Do local knowledge spillovers matter for development? : an empirical study of Uruguay's software cluster

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Do Local Knowledge Spillovers Matter for Development?

An Empirical Study of Uruguay's Software Cluster

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ABSTRACT

In economically advanced countries, local knowledge spillovers (LKS) among agglomerated firms are seen as major drivers of regional innovation and growth. In contrast, innovation research focusing on developing countries has emphasized the importance of international linkages, while LKS have remained unstudied. This paper assesses the importance of LKS for the innovation performance of clustered firms in a developing country setting. An econometric analysis with new survey data from software firms in Montevideo, Uruguay, shows that LKS have a significantly positive impact on firms' innovation performance through labour mobility, company spin-offs and informal interactions among actors. LKS are also shown to be highly important relative to other sources of knowledge used by the firms.

Keywords: Local knowledge spillovers; Innovation; Clusters; Software Industry; Economic development; Uruguay

1. Introduction

In economically advanced countries, knowledge spillovers among geographically clustered firms have been widely viewed as a major driving force for innovation, learning and economic growth. In a well-known early study in this field, Saxenian (1994) argued that the semi-conductor industry in Silicon Valley has outperformed the same industry along Boston's Route 128 because the first region draws advantages from strong interdependencies between its firms, which help foster the informal exchange of ideas and knowledge that are so crucial for learning and innovation. Social get-togethers among employees and managers of local firms contributed to informal knowledge exchange, while high inter-firm labour mobility and the establishment of many spin-off ventures by ex-employees of leading firms gave rise to high circulation of human-embodied knowledge within the locality.

Using a variety of methodologies, a number of innovation researchers have obtained results that support a similar view (e.g., Jaffe et al., 1993; Audretsch and Feldman, 1996, 2003; Verspagen and Schoenmakers, 2000; Caniëls, 2000). This has given rise to a broad consensus that knowledge spillovers are to some extent geographically bounded. It has

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also been noted that this is especially the case in new high-technology sectors, because tacit knowledge plays a more important role there than in mature sectors where innovation is less prevalent. Tacit knowledge is hard to transfer except through ‘learning-by-doing’ based on direct observation and interaction. Its creation also tends to be a cumulative process (Dosi, 1988). Physical proximity between business parties facilitates the direct contacts needed for the build up and diffusion of this kind of knowledge.

In stark contrast to the academic discourse about innovation and growth in advanced economies, however, LKS have barely featured in the research about innovation and technological change in less developed economies. The dominant focus in the latter has been on the creation of international linkages between local firms and foreign actors and the knowledge-related advantages this could bring (see Evenson and Westphal (1995) for a good review). Widely used concepts like “international technology transfer” (Enos, 1989), “global value chains” (Gereffi and Kaplinsky, 2001), “catch-up” (Abramovitz, 1986) and “international knowledge spillovers” (Coe et al, 1997) testify to this orientation. It is no exaggeration to state that the literature about technological change and innovation in developing countries is awash with contributions emphasizing the importance of accessing and absorbing international knowledge for acquiring competitiveness and achieving economic growth. The main sources of technological advance are seen to lie in the external domain, and the task is to tap and master that foreign knowledge. There appears to be a tacit underlying assumption in that literature to the effect that there is simply not enough original new knowledge being generated within these countries for local knowledge spillovers to be able to play any noteworthy role alongside international ones.

Yet, a voluminous body of empirical research about the functioning of industrial clusters in developing countries tentatively suggests something different (e.g., Schmitz, 1999; Rabellotti, 1995; Nadvi, 1996). Writers in this line have consistently pointed up the importance of collaborative behaviour backed by social institutions like shared norms and trust. Such “active collective efficiency” has been consistently found to be crucial for improving competitiveness. One can infer from this that joint action allows clustered parties to internalise certain agglomeration-related externalities. Surely, LKS would be among these, alongside static scale and scope economies realised through actions like collective buying, production and marketing.

Unfortunately, the insights about LKS that one can derive from the cluster literature end there. Its concern has been more with social and institutional factors underlying economic competitiveness than with knowledge accumulation processes and their impact on technological capacity and innovation. This is reflected in the choice of key concepts such as “active collective efficiency”, that cannot be easily related to the analytical instruments used by researchers in the economics of technological change.¹ Moreover, its

¹ One problem is that “active collective efficiency” lumps LKS together with static production economies. Another problem is that it excludes all the agglomeration advantages that occur without any joint action. These spontaneous externalities, or “passive collective efficiency”, have not received much attention in the cluster studies. Yet, some of these do constitute LKS. In fact, these would be the very spillovers that Marshall (1920) referred to when he wrote that certain bits of knowledge in industrial agglomerations are simply “in the air”.

dominant focus has been on traditional low tech sectors, because the concerned researchers were mainly interested in gaining insight into the question to what extent cooperation strategies in clusters could constitute a viable route out of poverty. However, LKS are least likely to play a notable role in traditional low technology sectors.

In sum, we still know very little about the nature of LKS and the role that they could play – and are possibly playing – in developing countries, and whether industrial strategies that attempt to harness the benefits of LKS could constitute a viable path towards competitiveness and growth. These questions are especially pertinent in relation to technologically dynamic sectors like biotech, pharmaceuticals and ICT, in which several developing countries are beginning to make their mark.

The aim of this paper is to shed light on these issues, through an in-depth quantitative analysis of LKS in a dynamic cluster in a developing country, namely the software cluster in Montevideo, Uruguay.

The scope of our analysis is limited to just one cluster in view of the data complexities involved. Extant econometric methodologies used in some of the leading advanced-economy studies about LKS could not be used for our purpose (see section 2). At the same time, we felt that a qualitative assessment would be too subjective and impressionistic. In our view the best way forward was to collect fresh survey data by means of personally administered interviews. In view of the time- and budget-consuming nature of that work, we decided on an in-depth study of one cluster case. Our findings and conclusions should therefore be interpreted as preliminary pointers towards a better understanding of the extent to which LKS are – or can be – drivers of innovation and learning in a developing country context, and of the specific LKS mechanisms at work. In addition, our paper is meant to feed a methodological discussion about the measurement and analysis of LKS in a developing country context.

In section 2 we survey important methodological issues associated with the measurement of LKS in the existing literature, and we introduce the approach adopted in this study to deal with these problems. Montevideo's software cluster and sampling issues are discussed in section 3. Our analytical model, detailed research questions and the measurement of the key variables are introduced in section 4. Section 5 presents the econometric analysis and a discussion of the results, and section 6 contains conclusions.

2. Measuring Local Knowledge Spillovers

Knowledge spillovers have been defined by economists as knowledge flows that occur spontaneously, and without any compensation to the knowledge source (e.g., Jaffe et al., 1993). However, it is clear from Saxenian's writings and several other studies in innovation management and economic geography (see, e.g. Harhoff et al., 2003; and Feldman et al., 2005), that knowledge spillovers can be also to some extent induced through purposive interaction between parties. The importance of "active collective efficiency" in developing country clusters also suggests the same. Therefore, the definition adopted in this paper includes both types. The defining characteristic that they share is that they occur outside the market – no transactions are involved. They have a direct effect on the firm's production function, in contrast to pecuniary externalities, which exert indirect influences through changes in prices (Scitovsky, 1954).

Although much has been said and written about LKS, not much is actually known about them. The very fact that they are direct and free makes them hard to capture. As Audretsch and Feldman admit ‘...there is no understanding of the way in which spillovers occur and are realised at the geographic level’ (2003, p. 13). Most of the leading empirical studies in economically advanced countries have used indirect methods in order to justify their importance for the localized nature of knowledge and innovation through analysis of patent citations and R&D expenditures. In patent citation analyses, the spatial distribution of granted patents is compared with the spatial distribution of citations of those patents in an area. Results have generally indicated a positive relationship. With respect to R&D expenditures analysis, it has been found that spatial clustering of R&D is greater than what one would expect on the basis of the spatial distribution of production activity.

However, such indirect methods have apparent shortcomings. In particular, Breschi and Lissoni (2001) have argued that the results from patent citation analysis constitute only weak evidence of the presence of LKS. The fact that the incidence of patents and citations from these patents correlate geographically, merely indicates that knowledge flows more intensively among local firms than among firms situated at a long distance from each other. It does not imply that all that knowledge actually circulates freely without compensation payments being made. In fact, in a study by Zucker et al (1998) it was shown empirically that knowledge exchanged between local firms and universities did involve market transactions.

From the perspective of the objective of our study, an even more problematic feature of these indirect methods lies in the nature of the data used. Patents (and even R&D statistics) capture only part of innovative activity. This is so even in advanced economies, but it is an especially severe problem in developing countries. The bulk of innovative activity in those countries consists of learning-by-doing based on adaptations and modifications of foreign technologies, to make them fit for local conditions that are different from the environment in which these technologies were originally generated (e.g. Lall, 1992). Although these activities have been shown to have major effects on firms’ productivity (Katz, 1987), the majority does not fall under the rubric of R&D, and the knowledge generated in this way hardly ever constitutes patentable innovations. Hence, much of what developing country firms do in the way of innovation does not feature in any statistical database (Bell, 1984). It would thus be rather futile if we were to try to adopt this kind of secondary data-based methodology for our study.

Recently, some more direct measures of knowledge spillovers have been constructed on the basis of firm-level data from innovation surveys like the EU Community Innovation Survey. The usefulness of such methodologies is also limited from the perspective of the objective of this paper, since the databases on which they are based do not carry information about the proximity (or otherwise) of the different sources of knowledge and information that the surveyed firms reportedly benefit from. They also share the problem of the indirect methods of including priced knowledge flows along with knowledge spillovers proper.² Even though firm-level innovation surveys similar to

² For example, Cassiman and Veugelers (2002) constructed a proxy for knowledge spillovers from CIS data by adding firms’ Likert scores (ranging from 1 = unimportant, through 5 = crucial for innovation) pertaining to the following information sources: (1) patent information; (2) specialised conferences, meetings and publications; and (3) trade shows and seminars.

CIS have been undertaken for several developing countries,³ these data are therefore unusable for our purpose. It also has to be said that the developing country innovation surveys suffer from very small (about 2 to 3 per cent) sample sizes that are not representative of their company populations.

We circumvented these problems by developing an approach in which LKS were measured and statistically analysed on the basis of new firm level data. These data are based on detailed information on firms' innovative activities and capabilities, and their different sources of knowledge, collected personally from a large sample of clustered firms. Using the relevant CIS questions as a starting point, we significantly expanded upon the questions eliciting information that could be relevant for capturing local knowledge spillovers.

In view of the difficulties experienced in extant studies in disentangling knowledge spillovers from transaction-based knowledge flows, we decided that we should aim to capture both by trying to measure them as directly as possible, and then differentiate between them on the basis of our own information about them. For this purpose we introduced the concept of 'knowledge flows', which encompasses both market-based knowledge transactions resulting from formal collaborations between actors, as well as free and direct knowledge flows arising from purely informal contacts, i.e. knowledge spillovers proper. Furthermore, in order to be able to single out the importance of LKS from among other knowledge-contributing factors for firms' innovative performance, we not only collected data about local knowledge flows, but also about non-local ones. In addition, we collected information about various activities associated with internal knowledge generation in firms.

In other words, our measurement methodology is different from earlier LKS research in the sense that we tried to obtain a complete picture of all the important local and non-local external and internal knowledge sources that firms might use, so as to be able to assess the relative importance of LKS in firms' knowledge accumulation process as a whole. In so doing, we are able to pitch into the controversy about the importance of local knowledge spillovers versus transaction-based local knowledge transfers; and we can also shed light on the question whether local knowledge sources – spillovers in particular – matter in relation to international sources for competitiveness and catch up.

3. Montevideo's Software Cluster: Introduction and Sampling

The software cluster in Uruguay was chosen as the object of our study for particular reasons. First, we wanted to choose a technologically modern sector, because LKS would more likely play a notable role there than in a traditional low tech industry. We considered software to be a good candidate for our study, since the sector is currently emerging in several developing countries – including low income countries such as Vietnam –, unlike other important modern sectors such as pharmaceuticals and biotechnology, which are more difficult sectors for developing countries to enter into.

We chose Uruguay as a research site because it is a small developing country with few evident competitive advantages relative to big countries like Brazil or India with their much greater resources and international bargaining clout. Software firms in Uruguay are highly clustered in and around the capital city of Montevideo; 98 per cent of the firms are

³ Including at least seven Latin American countries, South Africa, South Korea, Malaysia and Thailand.

located in Montevideo itself, while 2 per cent are located in Zonamerica – the Business and Technology Park on the city's outskirts.

The recent performance of this cluster has been remarkable. Like many other Latin American countries, Uruguay's economy was performing very badly during the 1990s. While industrial value added declined by 1 per cent per annum during 1991-2001, the software sector grew by 4 per cent per annum during the same period.⁴ This growth was mainly directed to the export market. At the end of the 1990s, exports constituted 39 per cent of the value added of Uruguay's software sector (Snoeck et al, 1992; CUTI, 2004). The pertinent question that presents itself is whether the recent thriving of Uruguay's software sector somehow relates to benefits deriving from its geographical concentration in Montevideo, and in particular to LKS occurring there? If so, that might also hold out some hope for other small developing countries seeking to increase their participation in the international 'knowledge economy'.

The emergence of the sector can be traced to the 1990s, a period of rising demand for software products and particularly services in Latin America in the years leading up to the new millennium. Compared to neighbouring countries such as Paraguay and Bolivia, Uruguay was in a better position to take advantage of this emerging market, thanks to the presence of well-qualified professionals in the country. One important factor in this has been the Uruguayan state, for which education has been a constant a priority.⁵ These professionals combined a high level of technical education with in-depth knowledge of specific sectors such as health, financial services and construction, which put them in an excellent position to tune into the growing market for sector-specific software applications and services.

According to the standard classification of economic activities adopted in the EU Community Innovation Survey (NACE Rev. 1 72), computer services include hardware and software consultancy services, analysis, design and programming of ready-to-use software, data processing and database activities, as well as the maintenance and repair of office machinery (Tether et al. 2001, p.101). It is a hybrid sector, encompassing technology provision, product-oriented activities that are very similar to manufacturing such as the production of packaged software, as well as service-oriented and technology-using activities such as data processing and database analysis.

In Uruguay, the software sector is a large part of the information technology industry, which comprises (i) software development, (ii) consultancy and services, (iii) internet and data transmission, and (iv) hardware production and sales. There are 2216 companies registered with the Uruguayan Chamber of Information Technologies (CUTI). CUTI assists firms to develop their business capabilities and reinforces common action for the promotion of Uruguayan software products in foreign markets.

'Knowledge intensiveness' was an important criterion for the selection of our sample, in view of the results from earlier LKS studies pointing to the importance of LKS in knowledge intensive sectors (especially, Audretsch and Feldman, 1996). We therefore singled out the two most knowledge intensive sub-sectors, namely software developers and consultancy services, as our target population. In total these firms number 149,

⁴ Own calculations, based on data from the Central Bank of Uruguay.

⁵ The country succeeded in achieving one of the lowest adult illiteracy levels in Latin America, two per cent in 2000 (*World Development Indicators*, World Bank, 2002).

excluding 1,600 one-person companies (Stolovich, 2003).⁶ A list of these firms was obtained from CUTI. However, after a first contact with these listed firms it became apparent that some were not carrying out any kind of software development or consultancy, so these cases had to be deleted from our population. At the same time, many relevant unlisted developers and consultancy firms were discovered by consulting the local telephone book, and through early interviews with resource persons and (listed) firms. This led to a final total number of 150 identified operating software developers and consultancy providers (excluding one-person operations).

Software developers and consultants in Montevideo provide a range of products and services. The software products are standardized systems and registered packages for various markets. These include management solutions for SME (such as for accounting and human resources management); software packages for education, health, and transport; software development tools for application by other companies in their specific sectors, and tools for financial markets. Customized software comes predominantly in the form of services, including implementation and adaptation of software products (either the company's own, or products made by third parties); maintenance; training; and consultancy for ad hoc problem solving (Stolovich, 2003; Mejía and Rieiro, 2002; Failache et al., 2004).⁷ We tried to ensure as best we could that our sample would be broadly representative of this heterogeneous nature of offerings and markets.

Primary data were collected through a field survey in Uruguay from October to December 2004. The survey used a structured questionnaire based to a certain degree on the Community Innovation Survey, adjusted to reflect peculiarities of the software sector in a developing country, and extended to be able to capture the different types of information flows discussed above. After a round of questionnaire testing and revision, the whole known population of 150 firms was approached and asked to take part in the survey. The questionnaire was administered by means of a face-to-face interview with the director and/or the chief engineer of the R&D department of each company. Ninety-eight firms agreed to participate, and we were able to collect full information from 97 of those, representing a 64 per cent response rate. We do not believe that there are significant biases in our results on account of non-participating firms.

4. Research Model, Questions and Variables

Figure 1 represents the conceptual model used in the analysis.

[FIGURE 1 ABOUT HERE]

The figure conveys that, in general, firms can increase their innovative performance by investing in internal and/or external learning activities. The extent and quality of internal learning would be contingent upon the absorptive capacity that the firm has already developed (Cohen and Levinthal, 1990). Absorptive capacity is represented in our framework by the R&D that the firm has undertaken, the experience and education of its employees, and finally the age of the firm as an entity.

⁶ Hardware and sales firms number 371, and internet and data transmission firms 96.

⁷ The main factor that differentiates custom-made products from registered packages is the degree of standardization (Bitzer, 1997).

Firms may also use a variety of mechanisms in order to learn from external sources. These sources can be located within the cluster or outside it. When a firm gains knowledge directly for free in an informal manner from a local source, it benefits from Local Knowledge Spillovers (LKS). Local knowledge can also be purchased, a case of Local Knowledge Transactions (LKT). Moreover, knowledge may be transferred through international linkages, either informally as free International Knowledge Spillovers (IKS), or as part of a transaction-based agreement, as International Knowledge Transactions (IKS). Non-local national linkages are not an issue in this particular study. There are no significant business activities in Uruguay outside Montevideo that could act as sources of new knowledge for our sample firms.

A number of studies suggest that purposeful investments in learning from internal and external sources tend to increase the technological capabilities of the firm (Katz, 1987, Lall, 1987; Romijn, 1999). Lall distinguishes production, investment and innovation capabilities (Lall, 1992). Although investment and production capabilities are relevant in the context of the software, we concentrate on innovation capability in this study, since the main characteristic of the software sector is its continuous product innovation effort. Innovation capability refers to the skills and knowledge which are necessary in order a firm to be able to improve and change products, processes and production organisation (Lall, 1992). In Figure 1, the firm's innovation capabilities are enclosed in a dotted circle to indicate that they are not directly observable and measurable.

What we do observe and measure are the outcomes from that capability, namely the firm's innovative performance depicted in the right hand side of figure 1. In general, innovation refers to the outcome of all the efforts of the firm – using its technological capabilities – which aim to "improve technological mastery, to adapt technology to new conditions, to improve it slightly or very significantly" (Lall, 1992, p.166).

With the help of this model, we pose the following questions for analysis:

1. To what extent do LKS occur in the Montevideo software cluster?
2. Do LKS in this cluster foster firms' innovative performance?
3. How important are LKS for firms' innovative performance in comparison to other types of knowledge flow?
4. Is the role played by LKS in this developing country cluster different from the function of LKS in high-tech clusters in economically advanced countries?

Next, we turn to the measurement of the key concepts in Figure 1, starting with innovation performance. Pavitt (1984) classified software firms as "specialised suppliers", and he stated that this type of firms are characterised by a high rate of product and service innovations.⁸ Accordingly, our indicators for innovation performance listed in Table 1 put emphasis on product and service innovation, and pay less attention to process innovation.

The first variable, NEW_PS, is meant to identify those innovations that were first introduced into the market by the respondent firm, i.e. they were not imitations in any way. These innovations would mainly concern standardised products rather than customised products or services. They usually address new functionalities of an existing product, or the same functionality through the use of a new product. The important

⁸ This orientation was confirmed through personal communication with one Dutch and one Silicon Valley software firm prior to the survey. Information from the survey and local resource persons in Uruguay itself confirmed the product innovation orientation of software firms.

feature of this indicator is that it captures a firm's capability to create a substantially new product and introduce it to the market.

The second indicator, CHANGE_PS, is meant to capture substantial changes undertaken on already existing products or services during 1999-2004. Such changes would normally come about in the process of trying to satisfy customers' needs. In other words, this type of innovation mainly concerns the creation of new services or customised software products. The difference with the previous indicator is that firms that had introduced a completely new product (NEW_PS) had not only created a new functionality, but they also possess the capability to do so to a generalised scale; they have gone from offering a personal solution (customisation or service) to providing a general solution with many applications (software product). Therefore, while NEW_PS denotes innovations that are new in the market, CHANGE_PS indicates those innovations that are new for the firm, but not necessarily very novel for the market as a whole.

Table 1: Variables measuring innovation performance

Variables	Variable names	Definition/Measurement
Product/Service – completely new in the market	NEW_PS	Dummy variable that takes the value of 1 if the firm was the first to introduce a new product and/or service to the market during the period 1999-2004, and 0 otherwise.
Product/Service - changed drastically	CHANGE_PS	Dummy variable that takes the value of 1 if the firm has changed a product and/or service in a radical manner during the period 1999-2004, and 0 otherwise.
Sales of Innovation Output	SALES_INNOV	Indicates the percentage of sales that derived from product and/or service innovations (NEW_PS and CHANGE_PS) in 2004. Censored variable because its lower limit equals zero.
Number of Innovations	NO_INNOV	Variable indicating the number of product and/or service innovations produced by the firm during 1999-2004.
Quality of Products and/or Services	QUAL_PS	Dummy variable that takes the value of 1 if the firm has a quality certification and 0 otherwise.

The third measure, SALES_INNOV, refers to the percentage of the firm's sales deriving from product and/or service innovations in 2004. This indicator identifies the ability of the firm to successfully commercialise its innovations. The fourth indicator, NO_INNOV, takes into account the number of innovative products and/or services created by the firm during 1999-2004. In general, software firms develop just one or a few products but then keep adjusting these to current technological and market trends by developing new versions. This indicator captures all these types of innovations – fundamentally new products as well as product adjustments in terms of product design, user-friendliness of functionalities, and the creation of new versions of older products to bring them up to date.

Finally, QUAL_PS refers to whether or not firms hold any of the internationally recognised quality certifications such as ISO 9000 and CMM (related to software). While the process of obtaining a quality certification might be a learning path for a firm which could improve its process quality, most of the firms tend to get such certificates in order

to access international markets. This suggests that the acquisition of a quality certificate reflects a change in the business practices of the software firms with the aim to improve their image in international markets. The acquisition of a quality certificate, then, mainly constitutes a form of organisational innovation, not so much a technological one.

As discussed with reference to Figure 1, firms may use a variety of mechanisms in order to learn from internal and external sources. We discuss the external ones first (see Table 2), because KLS, being our main object of study, are in this category.

For the measurement of LKS we follow earlier spillover and cluster studies that have pointed to three main mechanisms: firm spin-offs, labour market circulation, and informal interactions among local actors (see, e.g., Saxenian, 1994). LKS_S is a dummy variable that denotes whether or not a firm is a spin-off from another local party such as a University, TNC, or a large firm. A spin-off process usually implies that crucial know-how and problem solving skills learnt in the mother organisation get transferred to the new start-up without the former being adequately compensated (e.g., Zucker et al., 1998).

The second proxy, LKS_L, captures the often found proposition in the spillover literature that the higher the firm's labour turnover, the more the firm's new local employees will represent a channel for free knowledge acquisition (e.g., Almeida and Kogut (1999). Thirdly, LKS_I refers to the importance, to the firm, of knowledge and new ideas that tend to get shared and sparked off spontaneously through informal contacts with other local parties such as universities, suppliers, clients, and even competitors. The detailed measurement and construction of this variable is explained below.

Table 2: Variables measuring external learning

Variables	Variable names	Definition/Measurement
Local Knowledge Spillovers through Spin-offs	LKS_S	Dummy that takes the value of 1 if a firm is a spin-off from a university or TNC located within the cluster, 0 otherwise.
Local Knowledge Spillovers through Labour Mobility	LKS_L	Percentage of employees that had joined the firm from elsewhere within the cluster during 1999-2004.
Local Knowledge Spillovers through Interaction	LKS_I	Constructed ordinal indicator based on Likert scales, which indicates the importance of intra-cluster sources of free knowledge arising from informal interaction with other local actors (details in text).
Local Knowledge Transactions	LKT	Constructed ordinal indicator based on Likert scales, which indicates the importance of intra-cluster sources of knowledge arising from knowledge transactions with other local actors (details in text).
International Knowledge Spillovers through Interaction	IKS	Constructed ordinal indicator based on Likert scales, which indicates the importance of extra-cluster sources of free knowledge arising from informal interaction with foreign actors (details in text).
International Knowledge	IKT	Constructed ordinal indicator based on Likert scales, which indicates the importance of extra-cluster sources of

Other intra-cluster knowledge flows take the form of local knowledge transactions between the firm and other parties: LKT. These transactions carry a price, and there is a contract of sorts. Aside from this aspect, the detailed measurement of this variable is similar to the KLS_I variable, as explained below.

The extra-cluster knowledge flows are represented by two indicators, of which one captures international knowledge spillovers through informal interaction with foreign parties, IKS. The other is international knowledge transactions, IKT. Aside from the international dimension, the measurement of these variables is identical to LKS_I and LKT, respectively.

All four indicators that reflect knowledge flows through inter-actor interaction, i.e. LKS_I, LKT, IKS and IKT, were constructed on the basis of the opinions of the respondents-entrepreneurs about the importance of the knowledge flows for the innovation efforts in their companies. We captured these opinions using a Likert scale running from 0 (non-existing or unimportant) through 4 (crucial). While subjective, it is assumed that the opinion of the manager of the enterprise reflects the strategy of the specific firm in respect of alertness to, search for, and utilization of external knowledge. In the 3rd Community Innovation Survey the questions regarding the importance of various sources of information for innovation are formulated in a similar way (CIS 3, 2004). Furthermore, research based on the CIS data interprets the answers to these questions as reflecting the intensity of information sourcing from the various sources (Mohnen and Hoareau, 2003). Our four knowledge-through-interaction indicators will be interpreted in a similar manner.

The detailed measurement and construction of the four variables was done as follows: Respondents were asked to rate the importance of various sources of information, advice or assistance to their upgrading or innovation efforts on the Likert scale. They were asked to do this for thirteen different potential sources of knowledge: business group; new personnel; customers; suppliers; competitors; alliance partners; consultants; research institutes; universities; innovation centres; sector institutes; exhibitions; and electronic information. Moreover, firms were requested to indicate the geographical location of each of these sources of knowledge (local versus international). Finally, firms were asked to clarify the nature of the relationship between their firm and each of the knowledge sources, i.e. whether it constituted a formal relationship involving knowledge transactions (KT), or an informal linkage or contact in which knowledge is transferred spontaneously in a purely informal manner without any compensatory payments (KS).

Using these three attributes – importance; location and type of the relationship – we were able to group the flows into LKS, LKT, IKS or IKT-type flows. Then, for each of these four categories of knowledge flow, we added up the Likert scores obtained for the 13 individual sources, ending up with one aggregate importance score for each flow category. LKS, LKT, IKS and IKT are thus ordinal variables, which can assume a minimum value of 0 and a maximum of 52.

The indicators measuring the quality and intensity of firm's internal learning processes (absorptive capacity) are listed in Table 3. The choice of variables in this area

draws on earlier studies on firm-level learning in developing countries (for example, Katz, 1987; Lall, 1987; Bell, 1984), in which similar explanatory factors were found to play a significant role in the accumulation of firms' technological capabilities. The first of these factors is R&D. Two proxies denote the R&D capacity of the firm in our study. The first one, R&D_MY, reflects the cumulative R&D effort of the firm during 1999-2004, in man-years. The second proxy, R&D_INTENS, reflects more the R&D intensity of the firm rather than its overall capacity. It is measured by the number of R&D personnel as a percentage of the total number of the firm's employees in the interview year.

Another set of indicators cover the educational background of the firm's employees. The first variable, EDU, is a weighted index of the average formal education level of the firm's employees, in which higher levels of education are assigned higher weights than lower levels. This average was constructed from information about (i) the percentage of employees whose highest level of education is vocational training related to computer programming; (ii) the percentage of employees whose highest level of education is a completed BSc in Software engineering; (iii) the percentage of employees whose highest level of education is a completed MSc; and (iv) the percentage of employees whose highest level of education is a PhD degree.

Table 3: Variables measuring internal learning (absorptive capacity)

Variables	Variable names	Definition/Measurement
R&D Man-years	R&D_MY	The firm's cumulative R&D effort during 1999-2004 measured in man-years
R&D Intensity	R&D_INTENS	Percentage of firm's labour force that carried out R&D in 2004.
Level of Education	EDU	Education index based on weighted percentages of different employee education levels attained in the firm (details in text).
Variation in Education Levels	EDU_VAR	Ordinal variable that denotes the variation of the education levels of the employees of each firm (details in text)
Postgraduate Education	EDU_DUM	Dummy that takes the value of 1 if a firm has any employee with MSc or higher degree, 0 otherwise.
Foreign Education	EDU_F	Percentage of the firm's employees with a foreign university degree.
Years of Experience	EXPER_Y	Index indicating the average years of experience in the software sector of the firm's employees.
Variation in Experience	EXPER_VAR_Y	Ordinal variable measuring variation in years of experience in the software sector by the firm's employees.
Experience in Number of Firms	EXPER_FIRMS	Index indicating the average number of occupations held by the firm's employees in the past.
Variation in Experience in	EXPER_VAR_F	Ordinal variable measuring variation in the number of occupations held by the firm's employees in the past.

Number of Firms		
Age of firm	AGE	Firm's age (reference year 2004).
Size	SIZE	Control variable denoting the firm's number of employees in 2004.

Index EDU was constructed by multiplying these respective percentages with weights of 3, 5, 7 and 11 respectively, and adding up the terms. The weights derive from 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, so this gets an implicit zero weight. Vocational or technical training is of 3 years' duration, hence the weight of 3 for the percentage of employees with vocational training as their highest level of education. A graduate degree at a university, the 'Licenciatura', takes 5 years, and an MSc another 2 years. A PhD degree is awarded after an additional 4 years. The index can thus assume a maximum value of 11.

A simple additional education proxy, EDU_VAR, was constructed with the same data, to denote the variation of education levels of employees within a firm. For example, when 100 percent of the employees of a firm have a BSc, a score of 1 was assigned to that firm. If, on the other hand, a firm consisted of 50 percent employees with BSc degrees and 50 percent with MSc degrees, a score of 2 was assigned to that firm. If a firm consists of 30 percent employees with vocational education, 40 percent with BSc degrees, 20 percent with MSc degrees and 10 percent with PhD degrees, a score of 4 was assigned to that firm. This is the maximum score for this ordinal variable.

Additionally, a dummy variable EDU_DUM, was created, which takes the value of 1 when the highest level of education obtained by at least one of the firm's employees is an MSc or PhD degree, and zero in all other cases. A positive score on this variable is a reflection of possessing advanced human capital, which is the result of postgraduate studies of the employees. A final education-related proxy, EDU_F, consists of the percentage of the labour force that has obtained a foreign university education, as this might add something extra to the firm's human resource capacities.

The next block of variables concerns the working experience of the firm's workforce in the software sector. An experience index called EXPER_Y was constructed, which denotes the weighted average years of experience in the software sector of the firm's individual employees. For each firm, the percentage of the employees with less than 6 months experience was multiplied by a factor of 0.25. The percentage of employees with 6 to 12 months experience was multiplied by 0.75. The percentage with 1 to 2 years experience was multiplied by 1.50. The percentage with 2 to 4 years of experience was multiplied by 3; and finally, the percentage with more than 4 years experience was multiplied by a factor ranging from 6 to 12, decided on a case by case basis.⁹ EXPER_Y is the aggregate of the resulting scores. An additional variable, EXPER_VAR_Y constructed with the same employee data. That variable denotes the variation in years of

⁹ The weight given to the employees with more than four years of experience depends on the age of the firm. Generally we assigned approximately one-third of the age of the firm as the multiplication factor. For example, if a firm has functioned for 25 years, the multiplication factor assigned to the percentage of employees with over 4 years experience would be 8.

software working experience of the employees within a firm. The method for constructing this ordinal variable is the same as the one adopted for EDU_VAR.

A second experience index, EXPER_FIRMS, takes account of the number of different occupations related to software that the firm's employees had held in the past. This index was constructed by in a way similar to EXPER_Y, above. In this case, the percentage of the employees with no previous experience is multiplied by 0. The percentage with previous experience in 1 or 2 firms is multiplied by 1.5. The percentage with experience in 3 or 4 firms is multiplied by 3.5, while the percentage with experience in 5 or 6 firms is multiplied by 5.5. Finally, the percentage of employees with experience in more than 6 firms is multiplied by 6. EXPER_FIRMS is the aggregate of these scores. Based on the same information, an additional variable, EXPER_VAR_F, was constructed in order to capture variation of experience levels of employees within a firm in terms of the number of firms they worked for in the past. Finally, the accumulated experience by the firm as an entity was taken into account by considering the age of the firm (AGE) in 2004.

Since some of the explanatory variables are not neutral with respect to firm size, it is necessary to control for firm size in the statistical analysis. Hence, we use a control variable SIZE, defined as the firm's total number of employees in 2004.

5. Empirical Analysis

We briefly review some key descriptive data about the sample before delving into the econometric analysis of the determinants of innovation performance.

The sample firms had 24 employees on average; the biggest one had 260. The standard deviation of 40 would indicate that the great majority of the firms employed below 100 workers. This implies that we are researching a true small- and medium (SME) industry cluster. Their mean establishment date is 1991-2, the period in which demand for software in the region began to pick up.

Despite their rather modest size, the sample firms showed lots of signs of innovation activity. Over half of them (52 per cent) had been first in introducing a completely new product to the market (NEW_PS), while 70 per cent had upgraded existing products and/or introduced new custom-based services (CHANGE_PS) during the five years preceding the interview. The average total number of realised innovations in this period was 4, and the average percentage of turnover deriving from those product innovations was as high as 45 in 2004. A large minority of firms (38 per cent) had also obtained an international quality certification.

Almost half of the sample firms (48 per cent) had come into existence as a result of a spin-off (LKS_S). Spin-offs apparently are a very commonly used mechanism of new firm formation in this industry. Labour mobility (LKS_L) also seems to have been important, but only up to a point, with over one third (35 per cent) of the workforce having joined the firm during the 5 years preceding the interview.

The average scores on the knowledge spillover variables are 6.1 for the local ones, and 5.9 for the international ones. The figures suggest, that firms on average benefit freely from, say, 2 to 3 local sources and the same number of international ones, and that the linkages to these sources are of moderate intensity, or that they have one single free source of knowledge that is crucial to them.

The average score for the international knowledge transactions (IKT) of 5.4 is a bit lower. This is probably explained by the fact that not many SME would engage in international knowledge transfer contracts. Of the four external knowledge-by-interaction variables, transactions-based local knowledge flows (LKT) get the highest average score of 9.1. Thus, quite lot of the local external knowledge is perceived by the respondents as not being ‘in the air’ – it does not come for free. However, it still remains to be seen whether these descriptive patterns also translate into similar effects on the firms’ innovation performance.

The sample firms also utilize internal resources to boost their technological capabilities. The cumulated average number of R&D man-years was 10.4, and the average percentage of R&D manpower in relation to the firms’ total workforce was 36 per cent, signifying the importance of continuous innovation in the industry. The average score on the EDU index of 4.8 suggests a reasonably good education level in the companies, with most or all employees having vocation or technical training and several having a graduate degree. Twenty-seven per cent of the companies employed someone with an MSc degree or higher (EDU_DUM). Eight per cent employed someone with a foreign university degree. Employee working experience is a little over 5 years on average, and these employees worked in 1,7 companies before joining the current firm. This statistic supports the earlier observation that labour circulation among firms in the sector is of some importance.

Since some of the dependent variables showed rather high correlations, it did not make sense to run regressions on all five variables separately. Principal Components Analysis revealed two components with eigenvalues greater than 1, which together explain nearly 60 per cent of the variance among the dependent variables. Table 4 shows the loads of the five innovation variables on these two components. The first factor, which we denote as ‘Technological Innovation Performance’ (TECH_INN), is explained predominantly by NEW_PS and CHANGE_PS. Both these variables are indications of a firm’s ability to bring about technological innovations, whether in the form of innovations that are completely new to the market, or significant changes to existing products/services.

Table 4: Components of innovation performance

	Component 1	Component 2
	Technological Innovation Performance (TECH_INN)	Organisational & Commercial Innovation Performance (ORG/COM_INN)
NEW_PS	0.895	0.009
CHANGE_PS	0.919	0.028
SALES_INNOV	0.200	0.277
NO_INNOV	-0.077	0.766
QUAL_PS	0.011	0.798

The second factor, which we call ‘Organisational & Commercial Innovation Performance’ (ORG/COM_INN), is explained by the variables QUAL_PS, NO_INNOV and to some extent by SALES_INNOV. These variables convey something about a firm’s capacity to organise its innovation processes professionally, and to commercialise its innovations successfully.

Obtaining a quality certification (QUAL_PS) is a necessary step for many firms in developing countries for entering foreign markets and gaining the trust of demanding customers. A quality certification is essentially a guarantee of the functionality of the firm's product, because the firm has to conform to certain standards in its processes that help to minimise the errors committed at every stage.

NO_INNOV is an indicator of commercial success. In the software industry it is common for a firm to hold just a few products and then produce numerous versions of those. Those versions represent the capability of the firm to react to changing market needs and sell its products in diverse forms. To a large degree this variable represents its capabilities to exploit its products to the full, by adapting and upgrading them continuously in response to changing market demands.

Finally, SALES_INNOV demonstrates that the specific firm is innovative, because a large percentage of its current sales come from innovative products and services. In addition, the variable indicates that the firm in question is able to commercialise its innovative products and/or services and profit from them. In other words, this variable expresses the capability of the firm to use marketing knowledge and sell its innovations in the market.

In the following regression analysis we use TECH_INN and ORG/COM_INN as the two dependent variables.

The Ordinary Least Squares regression results for TECH-INN are reported in Table 5.¹⁰ Regression A was performed by entering all explanatory variables listed in Tables 2 and 3. The adjusted R^2 of 0.168 is quite low, and only two variables emerge as statistically significant. However, both of these are spillover variables. LKS_I, the interaction-driven LKS variable, is highly significant (t-value 2.939), while its international equivalent IKS records a more modest significance (t-value 1.931). This suggests that firms with higher-intensity contacts involving free knowledge flows record a better technological innovation performance than others, all else equal. At the same time it is puzzling that no single variable associated with internal learning / absorptive capacity emerges as significant alongside the external learning variables.

Regression B excludes all the variables with low t-values in regression A. Moreover, where high collinearity between some of the explanatory variables occurred in regression A¹¹, only the variable with the highest level of significance was included in regression B. Model B has an adjusted R^2 of 0.212, implying that we remain unable to explain close to 80 per cent of the variation in the dependent variable. This is not so satisfactory, but the results in Table 5 are interesting. The significance of LKS_I has increased compared to regression A. There is also a second significant local spillover variable LKS_L (t-value 2.234), suggesting that firms with a high rate of labour turnover exhibit a better technological innovation performance than firms that tend to retain their employees, through new skills and knowledge that fresh workers bring with them.

While the international spillover variable has lost its significance compared with regression A, we observe instead a modestly significant variable measuring transactions-

¹⁰ The regressions satisfy the requirements of OLS regression analysis. The residuals are normally distributed with zero mean, meaning that the regressions meet the normality assumption. An examination of the histograms and normal probability plots of the predicted values of the dependent variables against the residuals did not reveal any signs of significant heteroskedasticity either.

¹¹ Notably between EXPER_Y and EXPER_VAR_Y.

based international knowledge flows, IKT (t-value 1.812). This has to do with a statistically significant correlation between IKT and IKS ($r=0.230$, p value 0.023). Hence, the effect that was picked up by IKS in regression A is being picked up by IKT in regression B. We may conclude from this that international contacts are important for generating knowledge flows, and that international contacts leading to knowledge transactions generate some knowledge spillovers at the same time.

Furthermore, EXPER_Y has become highly significant in regression B, but with a negative sign (t-value -2.805). At first glance this would seem surprising. We would rather expect that experience augments the technological innovation performance of the firms. Regression C throws more light on the issue. This is identical to regression B, except that EXPER_Y has been substituted by AGE (age of the firm), which is highly correlated with EXPER_Y ($r=0.704$, p value 0.000). AGE has a significant and negative impact upon TECH_INN as well. In other words, the older a firm, the lower its technological innovation performance is likely to be.

Table 5: OLS Regression Results for Technological Innovation Performance (TECH_INN)

Explanatory 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)	0.177	(1.812)*	0.187	(1.882)*
RD_MY	0.123	(1.046)				
RD_INTENS	-0.077	(-0.752)				
EDU	0.063	(0.504)				
EDU_VAR	-0.033	(-0.211)				
EDU_DUM	-0.051	(-0.288)				
EDU_F	-0.189	(-1.652)				
EXPER_Y	-0.289	(-1.568)	-0.265	(-2.805)***		
EXPER_VAR_Y	0.023	(0.167)				
EXPER_FIRMS	0.183	(1.438)				
EXPER_VAR_F	-0.098	(-0.858)				
AGE	0.001	(0.006)			-0.231	(-2.475)**
SIZE	-0.035	(-0.294)				
Intercept						
N	97		97		97	
Adj. R2	0.168		0.212		0.198	

Note: t-values in parenthesis; ***p<.01, **p<.05, *p<.10

This result is supported by innovation studies undertaken in economically advanced countries. Hansen (1992) examined the proportion of sales due to innovations in American firms and found that it is inversely related to firm age. Huergo and Jaumandreu (2004), who examined Spanish firms, found that entrant firms exhibit a higher probability of innovation compared to older firms. Our finding suggests that the same pattern occurs in an economically less developed setting as well.

A number of different interaction effects between the explanatory variables, such as LKS_L x IKT and LKS_I x IKT, were also tested in a number of regressions, but none of these generated any significant effects, nor did they increase the R^2 . Therefore the results of these analyses are not reported in Table 5.

The relative importance of LKS for the technological innovation of the firms can be assessed by examining the standardised beta coefficients¹² reported in Table 5. Taking best-fit regression B as the reference, our results indicate first of all that knowledge *spillovers* are stronger predictors of technological innovation performance than knowledge flows based on *transactions* (i.e., IKT), not only in combination but also individually. Secondly, we note that both these spillovers, LKS_I and LKS_L, are indeed *local*. Thirdly, while local knowledge transactions (LKT) were given the highest importance by the respondents compared to other types of knowledge flow, these local transactions are nevertheless insignificant predictors of innovative performance. In sum, barring measurement imperfections, our results suggest that LKS through inter-actor interaction, followed by LKS through labour market mobility are the most important mechanisms for technological innovation of the firms within the software cluster of Montevideo.

Next, we assess the relative contribution of LKS to the organisational and commercial innovation performance (ORG/COM_INN) of the firms. The procedure is the same as for the TECH_INN regressions. Table 6 reports the results. Regression A includes all the explanatory variables, while regression B is the best fit. Various interaction effects were also tested, but the results are not included in the table since no significant effects were found.

Model A has an adjusted R^2 of 0.396 and model B an R^2 of 0.431, which is better than the TECH_INN regressions. The one important similarity between the ORG/COM_INN and the TECH_INN regressions is the statistical significance in both of the variable capturing international knowledge transactions, IKT. In the case of ORG/COM-INN, however, the causality may run both ways. Firms that are relative capable in terms of their organisational processes and commercialisation of their innovations also could be expected to be in the best position to develop fruitful international contacts that yield additional useful knowledge in these fields.

The other statistically significant variables in Table 6 (for model B) are all different from those reported in Table 5. They include LKS_S, RD_MY, EDU_DUM, EXPER_VAR_F and AGE. This list includes the one LKS mechanism that was insignificant in the TECH-INN regressions, namely free knowledge reception through firm spin-offs (LKS_S). Firms that were started as spin-offs evidently exhibit a better performance in terms of organisation and commercialisation of their innovations than the others. Conversely, the interaction- and local labour market-based spillovers that were found to be significant in the TECH-INN regressions are not statistically significant in the ORG/COM_INN regressions. This suggests that different local spillover mechanisms matter for different aspects of the firms' innovative performance. Organisational and

12 Before conducting the regressions, all explanatory (predictor) and dependent (response) variables were standardised by subtracting the means from their values, and dividing the resulting values by their standard deviations. The beta coefficients in Tables 5 and 6 thus represent the proportion of change in response to a change of one standard deviation of the predictor variable (Gujarati, 1988).

marketing-related capabilities are carried across from parent firms when people start their own ventures, but entrepreneurs rely on fresh worker talent and interactions with other parties in their cluster in order to access the knowledge and capabilities needed to develop successful technological innovations.

The list further includes a number of variables that can be associated with internal learning. The positive significance of RD_MY suggests that firms that invest more in R&D exhibit higher organisation- and commercial capabilities for successful innovation than others. The significance of EDU_DUM points to the relevance of postgraduate education (MSc and/or PhD level) for effective organisation and successful innovation commercialisation. Furthermore, firms that are characterised by a large variation in terms of the number of prior workplaces of their employees (EXPER_VAR_F), perform better on organisation- and commercialisation-aspects of innovation than firms that are more homogeneous in this respect.

Table 6: OLS Regression Results for Organisation & Commercial Innovation Performance (ORG/COM_INN)

Explanatory Variables	Regression A		Regression B	
	Standardized Beta Coefficients		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	-0.086	(-0.811)		
EDU_VAR	-0.182	(-1.347)		
EDU_DUM	0.338	(2.252)**	0.203	(2.466)**
EDU_F	-0.054	(-0.552)		
EXPER_Y	0.124	(0.790)		
EXPER_VAR_Y	0.071	(0.612)		
EXPER_FIRMS	-0.057	(-0.527)		
EXPER_VAR_F	0.236	(2.423)**	0.197	(2.347)**
AGE	0.221	(1.346)	0.343	(4.094)***
SIZE	-0.038	(-0.369)		
Intercept				
N	97		97	
Adj. R2	0.396		0.431	

Note: t-values in parenthesis; ***p<.01, **p<.05, *p<.10

In contrast to Table 5, AGE is significant with a positive sign with respect to ORG/COM_INN. Older firms apparently exhibit higher organisational and commercial capabilities for innovation than younger firms. This suggests that firms accumulate marketing and organisational capabilities over the years, enhancing their performance. So, while older firms become relatively less active in producing technological innovations (see Table 5), younger firms are behind them in terms of organisation and commercialisation skills.

Examination of the beta coefficients shows that LKS – in this case, through firm spin-offs) are stronger predictors of the organisational/commercial innovation performance of the software firms in Montevideo than any other type of external knowledge flow. Besides, the coefficients clearly point to the importance of internal absorptive capacity and internal learning as determinants of this aspect of innovation performance. R&D capacity, higher university education and, especially, experience matter a great deal.

6. Conclusions

In this paper we investigated the significance of a particular mechanism of knowledge diffusion, local knowledge spillovers (LKS), in an economically less developed country. Using new firm-level data about software firms clustered in Montevideo, we tried to find evidence that LKS occur, and that they have a positive effect on the innovation performance of these companies. Our results show that LKS do indeed occur, and also that they matter for the firms' innovation performance. We 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, our econometric analysis suggests that all these mechanisms of knowledge transmission have a significant impact on the innovative performance of the firms. To the extent that it would be possible to generalise based on a case-study, we tentatively conclude that the role played by LKS in knowledge-intensive sectors in the Latin American context is quite similar to what has been found for high-tech clusters in economically advanced countries.

Our methodology, a firm-level survey intent on capturing directly different types of knowledge flow and a range of innovation performance aspects, also yielded more detailed insights. In particular, it emerged that different mechanisms of LKS appear to be important for different aspects of the firms' innovation performance. Labour mobility and informal interactions matter for *technological* innovation performance, while firm formation through spin-offs positively influence *organisational and commercialisation* capacity.

We also found that the role played by LKS is very important relative to other mechanisms of knowledge flow in the cluster. In fact, its impact on technological innovation performance of the firms dominates all other sources of knowledge in our econometric results. With respect to organisational/commercial aspects of the firms' innovation performance, we can conclude that LKS emerges as the most important external knowledge mechanism, alongside crucial internal sources of learning.

On the basis of our results we have reason to challenge the dominant focus on channels of international knowledge transmission in the literature about technological change in developing countries. Our findings indicate that international knowledge flows do matter, because they are the conduit for the transfer of international knowledge related to market trends and customer needs. However, local knowledge spillovers appear to matter even more. Clearly, then, there is a need for studies with a broad scope that will assess firms' knowledge acquisition activities from an integral perspective, so as to capture all possible knowledge flows irrespective of their source locations. We view this study as a starting point for this type of work.

This study is also set apart from previous studies about clusters in developing countries. Although writers in this line do acknowledge the importance of cluster advantages, they did not separate out (both theoretically and empirically) the different types agglomeration advantages, and the different channels and mechanisms through which these impinge upon firms' technological and economic performance. In particular, there is no clear distinction between knowledge-related advantages and scale and scope-related pecuniary advantages in clusters. The introduction of the theoretical concept of LKS and the adoption of an innovation survey methodology has made it possible for us to focus squarely on knowledge flows and their impact. More importantly, in this way we were able to also single out LKS from other knowledge flows, and examine in a quantitative manner their relative importance for the innovative performance of the firms in our sample.

Our findings have a number of policy implications. Policies supporting LKS in developed economies encompass mainly government subsidies towards universities and firms that conduct substantial R&D. These policies have come under criticism because of the extensive role played by the state, and its potential failure in allocating resources efficiently. Yet, there is considerable evidence that developmental states have played a major role in enhancing the human capital and the capabilities of their countries in the past, negotiating with international capitalists, attracting investment, and forwarding investment into dynamic technology-intensive sectors with high growth potential (Amsden, 2001; Kesidou, 2004). Our research points to the potential of LKS as a path towards learning, innovation, and economic development of developing countries, including small ones. Awareness of the importance of LKS for innovation is thus crucial for drawing up policies that enhance accumulation and circulation of knowledge. With this awareness, a developmental state can harness the knowledge transmission benefits associated with labour mobility, informal interactions of agents and firms spin-offs. In the case of the software cluster in Uruguay, this means continued investments in education for the formation of highly-skilled employees, endowment of more R&D subsidies, and facilitating labour mobility by relaxing labour laws, especially for SMEs.

Figure 1: Conceptual Framework

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