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DEVELOPING THE U.S.-MEXICO BORDER REGION
FOR A PROSPEROUS AND SECURE RELATIONSHIP:

INNOVATIVE COMPANIES AND POLICIES FOR
INNOVATION ON THE U.S.-MEXICO BORDER

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Innovative Companies and Policies for Innovation on the U.S.–Mexico Border

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Innovative Companies and Policies for Innovation on the U.S.–Mexico Border

Abstract¹

The primary purpose of this work is to describe innovative enterprises and industries in the northern border region of Mexico and to analyze federal and state government efforts to increase their competitiveness. The importance of this analysis lies in the possibility of creating a virtuous circle around which innovation by the productive sector (which seems tied to higher value-added activities, high-quality work, and higher tax payments) intersects with the government and education sectors—which, in turn, participate in the development of local innovation systems.

The document is divided into four sections:

- Main concerns: An analysis of Mexico’s loss of competitiveness and changes in the international and national context in which maquiladoras operate.
- Policies to promote innovation and competitiveness: Presentation of federal policy changes that impact local support for innovation efforts, and of multiple federal programs and their implementation in the northern border states.
- Maquiladora industry: Presentation of several years of research on innovation and industrial upgrading of products, processes, and functions, as well as examples of innovative sectors, firms, and programs.
- Promising initiatives: Presentation of successful examples of public-private partnerships at the federal and local level.

The conclusions are that there is a clear process of innovation in the maquiladora industry, but it is limited and heterogeneous; while there is some institutional upgrading at the regional level, it is mainly accomplished at the federal level; and the northern border region is better positioned for innovation compared with the interior areas of the country. Despite considerable efforts by different levels of government and the private sector, there is a clear loss of competitiveness in Mexico. The path to a substantial increase in innovation and competitiveness seems long and winding.

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Introduction

The purpose of this paper is to describe innovative companies and industries in the northern border region of Mexico and to analyze efforts by federal and state governments to institute policies that will increase economic competitiveness. Among the advantages associated with the development of products and services with higher value-added are increased transfers of technology, the accumulation of local technical and human capabilities, and an increase in competitiveness and innovation. Ideally, innovative companies and sectors should generate high-quality jobs (in terms of wages and working conditions), as well as more tax revenue to be used for local purposes. In this way, fostering and developing so-called “local innovation systems” in the border regions could produce a virtuous circle.

In this sense, innovation is a process linked to the stages of society; and therefore the logic of innovation and competition is modified in accordance with each “technological wave” (Pérez 2008). We should then ask ourselves which wave or stage we are in currently. The consensus seems to be that we have been in the revolution stage or the Information Technology (IT) age since the beginning of the 1970s. According to Carlota Pérez, seven characteristics stand out in this stage:

- Planning: The move from rigid central strategies to flexible and adaptable strategies.
- Structure: The move from centralized pyramids to decentralization in open networks.
- Operations: The move from optimum standardized routines to continuous improvement.
- Human resources: Salary is viewed not as a cost to be minimized, but as an investment in human capital.
- Suppliers: The move from a remote relationship to innovative cooperation and alliances.
- Products: The move from raw material transformation to using “gray matter” to create value by processing knowledge.
- Markets: The move from internationally standardized markets to segmented markets in multiple local, national, sector, and global niches (Pérez 2008).

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According to Pérez in the previous paradigm, any big, respected company had to have a research and development (R&D) department; today, however, even the smallest company deals with technology not as a separate function, but as an integral part of business management. Innovation has three outstanding features:

- Simultaneous engineering, with teams inside and outside the company and with the participation of all personnel.
- Innovation is incorporated in the management of the company, as well as in its strategy and network of partners and associates.
- Constant innovation is based on continuous improvements and exploration of different avenues during different business stages.

In other words, innovation is no longer exclusive to technical centers and R&D departments; it has become part of all stages of a business. This new form of innovation can be achieved in following ways: 1) intra-firm (through multilevel work teams and continuous improvement); 2) inter-firm (through complex, long-term relationships with customers and a long list of direct and indirect suppliers); and 3) through its surroundings (mainly through contact with the academic and government sectors). Many organizational models have contributed to the development of this process, including: the Toyota Production System (TPS) (Abo 1994, 2007), in wide use since the 1980s, and which promotes innovation in the work process through internal synergies, as well as with the closest suppliers; and the Triple Helix Model (Etzkowitz and Leydesdorff 2000), which fosters communication between companies, universities, and government. The innovation process thus has a double origin with respect to new organizational models—the companies and the environment in which they operate.

Innovation, in a general sense, is closely linked to the development of networks inside and outside of the companies, and to the synergies established at different levels of a company's operations. This explains the development and success of new schemes to drive local development, such as systemic competitiveness (Klaus et al. 1996). According to this concept, well-grounded competitiveness depends on the following factors: an organization that is capable of applying the lessons learned from innovative processes that are occurring company-wide;

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collaboration between networks geared toward innovation and supported by different institutions; and an institutional environment capable of fostering innovation. To accomplish this, this scheme integrates the *meta* (culture), *macro* (economy), *meso* (institutions), and *micro* (companies) levels.

Considering this, the development of clusters and industrial districts,² as well as of local production systems (Giuliani et al. 2005), are industrial development models tied to a territory, and that foster ties between organizations and institutions in order to increase international competitiveness. These models therefore recognize the important role that local governments play in the economic organization of towns. Local development thus becomes a main focus of academic research and political interest in most countries, and of international organizations such as the World Bank, International Monetary Fund, United Nations Organization for Industrial Development, and World Trade Organization (Sforzi 2007). In this case, “local” is defined by the territory; its limits are defined by stakeholders who carry out a development strategy by inter-relating with one another, and through a decentralization initiative that benefits local governments (Sforzi 2007).

In summary, the development of innovative productive companies and sectors (the endogenous component of innovation) and of innovative local systems (the exogenous component of innovation) are related to the synergies achieved in the complex productive stages (Novick 2002), where multiple social stakeholders generally intervene, as we will see later. Perhaps what is most interesting in a search for models that increase competitiveness is that the environment in the new paradigm has moved from serving as context to becoming an integral part of the process.

² *Cluster* is commonly understood as a sectorial and/or geographical concentration of enterprises that carry out the same activity or related activities—both backward (input and equipment suppliers), as well as forward and sideways (processing and user industries); and as services and activities closely related to important and cumulative external economies, of agglomeration and specialization (the presence of producers, suppliers, and skilled labor and related services specific to the sector), and with the possibility of carrying out a joint action in search of collective efficiency. The efficiency of the whole complex is greater than that of each company in isolation because of the externalities that each company generates for the rest; that is, because of the action, each company generates benefits for itself, as well as for the rest of the enterprises of the complex. In the case of industrial districts, there are different definitions, but in all of them there are a series of common elements: a) grouping of mainly small- and medium-sized enterprises, concentrated spatially and specialized in sectors; b) a set of links forward and backward, based on market and extra-market relations, for the exchange of goods, information, and human resources; c) a common cultural and social environment that links the economic agents and allows the creation of common explicit and implicit behaviors; and d) a network of local public and private institutions of support to economic agents (Perego 2003).

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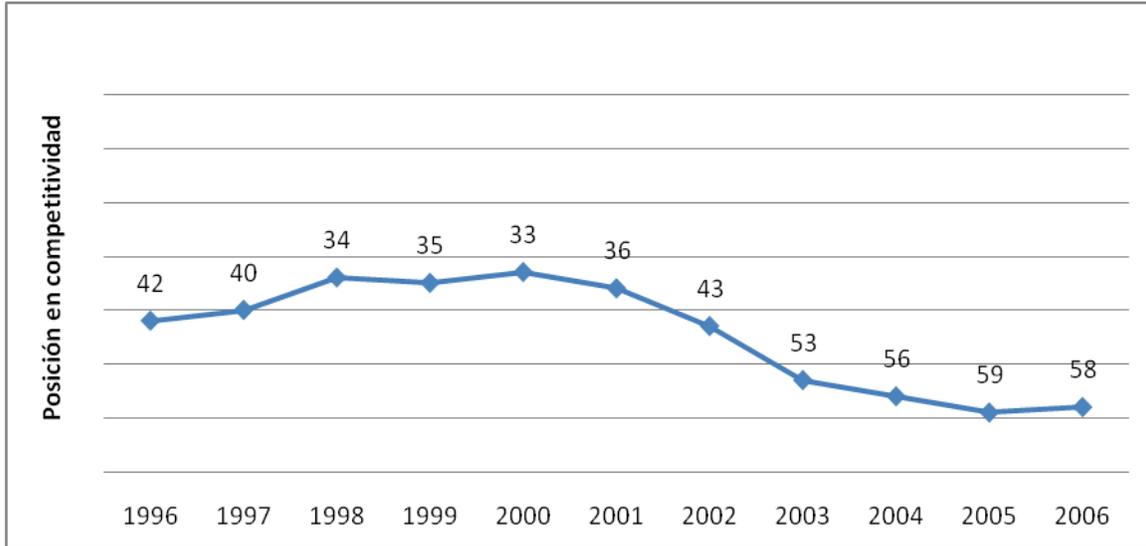
Latin American governments, like the one in Mexico, that strongly decreased participation in productive development during the trade liberalization process now face a big challenge, given a stronger demand for more active national and subnational governments. In the case of Mexico, this represents a great opportunity because of the leadership role in production activity played by multinational corporations, which have been dissociated from the regional economies in the northern border (Dussel-Peters 2000). However, a significant challenge remains because of the lack of financial and human resources, as well as of coordination.

1. Main Concerns

Competitiveness³—the need to increase or at least maintain market share—has been and continues to be the main concern of private companies, both foreign and Mexican. This is understandable given Mexico's low competitiveness ranking internationally, according to different indexes; far from improving, competitiveness in Mexico has been deteriorating since 2000. In 2008, the Mexican Institute for Competitiveness (IMCO, in Spanish) presented its most recent indicators, concluding that between 2004 and 2006, Mexico fell back three places—from position 30 to 33—among the 45 most competitive economies. Chart 1 shows this same pattern.

³ Global competitiveness is a wide and inclusive term but it can be considered an indication of a country's capacity to generate wealth and economic prosperity for the population (Interview: Irene Mia, associate director and economist of World Economic Forum, CONACYT, 2008).

Chart 1. Competitive stagnation in Mexico

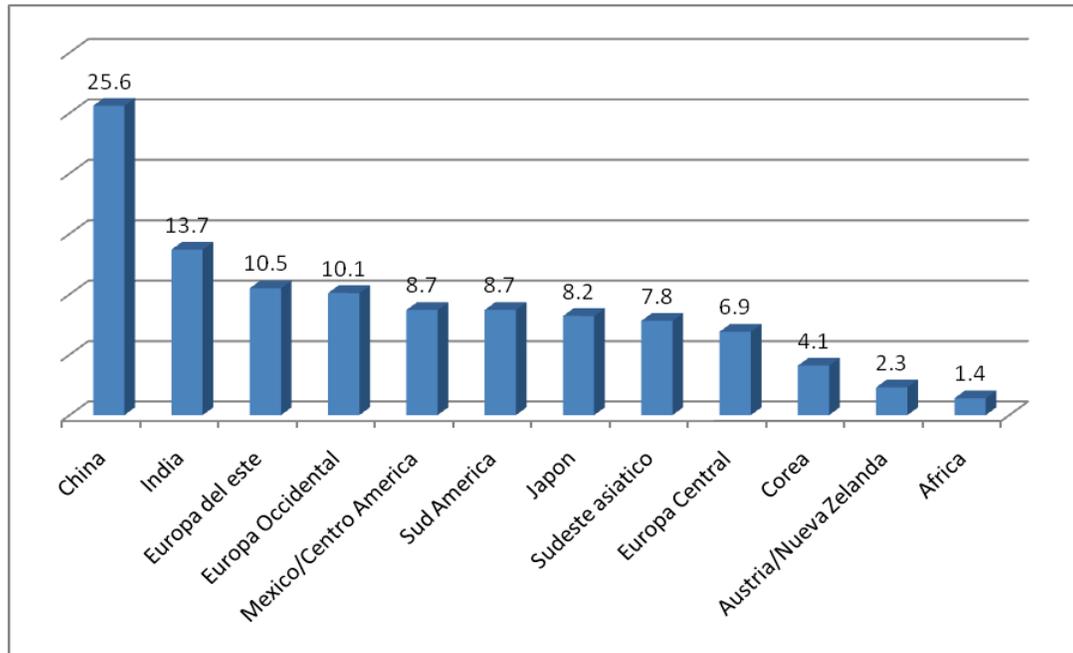


Source: COPARMEX. Based on data from the Global Competitiveness Report.

In an interview, Saul de los Santos, director of Axis-Producen (Tijuana, August 2008), cited a 2007 unpublished study by the Organisation for Economic Co-operation and Development (OECD) that concluded that Mexico is falling behind in adopting information and communication technologies and incorporating human resources in science and technology for industry. The recommendation from the OECD analysis is clear: Either Mexico must focus strongly on this shortfall or it will be left behind in the international race, amid aggressive competition from emerging countries like China and India. In words of Saul de los Santos, “either we get on board 100 percent or we are left behind.” Chart 2 shows that U.S. foreign direct investment (FDI) in emerging countries is focused on engineering and R&D activities. In other words, innovation is no longer the domain of mature economies; rather, it can emerge from any part of the world, creating changes and opportunities for growth (Frank Kern, IBM Global Sales vice president, National Council of Science and Technology [CONACYT], 2008). The OECD results were presented unofficially in 2008 to strategic institutions in Mexico, including CONACYT, the Mexican Association of Directors of Applied Research and Technological Development (its Spanish acronym is Adiat), the House of Representatives, and the Secretariats of Economy and Education. There are several organizations aware of the work developed by OECD, and consider it essential to strategically suggest the issue in the national agenda.

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Chart 2: U.S. multinational enterprises: Engineering and R&D per country, 2008 (percentages)



Source: Ornelas (2008) based on Deloitte Research.

The OECD identified globalization, innovation, and technological development as essential drivers to increase global competitiveness. The following factors limit innovation and competitiveness at a national level and in Mexico's northern border region:

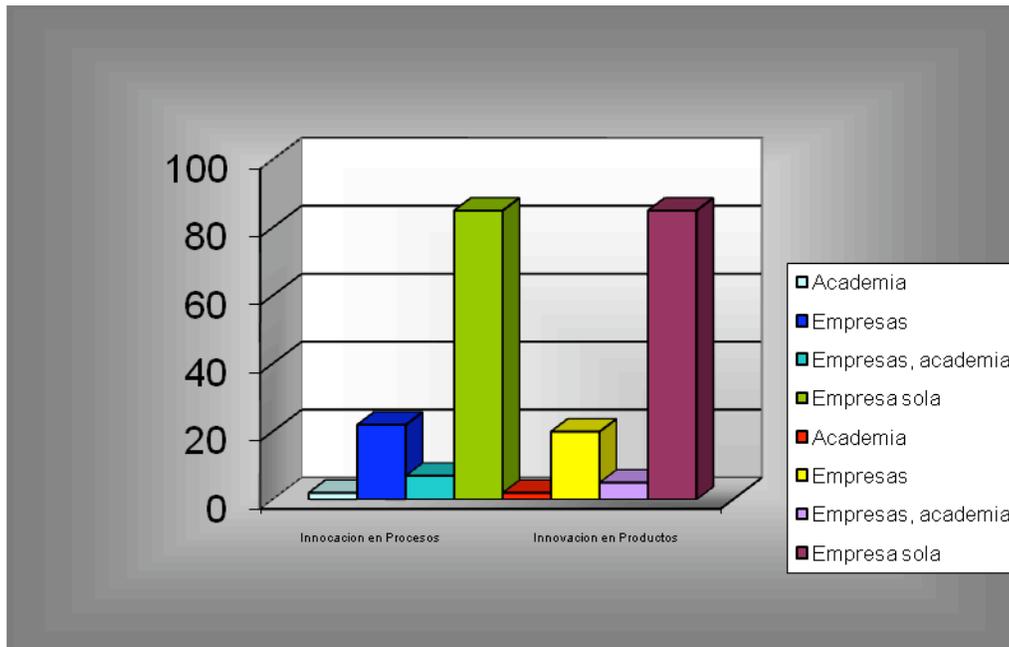
- Lack of funding for innovation, mainly for infrastructure and incentives to create and support links between innovation demand and supply. There is also a lack of funding to create a market for innovation (Enrique Cabrero Mendoza, general director of the Center for Economic Research and Teaching [Centro de Investigación y Docencia Económicas, CIDE]).
- Absence of a legal framework to generate incentives and minimize the barriers to innovation (Ramón Muñoz Gutiérrez, chairman of the Competitiveness Committee).
- A need for stronger links between and among academics and industry leaders. There is a fragile link associated with product and process innovation within academia, companies and academia, and within companies themselves. Yet companies independently generate 80 percent of innovation (in process and product).

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- There are no technology transfer offices (OTT) in Mexico, which are generally located at universities. As a result, there is no consulting and services market regarding technology transfer, brokers, etc. (Interview with Saul de los Santos, Axis-Producen, August 2008).
- Lack of a culture of innovation. Companies, especially the small and medium size ones (PYMES), do not completely understand the concept of innovation. Thus, they come close to innovative projects and initiatives, but these are not carried out because of a lack of understanding (de los Santos).

There are not enough innovative companies, and the northern states are not involved enough in innovation. Although niche or cluster (maquila, service, etc.) opportunities have been identified, these are isolated actions (de los Santos). Chart 3 clearly shows the fragile link between the sectors and the predominance of enterprises themselves in innovation.

Chart 3: The fragile linkages in Mexico associated with innovation



Source: Opportunities in Science and Technology, CONACYT, 2008

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1.1: The Case of Maquiladoras⁴

Let us consider, in more depth, the main challenges faced by maquiladora exporting companies in northern Mexico, since this sector reflects progress within the companies and the dynamic context in which they operate. At the same time, the sector shows the transformation of the environment in which the firms function.

The innovation and competitiveness context for maquiladoras fundamentally changed in the new century. Previously, the continuous devaluation of the Mexican peso since 1976 had allowed maquiladoras to compete with low-cost goods; the globalization of production and the development of sophisticated logistics gave maquiladoras access to low-cost raw materials, components, and various services that came from distant places, such as Asia. Also, new rules under the North American Free Trade Agreement (NAFTA) prompted many multinational companies to relocate production to Mexico—particularly along the country’s northern border—as was the case with companies producing clothing and TV sets. Similarly, since the mid-1980s, best practices (such as those that meet international standards set by the International Organization for Standardization [ISO]) were easily introduced to the maquila companies mainly due to labor flexibility. All of this strengthened the more or less “spontaneous” development of clusters and the formation of “world capitals” such as maquiladoras that produced jeans in Torreon, TV sets in Tijuana, or harness cables in Ciudad Juarez.

In this context of economic prosperity, governmental, central and state policies were focused primarily, if not exclusively, on the promotion of new foreign direct investment (Mortimore 2000). (Although there were other programs, such as those aimed at developing local suppliers, in reality they had little success.) Local economic groups in the northern border associated with industrial development were primarily devoted to the promotion of DFI and above all, to the building of industrial parks for sale and rent.

NAFTA introduced important changes in the Mexican commercial environment. The country’s industry was abruptly exposed to foreign competition, and technological policy became more

⁴ Maquiladoras are plants that import raw materials, components, and machinery for processing or assembling in Mexico and later re-exporting, mainly to the United States. Taxes are paid only over added value.

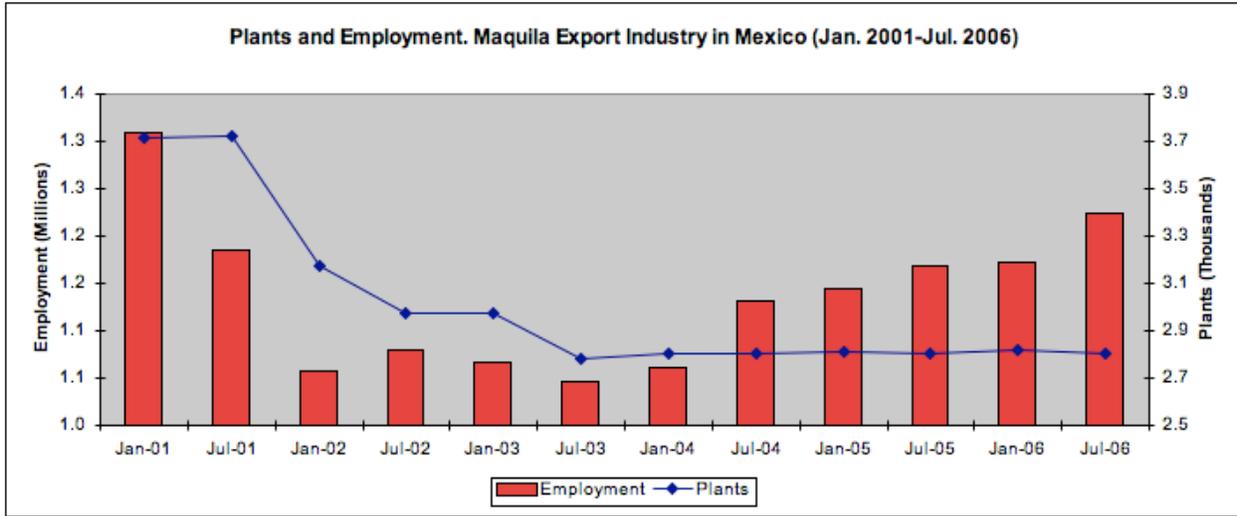
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open. According to Ramirez and Unger (1998), the response to innovation and technology transfer in Mexico was moderate in the 1980s and the early part of the 1990s. These authors found the following main problems: 1) insufficient funds for science and technology (S&T) (0.48 percent of the GDP during the 1980s); 2) dependency of S&T on public funds (the private sector represents a limited role and its contribution to S&T was between 15 percent and 23 percent during the period); 3) the weak link between technology users and producers. CONACYT has reported that the number of researchers and scientists currently in Mexico is not large (about 14,000 in the National Researchers System [Sistema Nacional de Investigación, SNI]); there a little more than 300 academic and research centers and the performance in innovation is poor.⁵ In 2005, of the 8,098 patents registered in Mexico, only 131 were Mexican; more than 50 percent were American (CONACYT 2006).

Meanwhile, companies in border zones such as Tijuana and Ciudad Juárez continued to face a shortage of skilled and unskilled labor (with monthly turnover rates greater than 10 percent) and urban infrastructure saturation. That is, while new plants were being built, infrastructure remained virtually the same, without important changes (Carrillo and Gomis, 2004). Many companies, particularly those associated with R&D, were able to acquire organizational capabilities in this context (for example, the successful and widely studied case of the motor vehicle company Delphi in Ciudad Juárez). This situation is considered part of the evolution of maquiladoras (Carrillo and Hualde 1996; Carrillo and Gomis 2007; Dutrenit et al. 2006; Lara et al. 2007).

⁵ “Of 9,957 patents granted in 2007 by Instituto Mexicano de la Propiedad Industrial (IMPI – Mexican Institute of Industrial Property), only 199 (2 percent) were Mexican. For comparison only, Xerox has 55,000 world patents, 10 every week,” according to Sophie Vanderbroek, Xerox Innovation Group, President (CONACYT, 2008).

Chart 4: Number of plants and jobs in the export maquiladora industry in Mexico (January 2001 to December 2006)



Source: Author’s chart based on INEGI data.

Maquiladoras had a two-digit outstanding annual growth during the entire decade of the 1990s. But in the second half of 2000, the situation changed radically (Chart 4). A new, less favorable context for the companies located in Mexico developed due to external and internal factors, as well as to structural and temporary factors (GAO 2003; Carrillo and Gomis 2004; Cañas et al. 2004). The factors included:

- A reduction in industrial production and consumption due to a severe deceleration of the U.S. economy and fallout from the September 11 attacks.
- The application of NAFTA’s rules of origin and Article 303, which generated new conditions because maquiladora companies were now considered “national companies.” This generated tax increases, which created important legal and customs uncertainty.⁶
- The costs of producing in Mexico increased due to macro-economic stability and the overvaluation of the Mexican peso against the U.S. dollar.
- A surge in exports to United States from countries like China and Central America.⁷

⁶ The recovery of the sector has not been able to exceed the number of plants and jobs established in Mexico. In December 2006—the last available figure—there were 2,783 plants with more than 1,170,962 employees, compared to 3,713 and 1,309,253 in January 2000 (www.inegi.gob.mx).

⁷ Between 2000 and 2005, Mexico experienced the following decreases in market share: 9.8 percent in the furniture industry; 7.9 percent in telecommunications; 5.3 percent in clothing; and 2.6 percent in computers.

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All of these factors resulted in negative growth rates in maquiladora activities, mainly in the electronics and garment industries.⁸ The fallout included the closure of companies (approximately 900), layoffs (25 percent labor), and the relocation of production to East Asia countries (48 percent of the closing companies moved to that region). The shifts also caused the loss of product niches (such as analog TVs), and a terrible uncertainty in the different business organizations representing that sector.⁹ Within a few years, Mexico went from being one of the main destinations for FDI to a second-tier option for transnational corporations looking for the best places for future investments.¹⁰ The participation quotas in the U.S. market, where more than 95 percent of the products are exported, decreased drastically, mainly in labor-intensive sectors such as the garment, clothing, shoe, and toy industries. Later, other sectors with more technology, such as electronics, became less competitive.

Several analysts spoke out about the loss of competitiveness and the need to review public policies (Gereffi 2007; Mortimore 2006; Ornelas 2005, 2006). Indeed, some sectors, like the automotive manufacturers in the north of Mexico, were able to strengthen in the first five-year period, although, since 2007, they have suffered again because of the American economic recession. The aeronautics sector was barely affected, however.

In this new context of shrinking competitiveness for companies and regions (Albuquerque 1995), the Mexican federal government and governments in the northern states, as well as several industrial development support institutions, recognized the need to foster activities with higher value-added, such as products and processes with more technology, R&D, design, and post-sales services. Strategic social stakeholders contemplated that these goals could be facilitated if the competitive advantages of the regions increased. Possible improvements included: increasing the capabilities of academic centers with R&D; better coordination between the production and education sectors; the development of highly skilled personnel, particularly engineers, at

⁸ In electronics, for example, more than 79,000 jobs were lost between 2001 and 2004, which accounts for a 22 percent decrease

⁹ During 2001 to 2004, the lack of support, the inefficiency, and the lack of understanding from the federal government was always present in lectures and speeches in each of the local and national entrepreneurial meetings

¹⁰ According to the World Economic Forum, Mexico fell from 44th to 60th place in technological and telecommunications development (Global Report and Information Technology, 2004–2005).

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universities and technological institutes; and the development of highly specialized service companies.

In summary, a fundamental concern is to create a highly favorable environment for business based on the interconnection of complementary capabilities that will foster innovation and the ability of companies to compete. For this reason, the development of local innovation systems has been viewed as a remedy to the structural problem of competitiveness loss.

Since the implementation of NAFTA in 1994, the Mexican federal government has used cluster development policy as the main instrument to promote competitiveness; state governments were left to define the sectors and activities they were interested in fostering. Under this model, decentralized decision making was the general characteristic of the 1994–2000 and the 2000–2006 presidential periods.

In summary, we could say that there was consistency in the federal policy and in state policies in regard to industrial grouping development. The states of Chihuahua, Nuevo León, and Baja California, for example, clearly defined economic activities at the municipal level under the same method, although under different terms. In Baja California, the process is known as “reasonable vocations.” Cluster leaders were tasked with incubating and promoting specific programs and instruments. A wide variety of funds—Fomix, Sectorial Funds, etc.—were created, some with important financial resources such as Prosoft. Even though the paradigm shifted when the National Action Party (PAN) entered the federal government—since science and technology for promoting innovation became a governing focal point of industrial policy, paradoxically—R&D expense as a share of GDP decreased. Also, in some states like Baja California, the state leadership did not contribute its part for financing certain programs (interview with de lo Santos, August 21, 2008). Thus, financial resources were not enough and there wasn’t the necessary match with the companies (Carrillo and Gomis 2004).

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According to the Scientific and Technological Consultative Forum (FCCyT 2008a: 48–79), the current concerns with cluster policy are:

- Identification and consolidation of economic sectors that can become long-term development poles and organize productive chains and networks of knowledge and social livelihood.
- Definition of regional productive motivations for their promotion. They should meet local, national, and global demands.
- Focus on strategic areas for economic, academic, and social development.
- Links between scientific research centers and the productive sector.
- Links between the scientific and technological development to solve regional problems, with priority given to high social-value strategies.
- Promoting interaction and coordination of all stakeholders and sectors in the development of science and technology, as well as production methods that improve sector innovation, coordination, and interconnectedness (FCCyT, 2008b).

2. Innovation and Competitiveness Support Policies

In Mexico, there is no continuity in the evolution of technological innovation and development, or in a state policy for the business sector (Corona 2007). The six-year plans that have been implemented since 1970 demonstrate this situation (see Table 1). In the regions, in a country that is so diverse, “the possible answers to local, regional and global environments can lead to a large number of opportunities and answers, which could at the same time, hinder the simple application of linear and homogeneous development models. However, the identification of regional problems or opportunities concerning several regions constitutes a first criterion in the definition of the areas and sectors that will be considered with higher hierarchy” (FCCyT 2008^a, 47). It seems that this has not been a characteristic in the national policy.

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Table 1: Science and technology plans in Mexico (1970–2001)

SIX YEAR PERIOD	PLAN	PROPOSALS	PRIORITIES	COMPANY	ORGANIZATIONS
	INIC: National Policy and Science and Technology Program August 1970	National System of Science and Technology?	9 National Problems	Concerted Actions	7 Red Books: CONACYT is under President's Office
1. Luis Echeverría Alvarez 1971-76	National Science and Technology Policy 1974: strategy, lines and goals	Scientific and Technological System. S&T Development. Self-determination Technology	Sectorial priorities	Manufacturing industry	Economic Planning
2. José López Portillo 1977-82	National Science and Technology Program 1978-82	142 programs with 2468 projects	9 priority areas	Links	Illusory Planning
3. Miguel de la Madrid Hurtado 1983-88	National Science and Technology Program 1984-88	SINCYT	17 SINCYT, 8 Secretariats, 11 Programs	Research-Production subsystem links. Modernize the production system.	Crisis: SNI. Opening of the Economy: 1985 (GATT). CONACYT under SPP?
4. Carlos Salinas de Gortari 1989-94	National Science and Modernization of Technology Program 1978-82	Technological modernization	Institutionality: Technological transfer. Protection of Industry. Measurability and Normalization. Consulting.	Integration with global production systems. EBT Incubators	NAFTA: 1994 CONACYT is now under the Secretary of Public Education
5. Ernesto Zedillo 1995-00	Science and Technology Program 1995-00	Technological and Scientific Policy Formation	Functional: Decentralization, diffusion, coordination, exchange, financing	Funds: Modernization, Forccytec, Enlace, Preaem, Incubators, PIEBT	Excellence: re-founding
6. Vicente Fox 2001-06	Pecyt 2001-06 October 2001	National System of Science and Technology	Sectors. Priority areas: - information and communications, biotechnology, materials, manufacture, infrastructure	Represents 1/3 objectives. State and Sector Funds are created ("mixed")	Pecyt: Program to separate science policy from technology policy. It is proposed that CONACYT to be Secretariat of CGCyT of the President's Office?

Source: Based on mentioned plans.

1. The concept of S&T systems was systematically proposed by B.T. Sagasti.
2. SPP, Programming and Budget Agency was integrated to the Treasury Department in the next six-year period.
3. CGCyT. General Council for Science and Technology.

2.1: Federal Policy to Support Local Efforts

Not more than 10 years ago, government funds to support innovation were distributed among multiple federal government organizations (in each one of the secretariats and under-secretariats, in the presidency itself, and mostly in CONACYT). In addition, resources and programs were available in each of the state governments. But each organization had its own rules, resources, and agendas. Thus, there was a large disparity and inconsistency in resource assignment. From open and closed contests and institutional assignments to even personnel assignments, the government organizations formed a wide resource distribution range for innovation promotion (previously known as productive modernization as well as technological or competitiveness development). The resources that were managed in a more professional and transparent manner were those that came from international organizations in the form of loans. These resources were

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managed by specific units. For example, World Bank programs in association with the Secretariat of Labor and Social Welfare funded widespread training (Probecat), the modernization of the productive system (Cimo) and labor competency standardization and certification (Conocer). A series of norms, assessments, and audits made these programs work efficiently.

With the beginning of the new millennium, the government began the difficult task of looking at ways to best coordinate and disperse funds, and to develop a consistent methodology to assign resources and make assessments. Funds are now managed at national level by CONACYT. CONACYT made great efforts to consolidate innovation and development, as well as science and technology research, with programs designed to:

- Support the development of scientists and technologists by strengthening the relationship between companies and universities through sabbatical and post-doctoral stays, employment generation programs, and post-graduate job fairs.
- Support scientific research with funds for basic research and for the development of scientists through the Researcher National System (SNI, in Spanish).
- Promote technological innovation and development by granting economic support, capital contribution, and credit lines.

According to the CONACYT's website, the following programs for technological innovation and development are also worth noting:

- **Tax incentives:** Tax incentives encourage investments in technology as well as R&D projects for new products, materials, or processes.
- ***Avance* program:** The main purpose of this program is to foster the detection and generation of business opportunities, and create new high added-value businesses, based on the application of scientific and/or technological knowledge.
- ***Idea:*** This is a support tool to improve a company's technological capabilities through R&D projects and the contributions of a professional with a master's degree or doctorate. This potentially strengthens the Science and Technology National System by increasing

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the companies' capacity to develop technology with skilled personnel. It provides an avenue for professionals with advanced degrees to further develop their knowledge and skills, and allows them to make connections with the private sector, which may lead to a permanent employment opportunity.

- **Sabbatical stays:** This is an instrument to support and improve the technological capability of enterprises through R&D projects and the contributions of Ph.D.s on sabbatical. Competitiveness and innovation are promoted during the sabbatical; the professional has room for development and time to make connections with the productive sector.
- **Research networks:** This effort promotes the liaison between research institutions and companies; acting together, they can increase the competitiveness of the productive sector under their responsibility. This effort fostered the creation of the Strategic Alliances and Innovation Networks (AERIs, in Spanish), which contribute to increase the competitiveness of productive sectors in Mexico; the AERIs also encourage technological and innovation development (TR&D&I).

Government funding for innovation in Mexico is characterized by transparency, open contests, peer evaluation, and follow-up assessments. Like many other programs, there also important limitations: bureaucracy, lack of flexibility in program management, and insufficient resources.

The academic sector participates in many ways in the promotion of innovation and technological development in Mexico. A well-coordinated organization of this type is the Scientific and Technological Consultative Forum. In 2005, the forum recognized that S&T should help increase the country's competitiveness and the population's social well-being. Therefore, the forum promotes a state policy of science, technology, and innovation that goes beyond presidential administrations. It takes into consideration priorities at all levels of government, involves social stakeholders in defining priorities, is based on the law, and guarantees accountability to society.

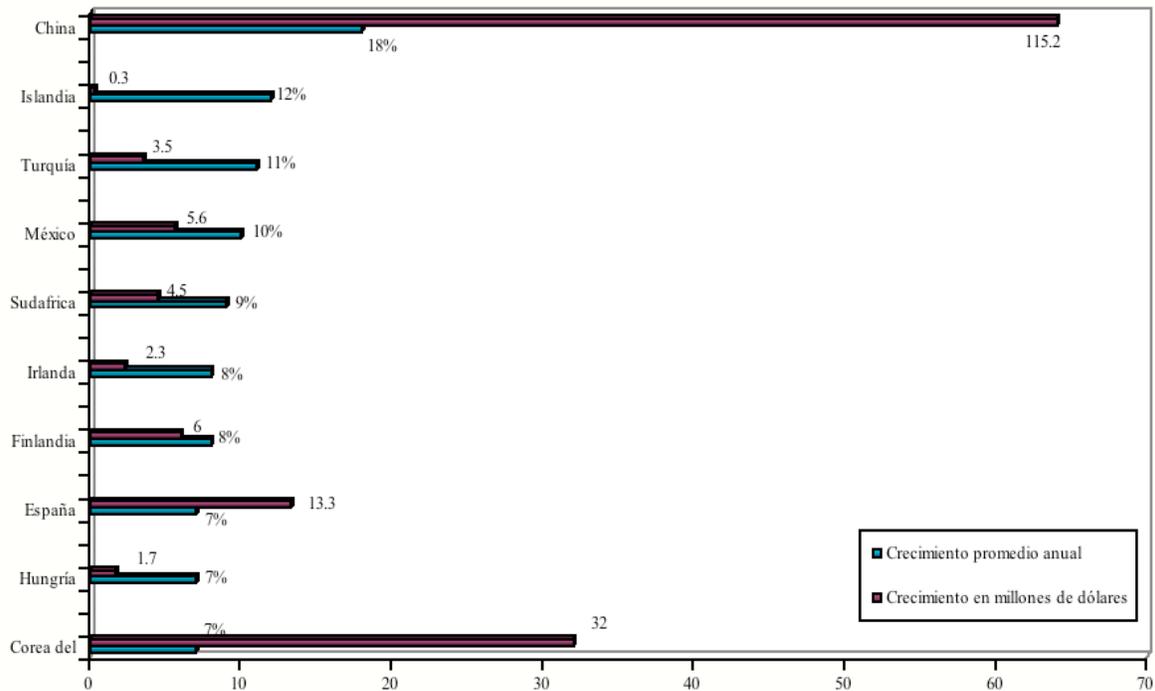
Despite the many funds and programs, there has not been enough investment in science, technology, and innovation in Mexico. In the last 35 years, investment in S&T in Mexico has not exceeded 0.35 percent of the GDP, while emerging countries such as Brazil invested 1 percent,

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Korea 2.91 percent (2003), Vietnam 2 percent (2005); in OECD developed countries such as the United States, 2.68 percent of the GDP was invested in 2004. Mexico invests 0.6 percent of the GDP a year in R&D. Chart 5 shows the percentage of growth in Mexico in 2005 and the amount in comparison to other countries.

Chart 5: Enterprises Research and Development Investment 1995–2005

Inversión en Investigación y Desarrollo por parte de las empresas, 1995-2005



Source: *Expansión*, 2008, based on OECD

2.2: Local Policies

The most outstanding local policies dedicated to the development of competitiveness and innovation are generally concentrated in the State Science and Technology Councils. The councils carry out an important activity by giving voice to different sectors (government, academic, and productive). In Nuevo León and Jalisco they are true hubs through which the different programs are analyzed, operated, and reviewed. Other state councils have a smaller but

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still important profile, as in the case of Coahuila and Sonora; in some states, such as Baja California, no council exists.¹¹

Perhaps the best effort to connect national policy to local policy and support state scientific and technological development is the Mixed Funds or Fomix, which consists of national and state funds. It is important to mention that CONACYT offices manage these funds. There are government contributions (through CONACYT) and from the state governments that receive these funds. The idea is to assign resources for scientific research and technological development through open contest, with research guidelines and reference terms to solve specific strategic problems expressed by the local stakeholders.

To qualify for Fomix, local stakeholders must present a proposal that: 1) meets the specific demands of the states or municipalities; 2) has institutional or corporate support; and 3) is sponsored by a company or institution registered in the National Register of Scientific and Technological Institutions and Companies (Reniecyt in Spanish).¹²

Below is a summary of efforts to foster technological innovation and development in each state of northern Mexico.

a. Baja California¹³

The Baja California state government has a strategic long-term vision for economic development that is based on productive vocations and new areas of opportunity that generate better jobs for the population. The industrial grouping model (clusters) was selected due to the competitive advantages derived from the collaboration of enterprises and institutions. Of major importance is the generation of knowledge and innovation, higher value-added, and increases in productivity and impact, especially in small and medium companies (in Spanish, *pequeñas y medianas empresas*, or PYMEs).

¹¹ However, Baja California “preferred” to develop a different model through Producen, which acted as the interconnection of the Secretariat of Economic Development (Sedeco). This organization changed from being a public-private “bridge institution” to currently being a private one.

¹² Reniecyt is the national register of institutions and companies linked to scientific research, technological development, innovation, and training of high-level human resources in Mexico.

¹³ http://www.bajacalifornia.gob.mx/sedeco/boletin/2008/boletin_09jun.htm.

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For the government, the success of a cluster depends on the synergy between all participants represented in a strategic alliance; the division of power; and the development of key competences and economies of scale. Fifteen clusters are identified in the state:

- Aerospace
- Farming industry
- Automotive
- Biotechnology
- Electronics
- Energy
- Fishing and water culture
- Furniture and wood
- Health care
- Information technology
- Logistics
- Medical products
- Plastics
- Tourism
- Wine

On June 10, 2005, the Baja California state congress approved the Economic Development and Competitiveness Promotion Act. The act offers new tax incentives for new and existing companies with new or expanding investments in technological projects. The incentive consists of a tax exemption of 25 to 100 percent on payroll during a one- to five-year period; and a 20 to 50 percent tax exemption on the water connection system. Projects are evaluated based on the number of jobs each will create; the inclusion of students, handicapped people, and citizens over 60 years of age; the quality of jobs; the amount of total investment and investment in technology; the number of national and local suppliers; and access to markets.

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Although Baja California has a State Science and Technology Council (Coecyt in Spanish), it is not an outstanding organization, and it not well-known. Its representatives have not been present at numerous forums that have been held on innovation and competitiveness.

Baja California aggressively participates in CONACYT's Fomix program, with a focus on human capital development in the aerospace, microelectronics, biotechnology, and IT industries. The German company Qcell will invest \$3.5 billion dollars for the manufacturing of solar dashboards in Mexicali, thanks to the technological profile of companies already established there.

b. Chihuahua

The Inadet (Technology Development Support National Institute) is located in Chihuahua. In addition, the state government's industrial policy promotes six main industrial clusters:

- Electronics and telecommunications
- Automotive and spare parts
- Textile industry
- Food and agriculture
- Forestry and furniture
- Mines and construction

According to the government website, there are four areas of opportunity to develop new industry and technology in the near future:

- Aerospace
- Electrical appliances
- Information technology
- Biotechnology

The state of Chihuahua has five R&D centers and 11 universities and technical institutes to foster industrial development through technological applications. Outstanding centers are:

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Cimav, Ciad, Institute of Ecology, Inifap, Cirena, and the Technological Development Center for the Dairy Industry.

This state is outstanding due to four reasons: 1) It has a large number of world class companies in the automotive and electronics industries, as well as a cluster of national suppliers of machining companies; 2) It was the first state, since the 1980s, to develop a long-term strategic vision for the private sector to attract enterprises with high added value; 3) In 2000, it implemented a long-term, sustainable vision for the city—the Strategic Plan of Juarez; 4) A local business organization—local Canacintra—has worked to help develop the maquila industry and related suppliers.

c. Coahuila

In the state of Coahuila, the government has developed Cooperative Innovation Networks within the cluster scheme. The networks promote cooperation and innovation in the following nine sectors:

- Nanotechnology and advanced materials
- Biotechnology
- Metal mechanic Industry
- Food and Agricultural Industry
- Renewable Energy
- Information Technology
- Sustainable Housing
- Furniture Industry
- Metallurgy and Mining Industry

The Coahuila State Science and Technology Council provides integral programs for innovation development, consisting of complementary projects and activities to promote scientific and technological research design, development, and applications for the economy, society, and environment. Each program is defined by functions: research and experimental

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development, advisory, finance, promotion, documentation, links and connections, as well as monitoring.

The state-specific demands in terms of the Fomix program are related to high-level education; consolidation of researchers through SNI; agricultural industry development; master plan for the development of a technological park in La Laguna region; and development of a state innovation system.

d. Nuevo León

Nuevo León was the first state involved in the promotion of innovation in the Northern region border and is second in R&D investment in the country. The government created a Regional Competitive and Innovation Program, focused around three development poles for the new economy: 1) knowledge and information society; 2) technological revolution; and 3) global markets. It is emphasized that competition is more between regions than between companies. That is the reason why the government adopted the cluster scheme. The main groupings are:

- Automotive industry
- Aerospace industry
- Information technology

The state has several programs to support innovation and research development. Among the most outstanding are the following:

- CONACYT funds¹⁴ for the promotion of scientific and technological research.
- Software industry development (Prosoft): Joint funds (federal and state) for software and service companies related to information technology.
- Technological awards: Recognition for the technological development efforts for organizations and individuals in Mexico, Texas, and Catalan region in Spain.

¹⁴ Joint funds (federal and state) for private companies.

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e. Sonora

Sonora actively applies Fomix Funds toward the development of science and technology. For example, funds have been used to measure wind for the development of clean energy industries; and for the development of a binational corridor of optic sciences in collaboration with the state of Arizona.

Sonora also receives funds and technical advice from the Mexico-U.S. Foundation for Science (Fumec), which together with the state government and the Secretariat of Economy, have applications in the SATE program (see Fumec box in section 4 of this document). Currently, 35 companies have received benefits from innovation and development projects. This program is particularly successful in the state because of the extensive links achieved between stakeholders; the number of local companies geared toward innovation; and it is located in an industrial environment that demands a high level of competitiveness, which promotes linkages with important firms, such as Ford and its close global suppliers.

A recent study shows the emerging phenomenon of industrial upgrading associated with the grouping of small knowledge-intensive local enterprises that offer higher value-added services, and the increasingly important role they are playing in the global supply chain of the automotive sector (Contreras, Carrillo, and Alonso 2008).

f. Tamaulipas

The State of Tamaulipas created the Tamaulipas Council for Science and Technology for the development of S&T. In order to provide economic support for research activities, the state also created the State System of Researchers with the objective of incorporating its researchers into the National System of Researchers (SNI).

Fomix funds are invested in ecotourism development, as this is one of the major demands in this state.

Among the states of northern Mexico, Tamaulipas is less developed in regard to policies and institutions supporting innovation, science, and technology.

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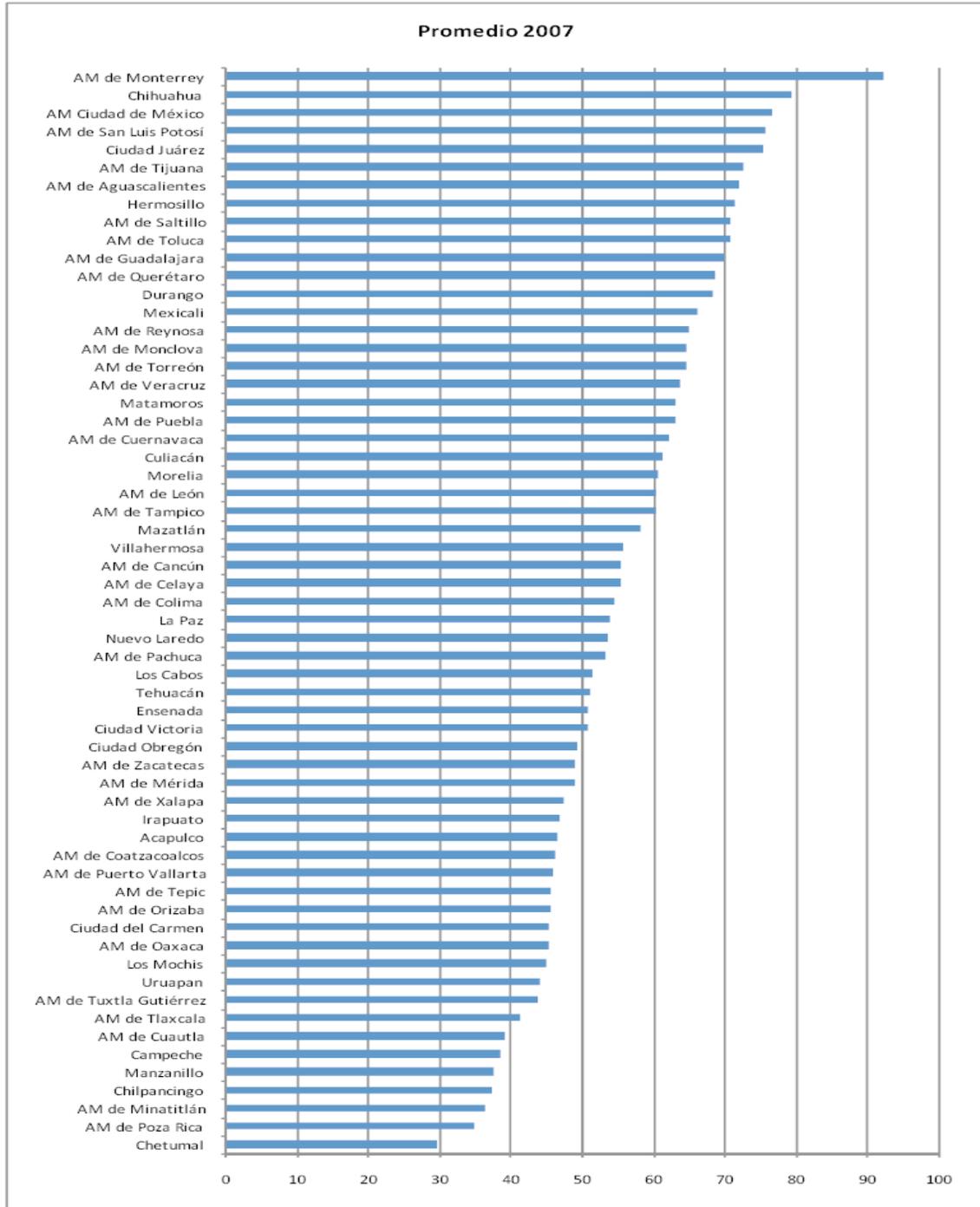
The efforts made by state governments, as well as their strategic stakeholders (companies, business organizations, universities, etc.), have resulted in favorable competitiveness rankings.¹⁵ In 2007, Tijuana, Mexicali, Ciudad Juárez, and Monterrey were among the 10 most competitive cities in the country (Cabrero Mendoza et al. 2007).

Based on the competitiveness indexes produced in Mexico, one can observe that cities in the north of the country hold the higher positions, as shown in Chart 6. CIDE's index shows that eight cities in Mexico's northern states are the most competitive among the first 15, IMCO's index shows 6 of the first 15, and the AREGIONAL index shows 5 of the first 15. The cities of Monterrey, Chihuahua, and Mexicali are among the first 15 in the three indexes. Chart 6 shows the average index of the 60 cities assessed by CIDE and the comparative report on the competitiveness component average index in 2003 and 2007, for the first 15 positions. The metropolitan areas of Monterrey and Chihuahua, and of Tijuana and Ciudad Juárez, have experienced important increases. Likewise, the northern states are well positioned in the IMCO index. Nuevo León is in second place, Baja California in third, Chihuahua in fourth, Coahuila in sixth, Tamaulipas in ninth, and Sonora in tenth.

¹⁵ It is important to point out that other states, such as Guanajuato, also have important programs and agents for innovation such as the Technological Innovation and Development Promotion Program (Lopez de Alba 2008).

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Chart 6: Average Competitiveness Index, 2007 Average (Integration of the four components)



Source: Based on IMCO, Chart 5.

Table 2: Most competitive cities in Mexico

CIDE	IMCO	Aregional
Monterrey (*)	Aguascalientes (*)	Monterrey (*)
Chihuahua (*)	Chihuahua (*)	Chihuahua (*)
AM. Cd. de México (*)	Guadalajara (*)	Guadalajara (*)
AM San Luis Potosí (**)	Ciudad Juárez (**)	Querétaro (*)
Ciudad Juárez (**)	Monterrey (*)	Mexicali (*)
AM Tijuana (**)	Valle de México (*)	Ciudad de México (*)
AM Aguascalientes (*)	Querétaro (*)	Hermosillo (**)
Hermosillo (**)	Mexicali (*)	Cancún
AM Saltillo (**)	Tijuana (**)	Morelia
AM Toluca (**)	La Paz	Cuernavaca
Guadalajara (*)	Mérida	Veracruz
Querétaro (*)	Reynosa (**)	Saltillo (**)
Durango	León	San Luis Potosí (**)
Mexicali (*)	Los Cabos	Tampico
Reynosa (**)	Puebla	Toluca (**)
		Aguascalientes (*)

(*) Coincide en la parte alta de los tres índices

(**) Coincide en la parte alta de dos índices

Source: Cabrero Mendoza, et al., 2008. Table 5.

3. Innovation in Companies and Maquiladora Sectors: Research Results

It is important to point out as background to maquiladora companies that during the imports substitution period in the 1970s, the government’s policies focused on the promotion of strategic sectors; this created a modest industrial base. However, “when the government spending was reduced and the industrial policies to promote strategic sectors were abandoned” (FCCT 2008), the achievements decreased and caused industrial contraction and polarization (Dussel, Peters 2000). The growth of industrial sectors since the 1980s is limited to the maquiladora industry, and to other multinational firms mainly producing for the international market, leaving aside the

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small and medium size companies. This lack of scientific and technological support affected all sectors, including the maquiladora industry, which has been one of the most dynamic sectors in Mexican industry, especially in the generation of jobs and foreign currencies.

Since then, export maquiladora companies have been the main manufacturing industry in northern Mexico, mainly in the border zone. The maquiladora companies are made up of a wide range of economic activities, including automotive, electronics, textiles, furniture, toys, and service industries.

Different studies have been conducted on maquiladoras in Mexico. Since the mid-1980s, an emerging phenomenon has been found: the introduction of new methods in the organization of labor under the Toyota Production System philosophy (Palomares and Mertens 1985). Since then, case studies and statistically representative surveys have allowed a clearer vision of this activity that is highly heterogeneous internally.

Maquiladora companies maintain an industrial upgrading process because they:

- carry out increasingly complex productive and technological processes
- increase the number of products and models they manufacture
- substitute products
- incorporate more process innovations and international certifications
- carry out more product design and engineering activities
- obtain recognition for their performance in quality, the environment, and safety
- hire Mexican nationals for foreign company management
- have a higher degree of autonomy in decision making.

In these processes, the firms, managers, engineers, workers, and organizations that represent them work in a learning labor environment (Contreras 2000). Technological, organizational, and human capabilities are formed in companies and institutions that support them. All these processes that could be summarized under the industrial upgrading concept reflect the evolution of maquila companies (Carrillo and Barajas 2007; Dutrenit et al. 2006; Lara et al. 2007). The

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information that supports the previous approaches was taken from studies conducted by the Colegio de la Frontera Norte (COLEF) for more than 15 years.

Industrial upgrading is defined as the capability of firms to innovate and increase the added value of their products and processes (Humphrey and Schmitz 2000). Four types of methods are considered: changes in the process, changes in the product, functional, and inter-sectorial (Humphrey and Schmitz 2000). All share the goal of improving the efficiency and quality of products and services, as well as acquiring a more advanced set of skills (Giuliani, Pietrobelli and Rabellotti 2005).

- The process level is the efficient transformation of components into products through its reorganization or the introduction of higher technology,¹⁶ in order to reach higher productivity and cost reduction. The Japanese Production System based on Just in Time, Jidoka and Kaizen (Toyota 1996) and a series of specific practices have this purpose. A good example in the case of maquila companies is the implementation of Six Sigma in 35 percent of their maquila plants in Mexico (Carrillo and Gomis 2004).
- Product level is passing from simple to more complex products of the same type or actions toward more sophisticated product lines in terms of value unit increase (Humphrey and Schmitz, 2000; Gereffi 1999; Gereffi and Tam 1998; Porter 1990). An example of this type is the change experienced in a short time in Baja California and Chihuahua when passing from production of analog TV sets to digital ones in maquila companies (de los Santos and Elias 2006; Carrillo 2004).
- Function level refers to the movement along the production chain to increase functional capabilities. This can be achieved through different methods, such as acquiring new and better functions in the chain that provide higher value, such as design or marketing, or low added-value activities may be substituted with higher value-added activities; like in the example of the production of jeans in maquila companies of Torreon that go from traditional assembly to the completed package (Bair and Gereffi 2003). Another method is to carry out a higher vertical integration as in the construction of the Delphi Technical

¹⁶ For example, the production in long lines versus production cells or quality control at the end of the line versus quality from the source. For technical and practical organization techniques of the American Production System and Japanese Production System process see Abo (ed.) 1994.

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Center (which is registered as a maquiladora company) in Ciudad Juarez to perform research, development, and design activities associated with the manufacture of auto parts (Carrillo and Hualde 1996). Another way is moving from automotive upholstery assembly to the production of complete seat modules, as was the case of the Lear maquiladora companies (Lara, Trujano, and Garcia 2003).

- The inter-sectorial level goes from primary products to manufactured or service goods (the secondary and tertiary sectors); and within manufacturing, from low value-added activities to capital- and technology-intensive activities. It involves the change of core competences to new value chains in order to increase the added value of firms and firm networks. For example, in the electronics industry of Baja California, where engineers working in maquiladora companies and other sectors formed their own companies and developed a group of 29 software companies integrated in a cluster (Hualde and Gomis 2006) coordinated from the regional IT, Electronics, and Telecommunications Association (Canieti).

In summary, industrial upgrading is closely associated to value increase of innovation processes to access niches with higher value-added products (i.e., from TV sets with kinescope to digital TV sets), enter to new sectors (from a product such as a TV set to multiple products, such as monitors, parabolic dishes, satellite signal receptors, etc.), or taking new productive or service functions (from assembly, to the complete package in the garment industry); or from assembly to synchronized design with manufacture in the auto parts industry, for example. In addition, upgrading is not only creating a new product (as in the case of the flat panel display), but also the evolution of process and product improvements that are new for the firm, which allows them to compete in the international market (Giuliani, Pietrobelli, and Rabellotti 2005). Considering the above, maquiladora companies introduce technological learning processes in traditional manufacturing sectors—such as the garment, furniture, and shoe sectors—and also in sectors with complex products, such as auto parts and electronics.

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3.1: Current State of Innovation in Industry

The maquiladora industry is the most widespread and developed industry in Northern Mexico. The following are the ten aspects that constitute the core of upgrading in the export maquiladora industry in Mexico. Starting from field work studies in companies as the methodology central strategy and comparing with the results from the study¹⁷ “Technological Learning and Industrial Upgrading: Perspectives for the Creation of Innovation Capabilities in the Maquiladora Industry of Mexico” carried out in Mexico during 2001–2004 (Carrillo and Barajas, 2006; Carrillo and Gomis, 2004), hereafter quoted as the COLEF Survey (2002). The results are as follows:

- Multinational company subsidiaries have great influence in economic activities in Mexico. Maquiladora companies have been on the list of the largest 500 companies in Mexico since the start of this publication. In 1995, 25 maquiladora firms were among the 160 largest companies, and, in 2005, 45 of the 160 largest companies accounted for 16 percent of employment. According to the Secretariat of Economy, there are approximately 2,500 to 3,000 multinational companies registered in Mexico, of which one-fifth correspond to maquiladora companies.
- There have been changes in economic roles since OEM companies—typically assembly plants, such as Delphi, Valeo, Visteon, Sony, Samsung, Thompson, Honeywell, or Philips¹⁸—have developed R&D processes, mainly in design. These companies not only manufacture their own brands, but other brands for competitors such as Sony and Samsung. The COLEF Survey (2002) found that 74 percent of the interviewed maquiladora plants manufacture OEMs. In the case of companies such as Lear, Yasaky, Sony, and Plantronics, the direct investment in Mexico through their plants is very significant for each corporation (Buitelaar, Padilla, and Urrutia 2000; Carrillo, Mortimore, and Alonso 1998). It must be said that Delphi, the main global player in the auto parts industry, has more employees in Mexico than in the United States and Canada (Carrillo and Lara 2005). The COLEF Survey (2002) found that there were 72 R&D centers installed in Mexico sponsored by multinational corporations (MNCs) with

¹⁷ See www.maquiladoras.info

¹⁸ The Philips plant developed Cenaltec, an important technical center in Ciudad Juarez, to meet the needs of the company and other plants established in that city (Hualde and Lara 2003).

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maquila operations. Of the total plants, 26 percent carried out design or design-engineering activities.

- Some industries, such as those that manufacture TV sets in Baja California and Chihuahua, were able to move from the manufacture of commodities to the production of high value goods, such as flat screens, digital, and HD television sets. Previous studies showed this process (Carrillo 2001a; Lara Rivero 1998).
- The product technology level (of television sets, computers, harness cables, seats, radiators, etc.) has increased substantially (Dutrenit, Garrido, and Valenti 2001; Lara Rivero 1998). Even in products that are standardized and of low added value, such as harness cables for automobiles, the technological component is higher and higher. The same situation occurs in intermediate-value products such as car seats or flat screen television sets—the technological change is also more dynamic (Lara 2003; Carrillo and Hinojosa 2000). The COLEF Survey (2002) found that 56 percent of the companies used the best technology available in the world market; 40 percent had a high degree of automation. On average, each plant had 24 computerized numeric control machines and five robots. One-third of the plants were automated in 50 percent of their productive processes. As a result, intensive companies on nonqualified jobs in Tijuana and Ciudad Juárez, among other cities, now have become technology-intensive maquiladora companies. Examples include Delphi, Valeo, Lear, Philips, Thompson, and many others (Dutrenit, Garrido, and Valenti 2001; Lara Rivero 1998; Carrillo and Hualde 1996).
- Organizational best practices have been widely diffused. Different studies show the transfer of new management models to maquiladora companies. Since the end of the 1980s, the application of organizational best practices such as “just in time” and “total quality”—new at that time—was widespread (Palomares and Mertens 1985; Carrillo and Ramirez 1991; Wilson 1992; Taddei 1992; Kenney and Florida 1994). It was calculated that, in 1990, 20 percent of the maquiladora companies located in cities like Tijuana, Ciudad Juárez, and Monterrey, and in dynamic sectors (such as electronics, auto parts, and textiles) could be considered modern and most innovative in best practices. By 2001, 60 percent of the plants used the best practices available. Lara Rivero (1998) and Contreras (2000) show that Japanese companies introduced the flexible organization with relative success and tried to turn plants into “learning organizations.”

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- Plants have invested in and developed information technology systems. In the recent past there have been important investments in networks, communications, and software. According to the COLEF Survey (2002), 68 percent of all the plants were using Enterprise Resource Planning (ERP) software; this was a recent event, since almost half of them implemented it in 2001–2002. ERP is one of the most important investments that an IT company can make. This software application is quite complex and costly (from several tens of thousands of dollars to several tens of millions). It integrates and manages into a single system all of the information generated by the activities of different departments that constitute the company. The investment in ERP-type software is a necessary step for the development of e-commerce, mainly in business-to-business (B2B).
- The companies that have acquired major autonomy in regard to their headquarters (in purchase orders, procurement, purchase of equipment, process improvements, product and design technology) find a “Mexicanization” process in the management of maquiladora companies (Katz 2001; Carrillo and Hinojosa 2000; Carrillo, Mortimore, and Alonso 1999; Buitelar, Padilla, and Urrutia 1999; Cimoli and Dosi 1994; Dutrenit and Vera-Cruz 2004). In other words, Mexican nationals are hired for foreign company management.
- Development of OEM clusters and its suppliers. There is enough evidence of relatively complex productive cluster development in the northern border; examples include the electronics OEMs in Tijuana and automobiles in Ciudad Juarez (Kenney, Jairo, and Choi 1994; Carrillo and Hualde 2000). In addition to trade and cooperative relations between OEMs and first-level companies, complementary clusters have developed. Many of software companies have developed because of their relationship with the maquiladora industry, or because their owners (engineers) were former workers of maquiladoras, and, when they resigned, they formed their own companies; the activity was outsourced and the company was formed; or there was a greater need for IT services, and subcontracting began. There is also the case of the machining industry in Ciudad Juarez, which has 144 small- and medium-sized companies (PYMES) that supply the automotive and electronics maquiladora companies. Dutrénit and Vera-Cruz (2004) conclude in a study of this machining sector that there is an important allocation of knowledge in the maquila

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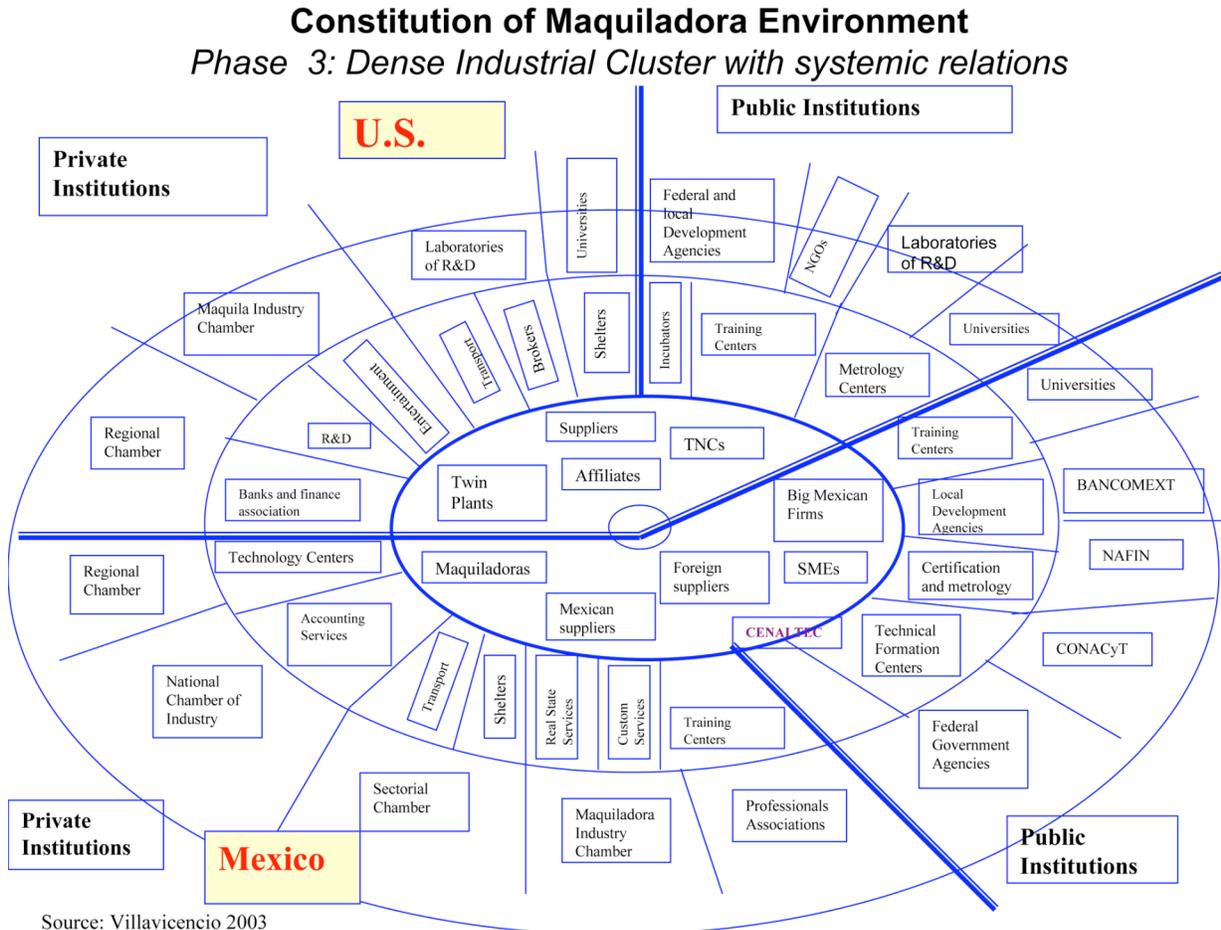
exporting industry (IME in Spanish), in small and medium size companies and also in institutions. Thus, the maquiladora became a source of technological and innovation capabilities. On the other hand, Lara and Arellano (2005) conclude that there is a technological convergence process between maquiladora sectors, such as electronics and automotive; and that there is a technological co-evolution between customers and suppliers when analyzing the production chain in the car seat industry, with the examples of Lear Corporation and the machining companies. Hualde (2001, 2003) and Contreras (2005) show the importance of engineers as key stakeholders in the acquisition of industrial learning and management in the relationship of local companies with transnational enterprises.

- Greater interconnection with the education sector. The education centers have achieved a relatively important linkage with the maquiladora sector. Although it is important to recognize that some plants work to keep and improve this connection, others in the sector are not involved in this process.
- The strengthening of institutional capabilities (a more recent topic for study). There is an important institutional structure that provides support to maquiladora and non-maquiladora industrial developments in different regions such as Tijuana, Ciudad Juarez, Monterrey, and Aguascalientes. Recent studies show relevant results: The framework is formed by national, state, and municipal public and private institutions. Binational institutions have also been developed in border cities. The environment is not the exclusive result of the strategic action of maquiladora companies, “but rather, it expresses the action taken with local public and private stakeholders who are interested in promoting the economic and social development of the region” (Villavicencio and Lara-Rivero 2003; see Diagram 1). There are combined efforts with the institutional stakeholders in their search for new opportunity niches and competitive sources; the industrial and institutional structure constitutes and replicates “business behavior patterns, cooperation mechanisms and institutional arrangements that did not exist before NAFTA” (Villavicencio 2004). New markets for goods and services, infrastructure, and stakeholders have been generated; that is, an international institutional environment that operates in a transborder territorial dimension has been created (Barajas 2000; Villavicencio and Lara Rivero 2003). Lastly, a recent study about Tijuana (Carrillo 2006)

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concludes that there is a constant and dynamic collective work by institutions; there is a shared vision among local stakeholders; institutions are highly flexible, which allows them to properly intervene when necessary; and there is high job mobility among institution representatives.

Diagram 1



3.2: Evolution of the Maquiladora Industry

Regional and sector studies, especially in the maquiladora cities of Tijuana and Ciudad Juárez, have confirmed the evolution of the sector and allowed for the following:

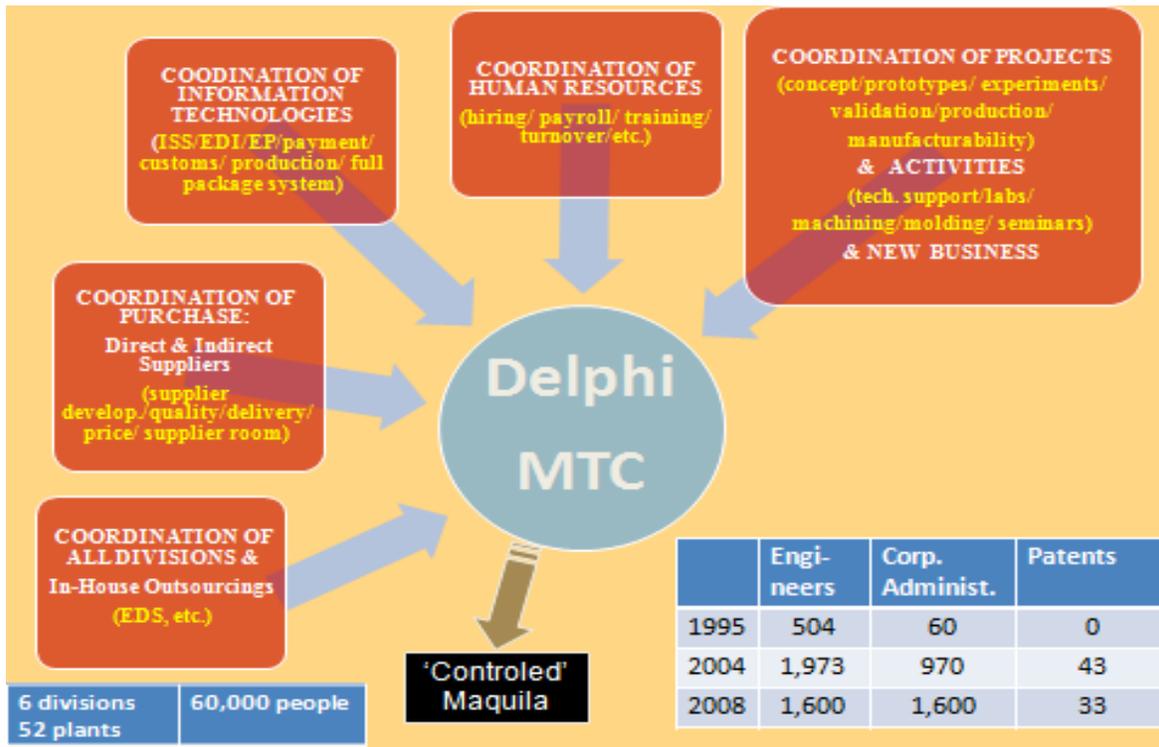
- A comparison between maquiladoras and the industry geared to the local market. The comparisons include variables such as economic growth, best practices, environment, and

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job safety, where results show a better performance for maquiladora companies (Contreras et al. 2006; Schatán and Carrillo, 2004).

- A better understanding of the technological, organizational, and labor capabilities in the electronics and auto parts maquiladoras in Tijuana and Juarez (Carrillo 1993; Dutrenit et al. 2006; Carrillo and Barajas 2007; Padilla et al. 2007).
- An understanding of the capacity to generate widespread interest among other suppliers in Juarez (Dutrenit et al. 2006; Lara, Arellano, and Garcia 2005) and with institutions that support industrial development in Tijuana and Ciudad Juarez (Hualde and Lara 2003; Villavicencio et al. 2006).
- The acquisition of industrial and territorial policy lessons in Mexico, such as those involving industrial clusters (Carrillo and Hualde 2000; de los Santos 2006). Juarez, for example, was the first location in Mexico that promoted the industrial grouping policy, and Tijuana has been one of the best examples of cluster follow-up.
- Understanding if the industrial structure in the case of maquila is bimodal, with few modern companies and many traditional ones (de la Garza 2005), or if there are specific configurations. This discussion led to the development of the concept of generations (Carrillo and Hualde 1997), which explains the evolution process of maquiladora companies. The examples are as follows:
 - First generation, based on the intensification of manual labor and simple assembly (“Assembled in Mexico”).
 - Second generation, based on the rationalization of labor, manufacture, and use of new technologies (“Made in Mexico”).
 - Third generation, based on the intensification of knowledge, research, development, and design (“Created in Mexico”).
 - Fourth generation, based on the centralized coordination of activities for all the plants located in the country belonging to the same firm (“Coordinated in Mexico”) (Carrillo and Hualde 1997; Carrillo and Lara 2003). Diagram 2 shows the capabilities of the Technical Center of Delphi in Ciudad Juarez.

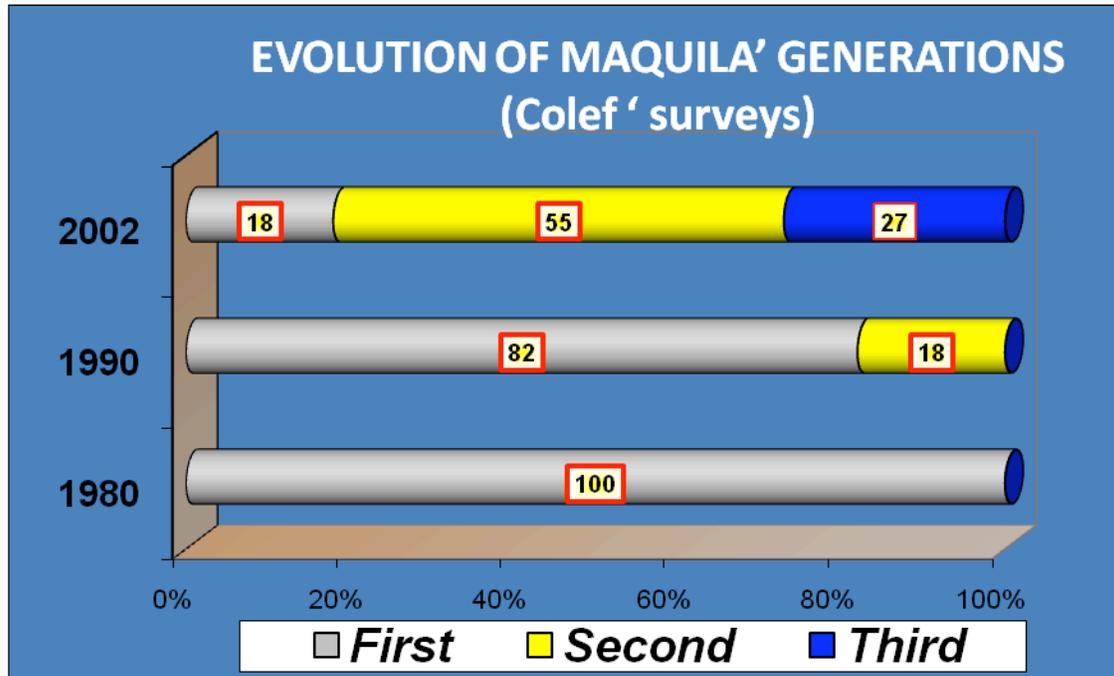
Diagram 2: Delphi, a centrally coordinated company in Juarez



Source: Based on interviews in the company, internal documents and on Arias, 2006

Different case studies on border towns have supplied evidence about the technological and labor evolution process with respect to the production of television sets in Tijuana and Juarez (Carrillo and Hualde, 2000; Uriostegui 2002); the garment industry in Juarez and Torreon (Bair and Gereffi 2001); auto parts in Juarez (Lara, Arellano and Garcia 2005); medical services in Tijuana (Martinez Pellegrini, 2006) and airplane parts in Baja California (Hualde and Carrillo 2007; ProduCen 2006). When comparing the results of COLEF surveys in 1990 and 2002 and previous research (Carrillo and Hernandez 1985), the conclusion is that there is a clear evolutionary process (Chart 7).

Chart 7



Source: Carrillo, 2008

In summary, it is important to emphasize that there are many similarities between maquiladoras and other export manufacturing programs. These similarities caused the 2006 integration of the maquila and Pitex programs (Temporal Import Program for Exports) into the one now known as IMMEX (Maquiladora and Manufacture Industry for Exports) at the end of 2006.

Different capabilities have been developed over four decades, both in Tijuana and in Juarez, maquiladora cities par excellence. While in the 1970s and 1980s, federal governments together with regional maquiladora business associations designed and implemented policies, in the 1990s policies were decentralized and a new type of institution was developed to link government and educational programs with the needs of companies. These policies seek to help companies with market needs. The diffusion of “bridge institutions” has been analyzed by academics in regions such as Jalisco, Nuevo León, Chihuahua, and Baja California, and show the formation of a relevant institutional structure (Caslet 2003; Villavicencio 2006; Carrillo and Moloman 2008), where one of the main aspects is that they emerge and develop locally, but in a completely globalized environment.

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The experience of new support institutions in Mexico is quite recent, according to Cassalet (2000). They began in the 1990s to respond to the industrial modernization process, which requires favorable conditions for the constitution and development of clusters or industrial groupings.¹⁹ However, while these institutions were developed in a context of enormous economic growth, they did so in a context of great uncertainty (Cassalet and Gonzalez 2006; Villavicencio 2006).

The boxes below show examples of innovative enterprises. The examples include maquiladora and non-maquiladora companies, large transnational companies and Mexican PYMEs, and companies located in important border cities, state capitals, and small towns. It is important to note that it is no longer necessary to distinguish between a company that is a maquila or not. In other words, even though this section was mostly dedicated to the maquila industry, the information also applies to non-maquila companies (foreign and national) that formerly operated under different export promotion schemes (Pitex, for example) (Dussel Peters, 2000; Padilla et al. 2007). Today, all export companies located in Mexico can register under the IMMEX program.

The seven innovative companies presented below show that innovation is not only present in products, processes, and R&D laboratories, but is also in a wide range of activities and functions, market niches, etc. Thus, the industrial upgrading concept previously presented is quite relevant to understand the innovation process within the enterprises in Northern Mexico.

¹⁹ The cluster policy is aimed to identify, link, and consolidate the different productive and service clusters in a specific region, through key institutions that accompany this process in order to potentiate the conglomerate synergies and increase its competitive advantages and the added value as a whole. Although there are numerous conceptualizations about the cluster approach (Lara, *et al* 2005), the definition taken by the government for the construction of a policy is that of Porter (1990: 205), “a cluster is a geographically dense group of enterprises and related institutions, belonging to a specific field, joined by common features and complemented by each other.” In this sense, the cluster policy is understood as the mechanisms and instruments that refer to economic and productive advantages derived from the cluster. Consequently, the firms of a conglomerate can take advantage of external economies (the presence of raw materials and component suppliers, new or second hand machinery, the presence of wage-earning labor with specific skills in a specific production (Humphrey, 1995)) and scale economies that derive from the interaction with specialized suppliers, because of the geographical closeness and because of the constitution of coordination mechanisms in production to reduce costs and lead times.

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a. Sony of Baja California (SBC): Tijuana, Baja California

Sony, the Japanese company, has maintained maquila operations in the Baja California region for more than 20 years, producing millions of television sets, audio equipment, and key components annually. As a result of a strategic vision focused on innovation, SBC has put special emphasis on the development of its engineering groups. A clear example is the design group, formed by Mexican engineers specializing in software, digital electronics, and mechanical design. The engineering groups have actively participated in the technological change related to the transition of kinescope analog television sets to flat digital television, as well as in the development and improvement of manufacturing equipment and a wide range of products related to video high definition and audio high fidelity technologies. Outstanding activities of higher technological degree are:

- Analysis and introduction of new projection optical devices.
- Incorporation of advanced processing systems in international standard digital televisions.
- Development of high technology applications of supply chain process integration (SCM) through electronics solutions of data management in real time.
- Design of new manufacturing concepts in the development of high precision welding pieces of equipment.
- Development of high level software and hardware for testing and adjustment equipment with advanced communication and data incorporation applications.

In this company, Mexican engineers have developed patents, but they are registered under the company's name. The expertise and high quality of human capital in the region is one of the main reasons Sony management has transferred an important part of its manufacturing, engineering, and design functions to SBC. In this way, Sony is able to efficiently respond to the growing market in a competitive way (Source: National Technology Award, 2006; visit to plant and interviews with COLEF team and engineers).

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b. Pro Organico: Monterrey, Nuevo León²⁰

In April 2003, Pro Orgánico, a company dedicated to the production of organic fruits and vegetables, began operations with an initial investment of US\$500,000. The vegetable garden and orchard initially produced 100 tons of oranges for a profit of only US\$1,500. It was a rude awakening to the world of costs, intermediaries, competition, and prices. The company has since created a 100 percent sustainable business with a basic production unit of eight hectares. Up to 50 varieties of fresh produce (lettuce, fruits, and vegetables) are produced without chemicals or artificial fertilizers. The company packs, ships, distributes, and sells produce throughout the year. “We have a great variety of alternatives to choose from: produce worm humus (compost), a fruit orchard, dairy cows, or vegetable gardens. They are alternatives for a community,” explains Dorita Elizondo, the founder. The company does not produce anything in greenhouses because that technology is not within reach of small producers. Today, Pro Orgánico has three orchards, and is working to share its methodology with other farmers willing to restructure.

c. Chrysler de México: Saltillo, Coahuila²¹

According to a Chrysler director, Mexico has become, in terms of production and exports, the most important production hub of the North American region. Chrysler de México already produces and exports more vehicles to the United States than its Canadian counterpart. In the last three years, thanks to the development of technology, education, and human capital in Mexico, Chrysler invested US\$1.85 billion to modernize its manufacturing platform in Mexico and began producing new, more fuel-efficient automobiles and engines that are more competitive globally. During this time, Mr. Joseph A. Chamasrour, the director, has led the supervision of a productive alliance with Nissan that involves the Saltillo plant. The plant, where the PT Cruiser was manufactured, had capacity to assemble only one automobile model; now, it will be able to produce different types, in accordance with demand. That is, the plant has been upgraded so that it is more flexible and can continue to compete in international markets.

²⁰ *Expansión*, Year XXXIX, No. 986, 2008

²¹ *Expansión*, 998 Edition, 2008.

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At the beginning of 2008, Chrysler de México signed an agreement with Nissan; the Japanese company will produce a compact automobile for Chrysler in Japan, and the American company will use its expertise in big vehicles to manufacture a pickup truck for Nissan. Chrysler de México will have a central role where the truck for Nissan will be built in the Saltillo, Coahuila plant, starting in 2010. In 2007, the firm announced an investment of US\$570 million to build a new plant of Phoenix and V6 engines in Saltillo. The new engines will be mounted on trucks and in automobiles; most will be for the export market. The new plant will have a production capacity of 440,000 units. The new Dodge Ram 2009 will also be manufactured in Saltillo; with this product, Chrysler expects to regain the American market.

The betting on Mexico is clear; it is one of the most attractive markets for corporations. With a market share of 11.2 percent, Chrysler de México was fourth in unit sales in the country during the first semester of the year. Among the big five automakers, it was one of two (Nissan was the second) companies to grow in this period.

d. C3 Technologies NearSoft: Hermosillo, Sonora²²

This micro company, established in Hermosillo, develops software. Supported by the Program for the Acceleration of Technological Enterprises of the Secretariat of Economy (TechBa), it specializes in employee development, upgrading of work teams, and supply-chain compliance. Thanks to its approach to product development and the experience it acquired in a relatively short time, the company can help customers and companies place their products on the market faster. Ingrooves, Tierra Natal, Axolotl, and TIBCO are among its main global customers.

One of the company's main competitive advantages is its location. It is in the same time zone as the United States and, unlike companies in India, can avoid working with a 12-hour time difference. The following are some of the company's primary achievements:

²² Fumec, 2008; <http://www.nearsoft.com/>.

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- Obtained software contracts over TaTa (of India)
- Attained 400 percent employment growth (40 new positions)
- Accumulated TechBA sales of \$2.02 million dollars
- Achieved an investment/sales ratio of \$1/\$20
- Employment generation: $40 \times \$227k = \900 thousand dollars

Thus, it has become one of the 10 main software companies in the Americas; competing with Softek and Hildebrando.

e. Scantibodies Laboratories: Tecate, Baja California²³

This company stands out because of its complex operations, manufacturing 1,500 different products, such as pregnancy tests and reagents for diagnosis, antibodies, and gauges. The company has a biotery for experiments with laboratory rats as well as an R&D department. The company has multidisciplinary work teams that manage technological and scientific projects with a primary focus on the development of bioengineering projects. The objective of the company is to become the wholesaler of biological products worldwide.

The company was formed 30 years ago in Santee, California, integrating biochemistry with diagnostic products, and the development and manufacture of medical tests. Today, the company has more than 500 employees (half of them in California and half in Baja California).

f. Towa Software: Monterrey, Nuevo León²⁴

Towa Software Company was created in 2007. It is based on Softek, which was created in 1985, an IT company that quickly acquired such clients as Bancomer, Superama, and Somex. In 1999 it formed an alliance with Teléfonos de México (the Mexican telephone company) to create the Sigma Tau company, a development center in Querétaro.

²³ Plascencia et al. 2008.

²⁴ *Expansion*, Year XXXIX, no. 995, 82–83.

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Towa Software has, as one of its best assets, the integration of methodologies originated in the 1980s in the Software Engineering Institute (SEI) of the U.S. Department of Defense. The SEI methodologies such as CMM, Team Software Process (TSP) and Personal Software Process (PSP) allow fewer errors in code lines and measurable savings in resources dedicated to programming. Currently, Towa has 188 employees. In 2007 it generated sales of \$3 million with clients such as Iusacell, Nextel, ABA Seguros, HEB, Farmacias Benavides, Axtel, Bancomer, Banamex, Ixe, and Grupo ADO.

g. Plantronics de México (Plamex): Tijuana, Baja California²⁵

Plamex began operations in Tijuana in 1972 with the purpose of assembling headphones for the North American market. The main products of Plamex (the company's legal name in Mexico) are loudspeakers, headphones, and earphones for all type cellular phones, including wireless and Bluetooth. The company states that the key to its success is a commitment to introduce the most advanced products and systems. To remain competitive, the company has focused on industrial upgrades and investment in training, research, and development. It is currently benefiting from the U.S. economic deceleration or recession.

In an interview, the human resources manager said that “thanks to local capabilities, the company can attract and negotiate new functions with the corporate office.” In the long term, the company wants to de-emphasize manufacturing in favor of innovation. The company has a laboratory and a group of high-level engineers for research and development on acoustics and improvements in the quality of product reception. In regard to post-sale services, a distribution and logistics center has been established to control from Mexico all the operations of Chinese, Mexican, and American plants, as well as among suppliers and end product consumers. The company is also working on increasing the capacity of the service call center, which has already evolved to a contact center where the clients not only receive attention and support by telephone, but also by e-mail.

The opening of the logistics and R&D departments, as well as the contact center, increases the functional advantage of the plant in the American corporate world. They also increase

²⁵ *Focus Group* carried out by researchers of the COLEF in Plamex, February 2008.

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regional participation in the global value chain, thanks to the development of competitive advantages that rely on training, specialization, and productivity of local employees

3.3: Historical Comparisons and Public Policies

At present the number of innovative companies in Mexico is unknown. There are now more than 30,000 companies operating with foreign capital in Mexico, according to the National Registry of Foreign Investment of the Secretariat of Economy. There are also many large companies with majority Mexican capital. Several of them are transnational companies. In 1997, the innovative companies in Mexico numbered approximately one thousand, and were concentrated in computer science (37 percent), biotechnology (34 percent), and energy (21 percent) (Corona 1997). Likewise, the sector integrated by specialized suppliers (machinery and equipment, instruments, and special inputs) invested more in innovation and was better linked to scientific research (Capdevielle 1999).

The Chihuahua 21st Century Project is one example of precedent-setting innovations. At the end of the 1980s, the Maquiladora Industry Association in Ciudad Juárez (AMAC), with the support of the municipal and state governments, undertook a study that demonstrated, for the first time, the value of focusing on industrial groupings starting with the global value chain. Business organizations realized the need to promote higher value-added activities in the region and move away from the traditional FDI attraction policy (which does not recognize the technological level, energy needs, or the benefits or harm to the environment). The study showed that industrial concentration at the time was based on labor-intensive manufacturing activities, and it was thus necessary to foster activities with higher value-added, such as R&D. The state government introduced the Chihuahua 21st Century Project and, based on a cluster policy, identified sectors of traditional activity for support. The electronics industry was within the groupings to be developed. One of the achievements of the Chihuahua 21st Century Project was the creation of seven technological research and transfer centers, all of them linked to the development of suppliers, as was mentioned above.

Although some maquiladora companies have had product design and development activities since the early 1990s, it was not until 1995 that the first maquila R&D center, MTC of Delphi,

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initiated operations in Mexico (see Diagram 1). The decision to open MTC—and others technical centers that followed—as well as the research, development, and design departments in maquiladora plants, were made by the corporate directors in their countries of origin. Nevertheless, we have to acknowledge that the decision to relocate activities with higher value-added has been linked to the development of local capabilities (engineers, highly skilled technicians, high-level educational institutions, etc.).

It took several years for the strategies developed in Ciudad Juárez to spread and be replicated in other northern states. However, the Chihuahua project, which was on the vanguard of maquiladora innovations, was abandoned during the local democratic transition between the PAN and PRI political parties. With the Chihuahua project went the dynamism and vision that had accompanied it. It was not until 2000, under a more ambitious and sustainable approach, that a new and broad collaboration plan was organized among the different social stakeholders. Called the Strategic Plan of Juarez, it has made important progress.

What lessons can be learned from this experience in terms of limitations to the development of innovation and competitiveness?

First, policies and its programs are not permanent. The change of political actors (different political parties and, as a result, the directors overseeing personnel in the programs) hinders the continuity of the programs and seriously limits their potential. Changes in high-level personnel interrupt the careers and professional services of employees that operate the programs.

Second, the same policies are more difficult to implement during economic crisis, and especially in contexts of serious public insecurity. Since policies operate in contexts of stability and crisis, the latter being more recurrent, and since the context where companies in Mexico operate has changed substantially, policies should incorporate this variable in their model.

Third, policies and programs can hardly reach their objectives if they do not have adequate financial resources.

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Fourth, policies aimed at fostering competitiveness and developing links with transnational companies require direct communication between local governments and businesses, and the corporate officials in the companies' countries of origin.

Fifth, none of the innovation and policies to promote competitiveness clearly or structurally incorporates the social factor in the equation (wages and working conditions), thus curtailing social programs and their synergies.

Sixth, policies and programs do not incorporate the internal heterogeneity variable of the sector or industry involved.

4. Promising Initiatives

The most promising initiatives to address the current challenges, according to the Scientific and Technological Consultative Forum (FCCyT, 2008) are:

- Interconnection of scientific research and technological development to the productive sector to meet regional and national productive and social demands.
- Strengthening of regional research and higher education institutions.
- Development and strengthening of the *Avance* program, an essential initiative that will cover gaps in business development and in the productive sector, and, at the same time, support profitable investments in knowledge-based projects. This program will spread and is expected to develop and encourage the establishment of innovative companies throughout country.
- Fiscal incentives, which are drawing more attention as they are increasingly used by domestic micro and small companies. This presents an opportunity for the productive, scientific, and government sectors to further develop innovation and technology.

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We can synthesize these initiatives to:

- Accelerate a co-evolution between science/technology and innovation to energize the innovative activity of the productive and business sector, address national and regional social needs, and promote development.
- Solve market, government, and system failures; promote an adequate incentive structure and promote interactions between the advanced research institutions and the public research centers, the productive and business sectors, and public administration at federal and state levels.
- Gradually change the role of the government from administrative director of Science, Technology and Innovation activities to facilitator, coordinator, arbitrator, and mediator of the country's shared vision.
- Promote a dynamic approach for the construction of S&T capabilities.
- Consolidate the S&T capabilities, strengthen research geared towards national and regional problems and foster innovation endogenization.
- Transform the organization of research of the advanced research institutions and the public research centers according to quality, excellence, relevance, and generational renewal criteria (FCCyT, 2006:33–35).

As we have seen, federal and local initiatives have strong potential. However, they present core questions: Do emerging institutions and programs under a local cluster policy in a globalization context have the capability to transform the industrial structure? Can they be upgraded to improve innovation and competitiveness? Let us see some relevant proposals:

4.1 Current proposals

a. Axis-Producen: Baja California²⁶

Axis-Producen is a good example of what happens in border towns with a strong industrial component in its economic development (Carrillo and Molomán 2008).

²⁶ Carrillo y Molomán, 2008; Interview with its director Saul de los Santos, August 2008.

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Producen was founded in 2001 to develop suppliers for the electronic sector in Baja California—mainly to attract global, world-class electronic companies, better known as contract manufacturers. Its origin is in the Canieti-Norwest, where staff members got advice and training in preparation for future operations. Although Axis-Producen’s objective was quite specific at the beginning, it changed very rapidly with time. This institution offers development strategies and is organized in a way that promotes flexibility instead of bureaucracy. It acts as a mediator to facilitate interaction between companies, research institutions and the private sector. A distinctive feature is that members of the institution have high geographical mobility and can move between sectors. They also have broad knowledge about the local environment.

It began as a nonprofit entity fostered by private initiatives; it became the right arm of a public institution, but maintained a private orientation. Its core objective was to develop key sectors of the state of Baja California, mainly of medium or high technology, through links of the state with the federal government, as well as with different business and associations and local, regional, and national institutions. Currently, this private organization is consolidating its autonomy under the figure of a public limited company (*Sociedad Anónima*) under the trademark “Axis” (Producen spin-off) Axis plays an important role in the State since it offers information that is useful to national and regional institutions, among which the following stand out:

- information about the location of companies and productive sectors;
- evaluation of short-, medium-, and long-term development strategies;
- market information and analysis;
- information about human resources training needs;
- information about industry and specific product trends;
- cluster creation, match-making, and follow-up;
- specialized classes and certificate courses

Thus, from its initial and very specific function, Producen becomes the state’s main consultant and a key actor in the institutional structure because it is able to link the private,

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educational, and government sectors. It even participates in the rearrangement of functions of various local institutions that support companies.

The economic achievements of Producen are also significant. From 2000 to 2006, the company increased its budget more than 10-fold—from US\$50,000 to \$550,000. During the same period, the company went from one employee to eight and the clusters it covered increased from one to seven. Also, it was able to change the structure of the board of directors so that public officers, state officers and private officials each accounted for a third of the board. Previously, all of the board’s members had been public officials.

b. Condominio Tecnológico: Tijuana, Baja California

This industrial park, located on five-hectares, is supported by local technological institutes and universities, as well as various R&D centers associated with the CONACYT network. The first of its type in Mexico, the project emerged as an initiative in the early part of the current decade to link the productive sector and the local, state, and federal governments. The governments invested US\$14 million in physical and service infrastructure; CONACYT contributed with US\$12 million and skilled personnel. The project has three main areas: First, it offers technology services (metrology, automation, polymers, energy efficiency, mecatronics, and the use of materials). Second, it offers applied research. Third, it offers human resources training and is an incubator for technological companies. This project is scheduled to be ready for complete operation in the year 2011 (Government of the State of Baja California, 2008).

c. San Diego Dialogue: San Diego, California²⁷

In 2005, San Diego Dialogue issued “Borderless Innovation,” a report describing how R&D, suppliers, and manufacturing capabilities on both sides of the San Diego-Baja California border can complement one another. The targets are key clusters that, if properly leveraged, could contribute to keeping and attracting to Southern California “good companies” in need of manufacturing partners; they could also contribute to the “attractiveness” and growth of Baja California’s manufacturers and suppliers, considering the proximity to the extraordinary

²⁷ The San Diego Dialogue, 2005.

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research and development clusters in Southern California. Three “big ideas” emerged from the report (The San Diego Dialogue 2005):

- There is a need for aggressive and collaborative marketing efforts describing the high added-value in the region’s cross-border clusters. Marketing should target high technology and biotech industries that could take advantage of the physical proximity of the innovation ecosystem, from R&D to manufacture and distribution.
- Leadership from both sides of the border should collaborate to significantly expand research and technical assistance programs, as well as professional and workforce education programs that are essential to assure sustainable growth and competitiveness.
- New social and institutional mechanisms are needed to change the cross border region beyond symbolism into action—action that involves shared leadership, co-investment, and well-orchestrated programs that enhance the competitiveness capabilities of the cross-border region.

San Diego County has developed an extraordinary set of scientific research (R&D) and technological development institutions. Baja California has developed more and more industrial capabilities of high added-value as well as networks with suppliers. Both regions are near the Pacific Ocean and share a clean environment that gives them a quality of life that cannot be compared to many other parts of the world.

d. FUMEC: Federal Organization²⁸

The Mexico-United States Foundation for Science (FUMEC) is a government organization created in 1992 that helps create binational synergies in novel and important areas of science and technology. The foundation has three general programs: 1) Health and environment; 2) Economic opportunities arising from technology; and 3) Human resources development in science and technology.

²⁸ FUMEC, 2008.

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The second program has two relevant sub-programs: the Business Technological Assistance System (SATE) and the Acceleration Program for Mexican Technological Companies (TECHBA). The SATE helps provide business support and the technological and innovation capabilities necessary for the development of small and medium size companies (PYME) and high-potential niches in specific regions and sectors. Its background is the Industrial Research Assistance Program (IRAP) of Canada, the Pennsylvania Technical Assistance Program (PENNTAP) and Small Business Administration in the United States. The SATE is supported by and receives subsidies from the Support Fund for the Micro and PYME, at federal level on behalf of the secretariat of economy and the state governments. It is currently present in Nuevo León, Sonora, Distrito Federal, Baja California, and the state of Mexico.

TechBA is a program of the secretary of economy operated by Fumec. The program collaborates with highly innovative companies to take them to the global market, increase their exports and generate high-value employment in Mexico. It operates in California's Silicon Valley, as well as other knowledge- and technology-intensive clusters.

Another relevant program is the Mexicans Abroad Talent Network (RTM). Through a 2005 Foreign Affairs Ministry initiative, the Institute for Mexicans Abroad worked with CONACYT and Fumec to establish a network of Mexican citizens who live abroad.

The objective of RTM is to promote a close relationship among Mexican scientists, professionals, and entrepreneurs in Mexico and the United States involved in high-tech development industries. The goal is to develop a binational community promoting high-value added businesses that contribute to strengthening innovative and technological development. This program is somewhat related to the lack of talent in Mexico. This phenomenon will continue growing worldwide in the following years, according to Manpower, the main headhunter company.

A good example of the programs' success can be found in Sonora. In this state, the SATE program promotes innovation in companies associated with the expansion of Ford in Hermosillo. TechBA focuses on the MEMS (Microelectromechanic System) in the development of software capabilities and in the sustainability binational laboratory.

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The SATE in Sonora assists the following sectors: TICS, Machining, Energy, Aerospace, Automotive, and MEMS. In 2007 and 2008, 20 local companies received assistance, including support funds for more than US\$3 million dollars (PYME-Fumec, CONACYT and Prosoft). Their action lines are: specialized consultancy of technological maps; analysis of strengths, weaknesses, opportunities and threats; cash flow maps; consultancy in commercial and marketing topics and linkage with experts in other companies and with government organizations.

The previous examples show, in a limited way, that the maquila and non-maquila exports industry is developed in an environment where local institutions, together with federal programs, have been able to increase their capabilities, and where there are cluster development industrial policies. In this sense, the industrial upgrading and the sectors mentioned in the previous sections are accompanied by the development of institutional structures. Thus, there is a co-evolution process, between clients, customers and suppliers, as well as among related industries, and sectors and institutions.

4.2 New Ideas

Innovative territories and the development of a company environment are very important concepts that were again included in the 2006 plan and the approaches of the Scientific and Technological Consultative Forum in Mexico. However, these ideas are not completely developed and are not a center of debate in business. The idea of social responsibility is not yet considered as an important factor. It is important to point out that higher profitability and sustainability that respond to local social needs and to national goals can offer more benefits in the construction and care of the social environment.

5. Conclusion

The Problem

The competitiveness metrics show that Mexico ranks low in international competitiveness. For example, in a study conducted by the Intelligence Unit of *The Economist*, Mexico in 1997 was

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44th in the world in technological competitiveness, according to the IT Competitiveness Index. Mexico's best ranking was in the area of government policies, where it was 34th.

Limitations

There are many limitations on innovation and competitiveness in Mexico. There is a lack of skilled personnel and a need to improve research and training institutions as well as the links between them. Professional experts or brokers are needed to bring these interests together.

Opportunities

The northern states, and specifically the border cities, are the best-positioned regions for innovation. This is confirmed by the sustainable competitive index, government programs, universities, and research centers.

The northern Mexico states have the most industrially-developed maquiladoras and are home to new sectors such as software, biotechnology, and medical devices.

Innovation associated with business development in manufacturing and services mainly depends on the companies themselves, which are primarily multinational, but also include local and foreign firms.

Business leaders are sharing information and becoming more aware of Mexico's lack of competitiveness. For example, in Baja California, out of approximately 60 to 70 leaders of organizations and clusters from the public and private sector, 20 attended an OCDE presentation and are more than ready to continue actively working to address the competitiveness problem.

Where to go from here

Public and private sector efforts to improve competitiveness need better coordination among and between themselves. Programs, stakeholders, and associated resources must be reviewed to avoid duplication.

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Other regional and international models must be reviewed, such as those in the state of Guanajuato (Lopez de Alba 2008). The main emphasis is on the associative model.

Despite many innovative proposals, the core problem remains a lack of speed, efficiency, and effectiveness. It is imperative that we completely commit ourselves to improvements in these areas. The multiple existing programs that address these issues lack metrics and a continuous evaluation system.

Globalization represents a challenge, but also a solid innovation opportunity because traditional barriers are surpassed and a more dynamic perspective is created (Frank Skern, Vice President, Global Sale and Distribution IBM in CONACYT, 2006). Thus, a culture of innovation must be established that combines investment, infrastructure, and talent with a general consensus from society.

To conclude, the current problematic situation in Mexico is critical and is characterized by: 1) a lack of economic and competitive growth; 2) insufficient scientific and technological capabilities due to a small number of researchers and quality graduate programs, as well as a poorly coordinated and limited infrastructure; 3) inadequate financing; 4) fragile and slow-moving mechanisms for innovation (this includes low productivity and an inadequate legal framework that does not favor innovation); 5) the absence of a long-term public policy vision; and 6) a lack of attention to opportunities and knowledge of strategic areas, and a weak national research system (FCCyT, 2006b).

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