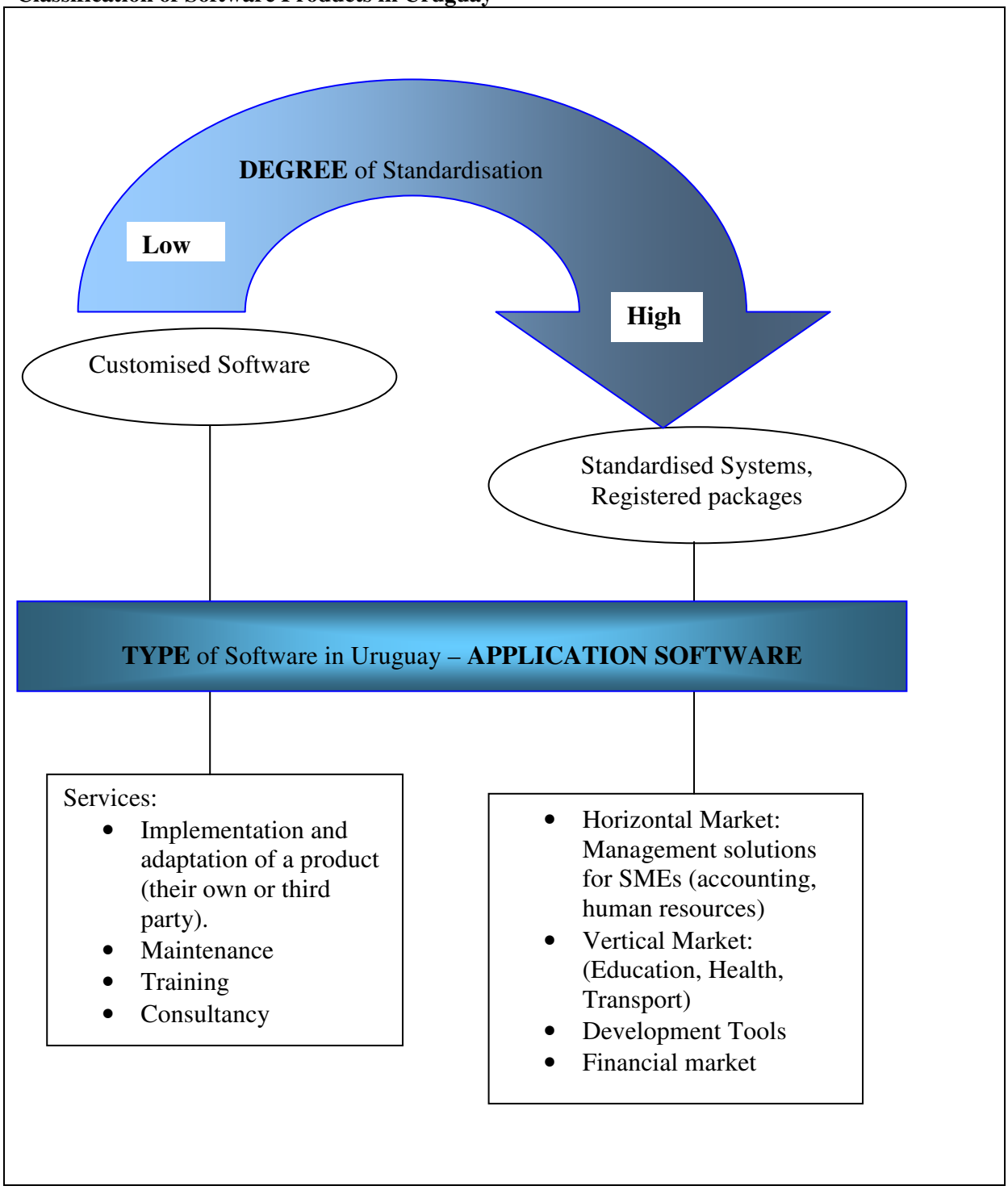
Appendix D:
Presentation of the Variables

Variables	Variable Name	Definition/Measurement
Dependent Variables		
Innovative Performance		
Product/Service - New to the Market	NEW_PS	Binary variable, which takes the value of =1 if the firm has introduced a new product/service (P/S) innovation to the market during the period 1999-2004, and =0 in other case.
Product/Service - Changed Substantially	CHANGE_PS	Binary variable which takes the value =1, if the firm has changed a (P/S) in a radical manner during the period 1999-2004, and =0, otherwise.
Sales of Innovation Output	SALES_INNOV	Censored variable because its lower limit equals zero. Indicates the percentage of sales that derived from (P/S) innovations in 2004.
Number of Innovations	NO_INNOV	This is a continuous variable that considers the quantity of (P/S) innovation that each firm has produced.
Quality of Product and/or Services	QUAL_PS	This is a dummy variable which takes the value of =1 if the firm has a quality certification, and =0 otherwise.
Economic Performance		
Sales	SALES	This is a continuous variable, which denotes the sales of software (P/S) of firms in US dollars in 2004.
Growth of Sales	SALES_GR	This variable denotes the growth of the sales of software (P/S) during the period 1999-2004.
Sales per Employee	SALES_EMPL	This variable measures the sales of the firm as a percentage of the number of its employees.
Exports	EXPORTS	This is a continuous variable, which denotes the exports of software (P/S) of each firm in US dollars in 2004.
Growth of Exports	EXPORTS_GR	This variable denotes the growth of the exports of software (P/S) of each firm during the period 1999-2004.
Share of sales to exports	EXPORTS_INTENS	This variable indicates the percentage of sales directed to foreign markets in 2004.
Growth of employment	EMPL_GR	This variable takes into account the growth of the employment of each firm during the period 1999-2004.
Independent Variables		
External Learning		
Local Knowledge Spillovers through Spin-off	LKS_S	This is a dummy variable that takes the value of =1 if a firm is a spin-off of a university/MNC that is located within the cluster and, = 0 in other case.
Local Knowledge Spillovers through Labour Mobility	LKS_L	This variable denotes the percentage of employees (inflow) in a firm that came from within the cluster during the last five years (1999-2004).
Local Knowledge Spillovers through Interaction – Importance	LKS_I	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from the non-pecuniary interaction of local actors.

Local Knowledge Spillovers through Interaction - Existence	LKS_I2	This is a constructed variable that indicates the existence of intra-cluster flow of knowledge that arises from the non-pecuniary interaction of local actors.
Local Knowledge Transactions - Importance	LKT	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from local transactions.
Local Knowledge Transactions - Existence	LKT2	This is a constructed variable that indicates the existence of intra-cluster flow of knowledge that arises from transactions.
International Knowledge Spillovers through - Importance	IKS	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from the non-pecuniary interaction among local and international actors.
International Knowledge Spillovers - Existence	IKS2	This is a constructed variable that indicates the existence of extra-cluster flow of knowledge that arises from the non-pecuniary interaction among local and international actors.
International Knowledge Transactions - Importance	IKT	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from transactions.
International Knowledge Transactions - Existence	IKT2	This is a constructed variable that indicates the existence of extra-cluster flow of knowledge that arises from transactions.
Internal Learning		
Research and Development Man-years	R&D_MY	R&D effort measured in man-years. It measures the cumulative R&D effort of the firm during the period 1999-2004.
Research and Development Intensity	R&D_INTENS	This variable denotes the percentage of firm's labour force that carried out R&D in 2004.
Education Index	EDU	Indicates the level of education of the employees of each firm.
Variation of Education	EDU_VAR	Ordinal variable that denotes the variation of the education levels of the employees of each firm
Postgraduate education	EDU_DUM	This is a dummy variable which takes the value of =1 if a firm has employees with MSc or PhD degrees, and =0 in other case.
Foreign Education	EDU_F	This variable denotes the percentage of the employees that have acquired a university degree abroad.
Years of Experience Index	EXPER_Y	Indicates the average years of experience in the software sector of the employees of each firm.
Variation of Experience	EXPER_VAR_Y	Ordinal variable that denotes the variation of the experience of the employees within a firm.
Experience in Firms Index	EXPER_FIRMS	Indicates the average No. of occupations that the employees of a firm have worked in the past.
Variation of Experience in No. Firms	EXPER_VAR_F	Ordinal variable which denotes the variation of the experience in No. firms of the employees within a firm.
Age	AGE	Firm's age (reference year 2004).

Control Variables Size	SIZE	Size of the firm measured by number of employees at year 2004.

Appendix E:
Classification of Software Products in Uruguay



Source: Adapted from Bitzer (1997)

Appendix F:
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
NEW_PS	97	0	1	0.52	0.502
CHANGE_PS	97	0	1	0.70	0.460
SALES_INNOV	98	0	1	0.445	0.3692
NO_INNOV	97	0	15	4	2.901
QUAL_PS	97	0	1	0.38	0.488
SALES	79	1900	70000000	2306891.35	8639197.207
SALES_GR	77	-48.143	125.000	9.291	29.035
SALES_EMPL	79	380	3043478	78436.91	344934.887
EXPORTS	76	0	30000000	1037733.03	3883531.318
EXPORTS_GR	76	-100	532	37.09	96.681
EXPORTS_INTENS	97	0	1	0.27	0.355
EMPL_GR	98	-23.660	200	12.741	31.536
LKS_S	98	0	1	0.48	0.502
LKS_L	97	0	1.3	0.350	0.3147
LKS_I	97	0	16	6.09	3.903
LKS_I2	97	0	5	1.93	1.139
LKT	97	0	22	9.10	4.513
LKT2	97	0	7	2.67	1.344
IKS	97	0	16	5.94	3.794
IKS2	97	0	4	1.66	1.117
IKT	97	0	18	5.40	4.363
IKT2	97	0	5	1.49	1.217
RD_MY	97	0	59	10.42	10.246
RD_INTENS	97	0	2.5	0.364	0.3628
EDU	98	3	7	4.75	0.589
EDU_VAR	98	1	4	1.76	0.747
EDU_DUM	98	0	1	0.27	0.444
EDU_F	98	0	1	0.077	0.161
EXPER_Y	98	1	22	5.23	2.396
EXPER_VAR_Y	98	1	5	2.20	1.148
EXPER_FIRMS	98	0	6	1.693	1.282
EXPER_VAR_F	98	1	5	2.11	0.836
AGE	98	1	67	12.47	9.373
SIZE	98	1	260	24.05	40.050

Appendix G:
Eigenvalues of Innovation Variables

Component	Eigenvalues		
	Total	% of Variance	Cumulative %
1	1.696	33.926	33.926
2	**1.297**	**25.934**	**59.860**
3	0.985	19.704	79.564
4	0.717	14.333	93.897
5	0.305	6.103	100.000

Appendix H:
Eigenvalues of Economic Performance Variables

Component	Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.583	36.894	36.894
2	1.858	26.539	63.433
3	**1.028**	**14.688**	**78.121**
4	0.912	13.034	91.155
5	0.393	5.617	96.772
6	0.212	3.032	99.804
7	0.014	0.196	100.000

Appendix J:
Correlation of the main Variables

	MARK_INN	L_PERFORM	EC. GROWTH	EXP_INTENS	LKS_S+	LKS_L	LKS_I	LKT	IKS	IKT	LKT2	LKS_I2	IKT2	IKS2	RD_MY	RD_INTENS	EDU_VAR+	EDU	EDU_DUM+	EDU_F	EXPER_Y	EXPER_VAR_Y+	EXPER_VAR_F+	EXPER_FIRMS	AGE	SIZE
TECH_INN	.000	-.024	.084	.278 (*)	.179	.311 (**)	.217 (*)	.037	.168	.202 (*)	.065	.187	.180	.162	.116	-.104	.070	-.013	.030	-.100	.228 (*)	-.278 (**)	.150	-.002	-.188	.033
	1.000	.847	.500	.023	.079	.002	.033	.716	.101	.047	.528	.067	.077	.114	.257	.310	.494	.897	.770	.329	.024	.006	.142	.983	.066	.749
MARK_INN	1	.203	.008	.125	.192	.091	.092	.223 (*)	.155	.397 (**)	.245 (*)	.109	.395 (**)	.215 (*)	.396 (**)	.028	.310 (**)	.093	.391 (**)	-.107	.237 (*)	.220 (*)	.277 (**)	-.278 (**)	.310 (**)	.282 (**)
		.099	.946	.312	.060	.375	.371	.028	.130	.000	.015	.290	.000	.034	.000	.785	.002	.363	.000	.297	.019	.031	.006	.006	.002	.005
L_PERFORM		1	.008	-.017	.091	-.084	-.009	.171	.029	.168	.110	.000	.137	.061	.198	.244 (*)	.243 (*)	.057	.291 (*)	-.032	.231	.001	-.018	-.195	.086	.223
			.949	.893	.463	.501	.940	.166	.816	.173	.374	.999	.267	.624	.109	.047	.047	.649	.017	.797	.060	.996	.887	.113	.489	.070
EC_GROWTH			1	-.020	-.002	.358 (**)	-.100	.071	-.033	.110	.063	-.040	.042	-.072	-.018	-.144	.049	-.214	-.062	-.173	.357 (**)	-.201	.089	.067	-.280 (*)	.112
				.870	.989	.003	.423	.566	.793	.374	.612	.750	.738	.563	.887	.246	.697	.082	.620	.162	.003	.103	.474	.589	.022	.368
EXP_INTENS				1	-.108	.318 (**)	-.124	-.234	.146	.422 (**)	-.179	-.161	.376 (**)	.125	.282 (*)	-.144	-.012	.089	.114	.021	.235	-.099	.201	-.079	.092	.631 (**)
					.385	.009	.319	.057	.238	.000	.147	.193	.002	.313	.021	.244	.926	.472	.360	.863	.056	.423	.103	.523	.458	.000
LKS_S					1	.075	.195	.180	-.001	-.071	.224 (*)	.207 (*)	-.073	.056	.032	-.106	.096	-.022	-.022	.093	.061	-.096	.288 (**)	-.038	-.324 (**)	-.031
						.463	.056	.078	.996	.491	.028	.041	.480	.589	.759	.300	.345	.828	.832	.364	.551	.346	.004	.711	.001	.758
LKS_L						1	-.117	-.107	.159	.340 (**)	-.040	-.055	.309 (**)	.190	.208 (*)	-.074	.053	-.109	.014	-.144	.294 (**)	-.231 (*)	.220 (*)	-.137	-.047	.125
							.253	.297	.120	.001	.696	.596	.002	.063	.040	.471	.601	.287	.891	.158	.003	.022	.029	.180	.648	.220
LKS_I							1	.198	.056	-.153	.161	.944 (**)	-.174	.019	-.217 (*)	-.004	.172	.067	.153	-.021	.033	.122	.112	.014	.098	-.020
								.052	.586	.134	.116	.000	.088	.851	.033	.966	.092	.511	.134	.840	.751	.236	.275	.893	.341	.845
LKT								1	-.189	.056	.935 (**)	.172	.038	-.131	.168	.015	.023	.083	.012	-.139	-.061	.055	.010	.069	-.001	-.068
									.063	.585	.000	.093	.712	.199	.100	.882	.825	.421	.907	.175	.555	.590	.919	.500	.994	.510
IKS									1	.230 (*)	-.165	.004	.259 (*)	.951 (**)	-.057	-.164	.256 (*)	-.034	.238 (*)	.200 (*)	.130	.170	.227 (*)	-.101	.220 (*)	.140

										.023	.105	.971	.010	.000	.581	.109	.011	.741	.019	.049	.205	.095	.026	.327	.031	.173
IKT										1	.092	-.162	.964 (**)	.236 (*)	.397 (**)	.002	.250 (*)	.100	.266 (**)	-.032	.186	.018	.170	-.270 (**)	.138	.359 (**)
											.369	.113	.000	.020	.000	.982	.013	.332	.009	.752	.068	.865	.096	.007	.179	.000
LKT2											1	.154	.120	-.096	.199	-.064	-.016	.085	-.025	-.122	-.095	.075	.074	.099	-.025	-.051
												.131	.242	.348	.050	.531	.873	.408	.810	.234	.355	.464	.471	.337	.811	.621
LKS_I2												1	-.162	-.003	-.222 (*)	.024	.151	-.011	.100	-.077	.052	.154	.152	.020	.125	-.037
													.113	.976	.029	.812	.139	.919	.329	.451	.613	.132	.136	.846	.223	.721
IKT2													1	.271 (**)	.415 (**)	-.024	.245 (*)	.067	.233 (*)	-.006	.139	.037	.196	-.252 (*)	.145	.316 (**)
														.007	.000	.813	.016	.517	.022	.953	.175	.715	.054	.013	.156	.002
IKS2														1	.011	-.163	.239 (*)	-.071	.227 (*)	.135	.156	.150	.247 (*)	-.151	.238 (*)	.164
															.915	.110	.018	.493	.025	.186	.128	.142	.015	.141	.019	.110
RD_ MY															1	-.020	.187	-.041	.183	-.023	.256 (*)	-.104	-.038	-.289 (**)	.054	.251 (*)
																.844	.066	.691	.074	.819	.011	.312	.710	.004	.602	.013
RD_ INTENS																1	-.015	-.021	-.025	-.146	.054	.038	-.126	.003	.123	-.219 (*)
																	.882	.836	.812	.153	.602	.711	.219	.976	.230	.032
EDU _VAR																	1	-.038	.696 (**)	-.089	.395 (**)	-.020	.259 (**)	-.325 (**)	.165	.364 (**)
																		.714	.000	.381	.000	.848	.010	.001	.104	.000
EDU																		1	.406 (**)	.201 (*)	-.015	.062	.032	.016	.019	.014
																			.000	.047	.880	.541	.751	.875	.856	.891
EDU_ DUM																			1	.055	.358 (**)	.074	.169	-.243 (*)	.198	.397 (**)
																				.591	.000	.469	.096	.016	.051	.000
EDU_F																				1	-.204 (*)	.052	-.014	.304 (**)	-.192	-.036
																					.044	.609	.893	.002	.058	.722

EXPER_ VAR _Y																					1	-.423 (**) .000	.363 (**) .000	-.244(*) .016	-.054 .597	.333 (**) .001
EXPER_ YEARS																						1	-.159 .117	.039 .704	.704 (**) .000	.030 .770
EXPER _VAR _F																							1	.038 .709	-.124 .224	.206 (*) .042
EXPER_FIRMS																								1	-.340 (**) .001	-.279 (**) .005
AGE																									1	.234 (*) .020

Note: Pearson Correlation. ***p<.01, **p<.05, *p<.10.
+Spearman correlations.
Source: Own computations based on author's survey.

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NOTES

Chapter 2

[1] Schumpeter was the first who recognised innovation as the driving force of economic development (Schumpeter, 1942).

[2] The most common case is the notion of a cluster as a sectoral concentration of SMEs that interact since they are connected through supplier-user relations. The other possibility is the presence of one large or a few large firms that, being self-sufficient, have few things to gain from co-location with other firms. What they are interested in is the presence of public institutions that provide adequate knowledge diffusion (Markusen, 1996).

[3] Clustering refers to firms that are located in close proximity. An important consideration that is relevant to LKS is that a cluster may be comprised of firms of the same industry or of firms of different industries. In the first case, knowledge spills over only between firms that belong to the same industry. The second case is about inter-industry knowledge spillovers. Much research has been done in trying to assess the significance of intra-industry KS versus inter-industry KS (Henderson, 1999).

[4] See for example Cooke, 2001; Morgan, 1997; Aydalot, 1986; Camagni, 1992; Porter, 1990; Storper & Scott, 1988; Saxenian, 1994; Piore & Sabel, 1984; Becattini, 1990; Schmitz, 1999.

[5] This refers to pure knowledge spillovers and does not include "Rent Spillovers". The latter, are considered of being cost advantages. For example, by using the latest technology of laser printer a user-firm may be benefited by its improved quality and speed and even have some gains [or 'rents'] if the supplier firm does not reflect the technology improvements on the price.

[6] The Third Italy comprises the regions of Veneto, Trentino, Friuli-Venezia, Giulia, Emilia-Romagna, Toscana, March and part of Lombardia.

[7] GREMI is a research group established in 1984 with the aim to examine the relationship of technology and space.

[8] This refers to the informal exchange of knowledge or *cafeteria effects.*

[9] The increase in the height of the furnace and the increase of the temperature of the blast were the two very important innovations that took place between 1850 and 1875 in the Cleveland district. These improvements took place in an incremental way, but their impact was significant. They reduced the fuel requirements and thus, production costs (Allen, 1983).

[10] They use three respective constructs for measuring knowledge spillovers: first, the transfer of technology through labour mobility is measured by the additional wages firms are willing to pay for workers moving from one firm to another, second, technological change through networking is measured by the difference in total factor productivity of the best-practice firm in an industry and the average, finally technology transfer due to firms' interaction could be indicated by a large degree of product change (as against process change) in the linked industries (Stewart and Ghani, 1991).

[11] Certainly this is an extreme view within the school of neo-classical economics. Advocates of the new growth theory argue that building of human capital is crucial for economic growth (Romer, 1986, 1990).

[12] Schmitz (1995) introduces two types of 'collective efficiency' advantages, namely 'passive collective efficiency' and 'active collective efficiency'. 'Passive collective efficiency' refers to spontaneous occurring externalities in clusters. He assumes that this type of 'collective efficiency' is not crucial for improving competitiveness of firms within clusters. On the other hand, 'active collective efficiency' refers to induced externalities as a result of local collaboration. According to Schmitz (1995) this type of collective efficiency is vital for improving the competitiveness of firms within clusters.

[13] At first, the literature of Global Value Chain was created in advanced countries in order to analyse new forms of international trade (Gereffi, 1999). Part of this literature has been applied to Developing countries and deals with the benefits (in terms of technological upgrading) enjoyed by firms with links to international actors (e.g. clients).
[14] Technological upgrading through exports gained support due to the successful example of the Asian Tigers. Learning from exporting and by meeting the needs of sophisticated customers reinforces the capabilities of firms in LDCs (Amsden, 1989, 2001).
[15]An external buyer and a local supplier do not collaborate closely. The relationship entails production activity of a standard product or custom-made product. This is a market-based relationship, in which process and product upgrading is usually slow.
[16] An external firm assumes ownership of a local firm.
[17] Network partners collaborate closely on equal terms. This relationship is created to fulfil usually the requirements for the production of more complex products. Thus partner firms attempt to complement each other and share different types of knowledge. Rarely do we see this case in LDCs because it requires a high level of complementary competences.
[18]An external buyer has the control over a local supplier regarding the product specifications and process of the production. Usually, large retailers or brand-name companies (e.g. in the garments and food industry) organise production systems that integrate producers in various countries but without themselves owning any manufacturing facilities. This type of relation may facilitate process and product upgrading of local firms but usually hinders functional upgrading.
[19] According to Humphrey and Schmitz (2002) functional upgrading represents the move towards more value added activities such as design and marketing.
[20] Knowledge system encompasses those flows of knowledge, stock of knowledge and organizational systems necessary in creating and managing changes in the products, process or organization of production (Bell and Albu, 1999).
[21] In the context of developed countries Audretsch and Feldman (1996) have underlined the importance of the life cycle of a cluster's product/technology.
[22] Universities in LDCs attempt to change the old conception of the university as the 'ivory tower'.
[23] In this study he introduced the notion of 'joint action'.
[24] For example, more emphasis is upon the role of export agents in assisting local firms with advice concerning quality standards and offering general technical assistance. Moreover the vertical disintegration of the production (backward linkages) found in the cluster is an indication of the presence of specialized suppliers that generate static advantages. The only indication of dynamic advantages was the presence of local institutions and especially that of the shoe fair organisation FENAC. The main contribution of the latter was the organisation of trade fairs.
[25] Export expansion.
[26] The first four studies are based on the industrial district approach (see Table 2.1). These studies address the reasons that underline the competitiveness of firms within clusters. The last study is based on the Regional Systems of Innovation approach (see Table 2.1) and its main objective is to understand the reasons that underline the innovativeness and competitiveness of firms within clusters.

Chapter 3

[27] The concept of absorptive capacity as defined by Cohen and Levinthan (1990) refers to the ability of a firm to identify new information outside the firm, acquire it and commercialise it.
[28] For instance, using data from CIS Cassiman and Veugelers (2002) measure knowledge spillovers as the sum of scores of importance (Likert scale 1= unimportant 5=crucial) of the following sources for innovation process: (1) Patent information, (2) Specialised conferences, meetings and publications, (3) Trade shows and seminars.
[29] Marsili (2001) classifies sectors with regard to their knowledge base using as an indicator the skills of the personnel. Those are derived from the US sectoral employment patterns in 1992. However, personnel skills differ greatly between developed and developing countries and this is the main problem in using such a classification.

[30] Services are half of the total value added in the European Union and more than one third of the total value added in developing countries (the added value of services in less developed countries is 1.798.723.959.000 billions while the added value of industry is 1.548.982.491.800 billion) (World Development Indicators, 2002).

[31] A similar categorisation is followed by OECD (1994). However, relying only on a single criterion (R&D) a partial perspective of innovation is adopted. On the other hand, UNCTAD's (1996) categorisation is based on multiple criteria taking into account labour intensity, capital intensity etc.:

1. Labour/resource intensive,
2. Low-skill/low-tech/low capital intensive,
3. Medium-skill/medium-tech/medium-capital intensive, and
4. High-skill/high-tech/high-capital intensive sectors

[32] Corporate R&D plays an important role for firms' innovation (Pietrobelli and Rabellotti, 2004).

[33] These are the firms without considering single-person companies (1600), Hardware and sales (371) and Internet and data transmission firms (96).

[34] Sales per employee.

[35] First, through telephone correspondents the organisations were informed about the survey and invited to participate. Second, for those organisations that were willing to participate another appointment was arranged, in which they were presented with a list of the survey participants.

[36] Appendix D presents a list with all the variables.

[37] Innovation is defined as a product and/or service new to the market and/or new in the firm.

[38] Idem.

[39] A formal relationship may result in informal exchange of knowledge. However, this is out of the scope of this research, which adopts the criterion of no compensation (pecuniary) to define spillovers.

[40] Zucker, Darby and Brewer (1998) have used spin-off firm formation to capture knowledge spillovers.

[41] Research on knowledge spillovers is divided on the issue as to whether labour mobility gives rise to local knowledge spillovers. Almeida and Kogut (1999), Saxenian (1994) and, Audretsch and Feldman (1996B) conceptualise labour mobility as a channel of knowledge spillovers, while others (Breschi and Lissoni, 2001) argue that the circulation of knowledge through labour mobility is not a pure knowledge spillover since a fee (in the form of a salary) is paid to the employee. I adopt the first position and I explain the theoretical but also empirical reasons that underline my point of view in Chapter 6.

[42] Where im = 1 when person has changed status from preceding years, 0 when not, N = number of persons i.e. stock in year t (Virtaharju and Åkerblom, 2003).

[43] The innovation survey that has been conducted in the software cluster in Montevideo explicitly asks information regarding the presence of national linkages. However, due to demographic reasons most of the economic activity, especially services and manufacturing, is concentrated in Montevideo. Thus, the national dimension regarding non-local knowledge flows was not particularly significant.

[44] For example, if the firm has carried out 3 projects for the development of a new product and/or service during the last 5 years and devoted for each one: 6 engineers were working 20 hours per week, during 12 months. Then, the overall value of R&D_MY of this firm is: (6 * 20/40) * (12/12) * 3 = 9 man-years.

[45] The educational index is constructed based on the characteristics of the educational system of Latin America and of the software sector. In particular, all employees in the software cluster of Montevideo have accomplished secondary education. Vocational or technical training has a duration of three years. This is the reason for assigning the weight of three to the percentage of employees with vocational training. University education in Latin America provides the graduates a degree, the so-called 'Licenciatura' after the accomplishment of five-year studies. A master degree takes an additional 2 years and a PhD degree is awarded after and additional 4 years on top of the MSc.

[46] The weight given to the employees with more than four years of experience depends on the age of the firm. If for example a firm functions for 25 years and 10 percent of its employees have more than four years of experience then we will consider the one third of the age of the firm as the weight to be given. For this case it will be 0.1*8=0.8.

[47] The same methodology as for the construction of EDU_VAR is used for the construction of the EXPER_VAR_Y variable.
[48] The same methodology as for the construction of EDU_VAR is used for the construction of EXPER_VAR_Y variable.

Chapter 4

[49] It consists of the following sub-categories: 721-hardware consultancy, 722-software consultancy and supply, 723-data processing, 724-database activities, 725-maintenance and repair of office, accounting and computing machinery, 729-other computer-related activities.
[50] International Standard Industrial Classification of all Economic Activities revision three.
[51] During the same period, population has grown at a rate of 0.5 per cent p.a. Thus, the growth of GDP per capita of the period 1980-2004 is 0.65 per cent p.a. (own calculation based on data from World Bank and National Institute of Statistics of Uruguay).
[52] Argentina and Brazil count for approximately 70 per cent of Uruguayan trade of goods and services (Licardo, 2001).
[53] Data on sales of software products and services exist for a numbers of countries, especially for the most important players in the international market of software such as United States, Western European countries, Japan, Israel, India, Brazil, Argentina, China etc. However, even these data are not entirely objective since they are gathered by business institutions and societies that use different methodologies. The lack of government statistics on the sector makes it difficult to evaluate the industry in each country and compare it with other countries.
[54] Campbell-Kelly (2003) reports that the price of a custom-made software item would be 1 million U.S.$ whereas the price of a corporate software product would range between 5,000-100,000US$. Finally, the price of software for PCs was approximately 100 or 500 U.S.$.
[55] Adult illiteracy rate is the percentage of people aged 15 and above who cannot read and write. In 1990 3% of the Uruguayan population could not read and write. This was the lowest rate among the Latin American countries, followed by Argentina 4%, Cuba 5%, and Chile 6%. A decade later, Uruguay still holds the lowest illiteracy level in Latin America with 2%; followed by Argentina and Cuba with 3%, and Chile with 4% (World Development Indicators, 2002).
[56] Sources: Universidad de la República, the ORT University and the Catholic University (author) Instituto Universitario Autónomo del Sur and the Taller de Informática. (Mejía and Rieiro, 2002).
[57] Income tax does not exist in Uruguay. The Tax on the Revenues of Industry and Commerce (IRIC) is 35 % of the revenues of industrial, commercial and similar nature activities realized by companies.
[58] The value-added tax is a 23 % levy on the value of the product.
[59] LATU stands for the Technological Laboratory of Uruguay (Laboratorio Tecnológico del Uruguay). LATU is a State Enterprise of private right. LATU is a technology transfer institute with the following activities: testing of applied technologies in pilot plants; technology support and information; quality control and certification of ISO 17025, ISO 9001:2000, ISO/DIS 9001:2000; expositions; incubation of enterprises, the so-called Ingenio (author's interview with the President of LATU).
[60] Author's interview with Miguel Brecher, President of LATU. Montevideo, 12 December 2005.
[61] The countries that were visited by various delegations of Uruguayan software firms were: Spain, Chile, México, Puerto Rico, Central America, Ecuador, Paraguay, Bolivia, Argentina and Brazil.
[62] Interview with Enrique Tucci, President of CUTI (EL PAIS Digital; 23 June 2003)
[63] The state-of-the-art infrastructure that is offered by Zonamérica includes: Fibre optic connection with key business capitals in the region; exclusive teleport for satellite communication; advanced microwave links (LMDS); Internet access (OC-3); Gigabit Ethernet backbone over a fibre optic network; telephone switchboard with own central office code; on-site help desk of experienced technical specialists; a Network Operation Centre (NOC) with dedicated technical team that conducts 24 x 7 systems monitoring and offers services of Hosting, co-location, and mail (Zonamérica, 2006).
[64] Author's interview with Mario Tucci Meise Vice-President of TCS-Iberoamerica in Zonamérica, Montevideo December 2004.
[65] Ibidem.

[66] Confidential interview conducted by the author, Montevideo, December, 2004.
[67] During the 1960s, the causes of inflation were among the main debatable topics among monetarists and structuralists. In particular, the monetarists argued that inflation is a monetary phenomenon which is caused by the expansion of money supply, which in turn is the result of ineffective control over the monetary system (Fischer, Sahay and Vegh, 2002). In contrast, the structuralists argued that the main cause of inflation stems from changes in the composition of demand which causes price increases, especially because of the inelastic supply functions (Davis, 1966). In addition, the structuralists stressed the external causes of inflation and in particular the fluctuation of the terms of trade (Maynard, 1961). Even though cross-section analysis supported the proposition of monetarists, Sheehey (1976) repeated the exercise in examining the factors that cause inflation and used monetary variables such as money supply and structural variables such as wages and exchange rates and found that the structural variables explain a greater variation of the dependent variable, namely inflation. However, the structuralist argument does not explain why Asian Countries – such as India – exposed to the same adverse global conditions as the Latin American countries did not presented an accelerated inflation.
[68] Exports from Latin American countries were hampered by overvalued exchange rates. In addition, many barriers were imposed on imports. As a result, Latin American countries were only connected to the international economy through financial flows.
[69] In 2003
[70] In 2003
[71] For example, software tools that aim to generate code have increased the productivity of many firms that are focused on application software.
[72] In Ireland the emergence of the software industry was based on MNCs.
[73] China still is governed by an authoritarian regime. It is not surprisingly then, that the government strongly supported an upcoming high-tech sector such as the software. The case of Israel was rather different. The software sector has emerged out of an ambitious scientific military research program and then was strengthened with the provision of research grants. In Brazil, the government has granted funds to almost all the software firms and procured the majority of the public sector projects to local firms.
[74] Ireland encouraged the entry of MNCs by providing financial and tax incentives. In addition, the Irish government restructured the education system in order to support the needs of the software industry. India followed a similar policy of education restructuring and tax incentives to local and foreign firms. Finally, Mexico's trade agreement with the North American neighbours (NAFTA) gave the green light for entry of MNCs.
[75] See section 4.4.
[76] Ireland (National Software Directorate, 2006; www.nsd.ie).
[77] The military regime during the 1970s gave tax incentives for the development of the hardware industry. During the 1980s, the so-called 'market reserve' IT policy took a number of protectionist measures for the local hardware industry. During the 1990s protectionism was relaxed and the new Informatics Law in 1991 provided tax incentives to local manufacturers under the condition of investing the 5 percent of their revenues in R&D activities (Behrens, 2005).
[78] The SOFTEX program was introduced in 1992. This is the main body for information about software development in Brazil. Its main initiative was the promotion of software firms as a whole and the upgrading of the business capabilities of these firms (Botelho et al. 2005).
[79] CAS stands for the Chinese Academy of Sciences.
[80] The Indian government introduced the Software Policy in 1986 which recognised the independent development of the software sector from the hardware sector. Since then, software exporters have been exempted from duties and restrictions on the imports of hardware. More importantly, in 1988, the Software Technology Parks were established, supporting small software exporters by providing tax-free exports to the export intensive firms. Finally, firms supported by the Software Technology Parks enjoyed a number of technical services and infrastructural advantages. (Athreye, 2005).
[81] Cross-section analysis has shown that a significant positive relationship exists between exports and growth (Balassa, 1985). Next the rapid growth of the four tiger countries (South Korea, Taiwan, Singapore, and Hong-Kong) was attributed to the outward-orientation of the economies (World, Bank,

1993). However, the evidence is not conclusive since time series studies and country case studies do not support the long-term relationship between exports and economic growth (Al-Yousif, 1997; Amsden, 1989, 2001).

Chapter 5

[82] This is a partial model because it leaves out traditional inputs of the production function, such as capital accumulation. Lack of data on capital investments is the main reason for not considering capital in this model. However, taking into account that the great majority of investments in the software sector is in human capital, the exclusion of capital inputs does not generate fundamental problems.

[83] The question in the CIS3 regarding sources of information is formulated as followed: "Sources of information for innovation during the period 1998-2000: The main sources of information needed for suggesting new innovation projects or contributing to the implementation of existing projects are asked in this question. Please indicate the degree of importance attached to various alternative information sources (0 = not used, 1 = low importance, 2=medium importance, 3=high importance" (CIS3, 2004, p. 296).

[84] This is because the explanatory power of these variables could be higher if they were loaded to a single compound variable.

[85] Where im = 1 when person has changed status from preceding years, 0 when not, N = number of persons i.e. stock in year t (Virtaharju and Åkerblom, 2003)

[86] Variables such as LKT, R&D_MY, R&D_INTES, EDU_VAR, EDU, EDU_F, EXPER_VAR_F, Exper_F, and SIZE were not included to model B because of very low significant levels with the technological innovation variable. Moreover, EXPER_Y was correlated with the EXPER_VAR_Y. Hence, to avoid multicollinearity I have included only the variable with the strongest correlation with the technological innovation variable.

[87] First, the residuals are normally distributed with zero mean. This means that regression B meet the normality assumption of OLS method. Second, to test for the presence of homoscedasticity or constant variance of the residuals across the independent variables, I have examined the histogram and normal probability plot of the predicted values of the dependent variables against the residuals, which performed well.

[88] Before applying the multiple regression equation, all variables (response and predictors) are standardised by subtracting the mean and dividing by the standard deviation. The beta coefficients, then, represent the change in response for a change of one standard deviation of the predictor (Gujarati, 1988).

[89] For instance, this is a firm which consists of 5 per cent of employees who have previous experience in more than 6 firms, 15 per cent of the employees with experience in 5-6 firms, 25 per cent with experience in 3-4 firms, 35 per cent has experience in 1-2 firms and 20 per cent of the employees has no experience.

[90] For example, this is a firm which consists of 50 of employees with experience in 5-6 firms and the other 50 per cent of employees with no experience.

[91] According to the Capability literature (Lall, 1992) as well as the Absorptive Capacity literature (Cohen and Levinthal, 1990), the internal learning activities or resources of the firm may influence the ability of the firm to use external knowledge.

[92] This implies that parts of the variability of economic performance, innovative performance and external learning are jointly determined by the internal mechanisms of learning of the firm (its capabilities).

[93] The variable Economic Growth did not produce any significant relations with neither innovation nor external mechanisms of knowledge flow. Therefore, it is not used in the systems method of estimation. However, Table 5.11 shows that the bivariate correlation of EC_GROWTH with LKS_L is strong and positive. This suggests that firms with high labour inflow grow faster the rest of the firms. This is an indication of the importance of local knowledge spillovers for the economic growth of the software firms at the cluster of Montevideo.

[94] This refers to (RQ 3b) the direct impact of LKS upon economic performance; (RQ 3a) the indirect impact of LKS (through innovative performance) upon economic performance; and finally, (RQ 2) the impact of internal learning mechanisms or absorptive capacity upon the external (to the firm) mechanisms of knowledge flow.
[95] This does not constitute a formal statistical test.

Chapter 6

[96] Among others Saxenian (1996), Zucker et al. (1998) and Almeida and Kogut (1999) have identified these mechanisms as the three most important ways in which local knowledge spillovers take place; namely (1) informal and direct interaction of actors, (2) labour mobility, and (3) spin-offs.
[97] Non-intentional spillovers refer to spontaneous sharing of public knowledge (know-why such as scientific and partly technological knowledge) through informal interactions among actors.
[98] Intentional spillovers refer to prearranged meetings and congregations that lead to the sharing of private knowledge (know-how such as application knowledge).
[99] Confidential interview conducted by the author, Montevideo, November 2004.
[100] The question was the following: "Which of the following actors are sources of information/advice or assistance in your efforts of upgrading or innovation? Please score between – 0 (unimportant) to 4 (crucial) - among these sources of information for innovation".
[101] For instance, the decision of a firm to locate within a cluster and to take advantage of the knowledge 'in the air' (through imitation rather than contact with other firms) involves some degree of intentionality.
[102] Confidential interview conducted by the author, Montevideo, November 2004.
[103] Confidential interview conducted by the author, Montevideo, November 2004.
[104] Confidential interview conducted by the author, Montevideo, October 2004.
[105] Confidential interview conducted by the author, Montevideo, December 2004.
[106] CES is the Centre for Software Testing in Uruguay.
[107] Confidential interview conducted by the author, Montevideo, December 2004.
[108] Project: Technological Development in Key Sectors of the Uruguayan Economy.
[109] Development Program.
[110] Confidential interview conducted by the author, Montevideo, November 2004.
[111] Confidential interview conducted by the author, Montevideo, November 2004.
[112] Confidential interview conducted by the author, Montevideo, October 2004.
[113] Confidential interview conducted by the author, Montevideo, October 2004.
[114] Confidential interview conducted by the author, Montevideo, October 2004.
[115] Confidential interview conducted by the author, Montevideo, November 2004.
[116] Confidential interview conducted by the author, Montevideo, November 2004.
[117] Confidential interview conducted by the author, Montevideo, December 2004.
[118] Confidential interview conducted by the author, Montevideo, November 2004.
[119] Confidential interview conducted by the author, Montevideo, December 2004.
[120] Confidential interview conducted by the author, Montevideo, December 2004.
[121] Confidential interview conducted by the author, Montevideo, December 2004.
[122] Idem.
[123] Confidential interview conducted by the author, Montevideo, October 2004.
[124] Confidential interview conducted by the author, Montevideo, December 2004.
[125] Confidential interview conducted by the author, Montevideo, October 2004.
[126] Confidential interview conducted by the author, Montevideo, December 2004.
[127] Confidential interview conducted by the author, Montevideo, November 2004.
[128] Confidential interview conducted by the author, Montevideo, December 2004.
[129] Confidential interview conducted by the author, Montevideo, December 2004.
[130] However, one could argue that often MNCs licence a new technology to their spin-offs. If this happens, there is a contractual element that ties the mother company to the spin-off. This is not true in the case in the software sector, which is characterised by low propensity to patent compared to other

sectors (Chabchoub and Niosi, 2005). This means that on many occasions, software products are not protected by patents. Spin-offs may use insights from the technology of the mother company without necessarily being tied to a contract.

[131] LATU stands for Technological Laboratory of Uruguay (Laboratorio Tecnológico del Uruguay). LATU is a State Enterprise of private right. LATU is a technology transfer institute engaged in the following activities; testing of applied technologies in pilot plants; technology support and information; quality control and certification of ISO 17025, ISO 9001:2000, ISO/DIS 9001:2000; expositions; incubation of the enterprises, the so-called Ingenio (author's interview with the President of LATU).

[132] Confidential interview conducted by the author, Montevideo, October 2004.

[133] Firms were asked the following three questions:
(1) "Which of the following actors are sources of information/advice or assistance in your efforts of upgrading or innovation? Please score between – 0 (unimportant) to 4 (crucial) - among these sources of information for innovation".
(2) "Which of the aforementioned actors are located in Montevideo, Nationally or Internationally (specify)"?
(3) "Do you compensate pecuniary the aforementioned sources of information? Which of them are provided for free"?

Chapter 7

[134] The asymmetric matrix was also constructed. However, it does not differ much from the symmetric matrix. One explanation for this could be due to the formulation of the question which was "With whom of the following actors do you communicate in order to solve technical or functional problems"? Since it was not clear whether the actors give or receive knowledge, their answer stated only whether they have an interaction which led to knowledge sharing with the other actors.

[135] For instance, if firm A states that it interacts three times with firm B, while firm B replies that interacts with firm A four times, then I assign the score of 4 for the interaction between A and B. However, if firm A states that it interacts with support institute C three times, and support institute C states that it interacts with firm A four times, then I assign the score of 3 for the interaction between firm A and support institute C.

[136] Ucinet 6 for Windows software has been used (Borgatti, Everett and Freeman (2002).

[137] The distance between two actors A and B is called a path, when each actor and each tie is used only once for connecting A and B (Wasserman and Faust, 1994).

[138] An ego network consists of a focal actor –the ego- and includes 1) the nodes to which the ego is connected [directly], and 2) the [direct] contacts among all these actors to whom ego has a connection. In other words, the ego network consists of the 'friends' of the ego and the 'friends of the friends' of the ego.

[139] The ties (or connections) of an ego are called alters.

[140] To put it simply, if an actor (ego) is connected to 5 other actors, which are isolated from each other, then the effective size of the ego network, is 5. If, however, all the alters are connected to each other (that is, each alter is connected to 4 nodes), then the effective size of the ego-network is 5-4 =1.

[141] Certainly, in order to examine the macro characteristics of a network, the whole population should be investigated. In that respect, network research is different from other methodologies that are based on sampling techniques. This is a weakness of this data set (since not all of the population was willing to participate to the survey) and thus, we will avoid drawing strong conclusions. Despite these shortcomings, we will attempt to use the network analysis as a descriptive tool, which will provides us with insights into the function of the knowledge network of the software cluster in Uruguay.

[142] In a valued data set, the density is sum of the value of all ties divided by the maximum value of possible ties (Hanneman and Riddle, 2005).

[143] I have used N=2 in order to construct the analysis of cliques because of the [large] size of the network. The underlying rationale for this decision is the limited ability of all 107 actors to have a

direct connection between themselves (N=1). It seems sensible that the actors within a large network have indirect (N=2) linkages among themselves.

[144] However, one could argue that the high degree of overlap is due to the analysis of 2-Cliques. In order, then, to have a more objective view of the knowledge network of the software cluster in Uruguay, we carried out the analysis of cliques by considering N=1 and then N=3. First, 1-Clique analysis means that every member of the sub-group has a direct tie to every other member of the same sub-group. Second, 3-Clique analysis relaxes the definition of Cliques and allows sub-group membership even if actors are not directly connected but they are linked through a distance of 3 paths. The outcome of the first analysis, as expected, produces a large number of sub-groups (712) which consists on average of 6 actors. 70 per cent of the actors overlap approximately in only 5 cliques. On the other hand, the 3-Clique analysis produces one group which comprises all actors. This analysis suggests that all actors are connected to each other indirectly. At the same time, they belong to small groups of 6, which overlap with few other cliques (5).

[145] Spearman correlation was applied because most of the network indicators are not normally distributed.

[146] The only exception is the CLOSENESS indicator, which exhibits a positive but not significant correlation with EDU_VAR. Still, closeness is positively and significantly correlated with EDU_DUM.

SUMMARY

The importance of localised knowledge spillovers (LKS) for innovation has been stressed in theoretical and empirical works in advanced countries (Jaffe, 1989; Jaffe et al, 1993; Audretsch and Feldman, 1996), yet it has been neglected in research in developing countries. Hence, with this academic effort I intend to examine whether local knowledge spillovers increase the innovation of firms within clusters in less developed countries (LDCs). Moreover, while a considerable effort has been put by researchers in developed countries to examine the relation between knowledge spillovers and innovation, not much is known on knowledge spillovers per se. As Audretsch et al (2003, p.13) pointed out **'...**there is no understanding of the way in which spillovers occur and are realized at the geographic level'. Thus, in this thesis I will shed light on the concept of knowledge spillovers and comprehend how they place at the geographic level.

I expect that the main contribution of this study will be the verification or rejection of the relation of LKS and innovation in the context of a developing country. The implications of this test may be crucial for the economic development of poor countries. Modern economic theory emphasises that innovation and technological change boost economic growth, due to the fact that innovation creates conditions of increasing returns in production (Romer, 1986, 1990; Griliches, 1992). Such conditions accelerate economic growth over the long run. Local knowledge spillovers are one of the key mechanisms through which this occurs.

The examination of a number of methodologies that have been used by scholars in advanced countries to analyse local knowledge spillovers led me to the conclusion that these methodologies could not be replicated in the context of a developing country. Among others, the most important reasons for this are the following: First, the scarcity of data in developing countries regarding patents, R&D, and other indicators of innovative inputs and/or outputs meant that I could not follow the methodologies of Jaffe *et al* (1993). Second, the lack of innovation surveys in many developing countries did not allow me to follow the

methodologies that have been applied by a number of scholars (Cassiman and Veugelers, 2002; Mohnen and Hoareau, 2003) using the datasets of Community Innovation Survey (CIS). Third, innovation in developing countries is many times informal. Thus, indicators such as R&D would not be useful. Consequently, only through a firm level study such information could be captured. In view of these difficulties, I selected a specific case study to examine the aforementioned research problem: the software cluster of Montevideo, Uruguay. Two field studies were conducted. During the first research trip, I carried out an Innovation Survey through face-to-face interviews with the majority of the software firms. During the second field study, I focused more explicitly on local knowledge spillovers and I carried out a Survey which was based on the methodology of the social network analysis. The same sample as the one of the first survey was used again, in order the variables to be comparable. Finally, during both research trips, I conducted 107 interviews with the managers and/or engineers of the software firms, academics, politicians and other professional involved in the sector.

The results of the econometric, social network and qualitative analysis show that LKS do indeed occur, and matter for the firms' innovation performance. I have found evidence of the same three main mechanisms of LKS that have also been mentioned in earlier studies focusing on high tech locations in economically advanced countries: new firm creation, labour mobility, and informal interaction among firms and with other local actors. Furthermore, the econometric analysis suggests that all these mechanisms of knowledge spillovers have a significant impact on the innovative performance of the firms. Finally, we may conclude that local knowledge spillovers play quite a similar role in the context of developing countries compare to advanced countries. However, local knowledge spillovers are not a sufficient condition for economic growth in developing countries. Even though local knowledge spillovers affect positively the innovation of firms within the cluster, it is international knowledge transactions which allow firms in developing countries to achieve economic success. In addition to giving attention to local knowledge advantages, it is also essential to keep in mind that international linkages continue to play a major role for the economic performance of firms in developing countries. Countries which are well connected to the global economy may gain through the development of formal but also informal linkages.

ABOUT THE AUTHOR

Efthymia Kesidou was born in 1977 in Rhodes, Greece. She studied Economics (BA) at the University of Macedonia, in Thessaloniki, Greece. In 2001 she continued her studies by pursuing an MA in Development Economics in the University of East Anglia, School of Development Studies, United Kingdom. By September 2002 Effie received her MA, and on October of the same year she started her PhD in the 'Eindhoven Centre for Innovation Studies' (Ecis), at the department of Technology and Policy, Eindhoven University of Technology, the Netherlands. Her thesis addressed the issue of '*Local Knowledge Spillovers in High-Tech Clusters in Developing Countries*; by examining *the case of the Uruguayan Software Cluster'*. The purpose of her research was to verify whether local knowledge spillovers are important drivers for innovation in a developing country context. During her PhD, Effie obtained the NWO (Netherlands Organisation for Scientific Research) grant, which allowed her to carry out the second part of her fieldwork in Montevideo, Uruguay. As of January 2007, Effie is employed as a research associate at the 'Centre for Enterprise', Manchester Metropolitan University, Business School, UK.

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