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Local Knowledge Spillovers, Innovation and Economic Performance in Developing Countries: A discussion of alternative specifications

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Abstract
This paper examines the importance of local knowledge spillovers for the innovative and economic performance of firms in a developing country context. Theoretical and empirical studies in advanced economies underline the significance of local knowledge spillovers for innovation. However, not much is known about whether local knowledge spillovers work similarly in developing countries. This analysis is based on an original innovation survey in the software industry in Uruguay. The survey focuses on the direct identification and measurement of local knowledge spillovers; pure knowledge spillovers are distinguished from commercial knowledge transactions. Both knowledge spillovers and knowledge transactions are measured at the local and at the international level. The study concludes that local knowledge spillovers play a crucial role in enhancing the innovative performance of software firms in Uruguay. However, for the economic performance of the firms, international knowledge transactions turn out to be more important than local knowledge spillovers. Local Knowledge Spillovers may be essential for innovation, but not sufficient for economic success. Firms in developing countries need to be connected to both the local and the international economy.

Keywords*:* local knowledge spillovers, innovation, economic performance, developing economies
JEL Codes: L86 (Information and Internet Services, Computer Software), O31 (Innovation and Invention); O33 (Technological change: Choices and Consequences; Diffusion Processes)

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Introduction

This working paper examines the relationships between local knowledge spillovers, innovation and economic performance of firms in clusters in developing countries[1]. A key hypothesis in the literature on Local Knowledge Spillovers (LKS) states that local knowledge spillovers are the main reason for the increased innovative and economic performance of the firms in clusters and/or regions in the advanced economies (Saxenian, 1994). Local knowledge spillovers in developing countries have so far received less attention. The objective of this paper is to examine the role of local knowledge spillovers in the innovative and economic performance of firms in clusters in the context of developing countries. In this paper, we focus on the software industry in Uruguay, analysing data from a survey specifically designed to address these issues.

The literatures on Economic Geography (Jaffe et al., 1993; Audretsch and Feldman, 1996), New Industrial Spaces (Saxenian, 1994; Storper, 1995; Scott, 2001, 2004), Innovative Milieu (Aydalot, 1986; Camagni, 1991), and Regional Systems of Innovation (Morgan, 1997; Keeble and Wilkinson, 1998; Lawson and Lorenz, 1999; Cooke, 2001) view local knowledge spillovers as the driving force behind the increased innovative and economic performance of firms in clusters and/or regions. The importance of local knowledge spillovers for innovation is derived from the tacit nature of knowledge. The fact that tacit knowledge is experienced-based and context-specific means that it cannot easily be transferred over long distances (Polanyi, 1966). It can only be assimilated by observation and face-to-face interaction, and will primarily spill over to firms located in the vicinity. This is why geographic proximity facilitates innovation: it enables the diffusion of tacit knowledge through face-to-face contact.

Research on clusters in developing countries underlines the significance of geographic proximity (Schmitz, 1995; Rabellotti, 1995; Nadvi, 1996; Visser, 1999; Cassiolato and Lastres, 1999). However, various advantages of agglomeration are usually examined as an undifferentiated phenomenon, lumping together economies of scale and scope, labour market advantages, infrastructural advantages, specialisation advantages and knowledge flows. Little attention is paid to the specific role of local knowledge spillovers as one of the important agglomeration advantages.

Such local knowledge spillovers are the central focus of this paper. In order to highlight the effects of local knowledge spillovers, they are distinguished from other types of knowledge flows such as international knowledge spillovers and [local and international] commercial knowledge transactions (Kesidou and Romijn, 2006, 2009).

We are not only interested in the relationships between spillovers and innovative performance. The relevance of innovative performance lies in the fact that it is presumably associated with improved economic performance. Therefore a second focus of the paper is on the direct and indirect effects of local knowledge spillovers

[1] It serves as a background to a shorter article with the same title forthcoming in the European Journal of Development Research (Kesidou and Szirmai, 2008). The working paper presents a wide range of alternative specifications of the regression models, from which the final specifications presented in the journal article were selected.

on economic performance. In this paper we focus specifically on two dimensions of the economic performance: export performance and productivity.

The following three research questions will be explored: (RQ1) to what extent do the internal learning mechanisms and absorptive capacities of firms influence their ability to acquire knowledge from external sources? (RQ2) how important are local knowledge spillovers for the innovative performance of firms, compared to other mechanisms of external learning? (RQ3) to what extent do local knowledge spillovers directly or indirectly affect the economic performance of firms, in comparison with other mechanisms of external earning?

Theoretical Insights and the Conceptual Framework

The literature on Local Knowledge Spillovers in advanced economies provides many insights into their contribution to the innovation of firms within clusters and/or regions (Jaffe et al., 1993; Saxenian, 1994; Audretsch and Feldman, 1996). However, important gaps still remain in this literature.

Local versus international knowledge flows

In the first place, it is problematic that studies have traditionally focused only on local knowledge advantages, while underestimating the importance of international knowledge linkages. Current studies (Simmie, 2003; Bathelt et al, 2004; Owen-Smith and Powell, 2004) call attention to the fact that innovative clusters and/or regions in advanced economies cannot be self-sufficient. They emphasize the importance of external linkages, the so-called 'trans-local pipelines'. Non-local linkages, 'pipelines', constitute channels for the entry of new information regarding markets and technologies into the cluster (Bathelt et al., 2004). This new knowledge is transmitted rapidly to the firms within the cluster through the function of knowledge spillovers. Simmie (2003) examined the interface of local and global knowledge flows in the United Kingdom. He found that, innovative firms are concentrated in a few locations (thus confirming the importance of regions/clusters). 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 more important for obtaining leading edge knowledge concerning market trends than for obtaining technological information. Technological knowledge is predominantly tacit and circulates best at the 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). 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.

In contrast to the advanced country literature on Local Knowledge Spillovers, the literature on Technology Transfer to developing countries has long ago recognised the importance of accessing and absorbing international knowledge (Evenson and Westphal, 1995; Szirmai, 2005, 2008). In particular, the literatures on Technology Transfer (Enos, 1989) and New Trade Theory (Coe at al., 1997; Jacob and Szirmai,

2007) underline the fact that the main sources of technological progress in less developed countries originate in the external domain. But, as indicated above, the literature on developing countries has paid insufficient attention to local knowledge spillovers. This provided the grounds for our decision to examine the relative importance of local knowledge spillovers versus international knowledge linkages in this paper.

Spillovers and economic performance

A second gap in the literature is that research on Local Knowledge Spillovers in advanced economies offers little evidence on whether LKS affect the economic performance of firms, directly or indirectly (through innovation). Though studies on the economics of innovation have established the link between innovation and productivity (Griliches, 1988), it is still not clear how LKS affect the economic performance of firms within clusters.

Agglomeration advantages and knowledge spillovers

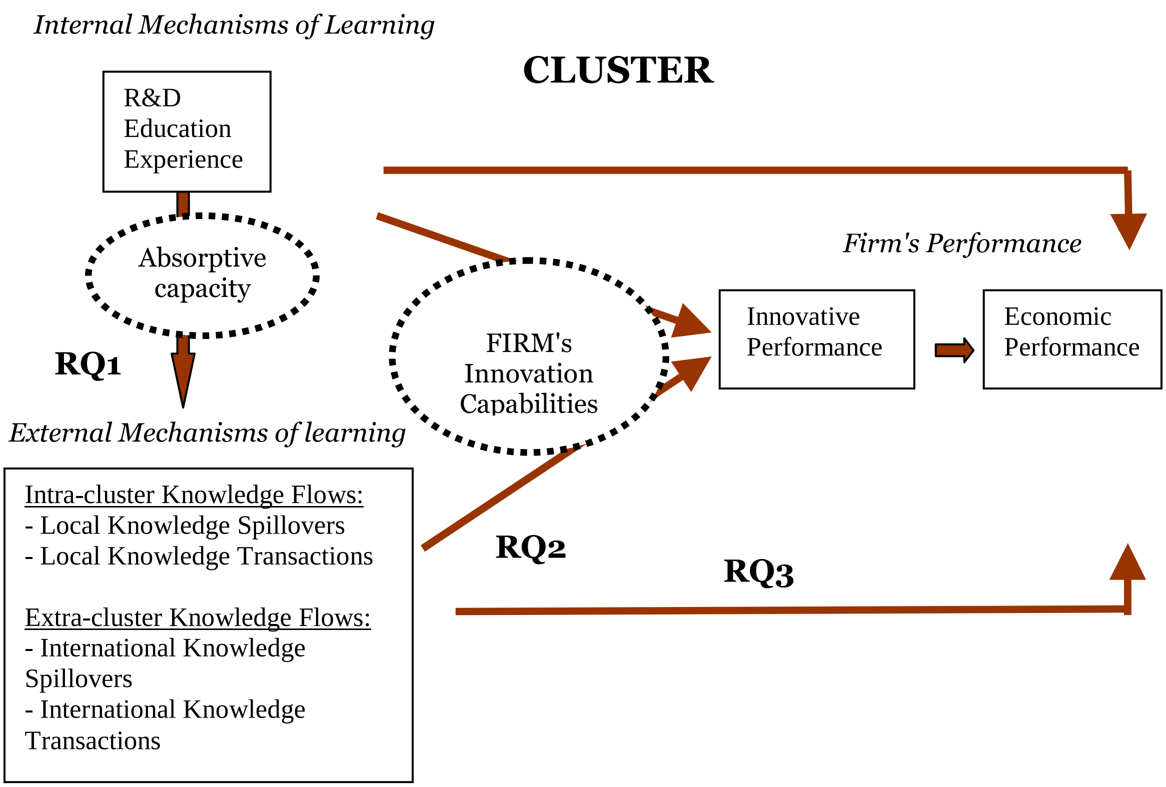
In the third place, the literature on Industrial Clusters in developing countries has offered evidence on the importance of agglomeration advantages for the technological and economic progress of firms in LDCs (Rabellotti, 1995; Nadvi, 1996; Schmitz, 1995, 1999; Visser, 1999). However, this literature does not make a clear distinction between knowledge spillovers and cost advantages. Neither does it differentiate between innovative and economic performance. Based on insights derived from this literature, this paper explicitly focuses on knowledge spillovers. It makes a distinction between *local knowledge spillovers* and *local knowledge transactions*. Spillovers refer to the free flow of knowledge. Knowledge transactions refer to formal flows of knowledge through market transactions. Next, we make a clear distinction between our ultimate dependent variables measuring the *economic performance* of firms and intermediate variables measuring the *innovative performance* of firms.

Internal learning and absorptive capacities

Finally, the literatures on Absorptive Capacities and Technological Capabilities have shown 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 (Dahlman and Westphal, 1981; Lall, 1992; Bell and Pavitt, 1993; Cohen and Levinthal, 1990; Romijn, 1999). 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. Based on the insights provided by the aforementioned literatures, we have developed the conceptual framework, summarised in Figure 1.

In this figure the square boxes refer to measured independent, intermediate and dependent variables. The ovals refer to latent concepts - innovation capabilities and absorptive capacity - which are not directly measured. The framework allows us to examine: (1) the impact of the internal learning mechanisms of the firm upon its ability to acquire external knowledge via external mechanisms of learning; (2) the relative impact of local knowledge spillovers [compared to the three other types of knowledge flows: local knowledge transactions, international knowledge spillovers and international knowledge transactions] upon the innovative performance of the firms; (3) 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. Local knowledge spillovers can affect economic performance both directly and indirectly via innovative performance. In the empirical analysis, the paper will primarily focus on two specific aspects of the wider concept of economic performance, namely export performance and sales per worker. Other dimensions of economic performance are explored in Appendix B.

Figure 1: Conceptual Framework - Local Knowledge Spillovers, Innovation & Economic Performance



Source: Authors

Data and Methods

A variety of methods have been used to analyse local knowledge spillovers (e.g. Jaffe et al, 1993; Cassiman and Veugelers, 2002; Mohnen and Hoareau, 2003; Bell and Pavitt, 1993). In view of the scarcity of secondary data, the specific nature of innovation in a developing country context and the need for detailed information regarding firms' innovative activities, we opted for an in depth case study of one cluster in order to examine the aforementioned research questions. We chose the case of the software cluster in Montevideo, Uruguay. This cluster offers an interesting example of high-tech activities in a developing country context. Research in advanced economies suggests that knowledge spillovers are especially important in knowledge intensive industries.

In the past 10-15 years, the software sector has emerged in many developing countries, and is currently expanding steadily. In the specific case of Montevideo, the cluster is dynamic, both in terms of technology and economic performance. The Uruguayan software cluster was also selected because it is export intensive, thus being useful for the comparison of the importance of local versus international knowledge flows.

A field study was conducted in the software cluster in Montevideo, using a tailor-made questionnaire. During the research trip, we carried out an Innovation Survey through face-to-face interviews with the majority of the software firms in the cluster (Kesidou, 2007). We followed the methodology of the Community Innovation Surveys (CIS), but made several changes and adaptations in order to adjust the questionnaire to the needs of the software sector (which includes service firms alongside manufacturing firms) and to the peculiarities of a developing country (see appendix A for the survey questions).

Of the full population of 150 firms in the Montevideo software cluster, 98 firms participated in the survey (a 65 per cent response rate). All of the large, medium and small firms participated. The non-responding firms were mainly micro firms (with less than 10 employees). Nevertheless, micro firms were well represented in the sample. 50 of the total of 103 micro firms participated in the survey (48.5 per cent). Our sample is therefore an adequate representation of the firm population.

Table 1 presents operationalisations of the concepts of figure 1. All the variables have been constructed from the responses to the survey. The first column shows the symbols of the variables while the second column contains the variable names. The third column provides a brief description of the variables while columns four and fifth present the descriptive statistics.

One set of variables captures different aspects of the economic performance of the firms: sales, sales per employee, exports, export intensity, and growth of sales, exports and employment. To measure the innovative performance of firms we rely partly on variables that have been used in the CIS (i.e. product/service new to the market, sales of innovation output). We have also introduced some new variables in order to represent adequately the innovative performance of software firms in a developing country context. The variable 'product/service changed substantially' captures innovations that are new to the firm, but not to the market. Software firms only develop a few products. Their innovative efforts result in new versions and variations of these products which address emerging market and technology trends. This is reflected in the variable 'number of innovations' which captures the efforts of the firm to adjust its products to current market and technology conditions.

Table 1: List of Variables

Symbol	Variables	Definition/Measurement	Summary	Statistics
Economic Performance			Mean	Std. Deviation
SALES	Sales	This is a continuous variable, which denotes the sales of software products/services (P/S) of firms in US dollars in 2004.	2,306,891	8,639,197
SALES_GR	Growth of Sales	This variable denotes the growth of the sales of software (P/S) during the period 1999-2004.	9.29	29.04
SALES_EMPL	Sales per Employee	This variable measures the sales of the firm divided by the number of its employees in 2004.	78,436	344,934
EXPORTS	Exports	This is a continuous variable, which denotes the exports of software (P/S) of each firm in US dollars in 2004.	1,037,733	3,883,531
EXPORTS_GR	Exports Growth	This variable denotes the growth of the exports of software (P/S) of each firm during the period 1999-2004.	37.09	96.68
EXPORTS_INTENS	Share of exports in sales	This variable indicates the percentage of sales directed to foreign markets in 2004	0.27	0.36
EMPL_GR	Growth of employment	This variable takes into account the growth of the employment of each firm during the period 1999-2004.	12.74	31.54
LATENT FACTORS		*Derived from principal component analysis*		
EXP_PERFORM	Export performance	This factor denotes the size of the exports and the export intensity of a firm.	0.12	1.06
EC_GROWTH	Economic growth	This factor indicates the growth of the sales, exports and employment.	0.007	1.05
L_PERFORM	Level of performance	This factor indicates the volume of the sales and the sales per employee.	0.005	1.08
Innovative Performance				
NEW_PS	Product/Service - New to the Market	Binary variable which takes the value =1, if the firm introduced a product/service (P/S) new to the market during the period 1999-2004, and =0, otherwise	0.52	0.50
CHANGE_PS	Product/ Service – Changed Substantially	Binary variable which takes the value =1, if the firm substantially changed (P/S) during the period 1999-2004, and =0, otherwise.	0.70	0.46
SALES_INNOV	Sales of Innovation Output	Indicates the percentage of sales that derived from (P/S) innovations in 2004.	0.44	0.37
NO_INNOV	Number of Innovations	This is a continuous variable that considers the quantity of (P/S) innovations that each firm	4	2.90

		has produced during the period 1999-2004.		
LATENT FACTORS		*Derived from principal component analysis*		
TECH_INN	Technological Innovation	This factor indicates the capability of the firm to create or change P/S based on technological and/or scientific advancements.	0	1
MARK_INN	Marketing/ Organisational Innovation	This factor indicates the capability of the firm to follow the market requirements (quality), trends and strategies and successfully commercialise its products and services.	0	1
External Learning				
LKS_S	Local Knowledge Spillovers through Spin-off	Dummy variable which takes the value =1, if a firm is a spin-off of a university or MNC located within the cluster, and = 0, otherwise.	0.48	0.50
LKS_L	Local Knowledge Spillovers through Labour Mobility	This variable denotes the percentage of employees in a firm that had come from other firms within the cluster during the period 1999-2004. It is measured by the Inflow Rate: $R(in)_t = \Sigma\ im_{t-1} / N_{t-}$.	0.35	0.31
LKS_I	Local Knowledge Spillovers through Interaction	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.	6.09	3.90
LKT	Local Knowledge Transactions	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from local transactions.	9.10	4.51
IKS	International Knowledge Spillovers	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge arising from non-pecuniary interactions among local and international actors.	5.94	3.79
IKT	International Knowledge Transactions	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from transactions among local and international actors.	5.40	4.36
Internal Learning				
R&D_MY	Research and Development Man-years	R&D effort measured in man-years. It measures the cumulative R&D efforts of the firm during the period 1999-2004.	10.42	10.25
R&D_INTENS	Research and Development Intensity	This variable denotes the percentage of the firm's labour force that carried out R&D in	0.36	0.36

		2004.		
EDU	Education Index	Indicates the level of education of the employees of the firm.	4.75	0.59
EDU_VAR	Diversification in Education	Ordinal variable which denotes the diversification of the education levels of the employees of a firm.	1.76	0.75
EDU_DUM	Postgraduate education	Dummy variable which takes the value =1, if a firm has any employees with MSc or PhD degrees, and =0, otherwise.	0.27	0.44
EDU_F	Foreign Education	This variable denotes the percentage of employees who acquired a university degree abroad.	0.07	0.16
EXPER_Y	Years of Experience Index	Indicates the average years of experience in the software sector of the employees of each firm.	5.23	2.50
EXPER_ VAR_Y	Diversification of Experience	Ordinal variable which denotes the diversification of the experience of the employees with the firm	2.20	1.19
EXPER_ FIRMS	Experience in Firms Index	Indicates the average number. of firms the employees of a firm have worked in, in the past.	1.69	1.28
EXPER_ VAR_F	Diversification of Experience in No. Firms	Ordinal variable which denotes the diversification of the No. of firms including the present one, for which employees of the firm have worked.	2.11	0.84
AGE	Age	Firm’s age (reference year 2004).	12.47	9.37
SIZE	Size	Firm size as measured by number of employees in 2004.	24.05	40.05

The independent variables measure the external and internal learning activities of the firm. Based on the examination of the existing literature on local knowledge spillovers we assume that local knowledge spillovers arise through spin-off firm formation (Zucker et al, 1998), labour mobility (Alemeida and Kogut, 1999; Audretsch and Feldman, 1996), and finally interaction of local actors (Saxenian, 1994; Allen, 1983; von Hippel, 1987; Harhoff et al, 2003). Besides local knowledge spillovers we attempt to capture knowledge flows that derive from local market transactions (LKT). In addition, we consider the knowledge flows from abroad in the form of international market transactions (IKT) and international knowledge spillovers (IKS). We consider various variables that denote the internal learning activities (i.e. research and development) and the absorptive capacity of the firm (i.e. education and experience).

Further discussion of the operationalisations

The variable knowledge spillovers through labour mobility (LKS_L) is measured by the Inflow Rate $R(in)t = \Sigma\, im_{t-1} / N_t$, which indicates the total number of workers who have left other firms to join the present firm in the year previous to year t divided by the total number of workers employed by the firm in year t (Virtaharju and Åkerblom, 2003).

The four external learning variables LKS_I, LKT, IKS, IKT are all constructed variables indicating the importance of different types of knowledge flows. The responding firms were asked 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). We 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).

The firms were also requested to report where the sources of knowledge that they use were geographically located (Local or International). Finally, firms were asked to classify the type of relationship between their firm and each source of knowledge that they use into two categories: Formal transaction relationships or Informal relationships not involving transactions).

Using the three attributes (Importance, Location, and Type of the relationship) we constructed the variables that denote the importance of the knowledge arising from various types of interactions. For instance, the international knowledge transactions (IKT) variable was constructed as follows: for every case (firm) we 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 the categories: Group, New Personnel, Customers and Suppliers were classified as formal. Even though user-producer interaction is not a strictly transaction-based relation, the knowledge flow between a firm and its suppliers or customers is the result of a formal market transactions and thus it is treated as a pecuniary knowledge flow. In contrast, all the relations between firms with Competitors are informal and thus are considered to give rise to knowledge spillovers. Likewise the acquisition of Electronic Information is generally free of charge and thus is considered as a knowledge spillover. The relations of firms with the categories Vertically connected firms, Consultants, Research Institutes, Universities, Innovation Centres, Sector Institutes and Exhibitions, are 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. The mode of conducting the survey in face-to-face interviews allowed us to clarify the precise nature of the interaction and to classify these categories on a case by case basis as either spillovers or transactions.

Each transaction variable (LKT and IKT) has a range from 0 to 44. The maximum value of the IKT variable for instance, would be 44, if a respondent would give the value of 4 (crucial) to all eleven sources of knowledge, all of which are acquired through market transactions from abroad. Each spillover variable (LKS and IKS) has a range from 0 to 36. For example the maximum value of the IKS variable would be 36 if a respondent would give the value of 4 to all nine sources of knowledge, all of which are acquired informally from abroad.

The educational index (EDU) is constructed based on the characteristics of educational systems in Latin America and of the software sector in particular. All employees in the cluster of Montevideo have completed their secondary education. The percentage of workers with only secondary education receives a weight of 1. Vocational or technical training has a duration of three years. Therefore we assign a weight of three to the percentage of employees with vocational training. University education in Latin America provides the graduates with a degree, the so-called 'Licenciatura' after the completion of a five year curriculum. A master's degree takes an additional 2 years and a PhD degree is awarded after an additional 4 years on top of the MSc. Hence, we calculated the Education Index as follows: for each firm, the percentage of the employees with vocational education is multiplied by 3. The percentage of employees with a BSc is multiplied by 5, the percentage of employees with MSc is multiplied by 7 and 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.

The variable EDU_VAR measures the variation in educational levels within the firm. With the same average level of education a firm with a high score on EDU-VAR will have more extremely highly schooled workers and less schooled workers. For example, when 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.[2] The same method is used to construct the ordinal variable EXPER_VAR_Y, which measures the variation of work experience in the software sector and the ordinal variable EXPER_VAR_F, which measures the variation of the number of previous firms in which workers were employed.

The variable EXPER_Y indicates the weighted 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. The aggregate of all these scores denotes the weighted average experience level of the employees of each firm.

EXPER_FIRMS is a second indicator of work experience. This variable 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

[2] The weights are based on ad hoc evaluations by the researchers.

experience level of the employees of the firm in terms of the number of previous occupations held by them.

Empirical Analysis

Factor Analysis: Economic and Innovative Performance Indicators

We use factor analysis for the economic performance variables for purposes of data reduction. Before carrying out the factor analysis, the variables are standardized, to account for the different units of measurement of the variables. Three factors explain approximately 80 per cent of the cumulative variance of the seven variables. Table 2 presents the three components and the variables that explain them. The first factor is explained by export revenues and by the export intensity of the firm. This factor is called export performance. The second factor is explained by the growth of sales, exports and employment. This factor is named economic growth since it represents those firms that grow rapidly. Finally, the third 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.

The three factors can be used as the dependent variables in the regression analysis. Their names are:

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

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

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

Table 2: Economic Performance Components

	Component		
	1 Export Performance	2 Economic Growth	3 Level of Performance
EXPORTS	0.679	0.213	0.530
EXPORTS_INTENS	0.858	0.055	-0.054
SALES	0.191	0.061	0.976
SALES_EMPL	-0.096	-0.028	0.955
SALES_GR	0.179	0.911	0.000
EXPORTS_GR	-0.140	0.689	0.061
EMPL_GR	0.293	0.761	0.012

We also examine whether the innovative performance of the firm can be measured using less than four variables. We again apply principal factor analysis. Factor analysis is useful for the purpose of this study because it allows us to transform dummy variables (i.e. NEW_PS) into variables measured at an interval level. The latter are essential for the use of system method estimation.

Two factors explain approximately 68 per cent of the cumulative variance of the variables. Table 3 exhibits the factor loadings of each innovation variable on the two factors. The first factor is explained mainly by the variables NEW_PS and CHANGE_PS. NEW_PS is an indicator of the uniqueness of the product in the market. 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 mainly technological changes: firms applied new scientific or technological knowledge into their products or adapted their products to the needs of the customer.

The second factor is explained by the variables SALES_INNOV and NO_INNOV. 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.

The variable NO_INNOV denotes the number of innovations that a firm produces. In the software industry, a firm commonly holds only a few products and then produces numerous versions of them. NO-INNOV captures these versions. 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.

Table 3: Innovation Components

	Components	
	1 Technological Innovation	2 Marketing Capability
NEW_PS	0.898	0.025
CHANGE_PS	0.918	0.049
SALES_INNOV	0.156	0.607
NO_INNOV	-0.118	0.807

We 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 capabilities with regard to innovative 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: The marketing capability factor indicates the ability of the firm to follow the market requirements, trends and strategies and successfully commercialise its innovative products and services.

System Method Estimation

Previous theoretical and empirical work has shown that innovation depends on external and internal learning (section 2). Additionally, the literature suggests that external learning may also be contingent upon the internal learning activities of the firm (Cohen and Levinthal, 1990; Lall, 1992). Based on this literature we have reasons to believe that innovation and external learning are not exogenous variables[3]. We therefore use simultaneous regression techniques to estimate equations referring to the three key research questions formulated in the introduction. The questions refer (1) to the impact of internal learning mechanisms (absorptive capacity) upon external knowledge flows; (2) to the impact of LKS upon innovative performance; and (3) to the direct or indirect impact of LKS upon economic performance.

In the following models, the economic performance of the firm is a function of the innovative performance, external learning and internal learning. The innovative performance of the firm is a function of external and internal learning. Finally, external leaning depends on internal learning. These concepts have been operationalised in a variety of ways by the variables in Table 1. Different dimensions of *Economic performance* can be operationalised by the factors in Table 2, namely export performance, level of performance or growth performance. But we have also done runs using the original variables in Table 1 such as export growth or sales per employee as the dependent variables. Similarly, *Innovative performance* can be operationalised by the factors technological innovation and marketing capability or by the original variables. In the empirical analysis various alternative specifications have been examined. In the current paper we present: A. Three models with the factor Export Performance as the indicator of economic performance in table 4. The export performance factor explains 37 per cent of the total variance of the seven economic performance variables. B. Three models with the original variable Sales per Employee as the indicator of economic performance in table 5[4] These models have been selected from a wide range of alternative specifications. Model specifications with Export Growth or Growth of Sales as dependent variables have been reproduced in Appendix B.

Three-stage least squares (3SLS) is used, which permits the parameters of all three equations to be estimated simultaneously[5]. This is a system method of estimation which is also referred to as a full information method, because it takes into account information from all equations at the same time. 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, 2003).

A. Export Performance

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[3] We tested for the endogeneity of the innovation and external learning variables and we found that TECH_INN, MARK_INN and IKT are endogenously determined, while IKS, LKT, LKS_I, LKS_S and LKS_L are exogenous variables.

[4] We used the original variable Sales per Employee as dependent variable, rather than the extracted factor L-Perform. One of the variables with high factor loadings on the extracted factor L-PERFORM is sales volume (SALES). One of the important independent variables is firm size. It would be tautological to regress a factor including sales volume on employment size (SIZE).

[5] STATA 10 Statistical Software is used for this analysis.

In this system, export performance (EXP_PERFORM) is the dependent variable. Technological innovation (TECH_INN), marketing capability (MARK_INN) and international knowledge transactions (IKT) are endogenous variables. In table 4, we compare models using two different dimensions of innovative performance - technological innovation and marketing capability - as the endogenous variables. We apply the 3SLS method in three subsequent steps:

The first step is to find instrumental variables for TECH_INN, MARK-INN and IKT. The instrumental variable for TECH_INN should be highly correlated with TECH_INN but should not determine EXP_PERFORM (idem for the instrumental variables of MARK_IN and IKT). The second step is to regress TECH_INN, MARK_INN and IKT on all the exogenous variables. Then we save the predicted values pre_TECH_INN and pre_MARK_INN, pre_IKT. The third step is to use these predictions (pre_TECH_INN, pre-MARK_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, 2003).

Table 4 reports the results of the system estimation analysis. Three models are reproduced using different combinations of the independent and intervening variables. Model 1 systematically tests the importance of local knowledge spillovers upon the economic performance of the firms, using TECH_INN as intervening variable. However, none of the indicators of LKS exhibit a significant impact upon EXP_PERFORM. We perform the Wald test for the EXP_PERFORM equation only, in order to test the null hypothesis that the variables LKS_I, LKS_L, LKS_S and IKS jointly do not affect EXP_PERFORM (Greene, 2003, p. 484). The Chi-square is insignificant, which means that we cannot reject the null hypothesis[6]. We drop these variables and thus get model 2. Model 2 satisfies the rank condition for identification which is a necessary and sufficient condition (Greene, 2003; Maddala, 2001; see Table C1 in Appendix C).

It is important to examine whether the instruments used in the 3SLS of model 2 are adequate. Weak instruments do not predict much variation in the dependent variable. Taking the reduced form regression we can evaluate the explanatory power of the instruments by applying an F-test. Stock and Yogo (2002) suggest that instruments are good when the F-test is above the critical value of 10. We first regressed TECH_INN on all the exogenous variables and then conducted the F-test. The F-test is statistically significant [F(3,89) = 11.14; Prob > F = 0.0000] and above the critical value of 10. We then apply the F-test for the reduced form equation of IKT. The F-test is statistical significant and well above the critical value [F(2,90) = 12.63; Prob > F = 0.0011].

We also test the impact of MARK_INN upon EXP_PERFORM in model 3 (we test the rank condition in Appendix C, Table C2). As in the case of model 2, we run tests for the adequacy of the instruments. We took the reduced form equation of MARK_INN in order to test the strength of the instrumental variables. The F-test was

[6] Chi2 (3) = 0.88; Prob > chi2 = 0.8301.

statistically significant and its value well above the critical value [F(4,88) = 12.48; Prob > F = 0.0002]. We then tested the instrumental variables for the IKT equation. The F-test was statistically significant and above the critical value [F(2,90) = 11.33; Prob > F = 0.0023].

In contrast to TECH_INN, Marketing Capability (MARK_INN) does not significantly affect the export performance of the firm. This shows that different aspects of innovation affect firm performance in different ways. In particular, technological innovation has a positive and significant impact upon export performance. Marketing capability also has a positive effect, but it is statistically not significant. An important finding of Model 3 is that local knowledge spillovers through spin-offs (LKS_S) positively affect the marketing capability of the firms.

We further examine our preferred model 2. There are 67 observations for the model of system equations in Table 4. Not all firms were willing to provide information regarding their economic performance. However, for the other variables, we have 97 observations. We tested the sub-system of TECH_INN and IKT to see whether the results are consistent with those of the full model and found that this was the case (see Appendix D).This suggests that the missing observations in the full model have not produced biased results. The results of model 2 can be interpreted as follows:

Concerning the EXP_PERFORM sub-system, we note that TECH_INN affects EXP_PERFORM 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_PERFORM. This implies that those firms that use local knowledge transactions intensively export less than those firms that use local knowledge transactions less intensively. Firms which are too strongly embedded in the local system of innovation are not the firms that are oriented to the outside world. Third, IKT has a positive and significant impact upon EXP_PERFORM. 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_PERFORM negatively. This implies that firms that exhibit a large diversification in the educational level of their employees export less than firms which are more homogeneous in terms of education. Fifth, SIZE has a positive impact upon EXP_PERFORM. Large firms export more than small firms.

Table 4: 3SLS estimation of the Export Performance models

Variables	Model 1		Model 2		Model 3	
	beta [a]	**(t-values)** [b]	**beta**	**(t-values)**	**beta**	**(t-values)**
Economic Performance						
EXP_PERFORM						
TECH_INN[c]	0.527	(2.37)**	0.392	(2.30)**		
MARK_INN[c]					0.015	(0.38)
LKS_I	-0.024	(-0.23)				
LKS_L	-0.078	(-0.57)				
LKS_S	-0.054	(-0.64)				
LKT	-0.234	(-2.36)**	-0.224	(-2.97)***	-0.188	(-2.16)**
IKT[c]	0.561	(1.97)	0.451	(2.63)**		
IKS	0.024	(0.26)				
RD_INTENS					0.102	(0.81)
EXPER_FIRMS					0.110	(1.08)
EDU_VAR	-0.328	(-3.11)***	-0.314	(-3.51)***		
SIZE	0.422	(4.03)***	0.458	(5.18)***	0.582	(6.85)***
Innovative Performance						
TECH_INN	TECH_INN		TECH_INN			
MARK_INN					MARK_INN	
LKS_I	0.283	(2.72)***	0.277	(2.74)***		
LKS_L	0.260	(2.50)* *	0.248	(2.43)**		
LKS_S					0.370	(3.79)***
RD_MY					0.259	(3.03)***
EDU_DUM					0.249	(2.68)***
EXPER_Y	-0.288	(-2.92)***	-0.297	(-3.11)***		
AGE					0.330	(3.60)***
External Mechanisms of Learning						
IKT						
RD_MY	0.324	(3.26)***	0.331	(3.36)***	0.284	(2.882)***
SIZE	0.268	(2.79)***	0.266	(2.77)***	0.291	(3.02)***
No. of Observations		67		67		67
Chi2 (model1)[d]		107.24		98.98		59.52
Chi2 (model 2)		20.04		20.68		44.29
Chi2 (model 3)		25.33		25.36		22.51
P1		0.0000		0.0000		0.0000
P2		0.0002		0.0002		0.0000
P3		0.0000		0.0000		0.0000

[a] Standardised coefficients (beta).
[b] t-values in parenthesis; ***p<.01, **p<.05, *p<.10
[c] Predicted values
[d] The Chi-squared-test provides the probability value for the Ch2-test of H_0: The regressors are jointly insignificant.
-3-stage least squares: Endogenous Variables: EXP_PERFORM, TECH_INN, MARK_INN, IKT. Exogenous Variables: LKT, EDU_VAR, SIZE, LKS_I, LKS_L, EXPER_Y, RD_MY.
Source: Authors computations based on authors' survey.

The standardised coefficients[7] are used to evaluate the relative importance of local knowledge spillovers for the innovative performance and the export performance of firms within the Montevideo cluster. Local knowledge spillovers do not have a direct impact upon EXP_PERFORM, though they do have an indirect effect through TECH_INN. Consequently, among the various mechanisms of external (to the firm) knowledge flows, it is IKT which exhibits the strongest positive effect on EXP_PERFORM. Local knowledge spillovers (LKS_I and LKS_L) exhibit the strongest positive impact upon the innovative performance of the firms. We also see that the acquisition of international knowledge through market mechanisms (IKT) depends on R&D, on of the indicators of internal learning activities and on the size of the firm.

Several theoretical and empirical studies have shown that exporting is a source of technological learning (Jacob and Szirmai, 2007). In the current study, we have also tested whether export intensity had an impact upon external learning, but we did not find any significant effects.

B. Sales per Employee

In table 5, we focus on a different aspect of economic performance, namely firm productivity. In the three models of Table 5, sales per employee (SALES_EMPL) is used as an indicator of the economic performance of the firm; marketing capability (MARK_INN) denotes the innovative performance of the firm while TECH_INN indicates the technological dimension of innovation. We apply the 3SLS method as we did in section A.

In Table 5 three alternative models are reproduced using different indicators for the independent variables. Model 1 systematically tests for the effects of local knowledge spillovers on the economic performance of the firms. However, none of the indicators of LKS exhibits a significant impact upon SALES_EMPL. We perform the Wald test only for the SALES_EMPL equation in order to test the null hypothesis that the variables LKS_I, LKS_L, LKS_S, IKT and IKS jointly do not affect SALES_EMPL (Greene, 2003, p. 484). The Chi-square is insignificant, which means that we cannot reject the null hypothesis. We drop these variables and get model 2. In Model 3 we test the impact of TECH_INN upon SALES_EMPL. However, the model produces statistically insignificant results (see Table 5; the Chi-square test for the SALES_EMPL equation indicates that the regressors are jointly insignificant).

From model 2 we derive the following conclusions: Concerning the SALES_EMPL sub-system, we first note that RD_INTENS affects productivity (SALES_EMPL) in a positive and significant way. This means that R&D intensive firms perform better than firms that invest less in R&D. None of the other variables has significant effects on the performance of the firm.

[7] We use the standardised beta coefficient because the independent variables are measured in different units. This makes the effects of the variables on the dependent variable difficult to compare. A well-known solution to this is to standardise all the variables so we can compare the effects of the various independent variables. For instance, a beta coefficient 0.561 tells us that a change of 1 standard deviation in IKT will cause a change of 0.561 standard deviation in EXP_PERFORM.

Table 5: 3SLS estimation of the Sales per Employee Models

Variables	**Model 1**		**Model 2**		**Model 3**	
	beta [a]	**(t-values)** [b]	**beta**	**(t-values)**	**beta**	**(t-values)**
Economic Performance						
SALES_EMPL						
TECH_INN[c]					-0.088	(-0.37)
MARK_INN[c]	0.259	(1.22)	0.278	(1.33)		
LKS_I	-0.12	(-1.04)				
LKS_L	-0.06	(-0.59)				
LKS_S	0.037	(0.32)				
LKT	0.152	(1.38)	0.128	(1.20)	0.137	(1.22)
IKT[c]	-0.012	(-0.09)			-0.237	(-0.95)
IKS	0.046	(0.42)				
RD_INTENS	0.467	(3.00)***	0.456	(3.00)***		
EXPER_FIRMS	-0.123	(-0.93)	00.148	(-1.16)		
EDU_DUM					0.205	(1.54)
EDU_VAR	0.057	(0.45)				
SIZE	0.004	(0.04)	0.004	(0.04)	-0.134	(-0.97)
Innovative Performance						
TECH_INN					TECH_INN	
MARK_INN	MARK_INN		MARK_INN			
LKS_I					0.306	(2.91)***
LKS_L					0.258	(2.16)**
LKS_S	0.296	(3.21)***	0.298	(3.40)***		
IKT[c]					0.95	(0.47)
RD_MY	0.333	(4.01)***	0.333	(4.13)***		
EDU_DUM	0.221	(2.45)**	0.233	(2.68)***		
EXPER_Y					-0.294	(-2.88)***
AGE	0.341	(3.91)***	0.333	(3.90)***		
External Mechanisms of Learning						
IKT						
RD_MY	1.487	(3.57)***	1.487	(3.57)***	0.347	(3.65)***
SIZE	1.248	(3.09)***	1.25	(3.10)***	0.277	(2.99)***
No. of Observations		75		75		75
Chi2 (model1)[d]		20.30		18.72		7.71
Chi2 (model 2)		52.06		52.39		22.81
Chi2 (model 3)		29.70		29.73		29.61
P1		0.0413		0.0022		0.1727
P2		0.0000		0.0000		0.0001
P3		0.0000		0.0000		0.0000

[a] Standardised coefficients (beta).
[b] t-values in parenthesis; ***p<.01, **p<.05, *p<.10
[c] Predicted values
[d] The Chi-squared-test provides the probability value for the Ch2-test of H_0: The regressors are jointly insignificant.
-3-stage least squares: Endogenous Variables: SALES_EMPL, MARK_INN, TECH_INN, IKT. Exogenous Variables: RD_INTENS, EXPER_FIRMS, SIZE, LKS_S, LKT, EDU_DUM, AGE, RD_MY.
Source: Authors computations based on authors' survey.

An interesting negative finding is that marketing capability does not have a significant effect on Sales per Employee. Local knowledge spillovers (in the MARK_INN sub-system) have an important positive effect on our measure of innovative performance MARK_INN, but they do not have a significant effect on economic performance. Other variables with positive significant effects on MARK-INN are R&D efforts, education and age.

The beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the innovative and economic performance of the firms. It turns out that local knowledge spillovers have neither a direct impact upon SALES_EMPL, nor an indirect effect through MARK_INN. The productivity of the software firms in the cluster of Montevideo depends significantly on the percentage of employees dedicated to R&D (an internal learning mechanism). RD_INTENS is the only variable which exhibits a significant effect upon SALES_EMPL. Local knowledge spillovers (LKS_S) affect positively the marketing capability of the firms. However, the absorptive capacity indicator (RD_MY) exhibits the strongest positive impact upon the marketing dimension of innovation. The most important insight derived from Table 5 is that marketing capability and knowledge spillovers do not affect the productivity of the firms in the software cluster in Montevideo.

Results and Discussion

We have found evidence indicating that firms with high absorptive capacity are better able to access external knowledge (RQ1). In particular, the analysis in Tables 4 and 5 has shown that firms with high levels of R&D (measured in man-years) use international knowledge transactions (IKT) more intensively. In addition, these firms are the larger ones. This implies that in a developing country such as Uruguay, firms that are small and weak in R&D are in some way disconnected from the international economy.

The fact that the other mechanisms of knowledge flow such as local knowledge spillovers (LKS), local knowledge transactions (LKT) and international knowledge spillovers (IKS) do not depend on the internal learning capabilities of the firm is a remarkable finding. It suggests 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. The latter finding is consistent with theories of international technology transfer to developing countries.

The results of the empirical analysis support the presence of local knowledge spillovers and their positive influence upon the innovative performance of firms within the cluster (RQ2). 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 marketing capability of the firms.

Acquisition of knowledge from international sources has no significant effect on innovative performance. This suggests that local knowledge spillovers matter more for innovative performance than the other sources of external learning. The rest of the explained variation of the indicators of innovative performance is due to learning carried out internally in the firm.

Local knowledge spillovers do not affect the economic performance of the firms directly (RQ3). We have seen that it is international knowledge transactions which have the strongest impact upon the export performance of the firms. In two of the models presented in Table 4, there are indirect effects of local knowledge spillovers on export performance (Models 1 and 2). But model 2 shows that the standardised beta coefficient of IKT is higher than the beta coefficient of TECH_INN. All the models presented in tables 4 and 5 indicate that local knowledge spillovers are not very important for the economic performance of the firms in the Montevideo cluster. It is primarily international knowledge transactions and in the second place technological innovation which influence the export dimension of economic performance of the firms. This means that those firms that are well connected in the international economy and acquire knowledge through international market mechanisms are those which export a large part of their production. A prerequisite for this is that these firms are technologically innovative.

Conclusions and Policy Implications

Taking the Uruguayan software cluster as a case study of the role of local knowledge spillovers in developing countries, we draw the following conclusions:

1. Local knowledge spillovers play an important role in enhancing the innovative performance of the software firms in the cluster of Uruguay.
2. Local knowledge spillovers do not have a direct influence on export performance or productivity. They do affect the export performance of the firms indirectly through their influence on innovative performance. It is one of the notable findings of this study that while local knowledge spillovers do affect the innovative performance of the firms directly in a positive manner, they do not have a direct influence on their export performance. 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. To be innovative is not the same as being economically successful. Rather, it is a prerequisite. With regard to productivity performance local knowledge spillovers have neither direct nor indirect effects.
3. International knowledge transactions are more important for the export performance of the firms than local knowledge spillovers. Local Knowledge Spillovers may be important for innovation of firms, but not sufficient for their economic success on export markets.
4. 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.

An important hypothesis in the literature of LKS in the advanced economies contends that LKS are the main reason for the increased innovative and economic performance of firms within clusters and/or regions (Saxenian, 1994). The results of this paper confirm the relevance of local knowledge spillovers for the innovative performance of firms in the context of developing countries. However, it is international knowledge transactions which allow firms in developing countries to achieve economic success on export markets. This suggests that firms in developing countries need to be well connected both to local and international sources of knowledge.

Two main policy recommendations can be derived 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. 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, provide more subsidies for R&D and facilitate labour mobility by promoting more flexible and less regulated labour markets, especially for SMEs. More importantly, the Uruguayan government should facilitate the interactions amongst firms and local institutions/universities through trade fairs, conferences and other professional or social events.

Second, 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.

Appendix A. Survey Questions

Variables	Survey Questions
-SALES -SALES_GR -SALES_EMPL -EXPORTS -EXPORTS_GR -EXPORTS_INTENS -EMPL_GR	Total sales of your firm for every year (1999-2004) Total exports of your firm for every year (1999-2004) Number of employees of your firm for every year (1999-2004)
-NEW_PS -CHANGE_PS -SALES_INNOV -NO_INNOV	Has your firm introduced products/services new into the market, between 1999-2004? Has your firm introduced products/services into the market, which were technologically improved or new to your firm, between 1999-2004? Which percentage of sales derived from these innovative products/services in 2004? How many innovated products/services has your firm introduced into the market during the period 1999-2004?
-LKS_S -LKS_L -LKS_I -LKT -IKS	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* 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)…….* How many skilled employees* did your firm had in every year (1999-2004)? **Skilled employees: This refers to employees that have a type of specialization in software of any level.* How many new skilled employees did your firm acquire during the period 1999-2004? From where do your new skilled employees come from? *-The same locality (Montevideo)* *-National* *-International (specify)…………………* 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 advice for innovation.

-IKT	*Group, New Personnel, Customers, Suppliers, Competitors, Vertically connected firms, Consultants, Research Institutes, Universities, Innovation Centres, Sector Institutes, Exhibitions, and Electronic Information.* Location: Which of each of the aforementioned actors are located in Montevideo, Nationally or Internationally (specify)? 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?
-R&D_MY	Please name the 5 most important product/service innovations your firm developed and/or introduced during the period 1999-2004 and indicate the time devoted in R&D (man-years) for these products.
-R&D_INTENS	Please, give an estimate of the R&D effort in your firm in 2004: -*Number of persons engaged in research/engineering activity. The above people work full time or part time on R&D?*
-EDU -EDU_VAR -EDU_DUM	How many (%) of your employees posses the following qualifications? -*Vocational education, BSc, MSc, PhD*
-EDU_F	How many (%) of your employees are educated in National Universities and in Universities abroad?
-EXPER_Y -EXPER_VAR_Y	How many months of experience do your skilled employees have in the software sector? *(≤ 6 months, > 6 and ≤ 12 months, >1 and ≤ 2 years, >2 and ≤ 4 years, > 4 years)*
-EXPER_FIRMS -EXPER_VAR_F	In how many firms did your skilled employees work previously? *(0-first job, 1-2 firms, 3-4 firms, 5-6 firms, >6 firms)*
-AGE	When was your firm established?
-SIZE	Number of employees of your firm for every year (1999-2004)

Appendix B. Alternative specifications

B.1 Specifications of the Export Performance Models

Table B.1a: 3SLS Estimation of the Exports Intensity Model

Variables	**Model 1**	
	beta [a]	**(t-values)** [b]
Economic Performance		
EXPORTS_INTENS		
TECH_INN[c]	0.385	(2.07)**
LKT	-0.14	(-1.71)*
IKT[c]	0.809	(3.83)***
EDU_VAR	-0.186	(-2.05)**
SIZE	0.167	(1.52)
TECH_INN		
LKS_I	0.288	(3.26)***
LKS_L	0.243	(2.68)***
EXPER_Y	-0.26	(-2.92)***
IKT		
RD_MY	0.303	(3.40)***
SIZE	1.281	(3.11)***
No. of Observations	67	
Chi2 (model1)[d]	48.58	
Chi2 (model 2)	26.03	
Chi2 (model 3)	28.07	
P1	0.0000	
P2	0.0000	
P3	0.0000	

[a] Standardised coefficients (beta).
[b] t-values in parenthesis; ***p<.01, **p<.05, *p<.10
[c] Predicted values
[d] The Chi-squared-test provides the probability value for the Ch2-test of H_0: The regressors are jointly insignificant.
-3-stage least squares: Endogenous Variables: EXPORTS_INTENS, TECH_INN, IKT. Exogenous Variables: LKS_L, LKS_I, LKT, EXPER_Y, EDU_VAR, RD_MY, SIZE.
Source: Authors computations based on authors' survey.

In Table B.1a we use the original variable Exports Intensity (EXPORTS_INTENS) to depict the economic performance of the firms instead of the factor Export Performance (EXP_PERFORM), which was used in Table 4. The results are similar to the ones in Table 4 with the only exception of the SIZE variable, which is not, as expected, statistically significant. We chose to use the factor and not the original variable in the analysis that we presented because the factor captures a larger variation of the economic performance of the firms compared to the original variable. Most of the beta coefficients in Table 4 are larger compared to the ones in Table B.1a.

Table B.1b: 3SLS Estimation of the Export Growth Models

Variables	Model 1		Model 2	
	beta [a]	(t-values) [b]	beta	(t-values)
Economic Performance				
EXPORTS_GR				
TECH_INN[c]			-0.017	(-0.07)
MARK_INN[c]	-0.103	(-0.30)		
LKT	0.211	(2.24)**	0.213	(2.36)**
IKT[c]	4.633	(4.30)***	0.637	(2.41)**
RD_MY	-0.264	(-1.69)*	-0.380	(-2.77)***
EDU_DUM	-0.227	(-2.06)**	-0.265	(-2.18)**
EXPER_VAR_F	-0.199	(-1.42)	-0.216	(-1.93)*
EXPER_VAR_Y	0.577	(4.35)***	0.585	(4.34)***
EXPER_Y	0.348	(2.14)**	0.326	(1.96)*
AGE	-0.35	(-2.24)**	-0.373	(-2.59)**
Innovative Performance				
TECH_INN			TECH_INN	
MARK_INN	MARK_INN			
LKS_I			0.299	(3.03)***
LKS_L			0.239	(2.50)**
LKS_S	0.342	(3.48)***		
IKT[c]				
RD_MY	0.339	(3.82)***		
EDU_DUM	0.170	(1.89)*		
EXPER_Y			-0.304	(-3.24)***
AGE	0.368	(3.89)***		
External Mechanisms of Learning				
IKT				
RD_MY	1.463	(3.57)***	0.328	(3.52)***
SIZE	1.261	(3.17)***	0.27	(2.98)***
No. of Observations		67		67
Chi2 (model1)[d]		40.89		28.56
Chi2 (model 2)		46.53		24.58
Chi2 (model 3)		29.70		27.66
P1		0.0000		0.0008
P2		0.0000		0.0000
P3		0.0000		0.0000

[a] Standardised coefficients (beta).
[b] t-values in parenthesis; ***p<.01, **p<.05, *p<.10
[c] Predicted values
[d] The Chi-squared-test provides the probability value for the Ch2-test of H_0: The regressors are jointly insignificant.
-3-stage least squares: Endogenous Variables: EXPORTS_GR, MARK_INN, TECH_INN, IKT. Exogenous Variables: LKT, LKS_I, LKS_L, LKS_S, RD_MY, EDU_DUM, EXPER_VAR_F, EXPER_VAR_Y, EXPER_Y, AGE, SIZE.
Source: Authors computations based on authors' survey.

In Table B.1b we estimate two models using the variable Exports Growth (EXPORTS_GR) as an indicator of economic performance. In model 1 we use MARK_INN as an indicator of innovative performance of the firms, in model 2 we use TECH_INN. The results show that the growth of exports depends on the acquisition of knowledge through market transactions from both local and international sources.

The results are quite different from the results for the export performance models in Table 4. Model 2 in Table 4 indicated that export intensive firms are driven by technological innovation and international knowledge transactions. Local knowledge transactions even had a negative sign. In contrast, the model in Table B.1b shows no significant relationship between export growth and TECH_INN. Both local knowledge transactions and international knowledge transactions have positive coefficients, though the beta coefficient for IKT is much higher than that of LKT. This suggests that in order to follow a path of continuous export growth, firms need to rely the market transactions and that innovative performance as such is not important for export growth.

We can also compare model 1 in table B.1b which uses marketing capabilities as intervening innovation performance variable, with model 3 in table 4. The coefficient of MARK_INN is not significant in both models. The main difference between the two models is that in the export growth model local knowledge transactions have a positive coefficient, against a negative one in table 4 and that international knowledge transactions do have a large and positive effect on export growth.

The differences between the export intensity models in table 4 and the export growth models reproduced here can be explained as follows: First, the two models do not measure the same phenomena. The export intensity models distinguish between exporters and non-exporters. The export growth variable distinguishes between firms with more or less export growth. A firm with rather low export intensity could even experience more growth than a firm with high intensity. For, our purposes, the export intensity models are more interesting. These have been included in the main text of the paper.

A substantive interpretation runs as follows. Export intensity depends on technological innovation and international knowledge transactions. Once firms have acquired the capability to export and compete in international markets, further export growth is explained by both international and local knowledge transactions. In order to augment their exports, firms need to focus on the continued acquisition of international knowledge [probably related to market trends and customer needs] through formal collaborations or transactions. But they also need to take advantage of local knowledge through market mechanisms (e.g. other agglomeration advantages).

B.2 Specifications of the Growth Performance Models

Table B.2: 3SLS Estimation of the Sales Growth Models

Variables	Model 1		Model 2	
	beta [a]	**(t-values)** [b]	**beta**	**(t-values)**
Economic Performance				
SALES_GR				
TECH_INN[c]			-0.184	(-0.61)
MARK_INN[c]	-0.333	(-1.15)		
LKS_S	-0.086	(-0.62)	-0.191	(-1.83)*
LKS_L	0.288	(2.86)***	0.337	(2.63)***
EXPER_VAR_Y	0.445	(3.03)***	0.384	(3.14)***
EXPER_Y	0.386	(2.19)**	0.347	(1.91)*
AGE	-0.40	(-2.25)**	-0.532	(-3.34)**
Innovative Performance				
TECH_INN			TECH_INN	
MARK_INN	MARK_INN			
LKS_I			0.287	(2.81)***
LKS_L			0.276	(2.72)**
LKS_S	0.315	(3.50)***		
IKT[c]				
RD_MY	0.294	(3.67)***		
EDU_DUM	0.214	(2.64)***		
EXPER_Y			-0.277	(-2.85)***
AGE	0.336	(3.89)***		
External Mechanisms of Learning				
IKT				
RD_MY	1.459	(3.53)***	0.326	(3.47)***
SIZE	1.291	(3.23)***	0.28	(3.07)***
No. of Observations		75		75
Chi2 (model1)[d]		26.51		31.17
Chi2 (model 2)		49.43		21.19
Chi2 (model 3)		30.31		28.43
P1		0.0002		0.0000
P2		0.0000		0.0001
P3		0.0000		0.0000

[a] Standardised coefficients (beta).
[b] t-values in parenthesis; ***p<.01, **p<.05, *p<.10
[c] Predicted values
[d] The Chi-squared-test provides the probability value for the Ch2-test of H_0: The regressors are jointly insignificant.
-3-stage least squares: Endogenous Variables: SALES_GR, MARK_INN, TECH_INN, IKT. Exogenous Variables: LKS_I, LKS_S, LKS_L, EXPER_VAR_Y, EXPER_Y, RD_MY, EDU_DUM, AGE, SIZE.
Source: Authors computations based on authors' survey.

In Table B2 we estimate 2 models using Sales Growth (SALES_GR) as an indicator of the economic performance of the firms, in particular growth performance. Both models in Table B2 show that local knowledge spillovers through labour mobility (LKS_L) affect positively the growth performance of the firms. Moreover, the variables that denote the years of experience of the employees in a firm exhibit a positive impact upon growth performance. In contrast, the age of the firm affects negatively growth, indicating that new firms grow faster than old firms.

The results are worth comparing to the ones for the Sales per employee models in Table 5. The two sets of models have in common that there are no significant impacts of innovative performance measures on economic performance. But there are also differences. While Table 5 has shown that the productivity of the firms is contingent upon R&D, Table B2 suggests that the growth of the firm (growth of sales) depends on local knowledge spillovers and in particular on local knowledge spillovers through labour mobility. This implies that in order to grow firms continuously need to re-new their stock of knowledge, (especially tacit knowledge) through the inflow of new employees. While R&D may increase the productivity of the firms it is not sufficient for driving the growth of the firm.

Appendix C. Testing the Rank condition

We use the array of columns in Table C1 instead of a matrix in order to test the rank condition for identification, which is a necessary and sufficient condition (Greene, 2003; Maddala, 2001). Table C1 shows the endogenous (g) and exogenous variables in the three equations. We mark with a cross x if a variable occurs in an equation and 0 if not (Maddala, 2001, p. 351). The rule for identification of any equation is as follows: (1) Delete the particular row; (2) Pick up the columns corresponding to the elements that have zeros in that row; (3) If from this array of columns we can find (g-1) rows and columns that are not all zeros and no column (or row) is proportional to another column (or row) for all parameter values, then the equation is identified (Maddala, 2001, p. 352). We check the rank condition for each of the three equations and we find that each equation is identified.

Table C1: Rank condition for Model 2

Equation	EXP_PERFORM	TECH_INN	IKT	LKT	EDU_VAR	SIZE	LKS_I	LKS_L	EXPER_Y	RD_MY
1	X	X	X	X	X	X	0	0	0	0
2	0	X	0	0	0	0	X	X	X	0
3	0	0	X	0	0	X	0	0	0	X

Table C2: Rank condition for Model 3

Equation	EXP_PERFORM	MARK_INN	IKT	LKT	RD_INTENS	EXPER_FIRMS	SIZE	LKS_S	RD_MY	EDU_DUM	AGE
1	X	X	0	X	X	X	X	0	0	0	0
2	0	X	0	0	0	0	0	X	X	X	X
3	0	0	X	0	0	0	X	0	X	0	0

Appendix D. Estimation of the Technological Innovation Sub-system

Table D: 3SLS estimation of the Technological Innovation sub-system

Variables	**Model**	
	beta [a]	**(t-values)** [b]
TECH_INN		
LKS_I	0.281	(3.12)***
LKS_L	0.231	(2.52)**
EXPER_Y	-0.74	(-3.00)***
IKT		
RD_MY	0.315	(3.46)***
SIZE	1.278	(3.07)***
No. of Observations	97	
Chi2 (model1)[d]	25.88	
Chi2 (model 2)	28.49	
P1	0.0000	
P2	0.0000	

[a] Standardised coefficients (beta).
[b] t-values in parenthesis; ***p<.01, **p<.05, *p<.10
[c] Predicted values
[d] The Chi-squared-test provides the probability value for the Ch2-test of H_0: The regressors are jointly insignificant.
-3-stage least squares: Endogenous Variables: TECH_INN, IKT. Exogenous Variables: LKS_L, LKS_I, EXPER_Y, RD_MY, SIZE.
Source: Authors computations based on authors' survey.

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