Clustering SME with maquilas in a local context: benefiting from knowledge spillover

Theme E: Building economic development on a base of local and regional innovation systems

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1. INTRODUCTION[1]

In Mexico, foreign direct investment in the manufacturing industry carried out by transnational corporations (TNCs) under the maquila regime plays an important role. These firms have a global definition of their business, policies and development strategy. The different national economic agents (government, domestic industry, training institutions, higher educational institutions) believe that the contributions of the maquila industry are limited to its contributions to the growth of exports and employment.

At international level there is a consensus that the TNCs can work as a channel of international diffusion of knowledge and technology and, referring to the developing countries, they can contribute to accelerate the economical development processes in the countries where they are established, through the effects of technological or knowledge spillovers. The effects of the spillovers are beneficial

1 This paper presents partial results of the project UAM/ADIAT titled "Diagnóstico de oportunidades de mejora e identificación de apoyos específicos para PYMEs: un enfoque sectorial y local". This paper is part of a research project "Technological learning and industrial upgrading. The generation of innovation capabilities in the maquila industry in Mexico", COLEF/FLACSO/UAM (Proyecto CONACYT núm. 35947-s)

as they are captured by the firms and local institutions linked to the TNCs.[2] None the less, in the Mexican case, this potential contribution of the maquila industry has yet to be perceived by the national economical agents.

The maquila industry was established in Mexico in the mid-1960s, with the "Program of Bordering Industrialization"[3]. The purpose of this project was to attract foreign investment, mainly from the US, to be established in a 10-mile strip along the northern border of Mexico, in order to lower the high rates of unemployment in the region. Assembly plants that used imported inputs for its assembling were established, they re-exported the finished goods to the headquarters. This bordering strip was considered a free trade zone, thus the firms established in that area only had to pay the value-added tax generated by the hand labor used. These assembly plants were named maquilas.[4]

During the decade of the 1990s, the maquila industry consolidated its role as an employment generating activity. However, its evolution was not limited to a growth in the number of establishments and employees. As a result of learning processes in the local plants, and modifications in the strategies of global firms, a large number of the maquilas established in Mexico have suffered important qualitative changes. A change in the nature of the productive and technological activities of a group of maquilas toward more complex products and activities of higher technological content has been observed.[5] Also, a gradual modification in the proportion of the Mexican personnel that occupy technical and managerial positions in the maquilas has been observed, as well as an accelerated growth and renewal of the technical abilities of the workers.

In contrast with the evolution mentioned, there has been a limited advance in the contracting of local suppliers. In the first stage – 1965 to the beginning of the 1980s – all the suppliers were foreign and located outside of Mexico. In the second stage – mid 1980s to the beginning of the 1990s – although most of the components were provided by foreign suppliers located abroad, some foreign suppliers of different inputs began to establish in the locality, and a few Mexican local suppliers of indirect materials (machining, packaging, production related services, etc.) were developed. Most of these Mexican local suppliers were small and medium enterprises (SMEs). This is how a local network of linkages between maquilas and local firms began to develop. In the third stage – since the mid 1990s – although the maquila industry has began to develop more complex technological activities, no significant changes can be observed in the backward linkages with the local SMEs.[6] In quantitative terms, although the percentage of national inputs in the total inputs of the maquila industry increased from 1.8% in 1991 to 3.4% in 2002, this percentage is still rather insignificant.

The development of the local institutions has been guided by the changes in the maquila industry. The maquila industry was established in bordering localities with a weak institutional and industrial infrastructure. Given the demand generated, institutions, training programs and higher education programs have been created to prepare the technicians required by the maquila industry. The profile of the demand has changed gradually; at first it was basically oriented toward technical training,

2 Hanson (2001).

3 It was originally named program of exploitation of excess manual labor along the northern border.

4 Lowe y Kenney (1999), Vargas (2000) y Buitelaar (2000).

5 Carrillo y Hualde (1997), Lara (2000), Dutrénit y Vera-Cruz (2002).

6 Urióstegui (2002), Sampedro (2003), Carrillo (2001) and Dutrénit (2003) provide evidence of these linkages.

later the need of mechanical-electrical engineers arose. By introducing more complex assembly processes and design activities, new demands of professional and training profiles have been generated. But the institutions have responded slowly and with difficulty to these changes.

Although the maquila industry has had a limited impact in the development of the local SMEs suppliers and institutions, its presence in Mexico has generated some effects of knowledge spillovers. Human capital spillovers can be observed (associated with learning through experience, technical training of employees, the creation of new firms with former employees of the maquila industry, the collaboration agreements with institutions of higher education and training, etc.) as well as some local experiences of backward linkages – development of suppliers.

The aim of this paper is to analyze a number of knowledge spillovers of the maquila industry in Mexico, and discuss the role of the local production system when benefiting from these spillovers. The paper focuses on discussing how some of the spillovers observed arose and what is their nature, rather than quantifying the increases in productivity and the improvement in the levels of competitiveness of the firms or the improvement in the efficiency of the institutions associated with these spillovers.

This paper is based on empirical evidence from a bordering locality, Ciudad Juárez, where 303 maquila plants are located, and a fifth of the employment generated by this industry. This paper combines three basic sources of information: (i) a census of the industrial machining industry (a supplier sector of the maquilas industry established in the locality) carried out between August and October of 2002;[7] (ii) case studies of maquilas and machining firms; and (iii) interviews carried out in several local institutions.

The structure of this paper is as follows: in Section 2 we describe the literature that analyzes the linkages between TNCs and SMEs in a local context; in Section 3 spillovers of the maquila industry toward local SMEs are analyzed. In Section 4 we analyze the knowledge spillovers toward local institutions. Finally in Section 5 we discuss the results.

2. THE LINKAGES BETWEEN TNCS AND SMES: ROOM FOR KNOWLEDGE SPILLOVERS.

The literature on the relationship between transnational corporations (TNCs) established in host countries and the development of SMEs suppliers in a local context is based on ideas from three different streams of literature: (i) the technological spillovers of foreign direct investment, (ii) the technological learning and capability accumulation processes, and (iii) the local, regional and national systems of innovation.

1) The literature on technological spillovers suggests that foreign direct investment involves both capital flows and the transfer of other tangible and intangible assets – administrative and organizational skills, managerial spirit, technology and access to markets.[8] Based on this approach we analyze and try to measure the knowledge spillovers of foreign direct investment, in other words, the transfers of technological knowledge (technical and organizational) that improve the performance of other associate, competitor or supplier firms, or of any other agents that they interact with.

7 In Dutrénit, Vera-Cruz y Gil (2003) the methodology used to carry out the census is presented in detail, together with the main results obtained.

8 Altenburg (2000).

This literature highlights a set of mechanisms that facilitate the capture of these spillovers;[9] two frequently mentioned mechanisms, that are of particular interest in this paper, are the backward linkages between the TNCs and the local suppliers,[10] and the technical training of employees who will later on establish their own firms in the locality.[11] Backward linkages are associated with the fact that most TNCs need a broad range of competitive, high quality inputs that are delivered on time. As TNCs cannot produce internally the whole range of parts, components and services, they need efficient external suppliers of such products, thus establishing subcontracting relationships with local SMEs. Technological and managerial knowledge is transferred through the linkages established. Human capital spillovers take place when the TNCs train personnel who subsequently leave the firms. These personnel are used to working with more advanced equipment, more modern managerial techniques and production processes, and with higher quality requirements than local firms. Although these personnel are not trained in all areas, they develop certain skills, ideas, and abilities from working in plants that produce according to international standards. When these personnel leave the TNC and create their own firms, they use the technical and managerial knowledge acquired.[12] Other effects of spillover occur when the TNCs establish personnel learning and training agreements with local institutions. Technical and managerial knowledge is also transferred through these linkages.

The spillovers are not immediate, the literature points out a number of conditions that make it easier to benefit from them, such as: the industrial context as well as that of public policies,[13] a certain level of human capital,[14] and certain absorptive capacity of the local firms.[15]

2) The literature on learning and technological capability accumulation in firms studies the learning processes involved in the gradual build-up of a minimum basis of technological knowledge that enables them to carry out innovation activities. This literature has focused on firms in developing countries, and documented how these firms are technologically immature, learn through time, and accumulate knowledge. Based on that, these firms are capable of progressively carrying out new activities and acquiring new technological capabilities. Learning is defined as a process that involves repetition and experimentation, which enables to carry out tasks in a better and faster way, and identify new production opportunities. It is the process through which firms create knowledge and acquire technological capabilities. Learning processes have a gradual, accumulative, systemic and idiosyncratic character.

9 In this paper we use the concept of knowledge spillovers instead of technological spillovers.

10 Rodríguez-Clare (1996).

11 Caves (1971), Blomström & Kokko (1998, 2003), Blomström, Globerman & Kokko (2001), UNCTAD (2000), UNCTAD (2001), Altenburg (2000), Belderbos, Capannelli & Fukao (2001), Lall (1980) y Romo Murillo (2003).

12 Altenburg (2000).

13 Blomström y Kokko (1998).

14 Noorbaksh, Paloni & Youssef (2001).

15 Kinoshita (2001).

3) The literature on systems of innovation suggests that the innovative activity of firms depends strongly on technological learning and technological capability creation processes, and that these processes are influenced by the national system of innovation and by the type of linkages created between the agents in specific contexts. Most of the definitions consider that a system comprises a group of agents and institutions linked to the innovative activity on the national borders (universities, firms, productive sectors, research centers, technological institutes, training centers, intermediate support organizations of managerial activity, and financial system), and the interrelationships established among them.

Recently, the study of the regional and local systems of innovations[16] has gained a great deal of importance, since the regional and local spaces are regarded as the context where agents operate and where the strategies of technological capability accumulation of firms can be given viability. This appears to be particularly true for SMEs as most of these firms evolve in local environments.

The idea is that within the regions and localities, a number of networks are created between firms, clients, suppliers universities and other agents that play an important role in the innovation process. The relations between the agents inside these networks are strongly influenced by the regional environment (economical, political, social and cultural). Thus the regional/local particularities contribute in certain regions to the creation of environments and relations that favor innovation, while in other regions relations and environments are developed that slow it down or do not favor it.[17]

Initially, the formation of local contexts was not necessarily oriented towards innovative activity.[18] At first, these local spaces are composed by a number of productive arrangements, afterwards they evolve toward local productive systems, and finally, as firms are capable of gradually developing innovation capabilities, toward local innovation systems.[19]

Thus, the learning and technological capability creation processes in firms are influenced by the characteristics of the innovation system. It is important to point out the great difference between the innovation systems of developed countries and those of latecomer countries, like Mexico.[20] In developed countries, the environment of the macroeconomic, commercial and industrial policies, as well as the regulatory frame are relatively stable and congruent among them. In contrast, in Mexico, the national innovation system is disarticulated and incongruent, although the agents do exist, they do not play a role that is well defined and oriented toward contributing to the development of the national innovative capacity.[21] In fact, it is hard to say that a national innovation system exists.

16 Cooke et al (1997)

17 Casas (2001)

18 Castro et al (2001) discuss to what extent we can talk about a system of innovation when the agents exist but there are no relations between them

19 Campos & Ramos (2001); Cassiolato, Lastres & Szapiro (2000); Szapiro et al (2001); Ruíz Durán & Dussel Peters (1999); Dussel Peters (2001).

20 Latecomer countries are developing countries that are trying to compete at international level.

21 The characteristics of the national system of innovation in Mexico are analyzed in Cimoli (ed.) (2000). See in particular, Casalet (2000) for the role of the bridge institutions, Casas, De Gortari and Luna (2000)for the role of the universities, and Gonsen (2000) and Dutrénit (2000b) for the processes of building up of technological capabilities by Mexican firms.

The literature on the linkages between TNCs and SMEs identifies a number of problems that render difficulty to the linkages that are relevant to this paper: (i) the TNCs transfer the pressures imposed by the global competence on the reduction of costs to the suppliers; (ii) many SMEs miss out on the opportunity to create linkages with TNCs because they do not have the appropriate performance and cannot reach the international standards of quality, price and delivery time,[22] or they do not have the production capacities necessary to supply large volumes; (iii) global firms consider that SMEs play a role of subordination in the global economy,[23] and (iv) the existence of trust between suppliers and buyers is a necessary condition for the transfer of technology to the SMEs,[24] but the TNCs may not have incentives to transfer the technology, particularly if such transfer implies substantial costs for the TNC.

The intensity of the linkages between the TNCs and the SMEs, together with the ability of the host countries and their firms to exploit these linkages for domestic industrial development, vary broadly, depending on how three groups of factors articulate: (i) The corporative strategy of the TNCs; (ii) The existence of SMEs with the potential to reach the standards that the TNCs demand from their suppliers, which depends on the type of technological and managerial capabilities of these firms; and (iii) The local context, together with the existence and efficiency of public policies to promote both the linkages between the TNCs and the national firms, and the knowledge spillovers to the latter ones.[25]

3. KNOWLEDGE SPILLOVERS TOWARD THE SMES

The process of creation and development of the industrial machining industry in Ciudad Juárez is analyzed in this section. This industry arose as a result of a backward linkage process of the maquila industry, thus constituting a knowledge spillover of the maquila industry. The process of evolution of the spillover and the problems faced by firms when trying to benefit from it are illustrated through the history of this sector of local suppliers.

3.1 Origin and growth of the machining industry

The precision machining industry is formed by the industrial firms that design and manufacture precision pieces. The most common equipment of this sector are drills, lathes, machining centers, grinders, EDM, etc.

The first machining firms in Ciudad Juárez appeared a the beginning of the 1940s, these were oriented towards the production of replacement pieces for different types of industrial and agricultural machinery, which could not be imported because of the restrictions of the War. This generation of firms had a family like organization and there was no integrated market for this kind of work.

22 UNCTAD (2000).

23 Harrison (1997).

24 Chew & Yeung (2001).

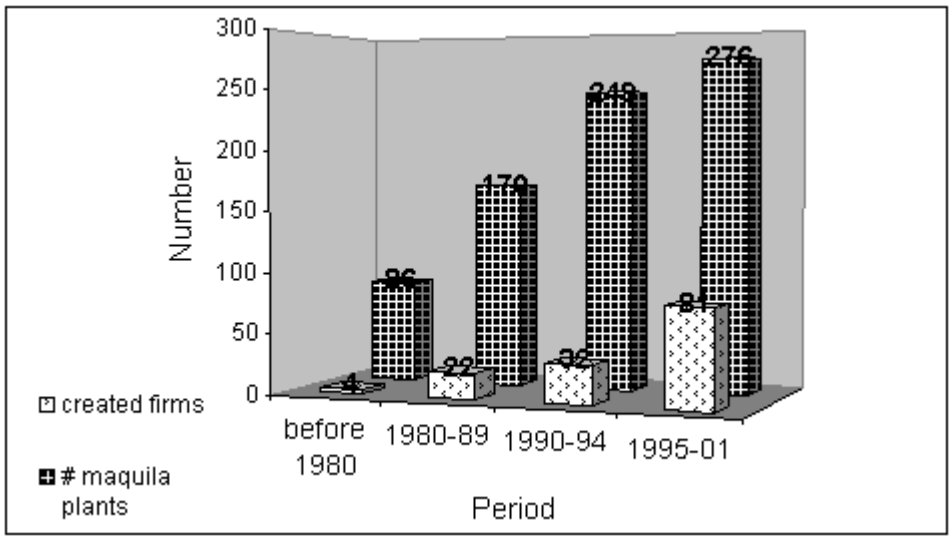
25 Altenburg (2000).

The integration of a regular market of machining pieces, and thus the creation of industrial machining firms took place in the decade of the 70s, in response to the needs of the harnessing maquilas to obtain tools and replacement pieces for the production equipment. Initially, the maquilas manufactured their own tools. From the mid – 1970s, firms like Allen Bradley, began to train operators and technicians in machine-tools. Many of these technicians saw a business opportunity and chose to set up their own work shops. This is how they became small independent suppliers. As these firms arose, the maquilas began to hire their services and the knowledge spillover effects started to occur. The first contracts of each new machining firm were usually established with the maquila where he used to work, as there was a certain level of trust and knowledge of the product required by the plant.

At first, the technological capabilities of the machining firms were very incipient, they were in a learning stage to build their routinely production capabilities. The maquilas did not demand any quality standards, they were only required to meet dimensional standards and in some cases tempered standards. Afterwards, some firms began to learn and accumulate certain innovative technological capabilities.

So, in the last decades, with the growth of the maquila industry in Ciudad Juárez the demand of machining pieces increased and the number of firms of the sector grew rapidly. As figure 1 shows, before 1980 there were 76 maquila plants operating in Ciudad Juárez (data corresponds to 1975), over the period 1980-89 the number grew to an average of 170 plants, during 1990-94 to 249 and in the period of 1995-2001 to an average of 276 plants. By 2002 there were 304 maquila plants in the locality.

Figure 1 Year of creation of the machining firms operating in 2002 and growth of the maquila industry in Ciudad Juárez



SOURCE: INEGI (NATIONAL INSTITUTE OF STATISTICS) AND DUTRÉNIT, VERA-CRUZ Y GIL (2003).

Together with the growth of the maquila industry and the rise in demand of machining pieces, the number of machining firms increased continuously. In 2002 there were 158 active firms,[26] half of which were created in the period of 1995-2001, as a response to the explosive growth of the maquila

26 The census carried out identified 158 active firms, of which 144 filled out the whole questionnaire.

industry through the decade of the 1990s. The growth in the number of machining firms suggests the existence of spillover effects of the maquila industry in the locality.

The maquila industry is the main client of the machining firms, 72% of the firms sell more than 90% of their production to the maquila industry, these are the suppliers of the maquila industry. The firms attend a broad marked integrated by at least 140 maquilas, amongst which stand out: Lear, Philips, Thomson, Delphi, Ammsa, Cadimex, Advance–Transformer, Breed, Contec, Honeywell and Coclisa. Every machining firm has several clients (maquilas), this allows them to reduce the risks associated to the dependency of one client, but makes it difficult to reach higher volumes and specialize. This situation suggests the existence of unstable linkages that neither benefits the clients nor the suppliers. Various case studies carried out in the firms prove this to be a generalized situation of the sector,[27] which suggests that in the case of the relations between the machining industry in Ciudad Juárez and the maquilas, no trust or commitment have been generated for the development of local suppliers as seen in other countries.[28]

The creation of the sector and the rise in the number of firms is in itself a knowledge spillover of the maquila industry. The machining industry was created, has grown and has been consolidated as a sector, as a result of the market of fixtures, tools, parts, equipment replacement pieces, etc. generated by the maquila industry.

In the year 2002, the industrial machining sector in Ciudad Juárez was formed by firms between precision levels 1 and 3, of 5.[29] The firms have equipment with different degrees of modernity, but given the precision level required, they do not need to use last generation equipment. The profile of the sector is presented in Table 1.

The sector shows a group of strengths to become part of the chains of suppliers of the maquilas, such as: advantages in closeness and costs, qualified personnel (engineers and tooling technicians), and knowledge of the way the clients operate and of the local idiosyncrasy.

27 Dutrénit et al (2003).

28 UNCTAD (2000 & 2001), Altenburg (2000), Perry & Tan (1998), Chew & Yeung (2001), Belderbos, Capannelli, & Fukao (2001).

29 According to the degree of precision and tolerance of the products elaborated, we can identify 5 levels of firms: Level 1: no tolerance specifications; Level 2: tolerances of 5/1.000; Level 3: tolerances of 5/10.000; Level 4: +- 1/10.000; and Level 5: +- 1/100.000. (Interview with the owner of Talleres Diversificados de Juárez)

TABLE 1 PROFILE OF THE SECTOR IN 2002

- **158 active firms in the sector**[30]
- **Sales over 30 million dollars**
- **Main client: maquila industry**
- **Main products: Fixtures for assembly; Help tools for assembly (anvils, etc.); Equipment tools (cutters, replacement pieces, blades, etc); replacement and repair pieces for the peripheral part of the moulds**
- **1462 workers in 2002 and 1916 in 2001**[31]
- **177 engineers, of which 61 are owners of firms**
- **100 contractors had prior work experience in the maquila industry**
- **3 firms certified with ISO 9000**
- **17 firms in process of certification of the ISO 9000**
- **90 firms have engineers, modern equipment, and potential to advance in the accumulation of technological capabilities**

SOURCE: DUTRÉNIT, VERA-CRUZ Y GIL (2003).

3.2 The creation of firms by former technicians of the maquila industry

It is interesting to put emphasis on the knowledge spillovers of the maquilas industry that occur as a result of training technical personnel who later create their own firms. The maquilas have been a school, mainly technical, for older firms. Many of the present owners of these firms were technicians of the local maquilas, many of them engineers. These technicians saw a business opportunity, left the maquilas and established their own firm. At first they had a 'closed market' and took advantage of the existing linkages with their maquilas of origin. Later on they had to compete with other firms.

Table 2 presents the number of years that the owners of firms operating in 2002 worked at the maquila industry. As it can be seen, 100 of the owners of industrial machining firms, that is 72.5% of the total, were trained at the maquila industry. 64% of them worked at the maquila industry for more than 6 years.

30 The census included 158 firms, but after the census was carried out 4 more firms were located, they appear in the "Directory of the machining industry" but are not included in the statistics.

31 The census gathered information from the years 2001 and 2002, which are the years of crisis of the sector.

TABLE 2 YEARS OF EXPERIENCE OF THE OWNERS OF MACHINING FIRMS AT THE MAQUILA INDUSTRY.

Did not work at the maquila industry	1 to 6	7 to 15	16 to 30	Total of firms
38	36	42	22	138
27.5%	26.1%	30.4%	15.9%	100%

SOURCE: DUTRÉNIT, VERA-CRUZ Y GIL (2003).

SAMPLE: 138 FIRMS

These owners acquired mostly technical skills at the maquila industry, 78.5% of them worked as operators, supervisors and production engineers, this gave them the necessary technical knowledge to operate their own firm. But only 21.5% occupied managerial positions, this limits their knowledge of basic administrative and managerial procedures, which is also necessary for the operation of the firms and to improve the absorptive capacity of knowledge spillovers of the maquila industry. However, as pointed out in Section 2, they were all exposed to modern administrative models, equipment, and production processes, and they learned skills and developed abilities to work with international standards.

If we compare the information on the experience of the maquila industry with the year of creation of the firms, we find that many of the owners of firms created during the period 1995-2001, period of apogee of the maquila industry and the machining industry, had no previous experience in the maquilas industry. These firms usually have lower technological and managerial capabilities. So there appears to be a relation between having prior experience at the maquila industry and achieving a minimum base of technological and managerial capabilities when creating their own firms.

4. SPILLOVERS AND LOCAL SYSTEMS

As it was pointed out previously, some spillover effects of the maquila industry go beyond specific supplier firms and contribute to the formation of local productive and innovation systems. In this section, the main agents acting in the locality are described, the evidence on the conformation of a new industrial environment is presented, and a number of spillovers toward training, education and research institutions is analyzed.

4.1. The agents in the locality

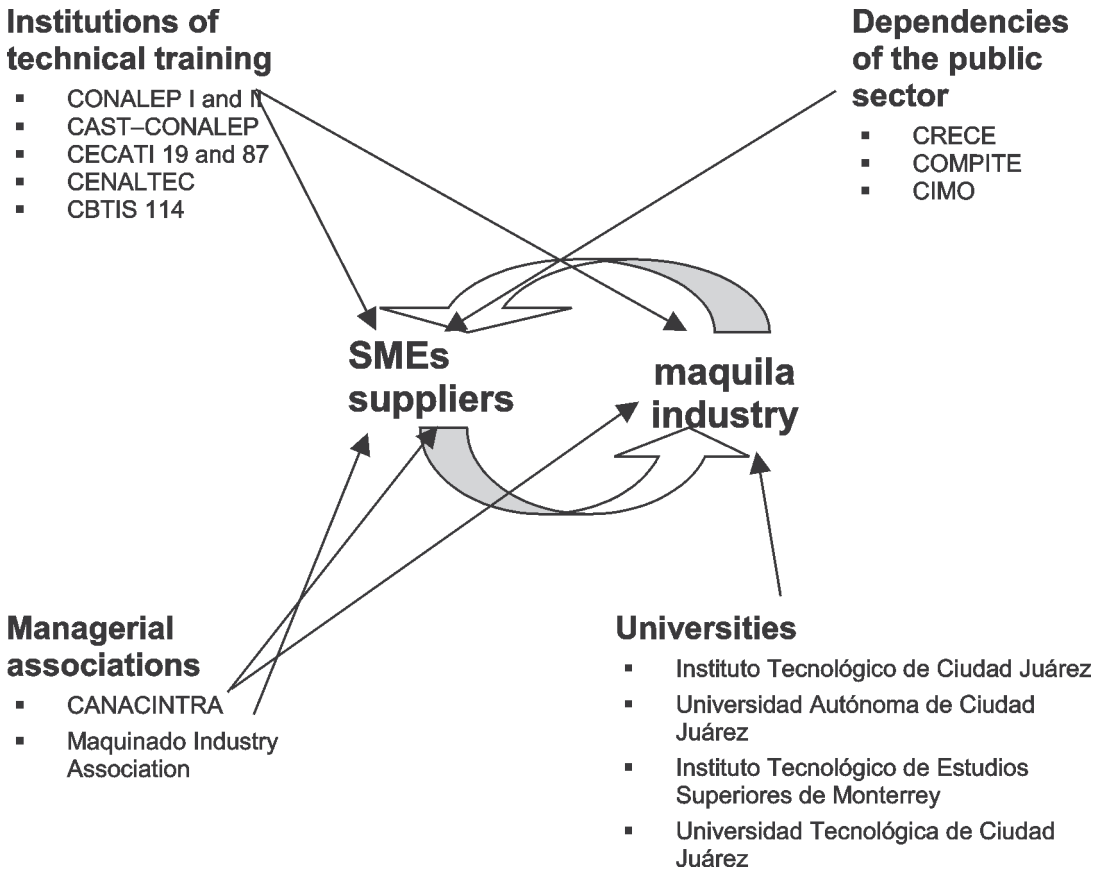
The technological capability accumulation processes in these firms depend on internal and external factors. In particular, the context in which the firms compete affects the accumulation processes. Since market failures exist, there are opportunities for the institutions to assume functions that play an important role in the accumulation processes.

The role of the institutions becomes relevant, particularly when referring to the technological accumulation processes of the SMEs suppliers for the maquila industry. Many of these firms have accumulated technical capabilities, but lack organizational structures and quality systems, which allow them to integrate easily to the chains of suppliers of global firms. In these cases, some institutions were created and they have to assume functions of quality control, thus helping the suppliers to

reach the requirement specifications set by the maquila industry, this can be observed in the linkage between CAST-CONALEP[32], Delphi Corp and machining firms. In other cases, training institutions contribute to the process of creation of the technical skills required from the workers, as in the case of CENALTEC.

Figure 2 below presents the main agents in the locality related with the machining industry and their linkages.

Figure 2 The local agents and their main linkages



4.2. Building a local industrial context

In this section, an analysis of some linkage experiences between maquilas, universities and local training institutions is presented. The spillover effects of the maquila industry in the locality that contribute potentially to the building up of productive and innovation systems can be observed through these linkages. Also, evidence that reveals the present fragility of these linkages is presented.

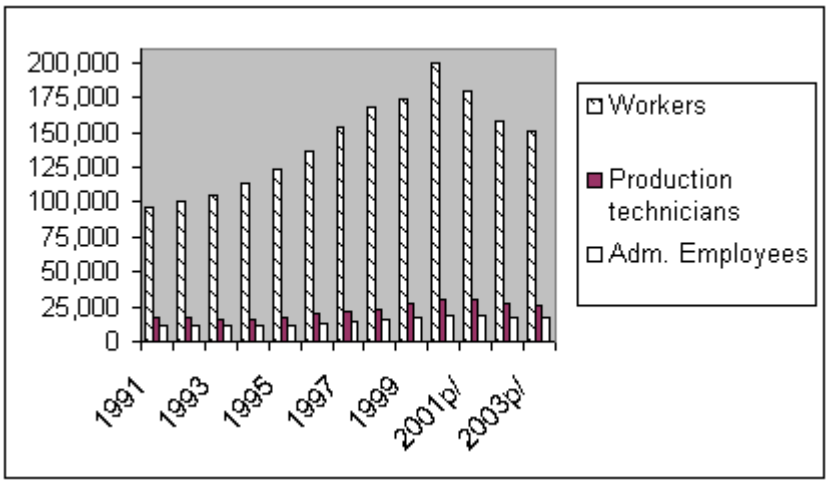
32 CONALEP is the National School of Professional Technical Education. It is a Mexican public organism created in 1979, it has 260 establishments and 8 assistance and technological service centers located all over the country. It has 39 careers for professional technicians. CAST is a technical assistance and training center for firms, it belongs to CONALEP.

4.2.1. Technical training of employees and increase in the number of technicians in the locality

The significant rise of employment caused by the maquila industry in the locality generates conditions for the existence of human capital spillovers, particularly given the existing high levels of rotation in the sector.

Figure 3 presents the evolution of employment of the maquila industry by profile. Between 1991 and 2003 there was a significant growth of employment –workers, production technicians and administrative employees. The direct employment grew from 123,888 people in 1990 to 194,606 in the first semester of 2003. Although the processes still require a lot of labor force with low qualification, the number of production technicians grew form 16,957 to 26, 237 with an increase of 55%. It is important to point out that all the workers are exposed to new techniques and ways of organization of production, which generates conditions for spillover effects of the maquila industry in terms of human capital.

Figure 3 Evolution in the number of technicians employed at the maquila industry in Juárez. 1991-2003/p



SOURCE: INEGI. MONTHLY STATISTICS OF THE MAQUILA INDUSTRY

Personnel turnover is one of the issues most studied about the maquila industry.[33] Turnover is considered a negative factor by many maquilas, thus discouraging them to invest on personnel training. But turnover also has positive effects, on one hand it generates a spillover effect of the maquila industry to other maquilas or domestic firms, and on the other it allows for the homogenization of the technical skills in the locality to occur.

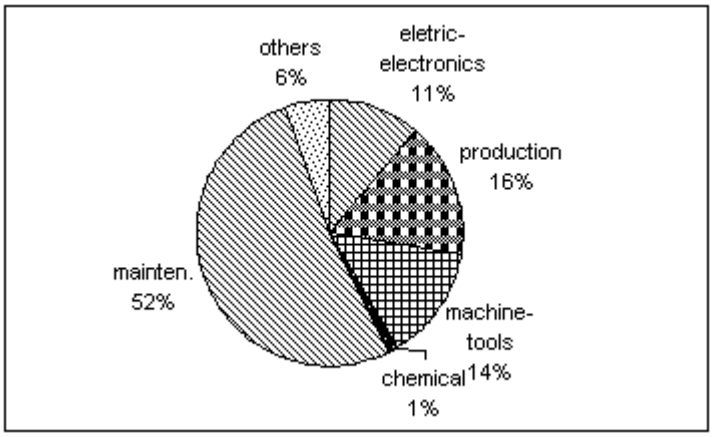
The increase in employment of the maquila industry, particularly of technicians, in a context of high turnover of the workers generates spillover effects of the maquila industry. However, the capacity of the SMEs to benefit from these spillovers depend on their capacity to attract the technicians trained at the maquila industry. Many SMEs lack resources to offer competitive salaries and loans, as

33 A study on the training needs in machine-tools carried out in 2002 showed that the average turnover of 100 firms surveyed was 8%. However, large differences between the firms were observed. In general, the maquilas presented a turnover rate lower than that of the domestic SMEs. (Market study of Cenaltec, February 2001).

well as employment stability. Once they get past that barrier, they can offer a more creative job environment and a more significant involvement with the organization.[34]

At the end of the year 2000, the INALTEC (*Instituto Nacional de Tecnología de Chihuahua* -The National Institute of Technology of Chihuahua) carried out a market study to identify the training needs in machine-tools of the maquila industry and the domestic industry (mainly industrial machining firms) in Ciudad Juárez. 100 firms (80 of the maquila industry and 20 SMEs) took part in this study. These firms employed about 6300 technicians, Figure 4 presents de profile of the technicians employed per area.

Figure 4 Technicians employed per area

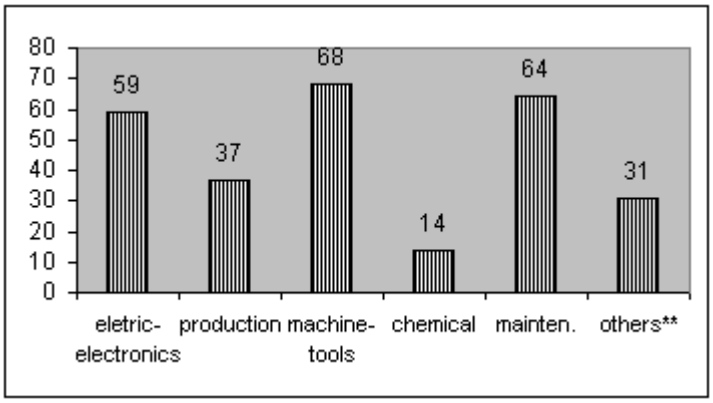


SOURCE: MARKET STUDY OF CENALTEC (FEBRUARY 2001)

NOTE: OTHERS INCLUDES TECHNICIANS IN REFRIGERATION, COMPUTING, MOLDING, CASTING, ENGINEERING, QUALITY, MECHANICS, ETC.

As shown in Figure 5, the training competences with higher demand in the industry were: Machine-Tools, Maintenance, and Electric-Electronics.

Figure 5 Labor competences where training is required



SOURCE: MARKET STUDY OF CENALTEC (FEBRUARY 2001).

NOTE: SAMPLE = 100 FIRMS, THE NUMBER CORRESPONDS TO THE ANSWERS.

THE LABEL "OTHERS" INCLUDES PROGRAMMING, MECHANICS, QUALITY, REFRIGERATION, WELDING, ELECTRO MECHANICS, ETC.

34 Interview in the NPD firm.

As maquilas have accumulated technological capabilities, the profile of the technicians they require has changed. Initially they demanded workers for subassembly processes of simple parts, later they began to demand qualified technicians and mechanic-electric engineers. After introducing electronic controls, electronic engineers were also required. Recently a demand has risen for engineers in mechatronics. Also, once they began to carry out design activities, some maquilas demanded design engineers.[35] These changes urge the education and training institutions to adapt their offer to the needs of the maquila industry, although most of the demand remains of more traditional training for the workers.

4.2.2. Demand for technicians and linkages with training institutions

From the beginning of the decade of the 1970s, Subensambles Electrónicos S.A. (SESA), Royal Philips Electronics' first maquila plant in Ciudad Juárez, had a machining work shop to solve the problems that arose in the first assembly lines of components. With the beginning of the final assembly process of televisions in 1987, the personnel of the machining work shop had an accelerated learning process. In 1991, the machining work shop received the name of Machine Factory, remaining in the plant dedicated to the assembly of televisions, known at that time as plant 5. The Machine Factory gave service to all of Philips' plants in Ciudad Juárez. It proved to have qualities not only in the areas of machining, but also in the design of blueprints for pieces. In 1997 it became an independent business unit and in 1998 it transferred to what became known as plant 7.[36] This new business required personnel trained in machine-tools. The key concept for Philips was high precision, but in the locality there were no technicians with this profile. This led Philips to interact with the local, state and federal governments to push the project of creation of the CENALTEC (*Centro de Capacitación de Alta Tecnología* -Training Center of High Technology) in Ciudad Juárez.

The CENALTEC represents an effort were three agents got involved for its creation and functioning: (i) the Federal Government contributed with the investment for buildings and the equipment of offices, classrooms and work shops, and the certification of the syllabuses and programs of the center through the *Secretaría de Educación Pública* (Office of Public Education), (ii) the Local Government supplied a piece of land of 3 hectares for the construction of the building, and (iii) Royal Philips Electronics provided the technical programs and a number of scholarships for their workers to be trained at CENALTEC.[37]

The aim of this project was the training of technicians with high levels of competence to support the maquilas industry by increasing the offer of personnel qualified on edge technology.[38]

A market study carried out by INALTEC, described in the last section, showed an insufficiency of specialized technicians and qualified personnel, and reduced training of the workers in the work centers. The need of training in machines-tools in the locality was identified. The needs of the

35 Interview in Delphi Corp's Technical Center.

36 In the mid-2001 plant 7 is integrated to Enabling Technologies Group (ETG), division of Royal Philips Electronics that gathered up all of its plants in the line of business of machining. In 2002 this division was put on sale.

37 Hualde and Lara (2002) and Urióstegui (2002) describe Cenaltec's case.

38 Interview with the Director of CENALTEC.

maquila industry and the local domestic industry were similar, the main areas that required training were: Manual lathe, Rectifier, Cutter, Manual milling machine, CNC machines and Clamp.

CENALTEC was created in 2001 and offered training programs in high precision machining with a high content of skills (80%), certified by the *Secretaría de Educación Pública* and by the Ministry of Education of the Dutch Government in the level SEDOC 2, also recognized by the certifying organisms of the Homologation Systems.[39] Representatives of the industry in Ciudad Juárez helped to select the courses that integrate the study programs, the evaluating mechanisms and the follow up of the training of the students.

In 2001 there were a total of 67 students, 52 financed with scholarships of the maquila industry, 4 national suppliers and 11 independent students with other sponsorships. Philips provided 37 scholarships. The students sponsored by Philips had one field day a week in plant 7.[40]

The idea was that once the students sponsored by Philips finished their studies, they would be hired by Philips. However, the corporative decided to sell the business of Enabling Technologies Group, so plant 7 could not fulfill the commitment of employing all the students sponsored by Philips. In fact, Philips lost interest in the CENALTEC project.[41] The decision of Philips' corporate and the crisis faced by the maquila industry in 2001-2002 affected the functioning of CENALTEC. The training center continues, but had difficulties during the years 2001 and 2002.

There is no doubt that CENALTEC represents an interesting experience in the creation of a public-private training institution. CENALTEC itself has been a transmission mechanism of knowledge spillovers of the maquila industry. But this case also shows the risk of creating public-private institutions that are so dependent of one global firm.

4.2.3. Demand of technicians and linkages with higher education institutions

At the end of the 1980s, Thomson Ciudad Juárez attained a series of agreements with training institutions, such as CONALEP, and higher education institutions like the *Instituto Tecnológico de Ciudad Juárez* (Technological Institute of Ciudad Juárez) and the *Instituto Tecnológico de Estudios Superiores de Monterrey en Ciudad Juárez* (Technological Institute of Higher Studies of Monterrey in Ciudad Juárez). Through these agreements, these institutions changed some of their syllabuses to cover the needs of Thomson's maquilas plants. Some of the agreements include donation of equipment, and the participation of Thomson's technicians in the training. For example, the plant MASA donated clamps to CONALEP and technicians of the TTM plant train students that are close to finishing their studies at that training center.[42]

Delphi has a special program for the formation of human resources with the *Instituto Tecnológico de Estudios Superiores de Monterrey*, with the *Universidad Autónoma de Ciudad Juárez, Universidad Autónoma de Chihuahua* and the *Instituto Tecnológico de Ciudad Juárez*. One of Delphi's strategies is to

39 The levels SEDOC correspond to the homologation system of the qualification levels of the technicians of the Economic European Community.

40 Interview with the Director of CENALTEC.

41 Urióstegui (2002) analyzes the evolution of the business of Philips' Enabling Technologies in Mexico.

42 Sanpedro (2003) based on an interview with the Manager of Human Resources, MASA.

influence the local universities to create new careers and improve the existing ones. At present they have two important projects: (i) a master in mechatronics and a master in engineering in mechatronics with the *Instituto Tecnológico de Estudios Superiores de Monterrey*; and (ii) a project to change the curricula and improve the career of mechanical engineering with the *Universidad Autónoma de Ciudad Juárez*.

Presently they have programs for *sabaticos* and long term visits of students with American universities, particularly in the Mexican border. They mention the possibility of establishing these agreements with Mexican universities in the locality.[43]

4.2.4. Collaboration efforts for the R&D

Delphi has explored the possibility of establishing collaboration projects in research and development activities (R&D) with universities and public research centers in Mexico. Delphi's Technical Center in Ciudad Juárez hires basic research from two sources: (i) Delphi Technology Inc., and (ii) American universities, like the University of New Mexico and the University of Dayton.

For the development of certain projects, the Technical Center has explored the possibility of establishing agreements with universities and public research centers in Mexico. In particular, in the years 1998-99, soon after beginning the R&D activities on sensors and actuators, a search was carried out in Mexico to identify research resources that allowed them to reinforce the capabilities of the Technical Center. However, they could not find in Mexico the partner they wanted for the development of basic and applied research required for the critical projects they had.[44] The firm's vision is described in frame 1.

Frame 1 Firm's vision on the difficulties to form linkages in Mexico

Delphi has the perception that the universities and public research centers in Mexico:

- Have potential for R&D, but are behind in knowledge and technical maturity in certain areas of interest for the firm
- Have an approach towards technological substitution
- Have many research areas dislocated from the needs of the international market
- Do not have a approach towards well defined development areas, work in development areas for production, and sometimes in advanced engineering (these activities correspond to the industry)
- Work in development areas were a defined market for carried out research does not exist
- Have no knowledge of how to handle technology and intellectual property transfer
- Have no knowledge of how to value the work of research to be developed, which results in more expensive projects than the US

SOURCE: DUTRÉNIT, G.; A. O. VERA-CRUZ; J. ALVAREZ; L. RODRÍGUEZ (2003).

43 Interview at the MTC.

44 Interview at the MTC.

Based on that experience, in 1999 the Technical Center changed its linkage strategy in Mexico.[45] First, they propose to handle the critical R&D for the business line in the Corporate Labs, universities and research centers in the US and Europe. Second, they decided to make a long-term investment on developing the skills and equipment at Mexican universities and R&D centers. This involved two phases: (i) influencing the local universities to create new careers and improve the existing ones; and (ii) launch non-critical research projects with Mexican universities and R&D centers to develop in them the capabilities required by Delphi.

Summing up, the linkages established by the maquila industry with training institutions, universities and public research centers are a mechanism of transfer of knowledge. Through these linkages, the institutions can learn to respond to a demanding client, to generate the practice of constantly actualizing the programs of study, and to accede to technicians of the maquila industry formed in other institutions to complement their teaching group. Afterwards this knowledge can be used by anyone who accedes these institutions. So, once the institutions learn, they have the freedom to use a great part of the knowledge acquired in other programs and with other students, thus having the capacity to spread the knowledge more broadly.

So far, given the needs of the maquila industry to improve its assembly processes, there have been more linkages for the training of technicians and the more standard formation of engineers than in the research areas. These process of establishment of linkages has been guided by the maquila industry. Some local institutions have followed its pace, others have not. The constant complaint of the maquila industry is that the institutions change slowly.[46]

In the 1990s, many maquilas had introduced in the locality plants technologically more complex processes, to respond to the industrial challenges of autoparts and consumer electronics. Also, some maquilas have began to develop product design activities, which allows for more knowledge spillovers and learning to occur. This represents an opportunity for the training, higher education and research institutions. But to take advantage of this opportunity, a change is needed in the capacity of response of the institutions.

4.2.5. Weakness in the linkages between agents

Punctual experiences of linkages between SMEs, maquilas, local training institutions and universities have been documented in this Section. The spillover effects of the maquilas industry in the locality can be observed through these linkages. However, the evidence also suggests that the structure of these linkages is weak.

The first aspect worth pointing out is that the structure of the linkages is guided by the maquila industry. The maquila industry promotes and dominates the linkages observed with SMEs, training and higher education institutions.

To discuss the weakness of the structure of linkages in the locality, we will focus on the linkages between SMEs and local institutions. To achieve this, we will rely on the empirical evidence obtained from the census carried out on the industrial machining industry.

45 Interview at the MTC.

46 Interviews with managers at Delphi, Thomson, Philips and Honeywell.

One of the topics included in the questionnaire was the technical training of personnel. As shown on Figure 8, half of the firms of the machining industry did not offer technical training in 2001.[47]

However, both the attitude towards training and its profile differ between different groups of machining firms. The more traditional firms did not offer training, while other more advanced ones did. The more consolidated firms search to provide a broader training, which includes: Basic Machining, Numerical Control, Quality Control, Blueprint Interpretation and Quality.

Figure 6 Areas of personnel training

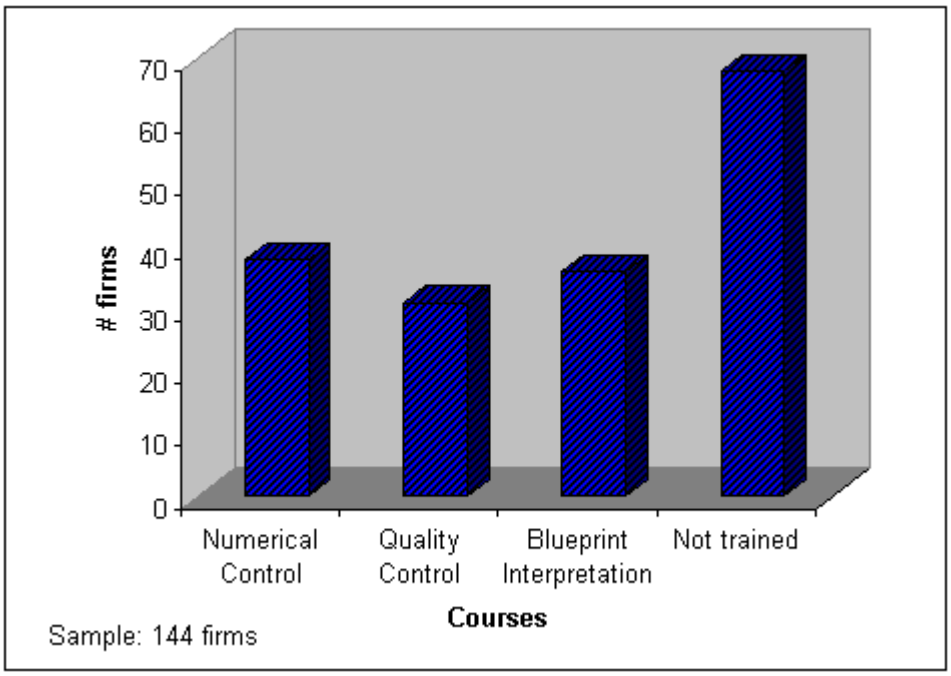


Table 3 presents the sources used by the machining firms for the technical training of their personnel. The main sources are: private consultants and in-house training. The more consolidated firms give priority to the use of private consultants, while the more traditional work shops with potential also use the training institutions. However, a little use of the public/private training institutions was observed, CECATI[48] is the training institutions most used by the machining firms and only 14.6% confirmed to having used this institution for the training of their personnel.

47 This result is similar to that observed by Chew and Yeung (2001) for the case of the machining industry in Singapore, where only 45% of the firms offered a formal training to their employees. Given the financial restrictions faced by the SMEs, these firms do not tend to offer much training and spend little on R&D, even though the workers receive much training through the practice (*on job training*).

48 Center of Industrial Technical Training.

TABLE 3 SOURCE FOR THE TRAINING OF PERSONNEL

Source	No. of firms
In-house training	31
Private Consultants	26
CECATI	21
CONALEP	7
CENALTEC	4
UACJ	2
CBTIs	2

SAMPLE: 144 FIRMS

The literature points out that one of the key functions of the government to support the SMEs competitiveness is the creation of educational infrastructure,[49] the case of the machining industry in Ciudad Juárez suggests that the impact of the government in this way has been limited.

In addition to the weakness of the linkages for training, the local linkages for production are also little integrated. On one hand, many of the maquila industry suppliers are situated outside of the locality, and some even outside the bi-national region of El Paso-Ciudad Juárez. On the other hand, to complete some orders, the local suppliers must send some pieces to the US for certain part of the production process to be carried out. Also, the interaction with intermediate institutions and other government agents are weak. There is not much trust in the support mechanisms offered by the government through the promotional institutions, and the SMEs neglect the use of the few credit lines offered by the domestic financial institutions. Since it is a bi-national region, often the firms accept the credit lines offered by the American bancs, particularly in those with sales offices in El Paso, Texas. However not all the firms have the necessary resources or the vision to establish a sales office in El Paso.[50]

5. FINAL REFLECTIONS

This paper analyzed some features of the process of creation and diffusion of the knowledge spillovers of the maquila industry in Ciudad Juárez, Mexico. Although the government, the domestic firms, and the training and higher education institutions believe that no knowledge spillovers have occurred, the evidence presented in this paper suggests the existence of such spillovers.

Two levels of knowledge spillovers have been analyzed: (i) two knowledge spillovers effects towards SMEs suppliers; and (ii) a number of spillover effects towards the local environment.

Referring to the spillovers toward the SMEs suppliers, the evidence shows that the sector is composed of 158 firms that have emerged and evolved because of the machining market generated

49 UNCTAD (2000).

50 Ciudad Juárez (México) and El Paso (US) are two bordering cities separated by a border line.

by the maquila industry. In 2001 the size of the market was over 30 million dollars. In terms of the human capital spillover, 100 of the owners of industrial machining firms, that is 72.5% of the total, were trained at the maquila industry. However, other works show the existence of substantial differences in the technological and managerial capabilities of these firms; this suggests that the potential to benefit from these knowledge spillovers vary broadly.[51]

Referring to the spillovers toward the local environment, this paper shows that the presence of the maquila industry has contributed to the creation of institutions in the locality (like CENALTEC), and to the development of others (such as CAST-CONALEP). It also generated a number of knowledge spillover effects over them. Today in Ciudad Juárez we can see a variety of public and private institutions of training, higher education, intermediation, etc. that have the commitment of strengthening the technological and managerial capabilities of the local SMEs. However, the structure of the linkages between these institutions and the firms remains a weak one. Likewise, the institutions have little flexibility to provide a fast response to the changing demand of the maquila industry, and thus to benefit from its knowledge spillover effects.

Unfortunately, only a small number of firms and institutions have benefited from these spillovers. A series of structural factors of the economy of the regions where the maquilas were established contribute to this situation, among which stand out the existence of immature industrial environments and the asymmetries between the economical agents.

These asymmetries limit the fields of communication and cooperation between the agents, for this reason, many of the potential spillovers observed do not become real spillovers of knowledge guided towards local development. The conversion of these potential spillovers to real spillovers requires the application of certain measures of industrial policy at the local level congruent with the development of domestic suppliers of the maquilas and local institutions of intermediation and support to the local firms.

Also, we show that the SMEs-maquilas, institutions-maquilas and SMEs-institutions linkages have emerged in a context of market relations that has systematically ignored the asymmetry between the economical agents. This has made it difficult for the local SMEs to count with the necessary tools to consolidate as independent firms, obtain new contracts and maintain an adequate rhythm of expansion.

The literature points out that one of the basic functions of the government is to generate a business context that allows the development of these SMEs, so as to be able to build networks of suppliers of the maquilas. Such context must include a legal and regulatory frame that facilitates the establishment and operation of the businesses, and the physical and educational infrastructure for the development of engineers and administrative abilities.[52]

The spillovers observed have emerged in a context of policies of attraction of the maquila industry to generate employment and exports, rather than from its use to foment the local, regional and national technological and economical development. The analysis suggests that to maximize the benefits obtained by the presence of the maquila industry, public policies oriented to generating conditions for the local SMEs suppliers to strengthen their managerial and technological capabilities, and strengthen their capacity of response to the market needs are required.

51 Vera-Cruz, Dutrénit y Gil (2003).

52 UNCTAD (2000).

The work developed opens a number of lines of research: (i) analyze other knowledge spillovers of the maquila industry; (ii) identify those minimum technological and managerial capabilities necessary to benefit from the spillovers; (iii) the characteristics of the local productive system and the role of the institutions when benefiting from the technological spillovers of the maquila industry in specific localities.

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