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THE FOREIGN FACTOR WITHIN THE TRIPLE HELIX MODEL: INTERACTIONS OF NATIONAL AND INTERNATIONAL INNOVATION SYSTEMS, TECHNOLOGY TRANSFER AND IMPLICATIONS FOR THE REGION: THE CASE OF THE ELECTRONICS CLUSTER IN GUADALAJARA, JALISCO, MÉXICO.

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Abstract

Within the context of global production the interactions among endogenous and foreign firms and their respective innovation systems, as well as strategic governmental policies favouring the exchange, may give rise to either virtuous or vicious circles of development through technological spillovers (Cantwell 1989, 1995a; Perez 1998), therefore, the foreign factor should be considered an important component within the triple helix paradigm in developing countries. This paper argues that in developing countries foreign direct investment is a factor needed within the triple helix paradigm as it may catalyzes some technology transfer and through its operations may create certain synergy that favours innovation, entrepreneurship and even the planning of a technological learning process in the host country. In order to develop the argument, this paper presents the case of the electronics cluster of Jalisco, Mexico.

Key Words: foreign direct investment, innovation, triple helix, technology transfer.

Introduction

Within the context of global production the interactions among endogenous and foreign firms and their respective innovation systems, as well as strategic governmental policies favouring the exchange, may give rise to either virtuous or vicious circles of development through technological spillovers (Cantwell 1989, 1995a; Perez 1998). As Perez confirms in his empirical study, the countries economies have been made, increasingly, more susceptible to the consequences of the international mobility of the production factors, of goods, and of technological knowledge. But, he said, given the pronounced mobility of production capital, the danger arises that erroneous economic and industrial policy choices may hamper the development of the national economies and favour those other countries which are better able to exploit the opportunities afforded by the globalization of national productive and innovative systems (1998, p.1). Thus, in the emergent economies the Triple Helix Model as conceived by Etzkowitz (2003) becomes more relevant within the context of the increasing global production and competition, based on knowledge creation and technological innovation. However, in the emergent economies these interactions demand a Triple Helix paradigm, where the foreign factor should be considered an important component in order to achieve a virtuous circle of development. Consequently, to find out what has been the impact of these interactions and what has been the role of the foreign factor within a Triple Helix paradigm in a particular industrializing economy is relevant.

This paper argues that in developing countries foreign direct investment (FDI) represented in this case by multinational corporations (MNC) is a crucial factor within the triple helix paradigm, as it may catalyzes some technology transfer since through its operations may create certain synergy that favours some innovation, entrepreneurship and even the planning of a technological learning process in the host country. In order to develop the argument, this paper analyzes the presence of MNC within the Triple Helix Model and its impact during the development of the electronics industry in Mexico along two decades that could be divided into three stages: a) formation of assembly and manufacturing location, b) building the electronics design function, and c) planning a technological learning process to create key competencies.
It is organized in five parts, after presenting the analytical framework, it first depicts the formation of the electronics cluster in Guadalajara, describing the role of FDI within the Triple Helix paradigm and the impact to the region during that initial stage. In order to do that, the study focuses in the analysis of the technology transfer and assimilation occurred through technical and research cooperation among national and international innovation systems, describing also the science – technology, educational, as well as industrial policies put in place by the Mexican government in order to favour these interactions in the electronics cluster of Guadalajara, Jalisco, Mexico. Thirdly, the paper presents the role of FDI within a Triple Helix paradigm in the transition from assembling and manufacturing to electronics design and the promotion of some entrepreneurial capacity. In the fourth part, it is described the current stage, where also FDI within a Triple Helix Model is playing an important role in the planning of a technological learning process to build key competencies. Although the process is still in the nascent stage, its purposes and the expected impact are discussed in the last part.

I. The Analytical Framework

The rational supporting the research design of this study is based on several lines of knowledge. Firstly, it is based on the research results of relatively recent empirical literature, which states that the cooperative activities and links between university and industry are important contexts of technology transfer (Robinson 1988; Stewart & Gibson 1990; Wigand 1990; Cutler 1988; Kwiram 1989; Larsen 1988). Secondly, there are several theoretical and empirical studies about technology transfer by MNC's, from which three main positions can be identified. However, two of them are of particular relevance to this paper. The oldest position claims that MNC's play a very important role in the technological advancement of the host country, given the technological spillovers and especially when the host country is a developing nation (Mansfield and Romeo 1980; Robinson 1988; Singh 1983; Safarian and Bertin 1987). Given the inclusion of the foreign factor, for the purpose of this analysis this study defines technology transfer borrowing the definition of Mason and the United Nations as follows:

> *Transfer of technology is the transmission of technology from foreign to domestic organizations and the corresponding assimilation of the technology by domestic organizations (Mason 1978a p.7) "The object of the transfer includes hardware (machinery and equipment), software (formulas, process description, etc., or else management and marketing know how between individuals or groups (UN 1988) within the industrial and the academic setting.*

The most recent position supports the idea that government intervention, especially, in the design of policies that encourage and support technological development of local firms and favour technological exchange and interaction between the international and domestic groups of firms and innovation systems may give rise to virtuous circles of development (Cantwell 1989, 1995a; Perez 1998). These authors argue that within the context of global production the interactions among endogenous and foreign firms and their respective innovation systems, as well as strategic governmental policies favouring the exchange, may give rise to either virtuous or vicious circles of development through technological spillovers (Cantwell 1989, 1995a; Perez 1998). As Tomaso Perez said, given the pronounced mobility of production capital, the danger arises that erroneous economic and industrial policy choices may hamper the development of the national economies and favour those other countries which are better able to exploit the opportunities afforded by the globalization of national productive and innovative systems (1998, p.1). Thus, these interactions promoted and concretized through a triple helix regime are of particular interest to emergent economies. As Etzkowitz (2003, p.6) sustains "A triple helix regime typically begins as university, industry and government enter into a reciprocal relationship in which each attempts to enhance the performance of the other. Most such initiatives take place at the regional level to address problems in industrial clusters, gaps in academic development and lack of governing authority". Thus, using these different but complementary lines of knowledge briefly enunciated above to enlighten the analysis, this paper demonstrates how the triple helix model having as an special element the foreign direct investment (FDI) have begun to address problems in the electronics cluster of Jalisco and has played a very important role in the change of nature of this industry, that is, it has set of the transformation from assembling and manufacturing functions to the design function in the electronics cluster of Guadalajara; and currently is also participating in the promotion of the planning of a technological learning process to achieve key competencies. The analysis is made on the basis of previous and current research[1], where information provided by about 92 interviewees from the academic, the industrial and the governmental settings about the cooperative relations and links occurring among them, is described and analyzed.

II. FDI as Part of Triple Helix in the Electronics Cluster Formation

The foreign factor plays a very important role in the electronics cluster formation of Jalisco, where also the Triple Helix paradigm could be identified. That is, without the establishment of some of the most important corporations, recognized as world class innovators and designers, in the metropolitan area of Guadalajara there could not be electronics cluster formation in Jalisco. Among the most significant of these corporations are: IBM, Kodak, NEC, Motorola –after On Semiconductors-Siemens, Lucent Technologies –after Phillips-, Compac, Hewlett Packard, Intel, Telmex, etc. This group of electronics firms identified as original equipment manufacturers (OEMs) has been able to attract international and mixed capital suppliers, contract manufacturers (CMs) and specialized suppliers, (SSs), so in this way have taken shape the electronics cluster in Jalisco.

Within the development of this electronics cluster could be identified the triple helix paradigm. First, in the participation of the government with the design of scientific-technological, educational and industrial policies, as well as some funding provided for the creation of a graduate and research institution, which main purpose was to link and respond to the industry needs. Some of these policies designed by the government were to attract FDI in electronics and computer and to promote the development of this industry in that region. Although since the 1960's some of these large electronics and computer corporations recognized world wide as innovators arrived and settled in Guadalajara, it was mainly during the decade of the 1980's and with stronger emphasis during the 1990's when this industry register a significant and impressive growth. The growth during the 1980's was mainly as a response to the new industrialization policy promoted by the Mexican Government, which allowed one hundred percent ownership to foreign capital. With this change in the industrialization policy, consisting also in offering tax exemption and other incentives, the Mexican government achieved the objective to attract FDI, demanding in exchange to international investors only the fulfilment of four main conditions: a) to increase exports, b) to transfer technology, c) to establish relations with Mexican academic institutions, and d) to train endogenous suppliers (OECD 1990; Whiting 1992). The impressive growth during the 1990's took place within the contextual framework of the opening of the Mexican market to imports and the North American Free Trade Agreement (NAFTA). So that, the performance of the electronics cluster in this region was spectacular until the year 2000, when exports reached $10,420 millions of dollars, providing about 70,000 jobs and representing 40% of FDI in that region.

The government designed also new scientific, technological and educational policies in order to promote and favour the interactions among foreign and endogenous firms and institutions. These changes registered in the National Development Plan, 1989-1994 could be summarized as major emphasis in the creation of scientific and technological capacities in order to make more efficient the assimilation of foreign technology by the national productive system and improve its competitiveness and also promoted some changes in the industrial property systems to deregulate and protected external technological flows to intensify it. Also, by the mid- 1980's the Ministry of Education (SEP) was stating more emphatically its demands on the universities for research and technological development, as well as for closer cooperation with the industrial sector, specifically to promote joint research projects with industry. Thus, within the framework of the industrial, scientific, technological and educational policies depicted above the other factors of the Triple Helix paradigm are going to be identified in the next section.

On the basis of the theoretical and empirical grounds depicted above, from interviews carried out in

[1] Rivera M. I. (2002) Technology Transfer Via University-Industry Relationship: The case of the foreign high technology electronics industry in Mexico's Silicon Valley. New York &London: RoutledgeFarland; Rivera M.I. y Regino J. (2004) "Entrenamiento y Aprendizaje Tecnológico en la Subcontratación: El caso de los proveedores endógenos en la industria electrónica". (Training and Technological Learning in subcontracting: The case of the endogenous suppliers in the electronics industry) *Comercio Exterior* Vol. 3, Marzo, No. 54; Rivera, M. I. (unpublished research results of research project 2006)

previous research[2] during 1997-1999, information provided by personnel from the academic, the industrial and the governmental settings about the cooperative relations and links occurring among them, is described. Thus, the occurrence of informal mechanisms of technology transfer is pointed out, and the level of capacity transferred is identified.

2.1 Cooperative Activities and Links

Although thirty one from the thirty-two activities[3] more commonly undertaken internationally between the academic-industrial and governmental sectors, were found in the Guadalajara region, only seventeen cooperative activities were identified between some of the foreign high technology electronics corporations included in the study and some of the national firms as well as research institutes and higher education institutions in the sample. Of those activities, fourteen are considered direct links and three are indirect links. From the fourteen direct activities undertaken, there are eight most-common activities in terms of the number of universities involved, which are: *l. guest speakers, 2. curriculum development, 3. custom courses, 4. cooperation programs for selection and hiring of university graduates, 5. education programs, 6. contracts for technical or academic service,* 7. *adjunct professors,* and *8. funding from industry to universities.* Most of these activities also involve a larger number of the corporations included in the study, with the exception of contracts for technical or academic service, funding, and cooperation programs for selection and hiring purposes. The study detected that some of the contracts with the foreign electronics firms are more sophisticated and relevant to technological spillovers than others. Among the most relevant detected are the technological development and design contracts between foreign corporations and one of the research institutes in the sample. However, most of these designs were done as a request of international electronics firms established in the United States and only three of these contracts were signed with international corporations operating in Guadalajara. These designs are considered to be joint applied research links and will be described below, as those of major impact and as a strategic cooperative relation for technological spillovers in the host country.

The other six direct activities are more selective in terms of number of academic institutions and corporations involved, but, some of these activities are the most important since these were found to lead to technology transfer. These are *l. donations of hardware or software sample programs, 2. professional summer study, 3. new course development, 4. research council participation, 5. applied research linkage,* and *6. donation of equipment.* The three indirect relationships detected are: *1. employment of current students, 2. classroom interface,* and *3. internships*. These activities take place mainly through students at these institutions who also happen to work at a particular corporation included in the analysis.

Referring to *applied research linkages*, as mentioned above in the section on contracts, this study records past applied research projects between one research institute and three of the corporations recognized as world class innovators. The outcome of the joint research projects with some of these corporations has been some technological developments such as an impact printer. The same Mexican research institute has designed also motherboards, multi-layer and printed circuit cards and more than one hundred printed circuit boards. However, neither the higher education institutions nor the corporations interviewed reported being engaged in basic research linkage projects between them, and as was mentioned earlier, the existing applied research links by 1999 were not in electronics or related areas.

Consequently, within the academic-industry relationship examined no co-publications and no joint efforts for securing patents were reported. This is despite the fact that some patents resulted from the joint applied research activities between foreign electronics corporations and the research institute, just described. As the projects described here show and the director of the Mexican research institute confirms, this institute has the capability to design and utilize technology that falls between key and cutting-edge technology. Thus, as can be seen, the data indicates a more substantial activity in the recent past than in the present. One of the reasons for the absence of cooperative projects in applied research might be that the foreign corporations chose the option of building their own research facilities. Six of the eight global corporations incorporated in the sample have their own research facilities in their Guadalajara plants and about 300 Mexican engineers were working as researchers there by 1997. The number of corporations with research and design functions in Guadalajara grew to eight in 2000. In fact, INTEL settled operations in Guadalajara during that year with the only function of electronic design. To begin operations in Guadalajara, INTEL bought “TDCOM”, a Mexican firm specialized in electronic design ASIC, which was created in 1998 by the Mexican research institute, CINVESTAV.

[2] Rivera M. I. (2002). Op. cit.
[3] See Cummings, W., 1995, 1998; Jones, H. and Jenkins S., 1999; Stewart & Gibson, 1990; Klingstrom, A., 1987; Powers, D., Powers, M.F., Betz, F., and Aslanian, C.V., 1988; Rosmalen, K., 1998; Stauffer, T., 1980; Wigand, 1990 in William and Gibson, 1990.

Some of these corporations have obtained a goodly number of internationally recognized patents and one of them obtained product responsibility in printer design. So, the lack of applied research projects between these corporations and the local higher education and research institutions could not be explained by lack of scientific and technological capacity for two main reasons. First because the experience in the immediate past and the outcomes discussed above demonstrate the opposite. Second, because the same Mexican research institute involved in the experience described maintains several applied research links with international electronics firms located in United States and Europe. But this 'missing link' could indeed be explained by the corporate research facilities installed in Guadalajara and the dominant functions of assembly and manufacturing in the electronics industry operating in Jalisco since the 1980´s.

In this case, the establishment of R&D facilities by foreign corporations in the host country seems to provoke ambivalent results. On the one hand it stirs up the innovation climate, providing an adequate atmosphere and operating conditions for the group of Mexican researchers working there. But on the other hand it diminishes significantly the possibility of research links with the higher education and research institutions – at least in the core technologies. The lack of linkage in applied or basic research, in turn, prevents substantial communication between corporate research and development personnel and their counterparts within the Mexican innovation system, and therefore, limits the technological spillovers. But also, as Dussel (1999) affirms, the segmentation in value added chain of a productive process is particularly meaningful, not only to the value added, but also to the use and development of technologies, processes, employment generation, supplying types, and in general to the learning process developed in the respective local and regional spaces. Thus, the electronics industry of Jalisco was placed in the low value added chain of the process such as assembly and manufacturing during its first stage of development. Consequently these functions determined the learning process developed in that region, which has been of limited impact to the region, as it will be analyzed in the following part.

2.2 The Technological Spillovers

Having described the type of interactions more relevant between the national and international innovations systems generated by the internationalization process under a Triple Helix paradigm with a dominant foreign factor, in this section will be identified the technological spillovers detected.

After an exhaustive analysis of these interactions and cooperative relations this study found evidence that four technologies were transferred and four technologies were just diffused in the region. The technologies transferred that the study identified are: a) the use of AS400 computer for software production, b) the use of manufacturing cell and flexible manufacturing, c) the use of automation and control systems, and d) quality control technology.

The analysis shows that the cooperative activities and links more conducive to technology transfer were i) hardware donation, ii) training to students, iii) training to professors, iv) training to endogenous suppliers, v) training to employees of MNC's, vi) software donation and vii) equipment donation

The use of AS400 computer was transferred through the equipment donation and training in the use of it to students of one of the nine universities within the sample. Also, in the case of flexible manufacturing technologies and the use of automation and control systems the transfer was through training provided to students, but in this case, the corporations included professors from four of the nine universities instead of only one. Also, the study carried out between 2001 and 2002 reported some flexible manufacturing courses to two of the endogenous suppliers (Rivera and Regino 2004). In the case of the quality control technology, this was transferred directly to employees in eight of the thirteen electronics corporations in the sample. But also, the same eight corporations provided this training to twelve endogenous suppliers. This quality control technology has been also diffused within the industrial culture of the region, mainly by imitation.

As far as the other four technologies, this study recognize only their diffusion because these were technologies already in use in some endogenous electronics firms that existed in the region by the end of the 1980's (Wilson 1996) and definitely, these four technologies were already utilized by one research institution, CINVESTAV[4]. The technologies diffused by the MNCs and detected by this study are: a) the use of the technology on electronic design ASIC's, b) the use of the technology on digital electronic design field programmable gate array (FPGA), c) the use of the technology on analogue electronic design field programmable analogue array (FPAA), and d) the use of the surface mount technology (SMT). In the case of the first three technologies, the study found that were received by four higher education and research institutions through software donated by five MNCs. As far as the surface mount technology, this was diffused through courses to students and the donation of equipment for training purposes to one technical education institution,

[4] See Rivera M. I. (2002). Op. cit.

Centro de Enseñanza Técnica Industrial (CETI) (Industrial Technical Teaching Centre)[5].

2.3 The Level of Capacity Transferred

In order to analyze the acquired level of capacity in the region with the eight technologies transferred and diffused, respectively, this study used the classification of Dahlman and Westphal (1983); Shiowattana (en Yamashita 1991). These authors consider technology transfer as a learning process that implies the gaining of deeper understanding of the technology they are dealing with. This is labelled as a deepening effect. The authors divide such levels of understanding into interrelated stages that goes from superficial to deeper understanding, which are acquisitive[6] capability, operative capability, investment capability, adaptive capability, and innovative capability.

Within this theoretical framework the analysis of the level of capacity transferred until the late 1990's to the region will be depicted. According to this study results the technology transferred to some of the students and professors of four higher education institutions, to corporate employees working at eight of the MNCs in the sample, and to twelve endogenous suppliers indicates that for the most part it is concentrated in operative capacity. That is, 78% of the training provided to corporate employees, 100% of the training provided to professors and students and 100% of the training provided to endogenous suppliers is concentrated in operative capacity.

As far as the investment capacity, this study did not found major evidence that these corporations have transferred some. This is because one of the most common mechanisms to acquire it is through joint ventures and this study did not detect a significant formation of these associations with nationals. By 1997 there were only eight joint ventures out of 60 corporations. Moreover, the major part of the 6 spin-off registered by the work of Palacios in 1994, by 1997 have disappeared or have been dissolved recovering the 100% foreign ownership as a result of the modifications in the foreign investment law in Mexico, which drop the required 51% Mexican participation. Furthermore, from the seven and eight small endogenous electronics firms reported in 1989 and 1994, respectively in the studies of Wilson (1996) and Palacios (1994), 71% and 40%, respectively, have disappeared by 1997. Consequently, this study does not recognize the acquisition of investment capacity in the region.

As far as the adaptation capacity, the results of the empirical research suggest that although limited, there is certain adaptation capacity promoted indirectly in Guadalajara by these corporations. This capacity is acquired through the reverse engineering performed to the software and hardware donated by these corporations to the higher education and research institutions. In addition, the funds provided by these corporations to two of the four institutions receiving software from the corporations have contributed to improve the laboratory practices for teaching and the creative exercises and competition promoted at these universities with the electronic design expositions and contests organized annually[7]. Also, the acquisition of adaptation capacity is promoted by the employment of Mexican researchers that according to the empirical research[8], by 1997 were about 300 in five corporate laboratories. This argument assumes that the Mexican researchers working in the research and design labs of these corporations have the opportunity to develop and strength their adaptation capability through the propitious work atmosphere and available resources; although, of course, these professionals were hired by the corporations already trained and with certain capacities to perform adaptation and innovation functions.

Referring to the innovation capacity, this study did not found evidence of an important impact. Despite that by the end of 1997 six of the thirteen corporations in the sample have already established their research and development labs, and by 2000 the corporate labs have grown to eight, there is not registration of significant impact neither in the academic community, nor in the industrial culture of the region since the links in research and development are very scanty and weak, as it was reported earlier. As analyzed before, these results could not be explained for the lack of capacity in the Mexican institutions, on the contrary, it could be recognized certain positive response of one of the research institutions in the region. The former is supported not only in the technological developments that CINVESTAV performed for four of these corporations in Guadalajara, but also by the incubation and development of the Mexican electronic design firm "TDCOM", acquired with all the engineering

[5] This centre was left out of the sample because it fell outside the parameters established for the sample design of this research, but was interviewed at the last minute when the researcher listen the news about the equipment donation to it by one of the corporations.

[6] This capability is not going to be analyzed here because the study focuses only in the informal mechanisms of technology transfer and acquisitive capability derives from the contracting of technology or consulting technical services, which is a formal mechanism of technology transfer.

[7] See Rivera M. I. (2002) Op. cit.
[8] Rivera M. I. (2002) Op. cit.

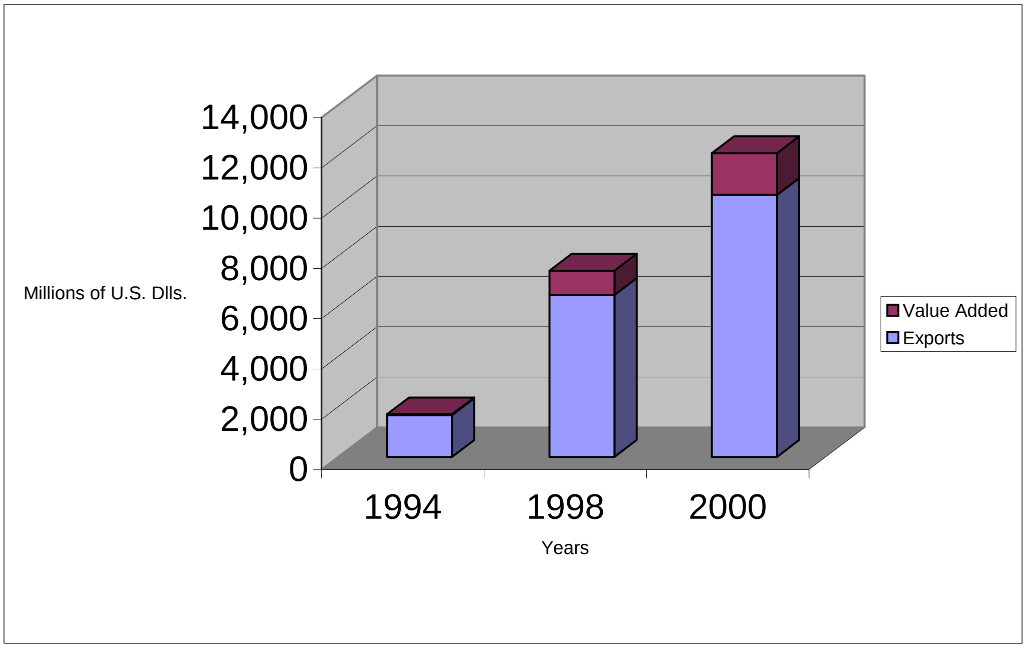
personnel working on it by INTEL in 2000. And, as it was explained before, all the engineering personnel working at this firm was trained by the same Mexican research and graduate education institution.

2.5 The Impact in the Emerging Mexican Economy

Using as indicator the level of integration in the region, in this section will be analyzed the impact of these MNCs in the emerging Mexican economy. The analysis is operationalized through the economic value added, which is taken as an expression of the creation of networks that Hirschman (1958) proposes as a strategy of economic development, as well as a possibility for technology transfer. It is represented by the acquisition of parts and components (inputs) by the MNCs in the host country from the endogenous industry. As Wilson (1996) points out, each transaction between the MNCs and the endogenous firms is a possible conduit for technology transfer. In Jalisco the value added[9] locally to the export value in the electronics industry is reported to have jumped from 2% in 1994 to approximately 15% in 1998 and 16% in 2000. However, when the level of integration found in Guadalajara is compared to what can be observed at the international level, it is considered very low. Wilson found in countries like Singapore[10], South Korea[11], and Taiwan[12], 42%, 33%, and 27%, respectively. Graph 1 below, contrasts exports and value added in Guadalajara for those years. As may be observed, despite the significant advance shown from 1994 to 1998, the national value added was still very slim in 2000. This makes evident that the level of national integration in this industry is very limited during the fist stage, with the consequent sparseness of economic and technological benefits derived from these high technology electronics corporations' operations in the region.

[9] The value added was estimated by The National Chamber of Electronics and Telecommunications Industry (CANIETI) using differences in export and import values without including labour.
[10] The figure for Singapore is for 1979.
[11] Korea's figure is for 1977
[12] The figure for Taiwan is for 1978.

Graph 1 Contrasting Exports and Value Added Locally in Jalisco's Electronics Industry



Source: Author's field research 1997-1999; Interviews to CANIETI (2001), Guadalajara, Jalisco, Mexico.

III. The Break-Trough, from Assembly and Manufacturing to Electronics Design

The change from assembly and manufacturing to electronics design began to take place through certain industrial restructuring promoted representatives of the tree sectors commonly identified within the Triple Helix paradigm, where FDI again play a very important role. The crisis in the electronics cluster of Guadalajara of 2001, when five large MNCs left to China and Malaysia with the corresponding decreasing foreign direct investment, employment and exports, as could be seen in the figures expressed in Table 1.1, below, made it clear the need for an alternative strategy in response to the crisis. Thus, the need for a move to a higher value added segment in the electronics industry was more obvious and imperative than ever. That is, the alternative answer was an industrial restructuring that could promote the change from assembly and manufacturing to electronics design.

Table 1 Overview of Electronics Industry Performance in Jalisco (1994-2001)

	1994	1995	1996	1997	1998	1999	2000	2001
Foreing Direct Investment (millions of dollars)	na	177	398	451	427	342	230	180
Employment (number of jobs)	12,360	17,250	29,000	50,000	60,000	80,000	70,000	45,000
Exports (millions of dollars)	1,660	2,300	3,500	5,200	6,440	9,029	10,420	9,500**

Source: Dussel, Galindo and Loria (2003) Condiciones y efectos de la inversión extranjera directa y del proceso de integración regional en México durante los noventa. (Conditions and efects of foreign direct investment and the regional integration in Mexico during the nineties). Mexico: Plaza y Valdez, S.A. de C.V., UNAM, BID-INTAL.

Notes:

** Some statistics include in this figure 1,500 millions of dollars for machinary and equipment belongin to firms that after closing operations in Mexico, exported those in the year 2001, but the authors substract this amount in this figure.

Therefore, it is within the context just described that the cooperative activities: ***new course development*** and ***funding*** among the three sectors identified within the Triple Helix Paradigm began to take place and promoted the industrial restructuring. In this case, the academic sector is represented by the endogenous research institution, CINVESTAV. The industrial sector is represented by the multinational INTEL and the Government sector is represented by The State Council of Science and Technology in Jalisco (COECYTJAL). In this effort CINVESTAV has worked with INTEL in the creation of totally new educational programs (training programs), which in turn have been financed by COECYTJAL and have been equipped with cutting edge equipment financed by the involved corporation, INTEL. The two programs developed through these cooperative relations aim to create world class electronic design capacity and technological entrepreneurship in the region. One of them is The Advanced Program in Electronics Design and Software (PADTS), which main objective is to train 500 high qualified and world class electronic designers in five years. In this program INTEL has invested about 50,000 US$ in the equipment and COECYTJAL, founded and financed by the government, is in turn providing the funds to sustain the educational program and the scholarships for the students. In the second program: Creation of Technological Entrepreneurship, the main objective is to consolidate at least 30 entrepreneurs in two years. Initially, the planned specific participation of INTEL in this program was to invest between 1 – 4 millions of US dollars.

Thus, this is the origin of a cooperative interaction, where the relationship within the Triple Helix regime becomes stronger and definitely more focused, but also, the presence of the foreign factor is outstanding, since the industrial sector is represented by the multinational INTEL and the nature of its participation. The impact of this cooperative activity has been determinant to foster the design function in the electronics cluster of Jalisco, as will be demonstrated in the following paragraph.

Between 2002 and 2004 it was registered a duplication of design activities just in this world class corporation, INTEL. In general, in the region there has been a growing investment in R&D and therefore in innovation, see Table 2 below. This has given place to certain synergy and MNCs that in the past left to China, have comeback to the region and have installed functions of research and design. One of these corporations is Motorola or On Semiconductors, which during the crisis closed its lines of production and transferred them to China. However, Motorola not only has cameback, but also it has installed functions of research and design. It has created a design centre named Free Scale, which is dedicated to applications design and semiconductors design. Thereafter, according to the State Council of Science and Technology, now in the electronics cluster of Jalisco there is value creation based on technology design (Medina 2004). As a result this electronics cluster by 2004 was compose of: 13 Original Equipment Manufacturers (OEMs), 17 Contract Equipment Manufacturers (CEMs), more than 400 Specialized Suppliers (SSs), 27 Design Houses, 19 of which are small companies, and 151 small firms dedicated to software development (Medina2004).

Table 2 Increasing State Investment in R&D

Year	Private Expenditure R& D (Manufacturing Sector) Thousand Millions US$	% State GDP
2001	193	0.51
2002	181	0.51
2003	194	0.52
2004 p	249.25	0.58

Source : Medina G., F. (2004) The Case of Jalisco and the Program of the State Council of Science and Technology. Paper presented at the Seminar on Challenges and Perspectives on Technological Development in Mexico, December 10th, 2004.

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IV. The Planning of a Technological Learning Process

An important effort of technology transfer to the region has been taking shape since 2005. The group promoting this initiative is composed of MNCs, government agencies, and some universities, thus, the Triple Helix Paradigm could be identified, as well as the foreign participation. Representing the foreign factor within this group are some of the most important MNC's with operations in Jalisco, such as INTEL, IBM, Hewlett Packard, Siemens, Free Scale, Jabil, etc., but also The United States-Mexico Foundation for Science (FUMEC). From the endogenous side the governmental sector is again represented by COECYTJAL while in the educational helix are two higher education institutions and from the endogenous industrial sector are some of the small software companies (recently created through the two special programs just reported above). The program's main objective is to transfer technology to the small firms aiming to develop capacities, so that it could be created and promoted key competencies in the region.

This group of technology transfer has designed strategies for the short and long run. The short run strategy has as a main objective to share best practices. The long run strategy aims to plan a technological learning process with the objective to build the key competencies on the basis of the key capacities previously identified in the region.

The short run strategy began since August 2005 with a program conformed of courses offered by the MNC's within the group to the small endogenous software companies. The courses offered until now are: a) Structured Solution to Problems, b) Strategic Marketing, c) Project Management, d) Methodology of Inventive Solution to Problems.

The long run strategy has recently began by trying to convince and get involve the small companies in a self evaluating process. This self evaluating process in the small software companies pretend to identify these companies' core competencies and therefore provide some guidance to these firms to define their main goals for development in the long run. Once these companies have defined their main goals in the long run they can start planning their technological learning process and develop the key competencies in the region. Currently, the capacities and interest identified by studies promoted by this group in the region are testing and embedded software. Therefore, the group of technology transfer is planning to promote a technological learning process in the region in these two functions, testing and embedded software.

V. Discussion and Conclusion

This paper illustrates how the Triple Helix Model identified along the development process of the electronics industry in Guadalajara, Jalisco, Mexico has been characterized by a strong participation of the foreign factor. It has been shown how this specific Triple Helix Model have begun to address problems in the electronics cluster of Jalisco and has played a very important role in the change of nature of this industry, that is, it has set of the transformation from assembling and manufacturing functions to the function of design in electronics and in addition is planning to foster the development of key competencies to become a competitive testing cluster.

As has been shown here, during the first stage in the electronics industry development the Triple Helix Model did not show very important impact to the region. However, during the second and third stages described here, it really has begun to show the importance of the strategy to achieve qualitative changes, such as the change in the nature of the electronics industry in Jaliso, which was placed in a higher value added chain of the process. But in addition, the process described points out the need of a lag period before achieving higher quality objectives.

Notwithstanding the former, this study has not demonstrated the consolidation of the Triple Helix Model in the region. Nonetheless, given the latest developments it is expected an important and positive impact for the creation and promotion of key competencies in building an specialized cluster in testing and embedded software.

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