The correlation between large firms´ knowledge spillovers and SMEs´ absorptive capacities: Evidence for the machining industry in Mexico♦

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Abstract[1]

The aim of this paper is to analyze the relationship between knowledge spillovers of large firms and absorptive capacities of small and medium enterprises (SMEs) using direct indicators for these two analytical concepts. Particularly, this study analyzes the machining shop industry that is located in Querétero, a Mexican locality. The SMEs of this sector are suppliers of domestic large firms and multinational corporations, which belong to the automotive and home appliances sectors. Direct indicators of large firms´ knowledge spillovers and SMEs´ absorptive capacities were built. A structural equations analysis about the relationship between these two analytical concepts was carried out. This paper argues that in this sector, one of the main spillover mechanisms is related to the backward linkages that are established between SMEs and large firms, and that SMEs' absorptive capacities are strongly influenced by organizational capabilities and innovation and learning activities. It was also found that large firms´ knowledge spillovers are strongly related to SMEs´ absorptive capacities, and that these SMEs do not tend to establish important linkages with other local agents, so that they cannot benefit from the science and technology infrastructure of the local innovation system.

Introduction

In Mexico, as in many Latin American countries, there is a strong heterogeneity between different regions in terms of the conformation of the innovation systems. While most of the agents that are defined by the innovation system literature can be found in some regions (Cooke, *et al*, 1997; Edquist, 1997; Rickne, 2001; Asheim and Isaksen, 2003; Tödtling and Kaufmann, 2003); in others some of them are absent (i.e. public research centers). Moreover, those local agents have different grades of maturity, which represent a difficulty for the establishment of linkages between them. In some regions, large firms, both domestic and transnational, are present, and they have attracted SMEs that look for becoming their suppliers. In the long run, large firms´ knowledge spillovers can contribute to the strengthening of SMEs´ absorptive capacities. As SMEs acquire higher capabilities, they are able to reach the large firms´ requirements, which are mainly related to delivery time, large volume, quality increase, and price reduction.

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In paper we focus on a Mexican locality –Querétaro. SMEs belong to the machining shops industry and they are suppliers of direct and indirect inputs of large firms of the automotive and home appliances sectors. We analyze knowledge spillovers that are related to three different mechanisms: demonstration-imitation effects, backward linkages and human capital training and mobility. We argue that SMEs´ absorptive capacities play a key role to get the benefits from the large firms´ knowledge spillovers.

However, within the region and sector that are analyzed in this paper, a low level of linkages between SMEs and other local agents, i.e. large firms has been observed. SMEs have not been able to receive the benefits related to the linkages that are established with large firms. Neither they have been able to get the benefits of the institutional framework in the locality. At the same time, they do not have the capabilities to produce complex products that need certain levels of quality, volume, delivery time and price. Large firms set high requirements that only a small proportion of local SMEs can reach. Thus, only these firms can get the benefits of large firms´ knowledge spillovers, which in turn strengthen their absorptive capacities, and increase their market share.

In order to increase SMEs´ market share, it is important to analyze how large firms´ knowledge spillovers can contribute to the increase of the SMEs' absorptive capacities. According the heterogeneity of firms, it is necessary to identify how SMEs have certain levels of absorptive capacities to get the benefits of large firms´ knowledge spillovers. The role played by other local agents can be central in the strengthening of SMEs' absorptive capacities. From this view, it is important to analyze the linkages established between these firms and other local agents, because SMEs can get the benefits of the local infrastructure.

We argue the need to go further in the discussion of the relationship that exists between SMEs´ absorptive capacities and large firms´ knowledge spillovers. The aim of this paper is to analyze the relationship between knowledge spillovers and absorptive capacities using direct indicators for these two concepts. We take into consideration the heterogeneity of firms that belong to the same sector and explore the effect of the local innovation system on the SMEs´ absorptive capacities, identifying the linkages established between these firms and local agents.

The use of direct indicators for knowledge spillovers will allow us to analyze the most important knowledge spillover mechanisms in a specific sector and locality. Meanwhile, the use of absorptive capacities direct indicators will allow us to identify the most important factors that explain SMEs´ absorptive capacities. Based on consistent information we probe the positive relationship between knowledge spillovers and absorptive capacities, determining the specific characteristics of this relationship.

This paper is written in four sections, next section presents the analytical framework that is used in this work. Section 2 describes the methodology. Section 3 discusses the empirical evidence about the relationship between absorptive capacities and knowledge spillovers. Finally section 4 presents the main conclusions of the paper.

1 Analytical framework

This research draws on three main bodies of literature: i) regional and local innovation systems; ii) knowledge spillovers; and iii) absorptive capacities; and three issues approached by these bodies: i) regional innovation systems; ii) backward linkages between large firms and SMEs; and iii) relationships between knowledge spillovers and SMEs´ absorptive capacities.

1.1 Regional innovation systems

In different localities there can exist a variety of agents that can contribute to the development of local firms´ technological capabilities. If linkages are established between these agents and firms, where knowledge is flowing to promote innovations, the locality can be defined as a regional/local innovation system.

A regional/local innovation system can be defined as a group of relationships between users and producers of knowledge, which is exploited for practical and commercial uses. This interaction is seen as a social process with feedback from the innovation process, which involves development, diffusion and adaptation of knowledge (Cooke, Gomez and Etxebarria, 1997). Additionally from this definition, this study incorporates the analysis from the perspective of Asheim and Isaksen (2003); Tödtling and Kaufmann (2003); and Rickne (2001); where the four former authors emphasize the role

of SMEs in regional/local systems of innovation. Meanwhile Rickne analyzes how regional systems can or cannot be present because of the functions that they perform.

According to the innovation system literature, linkages that firms establish with other firms and with other local agents are central for innovation. However, the knowledge about the kind of mechanisms that support knowledge flows or spillovers between firms, is still limited (Edquist, 1997; Rickne, 2001; Asheim and Isaksen, 2003; Tödtling and Kaufmann, 2003). Most of this literature have focused their analysis at the sector level, and have not tackled the heterogeneity of firms in the same sector. Additionally, some studies emphasize the importance of the locality, but they scarcely analyze the linkages established between firms and local agents that can help to strengthen firms´ absorptive capacities.

Even though the literature of local/regional innovation systems put firms at the center of the study, they do not analyze knowledge spillover mechanisms between them, and they do not analyze quantitatively the absorptive capacities of firms. Absorptive capacities are important for enterprises to get the benefits of knowledge spillovers. As the main objective of this paper is to analyze the relationship between large firms´ knowledge spillovers and SMEs´ absorptive capacities, we have had used the literature of foreign direct investment (FDI) effects over local firms.

1.2 Large firms´ knowledge spillovers

Several studies that analyze the impact of foreign direct investment on host countries focus on knowledge spillovers from Multinational Corporations (MNC) to local firms. These studies correlate FDI with increases in local firms´ productivity, arguing that productivity increases are directly related to knowledge spillovers. These studies use productivity increases as an indicator of knowledge spillovers. Nevertheless, the use of these indicators does not permit one to observe whether local firms´ productivity increases are in fact due to FDI knowledge spillovers that are diffused through different mechanisms.

According to Blomström and Kokko (2003), MNC´s spillovers to local firms happen when they get the benefits from higher knowledge related to product, process or market technologies from MNC, without incurring into a higher cost than the benefits obtained

by the increase in productivity. From this perspective, knowledge spillovers arise when part of the knowledge generated by an organization spills over its boundaries and become available to other organizations (Escribano, Fosfuri and Tribo, 2005).

From the same literature, some spillovers mechanisms have been identified by several authors (Blomström and Sjöholm 1998; Sjöholm, 1999; Chung, 2001; Blomström and Kokko, 2003; Vera Cruz and Dutrénit, 2005). The most important mechanisms that have been identified in the literature are related to: i) demonstration-imitation effects; ii) backwards linkages effects; iii) human capital accumulation and mobility; iv) effects on the market structure; v) effects of foreign linkages to get a major propensity to export; vi) direct technology transfer; vii) adverse selection; and viii) training effects (to acquire abilities) (Görg and Greenaway, 2001; Chung, *et al*, 2002 Blomström and Kokko, 2003; Aitken and Harrison, 1999; Jordaan, 2005).

In spite of the fact that the literature that analyzes FDI impacts on local firms has proposed some spillover mechanisms, only few works have analyzed quantitatively the occurrence of those. They analyze the specific kind of spillovers mechanisms which have a greater impact in a specific sector and locality (Ivarsson and Göram, 2005; Vera-Cruz and Dutrénit, 2005). According to these, the present research uses direct indicators to analyze knowledge spillovers, which are based on some of the spillover mechanisms proposed by other authors.

Knowledge spillover mechanisms that are analyzed in this research are related to: i) backward linkages; ii) human capital accumulation and mobility; and iii) training effects.

Knowledge spillovers through backward linkages can increase SMEs capacities in two ways: i) clients establish supportive linkages to supplier firms and they can help other firms to increase their capabilities directly; and ii) clients put some pressure on their suppliers and they become more efficient in their efforts to produce the inputs that reach the large firms' requirements of quality, quantity, delivery time and price (Jordaan, 2005). The backward linkages that are analyzed in this paper refer to the kind of supply relationship (formal or informal), and to the kind of knowledge that is transferred through supply relationships.

Knowledge spillovers through human capital mobility are associated with the development of skills of local employees. Large firms increase the stock of human capital through increasing employees' skills. When employees move to other firms, they take with them new technology and new management techniques, so that they are direct agents of technology transfer. This mechanism can be one of the most important spillover mechanisms (Blomström and Kokko, 2003; Görg and Greenaway, 2001; Chung, *et al*, 2002; Aitken and Harrison, 1999; Vera-Cruz and Dutrénit, 2005). Two kinds of spillovers through human capital mobility are analyzed in this paper: i) SMEs hire highly trained employees by large firms; and ii) employees that are trained in large firms establish their own firms.

Knowledge spillovers associated with training refer to SMEs' employees that are trained by their clients (Kinoshita, 2000). From the sector and locality analyzed, we observed that large firms are an important source of training, which can represent an important knowledge spillover mechanism.

1.3 SMEs absorptive capacities

To complete the analysis, it is necessary to identify the determinants at firm level that can affect the absorption of knowledge spillovers to increase their competitiveness. They are related to the individual performance of firms (Albaladejo, 2001; Giuliani, 2003 and 2005), and reflect their technological capabilities. These determinants have been built through a specific trajectory. From this perspective, it is important to analyze firms' absorptive capacities, which can help them to get the benefits of large firms´ spillovers.

According to Cohen and Levinthal (1990), absorptive capacities are the ability of firms to recognize the value of new information, assimilate it and apply it to commercial ends, which is critical to their innovative capabilities. This definition of absorptive capacities involves the establishment of networks with other agents for knowledge flows.

Some authors have stressed the importance of local firms´ absorptive capacities to obtain the benefits of knowledge spillovers (Kinoshita, 2000; Criscuolo and Narula, 2002; Girma and Görg, 2002; Girma, 2002). These studies have used *proxy* indicators for absorptive capacities, like the technology gap between firms, and they use local

firms´ productivity increases as an indicator of multinational companies´ knowledge spillovers. Some other works have used direct indicators for absorptive capacities (Chudnovsky, López and Rossi, 2003; Dutrénit and Martínez, 2004; Marin and Bell, 2006) such as R&D expenditure, patents, human capital, scientific and technical training, and investment in capital-embodied technology.

Most of the studies that emphasize the importance of firms´ absorptive capacities focus their analysis at the sectoral level and only few of them tackle or at least mention the heterogeneity of firms.

This paper employs direct indicators for the analysis of absorptive capacities. They are related to the experience and formation of employees and owners, technology embedded in equipment, organizational capabilities, learning and innovation activities, and linkages established with other local agents. From the analysis of SMEs´ absorptive capacities, we explicitly consider the heterogeneity of firms that are analyzed, and we classify them in four clusters according to their absorptive capacities.

Additionally, we analyze the linkages that SMEs have established with other local agents, who can increase their absorptive capacities, arguing that SMEs with higher capacities tend to establish more linkages with other local agents, and they can receive the benefits of the local infrastructure.

1.4 Relationship between knowledge spillovers and absorptive capacities

There is a common agreement that a positive relationship between FDI knowledge spillovers and local firms´ absorptive capacities is present. In this direction, some authors have emphasized the importance of firms´ absorptive capacities to capture the benefits of knowledge spillovers (Kinoshita, 2000; Girma, 2002; Girma and Görg, 2002; Criscuolo and Narula, 2002; Chudnovsky, López and Rossi, 2003; Dutrénit and Martínez, 2004; Jordaan, 2005). However, most of these studies have used indirect indicators of knowledge spillovers and absorptive capacities. In the case of the absorptive capacities, they are related to the technology gap between MNC's and local firms based on a Cobb-Douglas production function (Girma, 2002; Girma and Görg, 2002; Jordaan, 2005). In some cases, vague results were obtained, such as that the technology gap cannot be strongly related to high or low absorptive capacities. From the

same literature, other authors (Chudnovsky, López and Rossi, 2003; Dutrénit and Martínez, 2004; Marin and Bell, 2006) have used direct indicators that reflect absorptive capacities.

From the agglomerations literature, different papers support the fact that higher levels of absorptive capacities are related to higher levels of knowledge spillovers. These papers emphasize that the specific nature of firms is an important factor that can influence clusters competitiveness (Giuliani, 2003; Giuliani, 2005; Albaladejo, 2001). These authors have mentioned that knowledge spillovers cannot be diffused homogenously "through the air", though it is necessary that local firms have certain levels of absorptive capacities, which are specific to the firm level. Giuliani (2005) mentions that one of the key elements in analyzing absorptive capacities depends on the firms´ knowledge base, which can be identified by the human resources (abilities, training and experience), and in terms of the intensity of the effort (Cohen and Levinthal, 1990). In this direction, it is important to emphasize the heterogeneity of firms according to their capabilities and knowledge bases (Dosi, 1988 and 1997 and Giuliani, 2005).

It can be argued that large firms´ knowledge spillovers are strongly related to SMEs´ absorptive capacities. SMEs with higher absorptive capacities can gain more benefits from large firms´ knowledge spillovers.

2 Methodology

This study analyzes the machining industry in a Mexican locality. This is a traditional and low-tech industry integrated by SMEs with a low level of absorptive capacities. This industry presents a *hub-and-spoke* type of arrangement with its clients,[2] which are mostly domestic firms and MNCs from the automotive and home appliances sector.

This paper is based on empirical evidence gathered through a survey applied during 2005 to this industry in Querétaro a Mexican locality. One hundred and seventy nine firms answered the questionnaire, which represented the 80% of the universe of firms in the locality. We use a multivariate analysis by principal factors technique to obtain absorptive capacities and knowledge spillovers indicators; and cluster analysis to

[2] See Markusen, 1996.

differentiate groups of firms according to their absorptive capacities. We perform a structural equations analysis to identify the relationship between knowledge spillovers and absorptive capacities.

2.1 Multivariate analysis to obtain absorptive capacities

We used direct indicators to obtain SMEs´ absorptive capacities. They are integrated by five first order factors related to: i) experience and formation of owners and employees; ii) technology embedded in equipment; iii) organizational capabilities; iv) learning and innovation activities; and v) linkages established with other local agents. Table 1 lists the variables that were used to build the absorptive capacity indicator.

Table 1 Variables employed to build the indicator for absorptive capacities

Factor	Variable	Kind of variable	Missing values	Mean	SD
Experience and formation of owners and employees	Entrepreneur degree	Ordinal	8	-	-
	No. of employees	Numeric	0	11.13	22.43
	% of engineers	Numeric	0	0.10	0.23
	Employees experience in CNC	Numeric	0	2.19	5.41
	Employees experience in design	Numeric	0	11.77	16.71
	Employees experience in CAM	Numeric	0	1.20	6.56
	Employees experience in measure	Numeric	0	15.11	31.05
	Employees experience in quality	Numeric	0	3.82	17.00
Technology embedded in equipment	CAM programming	Ordinal	31	-	-
	No. CN and CNC equipment	Numeric	0	0.71	1.66
	Years of CN and CNC equipment	Numeric	0	1.61	3.23
	Tolerance for products	Ordinal	2	-	-
Organizational capabilities	Years in the market	Numeric	11	11.11	9.21
	Use of past experience for decision-making processes	Ordinal	0	-	-
	Use of technical knowledge for decision-making processes	Ordinal	0	-	-
	Formal contracts with clients	Ordinal	1	-	-
	Quality certification	Ordinal	0	-	-
	Certificate of raw material compliance	Ordinal	4	-	-
	Delivery of quality certificates	Ordinal	3	-	-
Learning and innovation activities	Projects with suppliers	Ordinal	0	-	-
	Projects with clients	Ordinal	0	-	-
	Process documentation	Ordinal	0	-	-
	Acquisition of machinery and equipment	Ordinal	3	-	-
	Documentation for changes in process	Ordinal	3	-	-
	Training programs to develop new products	Ordinal	6	-	-
	New marketing programs	Ordinal	7	-	-
	Product innovation	Numeric	14	1.59	5.85
	Process innovation	Numeric	16	1.10	4.45
Linkages established with other local agents	Suppliers	Ordinal	0	-	-
	Customers	Ordinal	0	-	-
	Competitors	Ordinal	0	-	-
	Technical institutions	Ordinal	0	-	-
	Industrial associations	Ordinal	0	-	-

Source: Author's own.
Software: SPSS

2.1.1 Cluster analysis to identify SMEs according their absorptive capacities

We used the methodology of cluster analysis to classify firms according their absorptive capacities. Once we obtained the five first order factors for absorptive capacities, we performed a cluster analysis by *k-means*. SMEs were classified according to their different levels of absorptive capacities, which depend on their knowledge bases and specific trajectories. According to these differences, firms with similar performance have been grouped in the same cluster. Four clusters were obtained, and 5 SMEs could not have been classified in any of these groups.

To identify the clusters obtained, two of the factors were plotted. SMEs were localized in different areas of the graphic according to their absorptive capacities. Factor 3 was plotted in *x* and factor 2 was plotted in *y*. Factor 2 is related to organizational capabilities and learning activities, and factor 3 is related to experience and formation of owners and employees, and to innovation activities.

2.2 Multivariate analysis to obtain knowledge spillovers

Knowledge spillovers are considered as a second order factor, which was built through four first order factors: i) entrepreneur's experience and training in large firms; ii) employee's experience and training in large firms; iii) formalization of linkages with clients; and iv) the kind of linkages established with clients. The first two factors are related to the spillovers mechanism of human capital mobility and training effects; the last two factors are related to the backward linkages mechanism. Table 2 presents the variables that were used to build those four factors.

Table 2 Variables employed to build the indicator for large firms´ knowledge spillovers

First order factor	Variable	Kind of variable	Missing values	Mean	SD
Owner's mobility	Years of experience	Numeric	6	17.04	11.54
	Experience in large firms	Ordinal	10	-	-
	Experience in management	Ordinal	5	-	-
	No. of training curses taken in large firms	Numeric	0	1.36	1.82
Employees mobility and training	No. of employees trained in large firms while working in SMEs	Numeric	0	1.33	12.89
	Importance of training by large firms	Ordinal	0	-	-
	No. of employees with experience in large firms	Numeric	11	3.65	12.50
Formal linkages with clients	Years of relationship with clients	Numeric	9	7.49	7.95
	Establishment of formal contracts	Ordinal	1	-	-
	Establishment of informal relationships	Ordinal	0	-	-

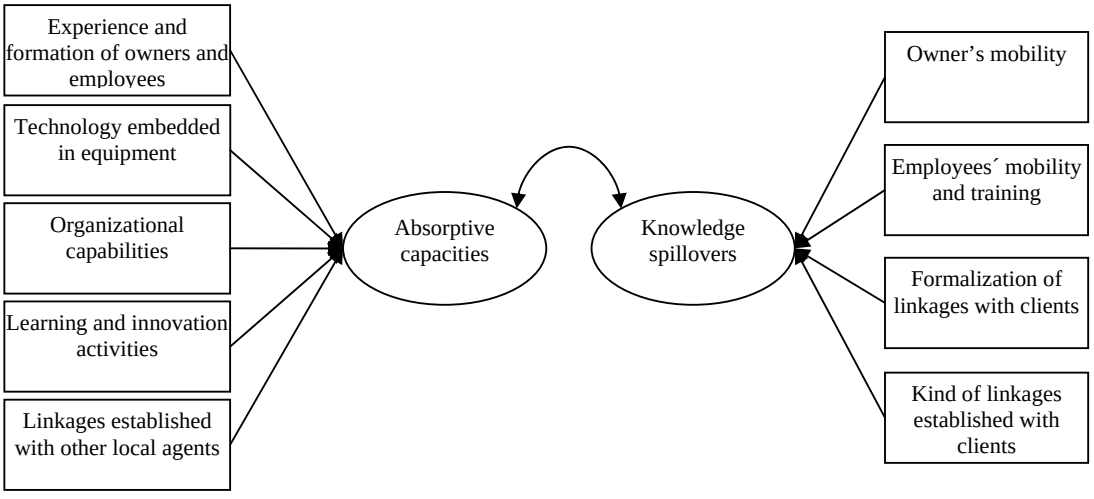
Kind of linkages established with clients	Calibration of equipment	Ordinal	0	-	-
	Product certification	Ordinal	0	-	-
	Sharing design capacities	Ordinal	0	-	-
	Sharing production capacities	Ordinal	0	-	-
	Supporting the incorporation of technologies	Ordinal	0	-	-
	Recommendations related to the lay out of the machine shop	Ordinal	0	-	-
	Clients have given equipment to SMEs	Ordinal	0	-	-
	SMEs can access large firms´ plants	Ordinal	0	-	-
	Technical advice given by clients	Ordinal	0	-	-
	Development of joint projects	Ordinal	0	-	-
	Sharing knowledge to export	Ordinal	0	-	-
	Clients´ proximity	Ordinal	0	-	-
	Openness to supplier recommendations	Ordinal	0	-	-

Source: Authors´ own.
Software: SPSS

2.3 Structural equations analysis to identify the relationship between knowledge spillovers and absorptive capacities

Based on the analysis made to obtain the indicators of absorptive capacities and knowledge spillovers, we analyzed the relationship between these two concepts through the structural equations analysis methodology. We built a structural equations model, were first order factors were obtained from building the indicators of absorptive capacities and knowledge spillovers. The second order factors are absorptive capacities and knowledge spillovers. Figure 1 presents the structural equations model.

Figure 1 Structural equations model for absorptive capacities and large firm's knowledge spillovers



Source: Authors´ own

3 SMEs´ absorptive capacities and large firms´ knowledge spillovers

3.1 Clusters of SMEs according to their absorptive capacities

We perform a multivariate analysis by the extraction of principal factors technique, to obtain the five factors that are related to SMEs absorptive capacities. Table 3 reports the percent of variance explained by these first order factors, which explain the 45.7% of the total variance.

Table 3 Total variance explained for absorptive capacities

Factor	% of variance	% Cumulative
1	16.80	16.80
2	8.83	25.64
3	7.73	33.38
4	6.74	40.12
5	5.59	45.72

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.
Software: SPSS
Extraction method: principal factor analysis

Once the component matrix was obtained, it was rotated. The rotation main objective is to find a better structure according to each factor. Table 4 presents the rotated component matrix.

Table 4 Rotated component matrix for absorptive capacities

First order factor	Variable	Component				
		1	2	3	4	5
Experience and formation of owners and employees	Entrepreneur degree	.171	.065	.275	.184	**-.318**
	No. of employees	.288	.104	**.572**	.141	-.045
	% of engineers	-.161	-.053	**.341**	-.085	-.259
	Employees experience in CNC	**.748**	-.003	.083	-.076	.009
	Employees experience in design	**.518**	.128	-.116	.207	-.187
	Employees experience in CAM	.302	-.087	.157	**.765**	-.226
	Employees experience in measure	**.838**	.140	.009	-.045	.092
	Employees experience in quality	**.807**	.172	.077	-.104	.194
Technology embedded in equipment	CAM programming	**-.535**	.080	-.343	-.341	.250
	No. CN and CNC equipment	**.659**	.026	.198	-.066	.029
	Years of CN and CNC equipment	**.348**	-.032	.351	.215	-.183
	Tolerance for products	**.240**	.159	-.155	.129	.143
Organizational capabilities	Years in the market	**.260**	-.073	.217	-.114	.173
	Use of past experience for decision-making processes	-.010	**-.634**	-.144	-.002	.290
	Use of technical knowledge for decision-making processes	-.065	**.587**	.087	-.002	-.304
	Formal contracts with clients	**-.358**	-.108	-.063	-.064	.016
	Quality certification	-.011	.021	**-.649**	-.197	.201
	Certificate of raw material compliance	.068	**.701**	.140	-.076	.154
	Delivery of quality certificates	.216	**.655**	.244	-.013	-.024

First order factor	Variable	Component				
		1	2	3	4	5
Learning and innovation activities	Projects with suppliers	.208	**.595**	-.163	.237	.084
	Projects with clients	.163	**.637**	-.044	.226	.036
	Process documentation	.107	**.638**	-.025	.042	.141
	Acquisition of machinery and equipment	.254	.214	**.435**	.014	.105
	Documentation for changes in process	.364	.295	**.430**	.054	.170
	Training programs to develop new products	.304	.306	**.622**	.081	.252
	New marketing programs	-.180	.091	**.512**	.054	.256
	Product innovation	.025	.084	-.009	.068	**.738**
	Process innovation	.083	-.007	.038	.073	**.716**
Linkages established with other local agents	Suppliers	-.112	.135	.074	**.713**	.059
	Customers	-.056	.264	-.025	**.633**	.161
	Competitors	-.194	.428	.041	**.407**	.105
	Technical institutions	-.012	.028	.030	**.631**	.076
	Industrial associations	.100	-.024	.007	**.705**	-.072

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.
Software: SPSS
Extraction method: Principal factor analysis.
Rotation Method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

Four clusters with different types and levels of absorptive capacities were identified. Table 5 presents the four clusters that were obtained and the number of firms that belong to each cluster.

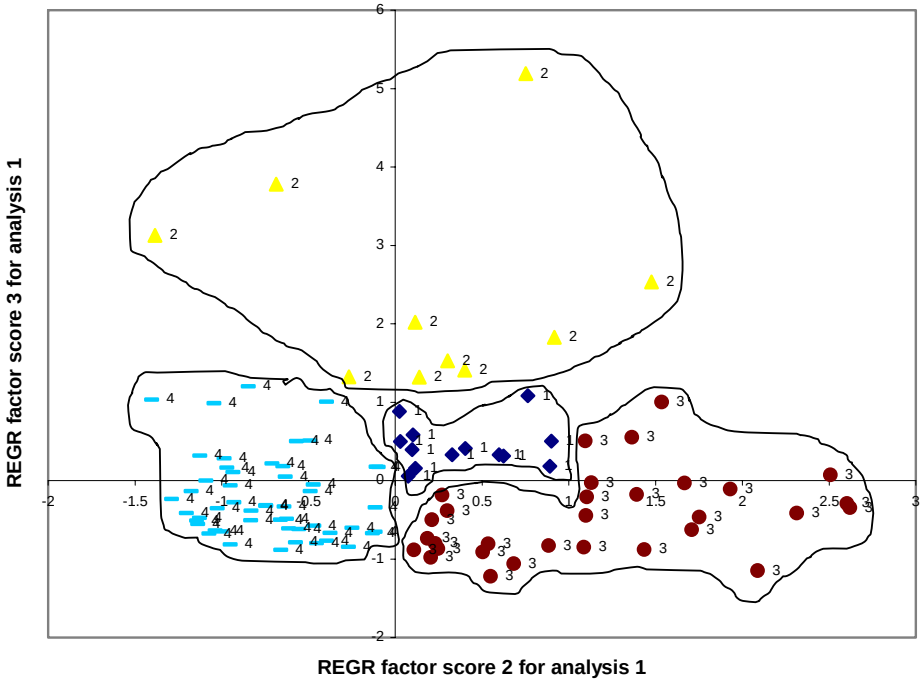
Table 5 Number of SMEs in each cluster

Cluster	No. of SMEs
1	13
2	10
3	31
4	51
SMEs not classified	5
Total of SMEs analyzed	110

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.

To identify the clusters obtained, two of the factors were plotted. SMEs were localized in different areas of the graphic according to their absorptive capacities. Factor 3 was plotted in *x* and factor 2 was plotted in *y*. Factor 2 is related to organizational capabilities and learning activities, and factor 3 is related to experience and formation of owners and employees, and to innovation activities.

Figure 2 Clusters of SMEs according to their absorptive capacities



Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.

The main characteristics of each cluster are presented in Table 6.

Table 6 Main characteristics of the clusters

Main characteristic	Cluster				
	1	**2**	**3**	**4**	**Total**
Number of firms	13	10	31	51	110
% of owners with a bachelor degree	76.9%	60.0%	29.0%	23.5%	36.4%
Number of employees	172	467	154	222	1,077
% of employees with engineer degree	7.6%	7.7%	5.8%	5.0%	6.8%
Engineers per firm (including the owner)	1.5	3.9	0.5	0.4	0.9
Experience of employees per firm in CNC	1.8	0.6	0.3	0.3	0.6
Experience of employees per firm in design	6.4	1.6	2.2	0.9	2.1
Experience of employees per firm in CAM	0.5	0.4	0.1	0.0	0.2
Technology embedded in equipment					
Conventional equipment per firm	5.5	4.5	4.3	3.6	4.1
CN machinery per firm	1.3	0.4	0.0	0.2	0.4
CNC machinery per firm	1.2	0.6	0.1	0.1	0.3
Wire EDM machinery per firm	0.6	0.7	0.1	0.1	0.2
Grinding wheel machinery per firm	1.5	1.1	1.2	0.6	1.0
% of firms that use CAM to program	77%	30%	0%	4%	16%
% of firms that establish formal contracts with clients	30.8%	10.0%	12.9%	11.8%	15.5%
Product innovation per firm	0.4	1.1	1.8	0.6	1.9
Process innovation per firm	0.7	1.0	0.8	0.4	1.3
Products	Diversified	Specialized	Specialized	Specialized	Both

Main characteristic	Cluster				
	1	2	3	4	Total
Annual total sales (USD)	$3,155,000	$2,150,000	$5,397,300	$3,213,700	$14,420,000
Average sales per firm (USD)	$262,916	$215,000	$179,910	$ 68,376	$138,653

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.
Sample: 110 firms
Note: Product and process innovation are new to firms, but they exist in the national market.

Cluster 1. Consolidated firms with potential to produce more complex products

Cluster 1 is formed by 13 SMEs, their average sales are in the order of $262 thousand dollars. Their production is diversified, and they mainly produce gears, fixtures, axis, molds, and assembly lines.

In relation to the experience and formation of entrepreneurs, 76.9% of them have a professional background, most of them in engineering. The 7.6% of employees have an engineer degree. Including the owner and employees, this cluster has 1.5 engineers by firm. Most of the employees have experience in CNC machining, CAM, and design, they have the capabilities to produce more complex products.

This cluster has the highest proportion of CNC equipment, and the 77% of these firms employ CAM to program their production, which permits a more efficient use of their equipments.

31% of these SMEs have formal contracts with their clients; according to these, they have a high level of certainty to plan future activities. However, the number of product and process innovations is low, even if they are compared to other clusters. Their organizational capabilities are relatively low.

According to the establishment of linkages with other local agents, the most important are those linkages that they establish with their clients to improve the products.

Cluster 2. Consolidated and innovative firms, with skilled human resources

Cluster 2 is formed by 10 SMEs. They are specialized and they mainly produce gears, fixtures, axis and molds. Their average sales are in the order of $215 thousand dollars.

Related to the entrepreneur's formation, 60% of them have a professional background, 30% of them in engineering, 7.7% of employees have an engineer degree. Including the owners and employees with engineering degrees, this cluster has 3.9 engineers by firm, which means that the activities related to engineering are better distributed. In this way, the owners can use most of their time for activities related to management and planning. Employees have experience in equipments for measure and calibration, quality systems and design.

SMEs from this cluster have mainly conventional equipment. The proportion of CN and CNC versus conventional equipment is low. This cluster only has one CN or CNC equipment by firm, and only 30% of these firms use CAM to program their production.

Only 10% of the firms have contracts with their clients, which can be a problem in relation to the decision taking process for long term investment. However, due to the linkages established with their clients, these SMEs have developed a high number of product and process innovations. Linkages established with other local agents are mainly with suppliers, clients, and other SMEs from the industry. Linkages with suppliers are mainly for training, linkages with clients are focused in the development of activities that can help to strengthen SMEs´ capabilities and to improve the products. Linkages with other SMEs are mainly to reach their clients´ specifications.

Cluster 3. Traditional firms with potential to strengthen their capacities

Cluster 3 has 31 SMEs. Their products are specialized; they mainly produce gears, fixtures, axis and molds. Their average sales per year are in the order of $179 thousand dollars.

In relation to the owners' background, most of them have technical studies; only 29% of them have professional degrees. 16% of the owners and 5.8% of the employees have an engineering degree. Including the owner and employees with engineering degrees, this cluster has less than one engineer by firm (0.5 engineers by firm).

Employees have experience in design, measuring and calibration equipments. Only a very small proportion of employees have experience in CNC machining and CAM

programming, which makes it difficult for them to produce certain products which need a higher level of precision and quality.

Enterprises in this cluster only have conventional equipment, they do not have CN and only three firms have CNC equipment, and they do not use CAM programming for their production.

Only 13% of SMEs from this cluster have contracts with their clients, which makes it difficult for them to make plans and to engage in a decision taking process related to investment for machinery and equipment.

Even though these SMEs have a small level of engineers by firm and do not have CNC equipment, they have developed a considerable number of product and process innovations. The number of product innovations is even higher than those for clusters 1 and 2. This is due to the fact that they have established an important level of linkages with their clients.

This cluster has established linkages with clients and competitors. Linkages with clients are related to activities that can strengthen the characteristics of their products. Linkages established with competitors are related to the exchange of information, subcontracting of orders and machinery sharing. These activities are mainly focused to reach the clients requirements.

Cluster 4. Traditional firms with basic production capabilities

Cluster 4 has 51 SMEs. They are specialized in the production of gears, fixtures and axis. Average sales are in the order of 68 thousand dollars per year.

In terms of the owner's background, most of them have technical studies or practical experience, only 23% of them have professional degrees. 16% of owners and 5% of employees have an engineering degree. On the whole, including employees and owners, this cluster has the lowest number of engineers, less than one engineer per firm (0.4 engineers per firm).

Employees have experience in measuring and calibration equipment, but they do not have experience in CNC machining and CAM programming. This cluster has mainly conventional equipment; only 24% of these SMEs have CN and CNC equipment, and 4% use CAM for their production.

Only 11% of these SMEs have established contracts with their clients, for this reason, it is difficult for them to engage in the decision taking process related to the investment of equipment and machinery.

They have not developed an important number of product and process innovations, because these SMEs have neither enough capabilities, nor have they established a high number of linkages with their clients that enable them to develop innovations.

This cluster has not established enough linkages with other local agents, the only important linkages are those related with their clients, where they mainly share production and design capabilities.

3.2 Large firms´ knowledge spillovers

By the extraction of principal factors technique, it was possible to obtain four factors that are related to large firms´ knowledge spillovers. Table 7 reports the percent of variance explained by these first order factors, which explain the 39.4% of the total variance.

Table 7 Total variance explained for knowledge spillovers

Factor	% of variance	% Cumulative
1	17.8	17.8
2	8.4	26.1
3	6.9	33.0
4	6.4	39.4

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.
Software: SPSS
Extraction method: principal component analysis

Once obtained the component matrix, it was rotated. Table 8 presents the rotated component matrix.

Table 8 Rotated component matrix for knowledge spillovers

First order factor	Variable	Component			
		1	2	3	4
Owner's mobility	Years of experience	-.033	-.298	-.181	**.414**
	Experience in large firms	.065	.041	.141	**-.689**
	Experience in management	.095	**-.375**	.169	-.224
	No. of training curses taken in large firms	.035	.126	.145	**.700**
Employees´ mobility and training	No. of SMEs´ employees trained in large firms	-.126	.122	**.599**	.243
	Importance of training by large firms	-.076	**.413**	-.050	-.028
	No. of employees with experience in large firms	**.577**	.104	.353	.297
Formalization of linkages with clients	Years of relationship with clients	**.220**	-.076	-.007	-.066
	Establishment of formal contracts	-.181	-.228	-.162	**-.490**
	Establishment of informal relationships	-.149	.352	**.370**	.310
Kind of linkages established with clients	Calibration of equipment	**.585**	-.029	.006	-.059
	Product certification	.208	.006	**.541**	-.225
	Sharing design capacities	**.506**	.460	-.074	-.153
	Sharing production capacities	**.484**	.224	.204	-.257
	Supporting the incorporation of technologies	**.615**	.287	.234	-.083
	Recommendations related to the lay out of the machine shop	.150	**.347**	.321	-.068
	Clients have given equipment to SMEs	**.506**	-.024	-.048	.237
	SMEs can access large firms´ plants	**.583**	.277	.085	.216
	Technical advice given by clients	.429	**.503**	-.075	.040
	Development of joint projects	.101	-.023	**.765**	-.049
	Sharing knowledge to export	.323	**.592**	.022	.046
	Clients´ proximity	.006	**.716**	.164	.054
	Openness to supplier recommendations	.079	**.492**	.247	.065

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.
Software: SPSS
Extraction method: Principal factor analysis.
Rotation method: Varimax with Kaiser Normalization.
Rotation converged in 6 iterations

i) The Owner's Mobility

Most of the owners have had an average experience of 18 years in other organizations. Their experience has been mainly in production activities, followed by quality and maintenance. A small percent of the owners have had experience in management. Management activities are related to a higher level of responsibility and knowledge transfer, which means that owners with previous management experience have acquired higher capabilities.

ii) Employees´ mobility and training effects

Almost 39% of the employees have had experience in large firms, and 43 of the employees have been trained by large firms while working in SMEs. This means that important mechanisms for knowledge spillovers are human capital mobility and training effects.

3.2.1 Backward linkages

SMEs have an average relationship of 6 years with their clients, though it is not common for these SMEs to establish formal contracts with their clients, which makes it difficult for them to have a high certainty level. This condition represents a barrier for investment projects.

The most common knowledge related to the backward linkages is: i) access to large firms´ installations; ii) large firms´ demonstration of interest in the recommendations made by their suppliers to increase products quality; and iii) transfer of design and production capabilities. These activities help SMEs to increase their capabilities and to produce more complex inputs. This is important for SMEs because it is possible for them to increase their market share by increasing their capabilities.

3.2.2 Relationship between knowledge spillovers and absorptive capacities

To analyze the relationship between knowledge spillovers and absorptive capacities, we designed a structural equations analysis model. The modeling of structural equations is a powerful tool of multivariate analysis. We used the technique of causal modeling; this kind of models can incorporate both, first and second order factors. For this model, first order factors where obtained previously, while second order factors represent absorptive capacities and knowledge spillovers.

According to the statistical analysis of structural equations, the correlation matrix explains the relationship between the first order factors. Table 9 presents the correlation matrix that was obtained.

Table 9 Correlation matrix of absorptive capacities and knowledge spillovers

	FORMA	TECNO	CAPORG	INNOVA	VINC	EXPERP	EXPERE	VCP	TIPO
FORMA	**1.000**								
TECNO	0.503	**1.000**							
CAPORG	0.309	0.084	**1.000**						
INNOVA	0.502	0.323	0.594	**1.000**					
VINC	0.084	0.092	0.252	0.365	**1.000**				
EXPERP	-0.103	-0.246	0.124	0.005	0.116	**1.000**			
EXPERE	0.065	-0.068	0.386	0.340	0.191	0.067	**1.000**		
VCP	0.281	0.324	0.366	0.509	0.525	0.066	0.310	**1.000**	
TIPO	0.322	0.261	0.298	0.565	0.395	-0.098	0.471	0.466	**1.000**

Source: Authors´ own. Survey applied to SMEs machining shops located in Querétaro, México, UAM-X, 2005.
LISREL
Note:
For absorptive capacities. FORMA: Experience and formation of owners and employees; TECNO: technology embedded in equipment; CAPORG: organizational capabilities; INNOVA: learning and innovation activities; VINC: linkages established with other local agents.
For knowledge spillovers. EXPERP: Owner's mobility; EXPERE: Employees´ mobility and training; VCP: Formalization of linkages with clients; and TIPO: Kind of linkages established with clients.

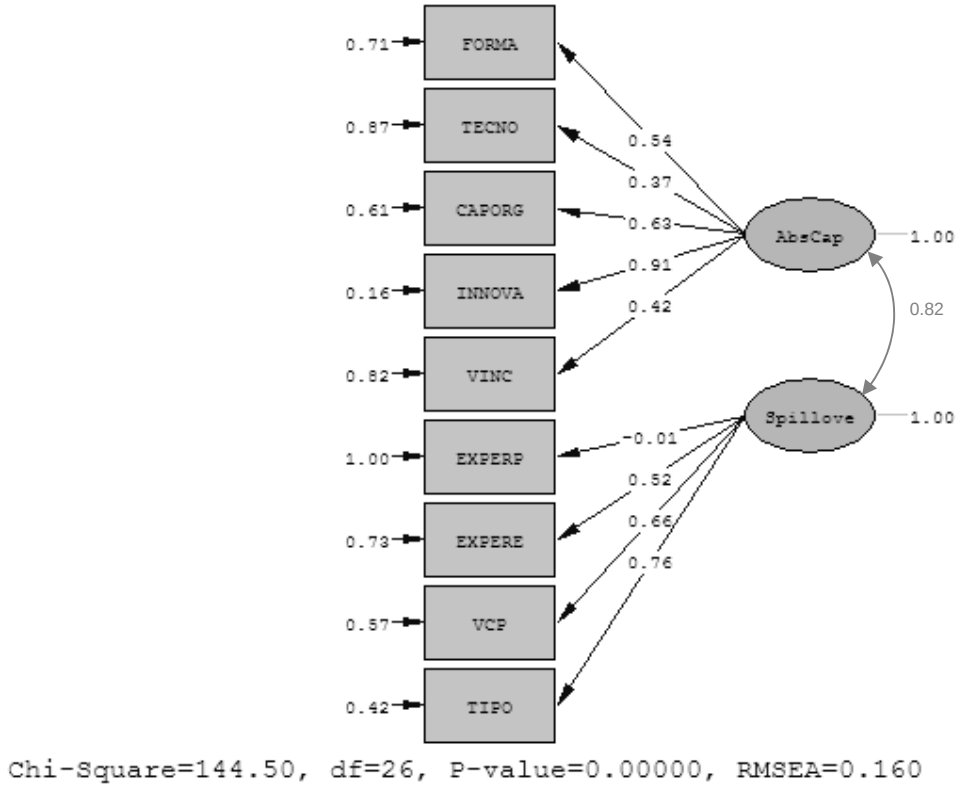
Through the correlation matrix analysis, it is possible to see that the formation of the owner and employees have a direct and important relationship to the technology embedded in equipment, and to the innovation and learning activities. Innovation and learning activities have a direct relationship to the linkages established with clients, to the kind of linkages that are established between SMEs and large firms, and to the SMEs´ organizational capabilities.

Figure 3 shows the correlations obtained from the structural equations analysis. This figure presents the correlation between each one of the first order factors with both of the second order factors. Particularly, we analyzed:

i. The correlation between absorptive capacities and: i) experience and formation of owners and employees; ii) technology embedded in equipment; iii) organizational capabilities; iv) learning and innovation activities; and v) linkages established with other local agents.
ii. The correlation between knowledge spillovers and: i) owner's mobility; ii) employees´ mobility and training; iii) formalization of linkages with clients; and iv) the kind of linkages established with clients.
iii. The relationship between both second order factors: absorptive capacities and knowledge spillovers.

All the factors that were analyzed are located in the diagram. Second order factors were placed at the right side of the diagram, where arrows show the relationship with the first order variables.

Figure 3 Structural equations model diagram between SMEs´ absorptive capacities and large firms´ knowledge spillovers



LISREL
Sample size: 110 observations.
Note:
For absorptive capacities. FORMA: Experience and formation of owners and employees; TECNO: technology embedded in equipment; CAPORG: organizational capabilities; INNOVA: learning and innovation activities; VINC: linkages established with other local agents.
For knowledge spillovers. EXPERP: Owner's mobility; EXPERE: Employees´ mobility and training; VCP: Formalization of linkages with clients; and TIPO: Kind of linkages established with clients.

According to the results of the structural equations analysis, we can see the following effects related to the correlation of each one of the first with the second order factors. In relation to the absorptive capacities, the factors that have the highest impact are innovation and learning activities, and organizational capabilities. 91% of innovation and learning activities; and 63% of the organizational capabilities explain SMEs´ absorptive capacities. From this point of view, it is important to strengthen organizational capabilities and innovation and learning activities, with the main objective to increase SMEs´ absorptive capacities. In relation to the other factors, 54% of experience and formation of owners and employees, 42% of the linkages established

to other local agents, and 37% of the technology embedded in equipment explain SMEs´ absorptive capacities. The low relationship that represents the linkages established to other local agents can be due to the fact that SMEs have low capabilities, and it is difficult for them to establish high levels of linkages to other local agents.

In relation to large firm's knowledge spillovers, the factors that have a higher impact are related to the mechanism of backward linkages, 66% of the factor related to the formality of linkages, and 76% of the factor related to the kind of linkages, explain large firm's knowledge spillovers. This correlation is due to the fact that SMEs´ absorptive capacities are strongly influenced by their clients.

The factor of employees´ mobility explains 52% of large firms´ knowledge spillovers, which means that the knowledge acquired by the previous experience of employees is an important mechanism for knowledge spillovers at the sector and locality analyzed.

On the contrary to that explained by other authors in relation to the mechanism of human capital mobility (Görg and Greenaway, 2001 Vera-Cruz and Dutrénit, 2005), the factor that has the lowest impact and even has a negative relationship is related to the owner's mobility. The variables that were used to build this factor were: i) years of experience in other firms; ii) experience in large firms; iii) experience in middle management; and iv) training courses in other firms. However, these variables do not help to explain the knowledge spillovers through the owner's mobility.

Related to the years of experience of the owner in other firms, and to their experience in large firms, we did not find any correlation to knowledge spillovers. It is not enough that the owners have had experience in large firms to gain the knowledge that can be diffused through spillovers. In the sector and locality analyzed, it was possible to see that owner's mobility is not an important spillover mechanism, due to the fact that there is a small percent of owners with professional background. This lack of formal education makes difficult for them to absorb all the knowledge because: i) as they do not have formal education, they can not develop high level activities in large firms; and ii) it is more difficult for them to absorb most of the tacit knowledge that can be acquired in large firms, and they have difficulties to codify it and to apply it at their own firms. The only representative variable for knowledge spillovers related to the owner's

mobility is their experience in middle management activities. The development of these activities requires, in most of the cases a professional degree, and this can help them to acquire organizational and technological activities.

According to the correlation between the two second order factors, Table 10 presents the correlation level that was obtained by the structural equations analysis.

Table 10 Correlation of absorptive capacities and knowledge spillovers

	Absorptive capacities	**Knowledge spillovers**
Absorptive capacities	**1.000**	
Knowledge spillovers	0.820 (0.054) 15.245	**1.000**

Number of Iterations = 22
LISREL Estimates (Maximum Likelihood)

According to Table 10, the relationship between absorptive capacities and large firms´ knowledge spillovers has a correlation of 82%. We have observed a positive and strong relationship between SMEs´ absorptive capacities and large firms' knowledge spillovers.[3] We have identified that linkages with local agents are strongly related to SMEs´ absorptive capacities. Thus SMEs with higher absorptive capacities tend to establish higher levels of linkages with other local agents. Meanwhile, SMEs with lower levels of absorptive capacities tend to establish lower linkages with local agents, and it is harder for them to obtain the benefits of the local infrastructure.

4 Conclusions

The main aim of this paper was to analyze the relationship between large firms´ knowledge spillovers and SMEs´ absorptive capacities. We focused in analyzing SMEs´ absorptive capacities in a specific sector and locality, the sector is low-tech and mature. Through the use of direct indicators, it has been possible to increase the knowledge which has been provided by other authors, related to absorptive capacities, knowledge spillovers, and the relationship between these two concepts.

Absorptive capacities were determined by the following variables: i) experience and formation of owners and employees; ii) technology embedded in equipment; iii)

[3] According to the indexes for the goodness fit statistics, this model is acceptable. Our sample size was 110, and the indexes CFI, IFI, and GFI are higher than 0.81, RMR and RMSEA indexes are 0.105 and 0.160 respectively.

organizational capabilities; iv) learning and innovation activities; and v) linkages established with other local agents. Knowledge spillovers were built based on some of the knowledge spillovers proposed by other authors, such as: i) owner and employees´ mobility; ii) backward linkages; and iii) training effects.

In relation to SMEs´ absorptive capacities, the factors with the highest influence are organizational, innovation and learning capabilities, which are strongly related to the owner's and employees´ background.

We observed that the most important factors that explain knowledge spillovers are related to the backward linkages established between large firms and SMEs. This is due to the fact that SMEs are strongly influenced by their clients. The mobility of owners does not represent an important mechanism for knowledge spillovers in the sector and locality analyzed. However, the only significant variable of knowledge spillover through the mechanism of owners´ mobility is related to the owner's experience in managerial activities. This is contrary to that found by other authors. However, due to the characteristics of the sector analyzed, the owner's mobility does not represent an important mechanism for large firms´ knowledge spillovers.

SMEs of the machining industry have accumulated different levels of absorptive capacities. The degree of accumulation has positioned them in different competitive levels; that is why it is possible to find a high level of firms´ heterogeneity in this sector. It was possible to obtain 4 clusters of firms according to their absorptive capacities.

Cluster 1 is formed by consolidated firms with potential to produce more complex products. The SMEs with higher absorptive capacities were clustered here. Most of the owners have professional degrees, and employees have the abilities to produce more complex products. These SMEs can increase their market share with appropriated policy measures to increase their linkages with their clients.

Cluster 2 is integrated by consolidated and innovative firms, with skilled human resources. This cluster has a high level of absorptive capacities. This cluster has the highest level of engineers by firm, and has a high level of linkages with their customers.

They have developed an important number of product and process innovations. Policy measures for their strengthening must be focused on the increase of their sales level.

Cluster 3 is formed by traditional firms with potential to strengthen their capabilities. This cluster has a low level of engineers by firm. However, they have established a high level of linkages with their competitors, were they share capabilities to reach their client's specifications. Policy measures must be focused on the strengthening of the owners´ abilities through technical and organizational training, and on strengthening the linkages established between firms in the same sector.

Cluster 4 is formed by traditional firms with basic production capabilities; they have a low level of sales by employees. Employees have experience in the most basic activities, but without a proper training scheme, it can be difficult for them to keep accumulating more complex capabilities. The strengthening of these SMEs requires policy measures focused on the development of their technical capabilities.

Large firms´ knowledge spillovers can strengthen SMEs´ absorptive capacities. Nevertheless, it is necessary that SMEs have certain levels of absorptive capacities. In this paper we have proved, through a structural equations analysis model and using direct indicators for knowledge spillovers and absorptive capacities, that there is a positive and strong correlation between these two concepts. From this point of view, the promotion of backward linkages between large firms and SMEs, can have a higher and positive impact on SMEs, thus it is important to develop policy measures focused on increasing SMEs´ absorptive capacities.

From this perspective, public policies at regional level should consider fostering absorptive capacities, but they have to design specific policies for each cluster. In addition to these policies, it is necessary to design schemes to promote stronger linkages between local agents and SMEs.

To strengthen SMEs´ absorptive capacities, it is necessary to reinforce their organizational, innovation and learning capabilities, as these factors where those of the highest importance for the SMEs´ absorptive capacities. Organizational capabilities and innovation and learning activities are strongly related to the owner's and employees´

background. From this point of view, it is important that the design of training courses focus on the strengthening of these capabilities.

We observed that the most important factors that explain knowledge spillovers are related to the backward linkages established between large firms and SMEs. This is due to the fact that SMEs are strongly influenced by their clients. To strengthen large firms´ knowledge spillovers, it is important to increase the level of linkages between large firms and SMEs, as the backward linkages mechanism was the most important for knowledge spillovers in this specific sector and locality.

It is still necessary to identify quantitatively if knowledge spillovers determine absorptive capacities or vice versa. According to the analysis, we can say that absorptive capacities determine knowledge spillovers; and at the same time, knowledge spillovers increases SME´ absorptive capacities. This interaction becomes the relationship between knowledge spillovers and absorptive capacities a virtual one that can help to increase the level of knowledge of SMEs.

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