SMEs´ absorptive capacities and large firms´ knowledge spillovers: Micro evidence from Mexico♦

Topic 4 Innovation and entrepreneurship: indigenous knowledge systems and traditional sectors (e.g. agriculture, handcraft, fashion, clothing, music, eco-tourism, etc.)

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Abstract

The aim of this paper is to analyze the relationship between large firms´ knowledge spillovers and small and medium enterprises (SMEs) absorptive capacities. We built direct indicators for these two concepts and we carried out a structural equations analysis to determine the relationship between them. Based on firm level original data from a survey that focus on SMEs in a Mexican locality, this paper argues that in a low-tech and mature sector, such as the machine shop sector, that operates in a loosely articulated local system, two spillover mechanisms are relevant: the backward linkages and the employees´ mobility. Regarding SMEs' absorptive capacities we found that they are strongly influenced by organizational capabilities and innovation and learning activities. We also found that knowledge spillovers are strongly correlated to absorptive capacities.

Introduction

During the past ten years, there has been a growing interest regarding the analysis of knowledge spillovers between firms. Several studies from different bodies of literature have identified some factors that affect the scope of knowledge spillovers, reaching some consensus that one of the most important are firms´ absorptive capacities. Even though there is a common agreement in regard the positive and direct relationship between knowledge spillovers and absorptive capacities, there are still some gaps when identifying the nature of this relationship, the main knowledge spillovers mechanisms and the main determinants of absorptive capacities.

There are important contributions from the FDI literature regarding the identification of different spillover mechanisms for different sectors, such as demonstration-imitation effects, backward linkages, direct technology transfer, training, human capital mobility, competence increase, and foreign linkages (Albaladejo, 2001; Chudnovsky, et al, 2003; Dutrénit and Martínez, 2004; Giuliani, 2005; Vera-Cruz and Dutrénit, 2005; Jordaan, 2005; Marin and Bell, 2006 among others).

From the FDI and the clusters literature, some studies have analyzed the importance of firms´ absorptive capacities to get the benefits of knowledge spillovers. They emphasize the role of investment in knowledge and abilities (i.e. investment in R&D), investment

in embedded technology, and firms´ innovation strategy as the main determinants for absorptive capacity (Chudnovsky, *et al*, 2003; Alcácer and Chung, 2003; Giuliani, 2003; Escribano, Fosfuri and Tribo, 2005; Ivarsson and Göram, 2005; Vera-Cruz and Dutrénit, 2005; Marin and Bell, 2006). These works have contributed to the analysis of some of its determinants for different sectors.

Most of the works that have analyzed the relationship between knowledge spillovers and absorptive capacities use proxy indicators for knowledge spillovers or absorptive capacities. The use of this type of indicators is problematic, as some of the works have reached contradictory results regarding the relationship among these two concepts.

Focusing on SMEs from a specific sector and locality in Mexico, we go further in the discussion and disentangle the specificities of the relationship between large firms´ knowledge spillovers and SMEs´ absorptive capacities. We also contribute to the analysis of the main determinants of each one of these two concepts. This paper is based on firm level original data from a survey applied during 2005 to SMEs that belongs to the machining sector in a specific locality in Mexico (Querétaro). Those SMEs are suppliers to medium and large firms, mainly from the automotive, home appliances and electric-electronic sectors. Querétaro has several agents, such as firms, public research centers, universities, government agencies, and industrial associations.

This paper is divided in four sections; the next section presents the analytical framework that refers to knowledge spillovers, absorptive capacities and the relationship between these two concepts. Section 2 describes the methodology. Section 3 presents and discusses the empirical evidence and the main results from the analysis. Section 4 concludes.

1 The importance of absorptive capacities to get the benefits of knowledge spillovers

This paper draws on the literature of knowledge spillovers and absorptive capacities. Several studies that analyze the impact of foreign direct investment (FDI) on host countries focus on spillovers from Multinational Corporations (MNCs) to local firms. These studies correlate MNCs´ spillovers with increases in local firms´ productivity, arguing that productivity increases are directly related to spillovers (SJÖHOLM, 1999; CHUNG, 2001; BLOMSTRÖM and KOKKO, 2003). Nevertheless, the use of these *proxy* indicators does not permit to observe whether local firms´ productivity increases are in fact due to FDI spillovers or to other factors.

Other bodies of literature focus on knowledge flows among agents within the same locality (Giuliani, 2003 and 2005). These works usually emphasize the heterogeneity of firms and some of them use direct indicators. These works stress the fact that knowledge flows can not be diffused homogenously through the air and local firms need certain level of absorptive capacities to reap their benefits.

Following ESCRIBANO, FOSFURI and TRIBO (2005, pp. 2), who define knowledge spillovers as involuntary knowledge flows that arise when part of the knowledge generated by an organization spills over its boundaries and become available to other organizations. We adapt their concept to analyze large firms´ spillovers –that can be either national or MNC, to local SMEs within a specific locality. We define knowledge spillovers as *"The organizational and technological benefits that local SMEs get from large firms knowledge flows, which can be either intentional or unintentional, and increase SMEs productivity"*.

There are several mechanisms for knowledge spillovers (BLOMSTRÖM and SJÖHOLM 1998; GÖRG and GREENAWAY, 2001; BLOMSTRÖM and KOKKO, 2003; VERA-CRUZ and DUTRÉNIT, 2005; JORDAAN, 2005), such as:

i. Backward linkages: mainly observed by direct technology support, to reach customers demands. MNCs increase their specific requirements and local firms have to use their resources more efficiently.
ii. Human capital mobility: Large firms increase the human capital pool. Their employees, engineers and technicians develop organizational and technical abilities, acquiring important experience. Employees are embedded with the technology, knowledge, and organizational techniques and they are direct agents of technology transfer.[1] This spillover mechanism can be observed through: hiring employees highly qualified; and entrepreneurship, creation of new firms.
iii. Training: Backward linkages sometimes promote the training of key employees of supplier firms to increase their abilities to reach customer demands.
iv. Direct technology transfer: Backward linkages also promote direct technology transfer from large firms to their suppliers to reach certain requirements.
v. Demonstration-imitation:[2] It usually occurs when firms observe and copy other firms´ processes, increasing their productivity.
vi. Competence increase: Large firms can increase competence if they encourage local firms to reach their demands and local firms take specific actions to maintain and

increase their market shares.[3] To keep their market shares, local firms use their technology and resources more efficiently to increase their productivity.

vii. Foreign linkages: Firms can learn how to export from other firms with more experience. Exportation processes involves a deep knowledge in regard to markets, quality, specifications, etc. Local firms can imitate their techniques and learn how to supply foreign markets.

Table 1 sums up the knowledge spillover mechanisms described above, and classify them according to the diffusion channel and type of spillover.

Table 1 Knowledge spillover mechanisms

Mechanism	Sources of productivity gain	Diffusion channel	Type of spillover
Backward linkages	– Support linkages – Efficiency increase	– Formal	– Vertical
Human capital mobility	– Increases in productivity – Tacit knowledge	– Informal	– Vertical – Horizontal
Training	– Tacit knowledge	– Formal	– Vertical
Direct technology transfer	– Increase in competitiveness	– Formal	– Vertical
Demonstration-Imitation	– Adoption of new production methodologies – Adoption of new management practices	– Formal – Informal	– Vertical – Horizontal
Competence increase	– Efficiency increase – Faster adoption of new technologies	– Formal – Informal	– Vertical – Horizontal
Foreign linkages	– Economies of scale – Exposition to international markets	– Formal – Informal	– Vertical – Horizontal

Source: Adapted from GÖRG and GREENAWAY, 2001.

Despite these important contributions, only few works have analyzed quantitatively the occurrence of knowledge spillovers, focusing on some of the above mechanisms within a specific sector and locality (ANDREA, MOTTA, and RONDE, 2001; VERA-CRUZ and DUTRÉNIT, 2005; IVARSSON and GÖRAN, 2005), but usually they do not analyze the relationship between absorptive capacities and knowledge spillovers. This paper focuses on two spillovers mechanisms, the backward linkages and human capital mobility. We go further in the identification of the importance of those mechanisms for knowledge spillovers within a specific sector and locality, and the specific relationship between knowledge spillovers and absorptive capacities.

As mentioned above, absorptive capacities are one of the most important factors that affect the scope of knowledge spillovers. In this direction, some authors have analyzed the importance of local firms´ absorptive capacities to capture the benefits of knowledge spillovers (CHUDNOVSKY, LÓPEZ and ROSSI, 2003; DUTRÉNIT and MARTÍNEZ, 2004; ALBALADEJO, 2001; GIULIANI, 2003 and 2005; JORDAAN, 2005). These

authors have mentioned that knowledge spillovers cannot be diffused homogenously "through the air"; in contrast it is necessary that local firms have certain levels of absorptive capacities, which are specific to the firm.

Absorptive capacities reflect firms´ knowledge bases and are related to the individual performance of firms (ALBALADEJO, 2001; GIULIANI, 2003 and 2005). According to COHEN and LEVINTHAL (1990, pp. 128), absorptive capacities are the ability of firms to recognize the value of new information, assimilate it and apply it to commercial ends.

Some works from the literature of FDI spillovers relate the technology gap between MNCs´ and local firms to the absorptive capacities of local firms (SÖHOLM, 1999; GIRMA, 2002; GIRMA and GÖRG, 2002). In some cases, the results are vague, because the technology gap cannot be strongly related to high or low absorptive capacities. In addition, the use of the technology gap as an indicator is sometimes problematic as it does not capture the main determinants at firm level that explain absorptive capacities. Thus, the importance of absorptive capacities to get the benefits of knowledge spillovers remains unclear in such studies.

From the same body of literature, other authors (CHUDNOVSKY, *et al*, 2003; ESCRIBANO, FOSFURI and TRIBO, 2005; MARIN and BELL, 2006) have used other type of indicators that reflect absorptive capacities, such as R&D expenditure, patents, human capital, scientific and technical training, and investment in capital-embodied technology. From the clusters literature, GIULIANI (2003 and 2005), has analyzed absorptive capacities, using indicators such as R&D investment, employees experience and formation, and the complexity of the production process. These studies have usually found a positive and strong relationship among knowledge spillovers and absorptive capacities.

To analyze the specificities of the relationship between knowledge spillovers and absorptive capacities, we have conceptualized direct indicators to analyze knowledge spillovers of large firms, and absorptive capacities for traditional and low-tech SMEs, where R&D activities are not common, and human capital is not specialized.

Using direct indicators for knowledge spillovers we will identify the most important knowledge spillover mechanisms in a specific sector and locality. Meanwhile, using direct indicators for absorptive capacities we will identify the key factors that explain SMEs´ absorptive capacities. Both indicators are the basis to analyze the relationship

between knowledge spillovers and absorptive capacities and the specificities of this relationship in a specific sector and locality.

2 Methodology

To analyze the relationship between large firms´ knowledge spillovers and SMEs´ absorptive capacities, we focus on the machining industry in Querétaro -a Mexican locality.[4] This is a traditional and low-tech industry integrated by SMEs. This industry presents a *hub-and-spoke*[5] type of arrangement with its clients, which are mostly domestic firms and MNCs from the automotive and home appliances sector.

The machining industry in Querétaro reported sales over $49 million dollars and employed more than 3,000 people during 2005. SMEs supply 10% of the total demand for machining products in the locality; their principal products are gears, arrows and dies (production and repairing). These are low technology products in comparison to the other 90% imported machining products.

Large firms include both subsidiaries of multinational corporations and others owned by domestic capital; 42% of those firms belong to the automotive and home appliances sectors.

This paper is based on original data gathered through a survey applied during 2005 to this industry in Querétaro. We identified two hundred twenty five firms belonging to this sector;[6] one hundred and seventy nine firms answered the questionnaire, which represent 80% of the population in the locality. However, we only have complete information to analyze one hundred and ten firms.

A previous version of this survey was applied to SMEs of the same industry in Ciudad Juarez, a border city with United States. However, this new version was modified in order to capture better the main characteristics of SMEs, and to build indicators of absorptive capacities and knowledge spillovers. To build those indicators we performed multivariate analysis by principal factors techniques. To identify the relationship between knowledge spillovers and absorptive capacities we performed a structural equations analysis.

2.1 Multivariate analysis to obtain absorptive capacities

To analyze SMEs´ absorptive capacities, we built five first order factors related to:

(i) **Entrepreneur and employees´ background**: Most of the works that have analyzed absorptive capacities emphasize the importance of human resources

and explicitly analyze education and experience. We analyzed variables related to formal education and to experience of owners and employees.

(ii) **Technology embedded in equipment**: Different authors have analyzed these types of variables as indicators of absorptive capacities. Machinery and equipment is highly correlated to the production of complex products in this industry.

(iii) **Organizational capabilities**: Within the sector and locality analyzed we observed that organizational capabilities are a key element for SMEs´ competitiveness, thus we incorporate some variables to analyze absorptive capacities.

(iv) **Learning and innovation activities**: R&D and innovation activities are a common indicator for absorptive capacities. However, within a mature and low technology sector, we considered variables related to learning mechanisms and innovative activities.

(v) **Linkages with other local agents**: Linkages with other agents represent an important activity to increase SMEs absorptive capacities.

Table 2 lists the variables that we used to build the five first order factors associated to SMEs´ absorptive capacities.

3 Table 2 Variables to build the five first order factors associated to SMEs´ absorptive capacities

First order factor	Variable	Kind of variable	Missing values	Mean	SD
Entrepreneur and employees´ background	Entrepreneur degree	Ordinal	8	-	-
	No. of employees	Numeric	0	11.13	22.43
	No. of engineers	Numeric	1	0.72	1.57
	% 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	-	-

First order factor	Variable	Kind of variable	Missing values	Mean	SD
	Sells per employee	Numeric	0	3.01	2.01
	Quality certification	Ordinal	0	-	-
	Materials certificates	Ordinal	4	-	-
	Delivery 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 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. Survey to SMEs located in Querétaro, Mexico (UAM-X, 2005).

3.1 Multivariate analysis to obtain knowledge spillovers

This paper analyzes large firms´ knowledge spillovers in a broad sense, including subsidiaries of MNCs and other large firms owned by domestic capital. We focus on knowledge spillovers that are diffused by three main spillover mechanisms:

i) Backward linkages: This type of spillovers is mainly observed by: i) direct technology support, to reach customers demands; and ii) increase of specific requirements, local firms uses their resources more efficiently to reach those specific requirements (LALL, 1980; JORDAAN, 2005).

ii) Human capital accumulation and mobility: These spillovers are associated to the development of skills of local human capital. Large firms increase the pool of human capital. When their employees move to other firms, they are embedded with the technology and management techniques from large firms; they are direct agents of technology transfer. This mechanism can be observed through: i) hiring employees highly qualified; and ii) entrepreneurship, creation of new firms by large firms´ former employees (BLOMSTRÖM and KOKKO, 2003; GÖRG and GREENAWAY, 2001; AITKEN and HARRISON, 1999; VERA-CRUZ and DUTRÉNIT, 2005).

iii) Training: Backward linkages sometimes promote the training of key employees of supplier firms. The main purpose of this training is to increase their abilities to reach customer demands.

To build the indicator of knowledge spillovers (second order factor), we built four first order factors related to: i) owner's mobility; ii) employees´ mobility and training; iii) formalization of linkages with clients; and iv) type of linkages established with clients. The first two are related to the mechanisms of human capital accumulation and mobility and training; the last two factors are related to the backward linkages mechanism. Table 3 contains the variables that were used to build these four factors.

Table 3 Variables employed to build the indicator of large firms´ knowledge spillovers

First order factor	Variable	Kind of variable	Missing values	Mean	SD
Entrepreneur'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 in large firms	Numeric	0	1.36	1.82
Employees´ mobility and training	Number of SMEs´ employees trained by large firms	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 suppliers	Numeric	9	7.49	7.95
	Formal contracts	Ordinal	1	-	-
	Informal relationships	Ordinal	0	-	-
Type 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	-	-
	Machinery and equipment to SMEs	Ordinal	0	-	-
	SMEs access large firms´ plants	Ordinal	0	-	-
	Technical advice by clients	Ordinal	0	-	-
	Joint projects	Ordinal	0	-	-
	Sharing knowledge to export	Ordinal	0	-	-
	Clients´ proximity	Ordinal	0	-	-
	Openness to supplier recommendations	Ordinal	0	-	-

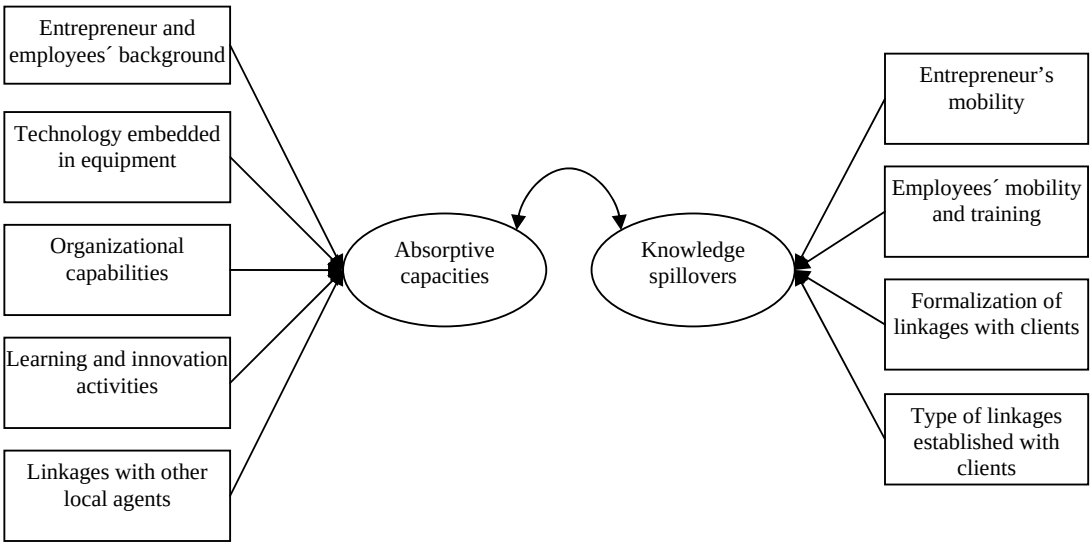
Source: Authors´ own. Survey to SMEs located in Querétaro, Mexico (UAM-X, 2005).

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

To analyze the relationship between knowledge spillovers and absorptive capacities, we built a structural equations model. We selected the technique of causal modeling. This kind of models can incorporate both, first and second order factors. However, we divided the construction of the model in two stages. During the first stage, as we described above, we built five first order factors associated to absorptive capacities and four order factors associated to knowledge spillovers. During the second stage we built the second order factors and identified the relationship between them using the technique of causal modeling.

¡Error! No se encuentra el origen de la referencia. presents the structural equations model to identify the relationship between absorptive capacities and knowledge spillovers.

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



Source: Authors´ own

The following system of equations expresses the second stage of the model.

SMEs´ absorptive capacities

$F_{1EEE} = \gamma_{11} X_{AC} + \varepsilon_1$

$F_{2TEE} = \gamma_{12} X_{AC} + \varepsilon_2$

$F_{3OC} = \gamma_{13} X_{AC} + \varepsilon_3$

$F_{4LIA} = \gamma_{14} X_{AC} + \varepsilon_4$

$F_{5L} = \gamma_{15} X_{AC} + \varepsilon_5$

Large firms´ knowledge spillovers

$F_{1OM} = \beta_{11} X_{KS} + \varepsilon_1$

$F_{2EM} = \beta_{12} X_{KS} + \varepsilon_2$

$F_{3FL} = \beta_{13} X_{KS} + \varepsilon_3$ $F_{KS} = \alpha_1 X_{AC} + \varepsilon_1$

$F_{4TL} = \beta_{14} X_{KS} + \varepsilon_4$ Relationship between factors

The results from the second stage of this analysis will help us to identify the most important knowledge spillovers mechanisms, and the most important determinants of absorptive capacities. We will also identify the fine determinants of the relationship between knowledge spillovers and absorptive capacities.

4 Knowledge spillovers and absorptive capacities: the evidence

Some authors (GIRMA, 2002; GIRMA and GÖRG, 2002, and JORDAAN, 2005 among others) have analyzed the relationship between knowledge spillovers and locals firms´ absorptive capacities. This paper contributes to identify the main knowledge spillover mechanisms and the main determinants of SMEs´ absorptive capacities within a specific sector and locality. We also contribute to demonstrate the specific relationship among these two concepts.

4.1 Large firms´ knowledge spillovers

We identified the significant variables and obtained four first order factors related to large firms´ knowledge spillovers using the extraction of principal factors technique. Table 4 reports the percent of variance explained by these first order factors. Table 5 presents the rotated component matrix.

Table 4 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

Table 5 Rotated component matrix for knowledge spillovers

First order factor	Variable	Component			
		1	2	3	4
[illegible]	Years of experience	-.033	-.298	-.181	**.414**

First order factor	Variable	Component			
		1	2	3	4
	Experience in large firms	.065	.041	.141	-**.689**
	Experience in management	.095	**-.375**	.169	-.224
	No. of training in large firms	.035	.126	.145	**.700**
Employees´ mobility and training	Number of SMEs´ employees trained by 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
Formal linkages with clients	Years of suppliers	**.220**	-.076	-.007	-.066
	Formal contracts	-.181	-.228	-.162	**-.490**
	Informal relationships	-.149	.352	**.370**	.310
Type 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
	Machinery and equipment to SMEs	**.506**	-.024	-.048	.237
	SMEs access large firms´ plants	**.583**	.277	.085	.216
	Technical advice by clients	.429	**.503**	-.075	.040
	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

The high factorial charges for each variable indicate a high correlation to the knowledge spillover mechanisms defined earlier.

Table 6 lists the knowledge spillovers related to the human capital mobility, training and backward linkages mechanisms.

i) Table 6 Knowledge spillovers related to the mechanisms of human capital mobility, training and backward linkages

Knowledge spillovers	Total
Entrepreneurs' mobility	
% entrepreneurs with experience in other organizations	90.9%
Years of experience in average	18.2
% of owners with experience in top management	4%
% of owners with experience in engineering	16.8%

Knowledge spillovers	Total
Entrepreneurs' mobility	
% of owners with experience in quality and maintenance	21.7%
% of owners with experience in production	61.3%
Employees´ mobility and training	
Number of employees with experience in large firms	4.1
Number of SMEs´ employees trained by large firms	0.4
Backward linkages	
% of SMEs that collaborates with their customers	12.7%
Years of the supply relationship in average	6.3
% of SMEs that share design capabilities	59.1%
% of SMEs that share production capabilities	38.2%
% of SMEs that receive technical advice from their customers	36.4%
% of SMEs with joint projects with their clients	28.2%
% of SMEs with formal contracts	15.5%

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

ii) Human capital accumulation and mobility

We analyzed two specific types of this spillover mechanism: i) entrepreneurship, employees that are trained in large firms and establishes their own firms; and ii) employees that are trained in large firms and then are hired by SMEs. In both cases they are embedded with production and organizational abilities from large firms. This experience can be extremely important for the SMEs.

Regarding the spillover mechanism associated to entrepreneurship, we observe that 91% of entrepreneurs have experience in other organizations (mainly large firms), they have worked in those organizations for18 years in average. Their experience has been mainly in production, quality and maintenance, only 16.8% of the owners have design engineering experience. Management experience is a key component for the survival and competitiveness of the new SMEs, however, only 4% of the entrepreneurs have got this experience.

Regarding the employees mobility, almost 39% of the employees have had experience in large firms. Their experience has been in production, quality and maintenance.

iii) Training

Within the locality analyzed we observed that some large firms train SMEs´ employees to increase their technical knowledge and reach their specific demands, 4% of SMEs´ employees have been trained by large firms.

iv) Backward linkages

In general terms, SMEs have an average relationship of 6 years with their clients; they usually do not establish formal contracts, which can represent a barrier for their investment projects.

The type of linkages that SMEs establish with their clients is important to identify the knowledge flows from these linkages. According to the evidence, the most common types of interaction are: access to large firms´ installations; joint projects to increase products quality; and transfer of design and production capabilities. These activities lead SMEs to produce more complex products and increase their absorptive capacities.

We suggest, based on the evidence, that there are large firms´ knowledge spillovers to SMEs through the 3 mechanisms that we analyzed. However, SMEs can gain the benefits of these knowledge spillovers if they have certain level of absorptive capacities.

4.2 SMEs´ absorptive capacities

We identified the significant variables and obtained five first order factors related to SMEs´ absorptive capacities using the extraction of principal factors technique. Table 7 reports the percent of variance explained by these first order factors. Table 8 presents the rotated component matrix.

Table 7 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

Table 8 Rotated component matrix for absorptive capacities

First order factor	Variable	Component				
		1	**2**	**3**	**4**	**5**
Entrepreneur and employees´ background	Entrepreneur degree	.171	.065	.275	.184	**-.318**
	No. of employees	.288	.104	**.572**	.141	-.045
	No. of engineers	.083	.054	**.746**	-.093	-.242
	% 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

First order factor	Variable	Component				
		1	2	3	4	5
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
	Sells per employee	-.032	.113	**-.398**	.088	-.307
	Quality certification	-.011	.021	**-.649**	-.197	.201
	Materials certificates	.068	**.701**	.140	-.076	.154
	Delivery certificates	.216	**.655**	.244	-.013	-.024
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 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

The high factorial charges for each variable indicate a high correlation to the determinants of absorptive capacities defined earlier.

We take into consideration the heterogeneity of SMEs within the sector and locality analyzed. In a previous paper (De Fuentes and Dutrénit, 2006), we performed a cluster analysis and identified four groups of SME according to their absorptive capacities.[7] Table 9 summarizes their main characteristics.

Table 9 Main characteristics of the clusters

Main characteristic	Cluster				
	1	2	3	4	Total
Number of firms	13	10	31	51	110

Main characteristic	Cluster				
	1	2	3	4	Total
% 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
Employees with experience in CNC per firm	1.8	0.6	0.3	0.3	0.6
Employees with experience in design per firm	6.4	1.6	2.2	0.9	2.1
Employees with experience in CAM per firm	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	77%	30%	0%	4%	16%
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
Annual total sales (thousands USD)	$3,155	$2,150	$5,397	$3,213	$14,420
Average sales per firm (thousands USD)	$262	$215	$179	$ 68	$138

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.

The evidence suggests that it is easier for SME with higher absorptive capacities to reap the benefits from large firms´ knowledge spillovers. SMEs with higher absorptive capacities have a higher number of engineers per firm, which leads a better task distribution. Thus, owners can spend more time in activities related to management and planning. Employees from these clusters have higher capacities in CNC machining, CAM, design, measuring, calibration, and quality systems. These SMEs have a higher proportion of CN and CNC equipment, and SMEs use CAM to program their production, which permits a more efficient use of the machinery. A higher percent of firms from these clusters have formal contracts with their clients.

On the contrary, SMEs with a lower level of absorptive capacities have more owners with technical studies, and a small percent of employees have an engineering degree. These firms have less than one engineer per firm in average. Employees from these firms have experience in design, measuring and calibration. A very small proportion of the employees have experience in CNC machining and CAM programming. Firms in these clusters have conventional equipment, they do not have CN and a small number of SMEs have CNC equipment, they do not use CAM programming for their production. These characteristics impede the production of certain products that require a higher level of precision and quality.

4.3 Relationship between knowledge spillovers and absorptive capacities

To identify the relationship between knowledge spillovers and absorptive capacities and the specificities of this relationship we build a correlation matrix that explains the relationship between them (see Table 10).

Table 10 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: Entrepreneur and employees´ background; TECNO: technology embedded in equipment; CAPORG: organizational capabilities; INNOVA: learning and innovation activities; VINC: linkages with other local agents.
For knowledge spillovers. EXPERP: entrepreneurs´ experience; EXPERE: employees´ experience and training; VCP: formalization of linkages with clients; and TIPO: kind of linkages established with clients.

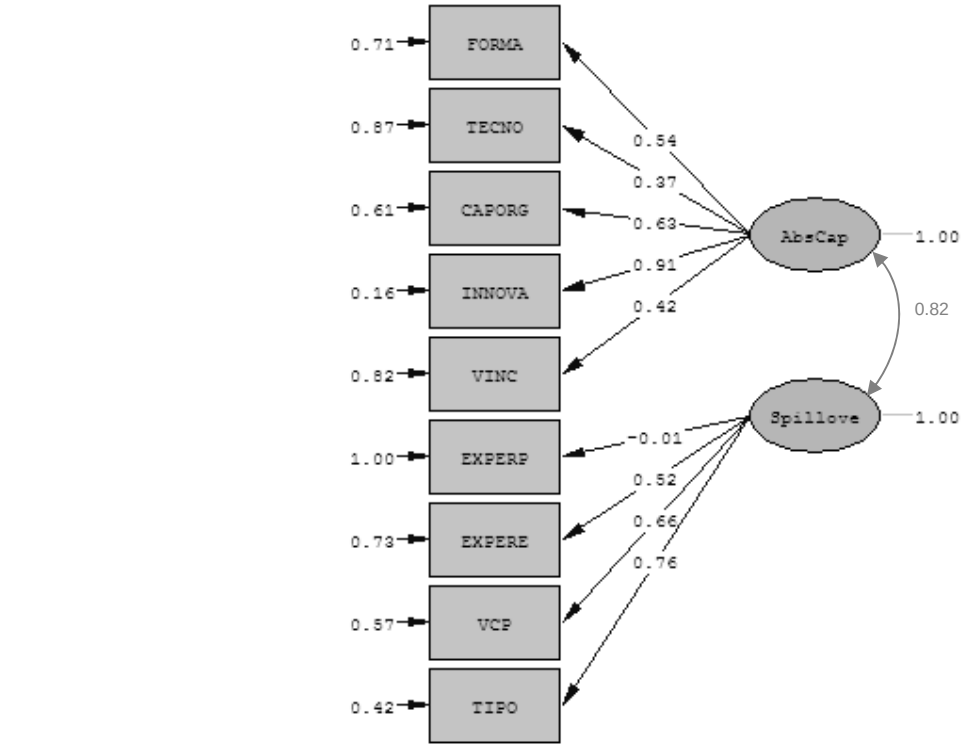
The entrepreneur and employees´ background have a direct and important relationship with the technology embedded in equipment, and with innovation and learning activities. On the other hand, innovation and learning activities have a direct relationship with the backward linkages, and SMEs´ organizational capabilities.

The structural equations model will show the following correlations:

i. Between absorptive capacities and: i) entrepreneur and employees´ background; ii) technology embedded in equipment; iii) organizational capabilities; iv) learning and innovation activities; and v) linkages with other local agents.
ii. Between knowledge spillovers and: i) entrepreneurs´ mobility; ii) employees´ mobility and training; iii) formalization of linkages with clients; and iv) kind of linkages established with clients.
iii. Between absorptive capacities and knowledge spillovers.

The second order factors (knowledge spillovers and absorptive capacities) are placed at the right side of the diagram; the arrows show the relationship between second and first order factors.[8]

Figure 2 Structural equations analysis diagram between SMEs´ absorptive capacities and large firms´ knowledge spillovers



LISREL
Sample size: 110 observations.
Note:
For absorptive capacities. FORMA: Owners and employees´ background; 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 experience; EXPERE: employees´ experience; VCP: formalization of linkages with clients; and TIPO: kind of linkages established with clients.

The structural equations analysis indicates the impact of first order factors on second order factors. In relation to absorptive capacities, the factors that have the highest impact are innovation and learning activities, and organizational capabilities, 91% and 63% of the factors explain SMEs´ absorptive capacities respectively. Entrepreneur and employees´ background has a medium impact on absorptive capacities. The factors that have the lowest impact on absorptive capacities are technology embedded in equipment and linkages with other local agents, 37% and 42% of these factors explain SMEs´ absorptive capacities respectively.

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

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

In contrast with the findings of VERA-CRUZ and DUTRÉNIT (2005), GÖRG and GREENAWAY (2001), ANDREA, MOTTA and RONDE (2001), that human capital mobility is an important mechanism of knowledge spillovers, the factor that has the lowest impact and even has a negative value is related to entrepreneurs´ mobility. The variables that were used to build this do not help us to explain knowledge spillovers through the entrepreneurs´ mobility.

Different arguments contribute to explain such result: i) there is a small percent of entrepreneurs with professional background, the lack of formal education difficult knowledge absorption and the application to their own firms; and ii) as they do not have formal education, they usually do not have access to top management positions in large firms, and they can not absorb more complex organizational and technological knowledge.

Regarding the correlation between both second order factors, Table 11 lists the correlation level that was obtained by the structural equations analysis.

Table 11 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)

The correlation between SMEs´ absorptive capacities and large firms´ knowledge spillovers is 0.82, which indicate a positive and strong relationship between these two factors.

5 Conclusions

The main aim of this paper was to analyze the relationship between large firms´ knowledge spillovers and SMEs´ absorptive capacities. We focused on analyzing SMEs´ absorptive capacities in a low-tech and mature sector that operate in a loosely articulated local system. Drawing on the existent literature and exploring the use of customized indicators, it has been possible to have a better understanding on the

determinants of absorptive capacities, the mechanisms of knowledge spillovers, and the relationship between these two concepts within a specific sector and locality.

The most important factors that explain knowledge spillovers are related to the backward linkages mechanism, which suggest that there are important knowledge flows that increase SMEs´ production capabilities, and that SMEs are strongly influenced by their clients. Thus, to strengthen large firms´ knowledge spillovers, it is important to increase the level of linkages between large firms and SMEs. In contrast with the findings by ANDREA, MOTTA and RONDE (2001) and VERA-CRUZ and DUTRÉNIT (2005), the entrepreneurs´ mobility does not represent an important mechanism for knowledge spillovers in the sector and locality analyzed. VERA-CRUZ and DUTRÉNIT (2005) analyzed the same sector in another Mexican locality; they concluded that owners' mobility from MNCs to SMEs is one of the most important mechanisms for knowledge spillovers. However, due to the idiosyncrasies of the sector, the characteristics of the local system, and the inclusion of large domestic firms and not only MNCs, the entrepreneurs´ mobility does not represent an important large firms´ knowledge spillover mechanism.

The factors with the highest influence for SMEs´ absorptive capacities are organizational capabilities and innovation and learning activities, which are strongly related to the entrepreneur and employees´ background. While the technology embedded in equipment and linkages with other local agents have a lower impact on SMEs´ absorptive capacities. This result suggest that to increase absorptive capacities it is extremely important to strengthen human capital abilities and to design schemes that promote knowledge sharing within the firm.

We found that large firms´ knowledge spillovers are strongly correlated to SMEs´ absorptive capacities within the sector and locality analyzed. More specifically, we found that the spillover mechanisms of backward linkages and employees´ mobility have a direct impact on the absorptive capacities determinant of innovation and learning activities. It is still necessary to analyze quantitatively if knowledge spillovers determine absorptive capacities or vice versa. We can say *a priori* that absorptive capacities determine knowledge spillovers, i.e. knowledge spillovers can be "in the air" but only SMEs´ with a minimum level of absorptive capacities can get the benefits of such spillovers. At the same time, the absorption of such knowledge spillovers increases SME´ absorptive capacities.

From this point of view, the promotion of backward linkages and schemes of knowledge sharing within SMEs can have a positive impact on SMEs. On the other hand, to strengthen SMEs´ absorptive capacities, it is necessary to reinforce their organizational capabilities and innovation and learning activities. This aspects can be strengthen by specific training courses to the entrepreneur and the employees, and by important efforts to internalize and share the knowledge embedded in the employees.

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[1] Lara, Arellano and García (2003), emphasize that MNCs such as the maquiladoras located in the border of Mexico and US promote the creation of SMEs by strengthening local providers, maquiladoras also provide a critical pool of human capital, that benefit the creation and strengthening of local firms.

[2] This is the most common type of spillover (Kim, 1997).

[3] Chung, *et al* (2002) argues that competitive pressure in the automotive sector is the main cause of productivity increase.

[4] Querétaro is geographically located at the center of Mexico. Querétaro has 1,615,118 inhabitants. Their main industrial activities are: metal mechanic, automotive, textile, chemistry and electric-electronic. Their contribution to GDP is 1.8%. Their local infrastructure such as electric services, industrial parks and road system has fostered the growing of industry.

[5] In the hub and spoke productive arrangements, some large firms act as anchors or hubs to the regional economy, with suppliers that spread out around them like spokes of a hub (See MARKUSEN, 1996). In the sector and locality analyzed, there are some key large firms, many SMEs have established around them to become their suppliers.

[6] From these firms 206 are micro firms, 13 are small firms and 6 are medium size firms.

[7] Cluster 1 is characterized by consolidated firms with potential to produce more complex products. Cluster 2 is characterized by consolidated and innovative firms, with skilled human resources. Cluster 3 has been defined as traditional firms with potential to strengthen their capacities. Cluster 4 is distinguished by traditional firms with basic production capabilities.

[8] According to the indexes of 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.