Local Knowledge Spillovers, Innovation and Economic Performance in Developing Countries

Empirical Evidence from the Uruguay Software Cluster

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1. Introduction

This paper examines the relationships between local knowledge spillovers, innovation and the economic performance of firms in clusters in developing countries. A key hypothesis in the literature on Local Knowledge Spillovers 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.

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, 1992), 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 derives 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 commercial knowledge transactions (Kesidou and Romijn, 2006).

A second characteristic of this paper is that we are not only interested in the relationships between spillovers and innovative performance, but also in the direct and indirect effects of local knowledge spillovers on the economic performance of firms.

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 learning?

2. 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 particularly problematic that studies have traditionally focused only on local knowledge advantages, while underestimating the impact of international knowledge linkages. Current studies (Simmie, 2003; Bathelt et al, 2004; Owen-Smith and Powell, 2004) pay attention to the fact that innovative clusters and/or regions in advanced economies cannot be self-sufficient and raise the importance of external linkages or the so-called 'trans-local pipelines'. Non-local linkages, namely the 'pipelines', constitute channels for the entry into the cluster of new information regarding new markets and technologies (Bathelt et al., 2004). The new knowledge is transmitted rapidly through the function of knowledge spillovers to the firms within the cluster. For example, Simmie (2003) considered the interface of local and global and found that in the United Kingdom, innovative firms are concentrated in a few locations (thus confirming the importance of regions/clusters) but at the same time, innovative regions have more linkages with international actors than less innovative regions. In his interpretation, international linkages [with customers and clients] are 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). Therefore, according to these new insights, clusters need to establish and maintain

external relations in order to sustain their innovativeness and competitiveness in the long run.

While these are new developments in the literature of Local Knowledge Spillovers in advanced economies, the literature on Technology Transfer in developing countries has long time ago recognised the importance of accessing and absorbing international knowledge (Evenson and Westphal, 1995; Szirmai, 2005). 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. This provided the ground for our decision to examine the relative importance of local knowledge spillovers versus international knowledge linkages.

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 advantages 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 advantages. 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.

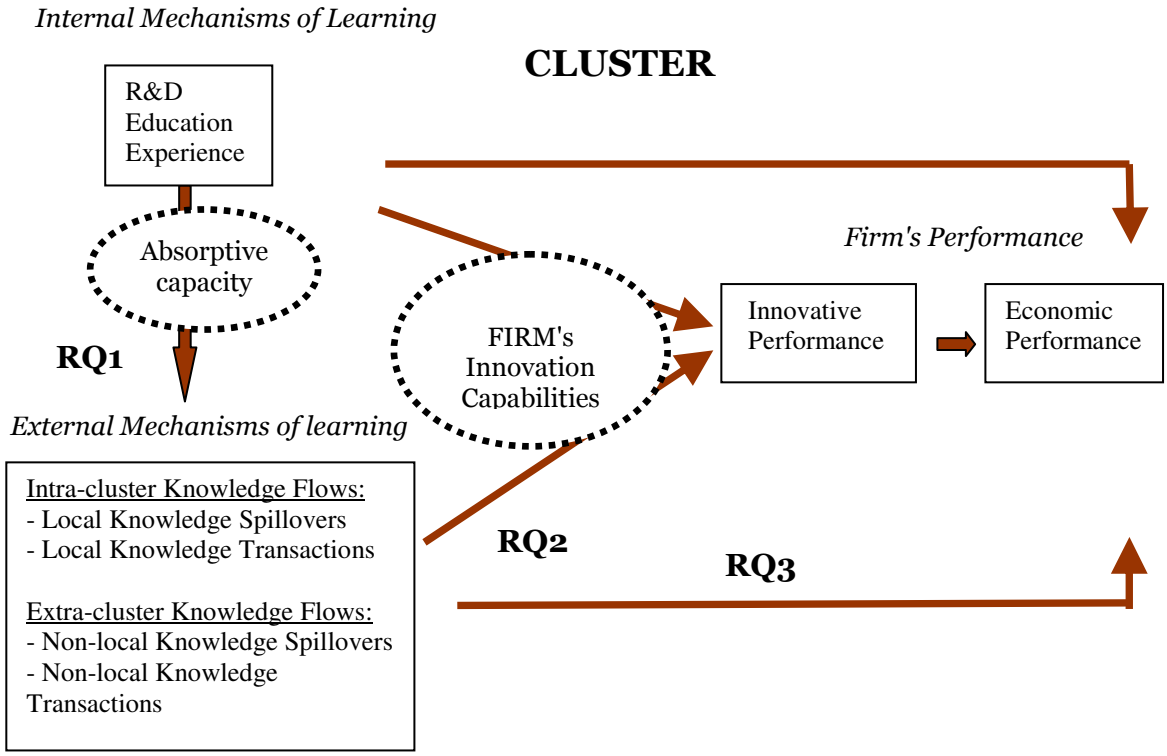
Internal learning and absorptive capacities

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 figure 1 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. This impact can be direct as well as indirect.

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



Source: Authors

3. 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. 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, but made several changes and adaptations in order to adjust the questionnaire to the needs of the software sector (which includes service firms alongside industrial firms) and to the peculiarities of a developing country.

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 contains the variable names, the second column shows the symbols of the variables. The third column provides a brief description of the variables.

Table 1: List of Variables

Variables	Symbol	Definition/Measurement
Dependent Variables		
	Economic Performance	
Sales	SALES	This is a continuous variable, which denotes the sales of software (P/S) of firms in US dollars in 2004.
Growth of Sales	SALES_GR	This variable denotes the growth of the sales of software (P/S) during the period 1999-2004.
Sales per Employee	SALES_EMPL	This variable measures the sales of the firm as a percentage of the number of its employees.
Exports	EXPORTS	This is a continuous variable, which denotes the exports of software (P/S) of each firm in US dollars in 2004.
Growth of Exports	EXPORTS_GR	This variable denotes the growth of the exports of software (P/S) of each firm during the period 1999-2004.
Share of sales to exports	EXPORTS_INTENS	This variable indicates the percentage of sales directed to foreign markets in 2004.
Growth of employment	EMPL_GR	This variable takes into account the growth of the employment of each firm during the period 1999-2004.
	Innovative Performance	
Product/Service - New to the Market	NEW_PS	Binary variable, which takes the value of =1 if the firm has introduced a new product/service (P/S) innovation to the market during the period 1999-2004, and =0 in other case.
Product/Service - Changed Substantially	CHANGE_PS	Binary variable which takes the value =1, if the firm has changed a (P/S) in a radical manner during the period 1999-2004, and =0, otherwise.
Sales of Innovation Output	SALES_INNOV	Censored variable because its lower limit equals zero. Indicates the percentage of sales that derived from (P/S) innovations in 2004.
Number of Innovations	NO_INNOV	This is a continuous variable that considers the quantity of (P/S) innovation that each firm has produced.
Quality of Product and/or Services	QUAL_PS	This is a dummy variable which takes the value of =1 if the firm has a quality certification, and =0 otherwise.

Independent Variables

External Learning

Local Knowledge Spillovers through Spin-off	LKS_S	This is a dummy variable that takes the value of =1 if a firm is a spin-off of a university/MNC that is located within the cluster and, = 0 in other case.
Local Knowledge Spillovers through Labour Mobility	LKS_L	This variable denotes the percentage of employees (inflow) in a firm that came from within the cluster during the last five years (1999-2004).
Local Knowledge Spillovers through Interaction – Importance	LKS_I	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from the non-pecuniary interaction of local actors.[1]
Local Knowledge Transactions - Importance	LKT	This is a constructed variable that indicates the importance of intra-cluster flow of knowledge that arises from local transactions.
International Knowledge Spillovers through - Importance	IKS	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from the non-pecuniary interaction among local and international actors.
International Knowledge Transactions - Importance	IKT	This is a constructed variable that indicates the importance of extra-cluster flow of knowledge that arises from transactions.

Internal Learning

Research and Development Man-years	R&D_MY	R&D effort measured in man-years. It measures the cumulative R&D effort of the firm during the period 1999-2004.
Research and Development Intensity	R&D_INTENS	This variable denotes the percentage of firm's labour force that carried out R&D in 2004.
Education Index	EDU	Indicates the level of education of the employees of each firm[2].

Variation of Education	EDU_VAR	Ordinal variable that denotes the variation of the education levels of the employees of each firm[3].
Postgraduate education	EDU_DUM	This is a dummy variable which takes the value of =1 if a firm has employees with MSc or PhD degrees, and =0 in other case.
Foreign Education	EDU_F	This variable denotes the percentage of the employees that have acquired a university degree abroad.
Years of Experience Index	EXPER_Y	Indicates the average years of experience in the software sector of the employees of each firm[4].
Variation of Experience	EXPER_VAR_Y	Ordinal variable that denotes the variation of the experience of the employees within a firm[5].
Experience in Firms Index	EXPER_FIRMS	Indicates the average No. of occupations that the employees of a firm have worked in the past.[6]
Variation of Experience in No. Firms	EXPER_VAR_F	Ordinal variable which denotes the variation of the experience in No. firms of the employees within a firm[7].
Age	AGE	Firm's age (reference year 2004).
Size	SIZE	Size of the firm measured by number of employees at year 2004.

A number of indicators capture 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 indicators that have been used in the CIS (i.e. product/service new to the market, sales of innovation output). We also introduce some new indicators in order to represent adequately the innovative performance of software firms in developing countries. The product/service changed substantially indicator captures innovations that are new to the firm, but not to the market. The number of innovations indicator captures the efforts of the firm to adjust its products to current market and technology conditions[8]. Finally, the quality of product/services indicator attempts to identify the firms that have acquired a quality certification on order to improve their image in international markets.

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

indicators that denote the internal learning activities (i.e. research and development) and the absorptive capacity of the firm (i.e. education and experience).

4. Empirical Analysis

Factor Analysis: Economic and Innovative Performance Indicators

We use principal factor analysis to identify the latent dimensions of economic performance. 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 intensity. The second factor is explained mainly by the sales, and the sales per employee. This factor refers to those firms that are commercially successful (Sales) and at the same time are characterised by a high productivity (Sales_Empl). This factor is called level of performance. Finally, the third factor is explained by the growth of sales, exports and employment. This factor is named economic growth since it represents those firms that grow rapidly.

Table 2: Economic Performance Components

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

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

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

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

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

We also examine whether the innovative performance of the firm can be measured using less than five 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 discrete variables. The latter are essential for the use of system method estimation.

Two factors explain approximately 60 per cent of the cumulative variance. 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. The first variable NEW_PS is an indicator of the uniqueness of the product in the market. The second variable CHANGE_PS represents a product/service that has undergone a significant change. In the first case, the product is new to the market, whereas in the second the product is new to the firm. This means that the firm has created and/or substantially changed a product or service. These are technological changes: firms applied new scientific or technological knowledge into their products or adapted their products to the needs of the customer.

Table 3: Innovation Components

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

The second factor is explained by the variables QUAL_PS, SALES_INNOV and NO_INNOV. The QUAL_PS variable indicates those firms that hold an international recognised quality certification. A quality certification improves the quality of the products of the firm and ultimately its productivity. Usually, it is a necessary step for many firms in developing countries that try to enter foreign markets and gain the trust of demanding customers. Terlaak and King (2006) suggest that certification with ISO 9000 reveals information to customers about differences in the organisational quality of suppliers. For instance, King and Lenox (2001) through an empirical study show that ISO 9000 reflects differences among firms with respect to organisational quality related to sophisticated management of technology, materials and labour. Thus, quality certification has to do with the organisational capabilities of the firm.

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

Finally, the variable NO_INNOV denotes the number of innovations that a firm produces. In the software industry, a firm commonly holds 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 therefore represents the commercial success of the firm and its capabilities in selling its original products by satisfying the needs of the current customers.

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 and organisational innovation capabilities with regard to products and services.

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

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

We proceed to the empirical analysis with the new dependent variables.

System Method Estimation

Simultaneous regression techniques are used to estimate three key equations referring to the respective research questions set in the introduction.

A. Export Intensity

The following structural model makes it possible to test the three research questions[9] simultaneously. In particular, export intensity (EXP_INTENS) is used as an indicator of the economic performance of the firm.

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

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

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

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

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

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

Table 4: Simultaneous Estimates of Export Intensity, Technological Innovation and International Knowledge Transactions

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

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

There are 67 observations for the previous model of system equations (Table 4). Not all firms were willing to give information regarding their economic performance. However, for the rest of the variables, we do have 97 observations. We may, at this point, test the

sub-system of TECHN_INN and IKT and see whether the results are similar to those of the full model.

Table 5: Simultaneous Estimates of Technological Innovation and International Knowledge Transactions

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

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

A comparison of the full model with the 3 equations (Table 4) with the model which consists of the 2 equations (Table 5) produces similar results. This suggests that the observations that are missing from the small sample would not produce different results.

Table 4 reports the results of the system method estimation analysis. Several models were tested using different indicators for the independent variables. The best-fit model in Table 4 shows that the R-square of the EXP_INTENS sub-system is 0.51. This means that 51 per cent of the variation of the export intensity is explained by the independent variables. Moreover, the R-square of the TECHN_INN sub-system is 0.26. Finally, the R-square of the IKT sub-system is 0.27. Overall, the model seems to explain a fair amount of the variation of the endogenous variables. Based on this model we may draw the following conclusions:

Concerning the EXP_INTENS sub-system, we notice that, first, TECHN_INN affects EXP_INTENS in a positive and significant way. This means that technologically innovative firms export more than less innovative firms. Second, LKT exert a negative and significant impact upon EXP_INTENS. This implies that those firms that use local knowledge transactions intensively export less than those firms which use local knowledge transactions less intensively. Third, IKT has a positive and significant impact upon EXP_INTENS. In other words, those firms that use international knowledge

transactions intensively export more than those firms that use international knowledge transactions less intensively. Fourth, EDU_VAR affects EXP_INTENS negatively. This implies that firms which exhibit a large variation in the educational level of their employees export less than firms which are comprised of employees with similar educational level. Fifth, SIZE has a positive impact upon EXP_INTENS. Large firms export more than small firms.

The beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the export intensity of firms within the Montevideo cluster. Local knowledge spillovers do not have a direct impact upon EXP_INTENS, but an indirect effect through TECHN_INN. Consequently, among the various mechanisms of external (to the firm) knowledge flows, it is IKT which exhibits the strongest positive effect on EXP_INTENS. Local knowledge spillovers (LKS_I and LKS_L) exhibit the strongest positive impact upon the innovative performance of the firms. We also have seen that the acquisition of international knowledge through market mechanisms depends on the internal learning activities (R&D) and the size of the firm.

B. Level of Performance

A similar methodology is applied using different indicators for the performance of the firms. In particular, level of performance (L_PERFORM) is used as an indicator of the economic performance of the firm, while marketing/organisational innovation (MARK_INN) denotes the innovative performance of the firm. The variables EDU_DUM and AGE are used as instrumental variables for MARK_INN. The variable R&D_MY and EXPER_VAR_F are used as instrumental variables for IKT.

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

$$\left.\begin{aligned} L\_PERFORM &= \alpha_1 + \alpha_2 MARK\_INN + \alpha_3 LKT + \alpha_4 RD\_INTENS + \alpha_5 EXPER\_FIRMS \\ &\quad + \alpha_6 SIZE + q \\ MARK\_INN &= \beta_1 + \beta_2 LKS\_S + \beta_3 IKT + \beta_4 RD\_MY + \beta_5 EDU\_DUM \\ &\quad + \beta_6 EXPER\_VAR\_F + \beta_7 AGE + v \\ IKT &= \gamma_1 + \gamma_2 RD\_MY + \gamma_3 EXPER\_VAR\_F + \gamma_4 SIZE + z \end{aligned}\right\}$$

Table 6 presents the results of the 3-stage least squares estimation method. A number of alternative models were tested using different indicators for the independent variables. The best-fit model in Table 6 shows that the R-square of the L_PERFORM sub-system is 0.22. Moreover, the R-square of the MARK_INN sub-system is 0.49. Finally, the R-square of the IKT sub-system is 0.27. Overall, the model seems to explain a fair amount of the variation of the dependent variables. Based on this model we may draw the following conclusions:

Concerning the L_PERFORM sub-system, we first notice that RD_INTENS affects L_PERFORM in a positive and significant way. This means that R&D intensive firms

perform better than firms that invest less on R&D. Second, SIZE has a positive impact upon L_PERFORM. Large firms exhibit a higher level of performance than small firms. With regard to the MARK_INN sub-system, Table 6 shows that IKT and RD_MY variables affect MARK_INN in a positive way. However, their effect is not statistically significant.

Table 6: Simultaneous Estimates of Level of Performance, Marketing/Organisational Innovation and International Knowledge Transactions

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

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

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

the capabilities to use IKT. Moreover, we notice that large firms use international knowledge transactions more intensively than small firms.

The beta coefficients are used in order to evaluate the relative importance of local knowledge spillovers for the level of performance of the firms within the cluster of Montevideo. It turns out that local knowledge spillovers have neither a direct impact upon L_PERFORM, nor an indirect effect through MARK_INN. The level of performance of the software firms in the cluster of Montevideo depends on their internal learning mechanisms and in particular of the percentage of employees dedicated to R&D. RD_Intens is the variable which exhibits the strongest effect upon L_Perform. Local knowledge spillovers (LKS_S) affect positively the innovative performance of firms. However, the absorptive capacity indicators (EDU_DUM, EXPER_VAR_F, AGE) exhibit the strongest positive impact upon innovation.

4. 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 Table 4 and Table 6 has shown that firms with high levels of R&D (measured in man-years) are able to use international knowledge transactions (IKT) intensively. In addition, these firms are the larger ones. This implies that in a developing country such as Uruguay, firms which are small and weak in R&D are in some way disconnected from the international economy. The fact that the rest of the mechanisms of knowledge flow such as LKS, LKT and IKS do not depend on the internal capabilities of the firm is 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. This 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 innovation 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 organisational/marketing innovation of the firms. Although, international pecuniary knowledge affects the innovative performance of firms positively, its effect is not statistically significant. This suggests that local knowledge spillovers matter more than the other knowledge flows. The rest of the explained variation is due to learning carried out internally in the firm.

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 economic performance of the firms. Even if we assume that local knowledge spillovers affect the economic performance of the firms indirectly, through innovation, Table 4 shows that the beta coefficients of IKT are higher than the beta coefficients of TECHN_INN. This means that local knowledge spillovers are less important for the economic performance of the firms in the Montevideo cluster. It is primarily international knowledge transactions and then technological innovation which

influence the economic performance of the firms. It is important to clarify that the indicator of the economic performance is the export intensity (EXP_INTENS) of the firms. This means that those firms that are well connected in the international economy and acquire knowledge through market mechanisms are those which export a large part of their production. A prerequisite for this is that these firms are technologically innovative.

5. Conclusions and Policy Implications

While LKS affect the innovative performance of the firms directly in a positive manner, they do not influence their economic performance directly. One reason for this could be the fact that LKS are usually the conduits of tacit knowledge, which needs first to be translated within the firm into explicit knowledge in order to have an economic significance. Nevertheless, LKS are connected indirectly to the export performance of the firm. This paper has shown that innovation affects the export performance of the firm in a positive and direct way, while innovation is contingent upon LKS.

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

Taking the Uruguayan software cluster as a case study of the role of local knowledge spillovers in developing countries, we draw the following conclusions: To begin with, local knowledge spillovers play a crucial role for the innovative performance of the software firms in the cluster of Uruguay. At the same time, the outcome of this study suggests that international knowledge transactions are important for the economic performance of the firms. LKS are important for the innovation of the firms, but not sufficient for their economic success. To be innovative is not the same as being economically successful. Rather, it is a prerequisite. To achieve economic success according to the results of this study, it is important that a firm is connected to the international economy. The latter is contingent upon the internal capabilities of the firm.

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

Two main policy recommendations can be drawn from these results: First, geographic proximity may generate advantages related to the fast circulation of knowledge, not only in advanced economies but also in developing countries. This suggests that knowledge advantages, as well as cost advantages, can benefit firms within clusters in LDCs. In the case of the software cluster in Uruguay, labour mobility, spin-offs, and the informal interaction of agents within the cluster seem to be the most important mechanisms for the transfer of knowledge. Thus, the Uruguayan government should continue to invest in education and training of high-skilled employees, should provide more subsidies for R&D and should facilitate labour mobility by promoting more flexible and less regulated labour markets, especially for SMEs.

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.

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NOTES

[1] Firms were asked in the survey to *assess the importance of various sources of information/advice or assistance for their upgrading or innovation efforts* on a Likert scale (0=unimportant, 1=less important, 2=important, 3=very important, 4=crucial). 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). Moreover, firms were requested to report *where the sources of knowledge that they use were geographically located* (Local or International). Finally, firms were asked to *clarify the type of relationship between their firm and each source of knowledge that they use* (Formal transaction-based or Informal not involving transactions). Using the three attributes (Importance, Location and Type of the relationship) we constructed the variables that denote the importance of the knowledge arising from interactions. For instance, the *international knowledge transactions* (IKT) variable was constructed in the following way: for every case (firm) 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 Group, New Personnel, Customers and Suppliers were classified as formal. Even though user-producer interaction is not a strictly transaction-based relation, still the knowledge flow between a firm and its supplier or customer is the result of a formal market transaction and thus it is treated as a pecuniary knowledge flow. In contrast, all the relations between firms with Competitors are informal and thus considered to give rise to knowledge spillovers. Likewise acquisition of Electronic Information is generally for free and thus considered as a spillover of knowledge. Finally, the relation of firms with other Vertically connected firms, Consultants, Research Institutes, Universities, Innovation Centres, Sector Institutes, Exhibitions, is ambiguous. For example, some firms form alliances in a formal way (i.e. by sharing R&D outcomes) while others keep them informal (i.e. by sharing information regarding problem solving activities). Knowledge that flows between these sources of knowledge and the firms can be either transaction-based or free. Therefore, the type of knowledge flow between these sources of knowledge and the firm varies for each case. Thus we classified them on a case by case basis. Each variable has a range from 0 to 52. The maximum value of the IKT variable for instance, would be 52, if a respondent would give the value of 4 to all thirteen sources of knowledge, all of which are acquired through market transactions from abroad.

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

[3] When for example 100 percent of the employees of a firm have a BSc, a score of 1 is assigned to this firm. If, on the other hand, a firm consists of 50 percent of employees with BSc and 50 percent with MSc, a score of 2 is assigned to that firm. Finally, if a firm consists of 30 percent of employees with vocational education, 40 percent with BSc, 20 percent with MSc and 10 percent with PhD, a score of 4 is assigned to that firm.

[4] An experience index has been also constructed, based on the aforementioned information, which indicates the weighed average years of experience of the employees of every firm. For each firm, the percentage of the employees with less than 6 months experience is multiplied by 0.25. The

percentage of employees with 6 to 12 months of experience is multiplied by 0.75. The percentage of employees with 1 to 2 years of experience is multiplied by 1.5. The percentage of employees with 2 to 4 years of experience is multiplied by 3 and finally, the percentage of employees with more than 4 years of experience is multiplied by a figure in a range of 6 to 12. The aggregate of all these scores denotes the weighted average experience level of the employees of each firm.

[5] The same methodology as for the construction of EDU_VAR is used for the construction of the variable EXPER_VAR_Y

[6] A second experience index has been constructed, based on the above information, which indicates the weighted average number of firms in which the employees had worked in the past. The percentage of the employees with no previous experience is multiplied by 0. The percentage of employees with previous experience in 1 or 2 firms is multiplied by 1.5. The percentage of employees with experience in 3 or 4 firms is multiplied by 3.5. The percentage of employees with experience in 5 or 6 firms is multiplied by 5.5, and finally, the percentage of employees with experience in more than 6 firms is multiplied by 6. The aggregate of all these scores denotes the weighted average experience level of the employees of the firm in terms of the number of previous occupations held by them.

[7] The same methodology as for the construction of EDU_VAR is used for the construction of the variable EXPER_VAR_F.

[8] 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.

[9] This refers to the impact of internal learning mechanisms or absorptive capacity upon the external (to the firm) mechanisms of knowledge flow; the impact of LKS upon innovative performance; and finally the direct or indirect impact of LKS upon economic performance.