

The Impact of Government Intervention in the Industry: A Case Study of the Electronics industry in Jalisco, Mexico

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Abstract

This paper examines the processes of interaction and cooperation in the electronics industry in Jalisco as well as the impact of government strategies on the industry's development of innovative activities. This paper relies upon the sectoral systems of innovation (SSI) as a theoretical framework for the analysis of the nature, structure, organization, and dynamic of the electronics sector of the metropolitan region of Guadalajara. The paper concludes that the interaction among public-private actors has been an important factor in fostering upgrades in the industry. It also highlights the role of the government at the state level in Jalisco as a key factor in facilitating the self-organization of a sector by creating bridge institutions that shape the interaction in the sector. Finally, the paper points out the limited integration in the scientific-educational sector and the necessity to incorporate domestic firms into the value chain of the industry.

Keywords: Mexico; sectoral patterns of innovation; competitiveness; public intervention; electronics industry

Dedication

For Ammar, this work is possible because of your support and encouragement, and it is our shared achievement.

Este trabajo representa el arduo trabajo durante mis estudios de posgrado, pero también la gran dificultad de estar lejos de la calidez de mi familia. Es por eso que con la misma importancia, este trabajo está dedicado a mi hermosa familia.

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1. Introduction

This paper is concerned with the potential of public policies as well as institutional support to aid the development of the electronics sector in Mexico. My focus is on the process of interaction and cooperation with other actors and agents of the region enables the development of innovative activities.

Developing countries under the new international economic order have substantially reduced the role of the state in innovative investment and have promoted the dependence on either private initiatives or on FDI. Mexico, as one of the leaders of neo-liberalism in Latin America, has been following this position by focusing on trade liberalization and foreign direct investment (FDI) to stimulate domestic productivity, employment, and economic growth. For many years, there has been a scarcity in government investment in R&D, education, and training.

Simultaneously, the processes of globalization have affected innovative activities differently, leading to the rise or fall of innovative investment in some industries. Such has been the case of the electronics industry, which in terms of FDI has been one of the most dynamic branches in Mexico's economy. For instance in 2008, the electronics industry was one of the main productive activities of the country, representing over 30 percent of total exports and contributing to about 8 percent of the manufacturing GDP. (Ministry of Economy, 2012)

However the electronics industry in Mexico has been suffering some structural changes. Some of these changes were the result of the same techno-economic transformation that the global electronics industry suffered (the information revolution and the conversion of the electronics industry as the core of the global economy). (Dabat & Ordóñez, 2009) But equally, many of the changes were caused by the same internal organization of the different electronics sectors of Mexico. One of the most important electronics sectors in Mexico has been consolidated in the state of Jalisco, more specifically in the metropolitan region of its capital, Guadalajara. To some extent,

during the 1990s, the liberalization strategy promoted by neoliberal policies seemed successful.

The electronics industry was one of the most dynamic industries because of its high employment rates and its contribution to the economic growth of the country. Exports increased by more than 300%, and, by 2001, the electronics industry accounted for 27% of Mexico's total exports (Dussel, 2000). But foreign direct investment (FDI) inflows fell sharply after 2001 due largely to the downturn in the U.S. economy and China's accession to the World Trade Organization (WTO). The electronics sector of Guadalajara underwent a drastic decline during the period between 2001 and 2004, suffering from unemployment and a lack of competitiveness. The collapse of this industry compelled the Mexican government to take a proactive role in building institutions and enacting policies that would not only attract foreign investment but would also raise local capacities for production and innovation and improve educational capabilities. Since 2004, the electronics sector of Guadalajara has begun to show an organizational transformation, which was reflected in the emergence of design and testing activities, the consolidation of a local software industry, and the resultant formation of a sector of information technology (IT). The main goals of this paper are to analyze the extent to which the government intervened to achieve this industrial upgrading and to determine the factors and conditions that helped this organizational transformation.

This paper will explore the processes of innovation and collective efficiency observed in the electronics sector located in the metropolitan area of Guadalajara which covers the areas of Zapopan, Guadalajara, Tlaquepaque, El Salto and Tlajomulco de Zuñiga. For the purpose of this paper this region will be referred to as "the electronics sector of Guadalajara". Moreover the paper will discuss the possibility of fostering competitiveness through government intervention. Government intervention can improve the infrastructure by acting as a mediator for cooperation between the public and private sectors.

Based on the characteristics of institutions and supportive instruments deployed in the electronics sector of Guadalajara, this paper assesses the following issues related to Mexico's competitiveness and innovation: 1) What are the factors affecting the innovation, commercial performance, and international competitiveness of the

electronics industry? 2) What institutions are shaping agents' cognition, actions, and interactions in the electronics industry? 3) How have government strategies for raising local capacities for production and innovation been implemented? (4) What roles have design centers and universities played in changing the innovative process? and 5) What has been the impact of these strategies on upgrading the electronics industry?

Innovation processes are influenced by many factors, and government capacities for monitoring the emergence of radical technological change differ substantially across countries. The use of a sectoral innovation system (SSI) approach allows us to better understand why the same factors, such as key actors, networks, demand, and institutions, affect innovation positively in some sectors and weakly in others (Malerba, 2009). Therefore, this paper focuses on the SSI approach as the unit of analysis for examining the specific industrial conditions and the innovation performance in the electronics industry in Jalisco. The driving elements of the analysis are to study knowledge, capabilities, interactions, and institutions across key actors within the sector

1.1. Agenda

The first chapter provides an introductory overview of the importance of innovation and competitiveness in promoting economic and social development. It discusses the purpose of the paper, which is to understand the processes of interaction and cooperation employed to upgrade an industry as well as the impact of government strategies on the industry's development of innovative activities. It will then explain the methodology used to explore this cooperation among the main actors in the electronics sector of Guadalajara. All steps, from data collection to the estimation of the major sources of transformation and growth of the industry as well as the agents' cognition, action, and interaction, are presented in summary form as an introduction to the more detailed presentations of the conceptual framework in the following chapter.

Chapter 2 will look at the theoretical framework on which this investigation is based. The concepts of innovation, knowledge, and competitiveness are explored to generate a better understanding of their importance for economic growth and to identify which factors and conditions foment this growth. This chapter also presents the paper's

analytical framework. It addresses a set of theoretical and methodological issues surrounding innovation as a function of the sectoral system of innovation.

Chapter 3 is divided into two main sections. The first section concerns the international trend of the global electronics industry. It will address the importance and transformation of the industrial cycle of the electronics industry as well as its role in innovation and competitiveness. It argues that a strong and competitive electronics industry is an important component of fast growing economies. It will also discuss the conventional classification of the electronics industry and the expansion of its fields. The second part provides a brief analysis of trends in Mexico's electronics industry, from its beginning at the national level to the consolidation of this sector in the metropolitan region of Guadalajara. It describes the boom of the industry during the 1990s and, in turn, the large decline of the industry from 2001 to 2004.

Chapter 4 focuses on the evolution of the electronics sector of Guadalajara after its crisis of 2001-2004. Specifically, it analyzes its dynamics and transformation over time with regard to technologies and relationships between actors. Although much research has been conducted on this theme, the structure of and changes in the relationships among actors in this system are not constant and particular characteristics of the electronics sector need further explanation (Palacios, 2008). Since the acceleration of economic growth is associated with increases in the proportion of manufacturers, exports, and employment, part of the chapter analyzes these indicators.

Chapter 5 presents the concluding remarks of the analysis of Mexico's competitiveness and innovation in the electronics sector of Guadalajara. It explains the factors and conditions behind the industrial development of the region. Finally, it identifies some deficiencies in the functioning of the system and proposes solutions to them.

1.2. Methodology

The objective of this explanatory and descriptive research was to explore the scope and limitations of government interference for the recovery and upgrade of the industry, and to obtain comprehensive explanations of the factors affecting

competitiveness and innovation in a dynamic and knowledge-intensive manufacturing industry. Among the various sectors of manufacturing, few have been as key to Mexico's competitiveness as the metropolitan region of Guadalajara. The region and municipality are populated by hundreds of firms, from small service providers to multinational companies, with the largest concentration in electronics and information technology. Therefore, the object of the study is the electronics industry in metropolitan Guadalajara. For the purpose of this analysis, the productive sector of the electronics industry in Mexico will be defined as the complex of activities that have a technological base articulating the integrated circuit, digitization and software, and a structure around the functional role of the computer (Dabat & Ordóñez, 2009). The main driving elements for the analysis of the electronics sector of Guadalajara are (1) knowledge, (2) capabilities, (3) variety of actors, (4) interactions, and (5) institutions.

To understand the change and transformation in the electronics industry in Jalisco, it is necessary to comprehend the nature, structure, organization, and dynamic of the industry. Therefore, the following questions need to be considered: (1) What are the factors affecting innovation, commercial performance, and the international competitiveness of the electronics industry in Jalisco? One of the key elements to understanding the development of the electronics industry in Jalisco is identifying the current sources of innovation and development. This study will answer this question using the sectoral innovation system approach, secondary data, national and regional data, and primary interviews with and surveys of the three main actors in the electronics industry of Jalisco: firms, government, and universities. (2) What were the strategies the Mexican government implemented or modified after the electronics crisis of 2001–2004 to increase competitiveness of the electronics industry in Jalisco? To understand the factors driving innovation in the electronics industry in Jalisco, we also need to understand the type of networks in the industry and the level of participation of the government to promote this integration. This study analyzes the formation of networks and knowledge systems in the electronics industry of Jalisco using the sectoral innovation system approach through secondary data, national and regional data, and primary interviews and surveys with firms, government and design centers and universities. (3) What has been the impact of these strategies on upgrading the electronics industry in Jalisco? To measure the impact of the strategies, this study will

compare the different development indexes and statistics at the national and regional levels of the electronics industry in Jalisco. This paper answers these questions by explaining the effects of innovation, diffusion, and production while focusing on the co-evolutionary settings in the metropolitan region of Guadalajara, Mexico.

Q1. What are the factors affecting innovation, commercial performance, and the international competitiveness of the electronics industry in Jalisco?

Sub questions	Concept/Actors	How defined	Data source
1.1) What are the major sources of transformation and growth of the electronics industry in Jalisco?	Companies	Knowledge and technology of the Electronics industry in Jalisco	Survey and Interviews with electronics firms in Jalisco
1.2) What formal institutions are shaping agents' cognition, actions, and interactions in the electronic industry in Jalisco?	Government	National patent system, sectoral labor market and sector-specific financial institutions	Interview with Government and Bridge institutions representatives
	Educational Institutions	Include norms, routines, common habits, established practices, rules, laws, standards and so on.	Interview with scientific-educational sector
	Companies		Survey and Interviews with electronics firms in Jalisco

Q 2. What were the strategies the Mexican government implemented or modified after the electronics crisis of 2001–2004 to increase the competitiveness of the electronics industry in Jalisco?

Sub questions	Concept/Actors	How defined	Data source
2.1) How have government strategies for raising local capacities for	Government	Governments should be able to promote and managed the restructuring process to a good extent	Interview with Government & Mexican Government Statistics
	Companies		Survey and Interviews

production and innovation been implemented?			with global firms in Jalisco
	Educational Institutions		Interview with Educational Institutions that perform research
2.2) What roles have research and academic centers played in changes in the innovative process?	Companies	Relationships and networks are key elements of the innovative and production processes	Survey and Interviews with IT firms in Jalisco
	Research centers		Interview with research center's representatives
	Educational Institutions		Interview with educational institutions and research centers
	Government		Interview with Government representatives at federal level, state and municipal level

Q 3. What has been the impact of these strategies on upgrading the electronics industry in Jalisco?

Sub questions	Concept/Actors	How defined	Data source
3.1) What has been the impact in innovation?	Capacity for innovation	Patent applications-resident share of total R&D expenditure as % of GDP, Scientist and engineers per million people, Science and technology journal articles, R&D technicians per million people	CADELEC, CANIETI, CINVESTAV World Bank INEGI, Government of Jalisco, Federal Government, OECD statistics, Year book of World Electronic Data
3.2) What has been the impact in the value chain of the industry?		Export index rates	
		FDI index rates	
		Electronics Export share of GDP	
		Electronics exports by type of program	
		Electronics export from Jalisco state	

		Investment in electronics in Jalisco state	
		Electronics production in Mexico and Jalisco state	
3.3) What has been the impact in employment?		Employment index rates	

1.2.1. Data collection

This study was conducted through documentation and field research. To obtain results relevant to the industry, interviews with the main actors representing the firms, government, and educational and research institutions were conducted. The primary data collection for this research involved in-depth, semi-structured interviews with

- Mr. Eugenio Godard Zapata: Guadalajara General Director, IBM (México)
- Dr. Enrique Cortes: Director Dell Services Latin America
- Mr. Kurt G. Rodriguez: International Promotion, FDI Attraction Director at Secretariat for Economic Promotion, State Government of Jalisco (SEPROE)
- Dr. Francisco Medina Gomez: Executive Director of the State Council of Science and Technology (COECYTJAL)
- Mr. Carlos Gomez Michel: President of the Suppliers Development for the Jalisco Electronics Industry (Cadelec)
- Dr. Bernardino Castillo Toledo : General Director of the Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), in Guadalajara
- Mr. Gerardo Rodriguez Barba: Director of innovation of Information Technology Institute of Jalisco (IJALTI).

The purpose of these interviews was to collect information: (1) the key factors that influenced in the recovery of the electronics sector of Guadalajara after the global crisis of 2001–2002; (2) the current major agents that affect the ongoing development and improvement of the industry; and (3) their perception of the role of the government (at the state and national level) in the facilitation of technology transfer and the upgrade in the value chain of the industry. All quotes have been anonymized to protect sources.

The second phase of the investigation took place immediately after the interview. The respondents were asked to answer a questionnaire to test the results obtained during in-depth interviews. Interviews were conducted with semi-structured question guides in metropolitan Guadalajara in 2012. Secondary data comprised information from the federal government, provincial/state government statistics, statistics on production in Mexico and Jalisco, general business publications, magazine and newspaper articles, annual reports, academic publications and library sources.

2. Innovation and Conceptual Framework

2.1. Introduction

In order to know how to improve the productive capacity of developing countries, the relationship among innovation, competitiveness, and development is constantly studied. One of the most important premises is that the learning process nurtures a country's capability to foster innovation and competitiveness (Lopez, 2000).

Many scholars have identified the forces that drive a knowledge-based economy. The majority agree that a country's competitiveness and economic growth are increasingly linked to the development of knowledge accumulation and diffusion, as the intensification of the productive use of knowledge and its valorization become central to production and social reproduction (OECD, 2000). Knowledge is fundamental in the formation of technologies and plays an important role in innovation. Innovation has been defined, in terms of capitalist competition, as superior technical performance, new products, opening new markets, and new types of organization. In fact, the Organization for Economic Cooperation and Development (OECD, 2000) stated that the development of the capitalist economy has its basis in innovation explained by a cyclical behavior that tends to regenerate the foundations of development.

The innovation process occurs over time and is influenced by many factors, but authors differ on the relative importance of various types of institutions, actors, and linkages for a respective production system. Innovation requires a viable structure of incentives and institutions able to develop a business climate that encourages innovation and economic growth. The goal is to activate the learning process, and government policies are the tools to promote the right conditions for the development of these processes (OECD, 2000).

Innovation is facing new challenges, however; its own dynamism has produced a world that requires in many ways a rethinking of innovation itself. The determinants of innovation performance have changed in a globalized, knowledge-based economy, partly as a result of recent developments in information and communication technologies. Globalization itself is a product of innovation. The application of constantly improved technologies to the massive means of transport and communication has produced an unprecedented level of global connectivity, forming a global production network (GPN) (Torun, and Çiçekci, 2007).

Because today's electronics sector is shaped by a constant stimulus for innovation, which in turn is affected by factors such as knowledge accumulation and diffusion, questions arise regarding the connection between innovation and electronics: What are the forces that drive knowledge accumulation in the electronics industry? Given that many view innovation mainly as the result of an interactive learning process, what is the relationship between innovation as an accumulative process and the technological trajectories of the electronics industry? How can governments encourage the development of the electronics industry to occupy a significant space and be an engine of growth in their country's economy? Therefore, it is necessary to understand the diffusion of knowledge across countries and how developing countries can actually generate innovation. This chapter aims to present these concepts. To start, it will define innovation and point out the characteristics of its process. It then will explore the transformation of the competitive dynamics and industrial organizations. Because a system of innovation can be analyzed on the national, regional, and local levels, the point of departure depending on the object of study, this chapter will explore innovation first as part of collective efficiency and as a result of systematic sector activity, and second as the intervention of various actors and institutions. The last section discusses the analytical framework used to measure competitiveness and the impact of government strategies on the electronics industry in Jalisco.

2.2. Innovation

Nowadays we live in a globalized world that is constantly transforming and highly competitive. The importance of innovation has been increasingly significant for policy makers and firms, who are continuously searching for strategies that will give them a sustainable competitive advantage. For policy makers, innovation is an important driver of economic growth and improvement. For firms, innovation is crucial to surviving adverse changes, to fostering growth, and to guaranteeing shareholders' returns (Mobbs, 2010). Therefore, innovation can be the explanatory factor for the successes and failures of some firms, regions, and countries. For instance, the superior innovative activity of Asia in the 1970s and early 1980s was the prime factor behind the huge difference in the performance of that region when compared to that of the Latin America region (Fagerberg, 2005).

The existing literature views innovation as changes in systems, organizations, market environments, production facilities, and knowledge. As a general concept, innovation is defined as the generation and application of new ideas and skills to renew change or create more effective processes and products that improve economic and social prosperity (Popadiuk & Choo, 2006). The link between innovation and long-term economic growth has been studied using different economic models. Within the neo-classical framework, innovation is viewed "largely as an exogenous variable, operating outside of the properties of their general equilibrium models" (Nelson, 1994; Wolfe, 2006, p. 6). More recently, according to the evolutionary model, economic development is seen as a process of qualitative change driven by innovation. This approach emphasizes the complex, uncertain, and interdependent nature of technological change as well as the role of firms and entrepreneurs. According to the evolutionary approach, "the process of innovation emerges out of the interactions between the cumulative increase in the knowledge base and the technological capabilities of firms in the development and diffusion of new technologies" (Wolfe, 2006, p.6).

In order to understand the diverse theoretical models of innovation, it is important to explore the different typologies of innovation. The scholar Joseph Schumpeter classified five different types of innovation: 1) new product, 2) new method of production, 3) new source of supply, 4) the exploitation of new markets, and 5) new ways to

organize business. But only product and process innovation have been the core focus for economics in the sense that they have a positive impact on the growth of income and employment (Fagerberg, 2005). According to the Oslo Manual of the OECD, product innovation “involves the introduction of a good or service that is entirely new or has significantly improved characteristics or uses,” whereas process innovation “refers to the adoption of a new or significantly improved method of production of method of delivering a service” (Wolfe, 2006, p. 7). Currently, the category of process innovation is divided into *technological process innovation* and *organizational process innovation*, because the organization of the firm’s business practices and its relations with other firms or outside organizations are relevant to economic growth (Wolfe, 2006). One applicable example of organizational innovation is the Global Production Network (GPN), which we will analyze later in this paper.

Another kind of typology of innovation is the classification of innovation as incremental or radical in comparison to existing technology. Incremental innovation is concerned with the exploitation of existing technology and its development and mostly occurs in the process of “learning by doing” or “learning by using.” Radical innovation involves the exploration of new technology generally as the result of directed research and development efforts within a firm (Wolfe, 2006). Scholars such as Schumpeter believe that radical innovation is the key to significantly improving productivity because it has a much broader effect on overall economic levels. Conversely, other scholars such as Lundvall have demonstrated that, in fact, incremental innovation has a significant impact on overall economic growth and productivity because introducing something in a new context often implies considerable adaptation (Lundvall,1992); thus, radical innovation requires a series of incremental improvements (Fagerberg, 2005).

2.2.1. Innovation process

Due to scientific and technological advances and the increasing globalization of a number of markets and activities, innovation has experienced a remarkable change in recent years (Molero & Garcia, 2008). Policy makers and business leaders are constantly trying to find the process through which innovations occur and the individuals, firms, organizations, and networks that participate in it. Therefore, after understanding

the definition and classification of innovation, the next question that should be asked is how innovation occurs.

The literature on innovation stresses its multilevel, spontaneous, and complex features. Innovation processes differ in many respects according to the economic sector, field of knowledge, type of innovation, historical period, and country concerned, while every country or region differs in the way in which knowledge flows are structured (Pavitt, 2005). However, there are some common features of innovation on which most of the literature seems to agree: 1) knowledge: the role of knowledge transfer is central to the innovation process; 2) network: innovation is a systematic phenomenon, since it is enacted through networks of social relations, rather than through singular events by isolated individuals or organizations (Fagerberg, 2005); and 3) size: innovatory advantage is unequivocally associated neither with large nor small companies. Small firm advantages are mainly behavioral, while those of large firms are mainly material (Molero & Garcia, 2008).

While innovation affects long-term economic and social changes, its development and diffusion are keys to maintaining and/or improving economic competitiveness. We are living in a knowledge-based economy that faces strong competition from all parts of the world due to the globalization of commerce. The process of innovation has been changing since accessing useful knowledge globally became more complicated. In response to these changes, some transformations have occurred in the organization of international economic transactions in which not only the transfer of knowledge but also the drivers and implications of knowledge are important. The GPN is the major organizational innovation in global operations that has transformed the production and use of knowledge.

Production processes are increasingly fragmented in the world. The countries that specialize in different stages of production are linked in a vertical chain through the trade in intermediate inputs. This phenomenon is often variously called vertical specialization, a production network, or a global value chain. The importance of the GPN is that it can sustain competitiveness by increasing the local capability formation in lower-cost locations through international knowledge diffusion (Ernst & Kim, 2001). Knowledge transfer, however, is not automatic. It requires a significant level of

absorptive capacity on the part of local suppliers and an ability to internalize disseminated knowledge

2.2.1.1. Transfer of knowledge

A successful knowledge transfer depends on the type of knowledge involved and how it is employed. According to Polanyi (1962), knowledge can be classified as tacit or explicit. Explicit knowledge can be embodied in a code or a language, and, as a consequence, it can be communicated, processed, transmitted, and stored relatively easily. It involves know-how that is transmittable and does not require direct experience of the knowledge that is being acquired. For example, explicit knowledge can be transferred in formats such as a blueprint or operating manual. On the contrary, tacit knowledge is not codified, is personal and hard to formalize, and cannot be communicated in any direct way. It is rooted in actions, procedures, commitment, values, and emotions. Tacit knowledge is not communicated in a language but is acquired by sharing experiences, by observation, and by imitation. Tacit knowledge can also be associated with scientific intuition (Ernst & Kim, 2001). Tacit and explicit knowledge are complementary; however, while the conversions of both types are essential to knowledge creation and lead to learning processes, an effective knowledge conversion requires an existing knowledge base (Ernst & Kim, 2001).

There are two main kinds of knowledge bases: analytical and synthetic; all innovation processes make use of both. An analytical knowledge base occurs mostly through the application or new combinations of existing knowledge and uses cognitive and rational models. University–industry linkages are an essential part of the knowledge transfer for sectors that rely upon this type of knowledge base. A synthetic knowledge base refers to the creation of knowledge through a process of testing or experimentation. This kind of knowledge base is usually related to industrial engineering (Wolfe, 2006).

2.2.1.2. Drivers of knowledge

According to Ernst & Kim (2001), knowledge transfer is not a sufficient condition for effective knowledge diffusion. It is also important to understand the transmission mechanisms that disseminate different types of knowledge. There are two categories of the organizational mechanism for knowledge transfer: formal or informal. The first is

limited to explicit knowledge and involves relationships governed by formal contractual agreement or institutional structure. The most significant and more studied example of a formal mechanism is FDI. An informal mechanism does not have an institutional structure or formal contractual agreement; the essence of an informal mechanism is to build informal networks among people so that knowledge can be transferred internally through experience

2.2.1.3. Implications of knowledge

One of the conditions required to augment international knowledge diffusion through a GPN to developing countries is the effectiveness of local capabilities in assimilating, adapting, and improving imported technology. Simultaneously, knowledge spillover across countries and industries is fundamentally dependent on domestic technological capabilities and the stage of industrial development.

Generally, technology transfer is the transmission of technology from one entity to another. The formal mechanism of FDI is one of the most important sources of the diffusion of technological knowledge across national boundaries. Federal and state-level policy makers across international boundaries are interested in attracting capital and spurring innovation, and technology transfer is what makes this all possible. However, FDI is not the only tool by which to engineer innovation in the host country. It is also important to acknowledge the role played by domestic technological capabilities that facilitate the adaptation of foreign knowledge and strengthen the innovative infrastructure at home (Lakhwinder, 2006).

2.2.2. Competitiveness

Due to the continuing evolution of the GPN and the substantial flows of FDI, competitiveness is derived from differentiated capabilities to innovate. Competition now arises with great intensity from practically anywhere in the world, based on a bewildering array of new technologies, advanced skills, and sophisticated supply-chain and distribution techniques (Lall, 2004). In order to compete and maintain a presence in global markets, it is essential to increase the human capital endowments of the labor force, whose members must have access to new knowledge and be constantly trained in new processes and in the operation of the latest technologies (Torun, 2007).

Competitiveness can be seen as a system as a whole and understood as the constellation of actors, institutions, organizations, and policies linked by complex communication mechanisms that determine the level of productivity of a country (Palacios, 2008). Many scholars have studied the sources and development of the competitive advantages employed by emerging countries in different regions of the world; innovation and agglomeration theories are some of the most often applied conceptual frameworks. Theories such as national, regional, and sectoral innovation systems and knowledge-based theories of agglomeration acknowledge the efficiency of economic processes and the imperfect nature of competition in domestic and international markets. These theories have stressed the importance of the production network, innovation, and knowledge flows in agglomeration processes (Palacios, 2005). The purpose of studies of innovation systems has been to explain how innovative activities can influence the limits of firm and technological activity partnerships in different knowledge-related activities and how ultimately innovation gives rise to economic growth (Malerba, 2009).

2.3. Systems of innovation

As mentioned, innovation is not isolated to individuals or organizations; it encompasses components such as certain institutions, structures, and values as well as the relations among them. These components and their relations are the ideas behind the system of innovation. According to Edquist (2005), the system of innovation comprehends all the determinants of innovation processes, which include “all important, economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovation” (Edquist, 2005, p.182). In a system of innovation, the main components are the players or actors and the rules of the game. Organizations (players) are understood as “the formal structures that are consciously created and have an explicit purpose.” Institutions (rules) are “the sets of common habits, norms, routines, and established practices that regulate the relation and interaction between individuals, groups and organizations” (Edquist, 2005, p. 182).

In the system of innovation (SI) approach, innovation and the learning process are the centers of focus. The SI approach employs an evolutionary perspective, because

it considers that processes of innovation develop over time and involve feedback. Unlike other studies of innovation, SI encompasses the technological processes of innovation (product and process innovations) and non-technological and intangible processes, such as service product innovation and organizational process innovation. Finally, institutions are important to this approach because it assumes that institutions are strong determinants of innovation (Edquist, 2005).

The kinds of knowledge prioritized by the SI approach are 1) innovation as organizational knowledge, in which the knowledge-related asset is controlled by firms; 2) research and development (R&D), which provides public and private knowledge and it is controlled by universities, public research organizations, and firms; and 3) competence building for human capital, which includes training and education and occurs in educational institutions and firms (Edquist, 2005). Due to its focus on these different kinds of learning, SI has been overwhelmingly used to study the factors that influence the development, diffusion, and use of innovation.

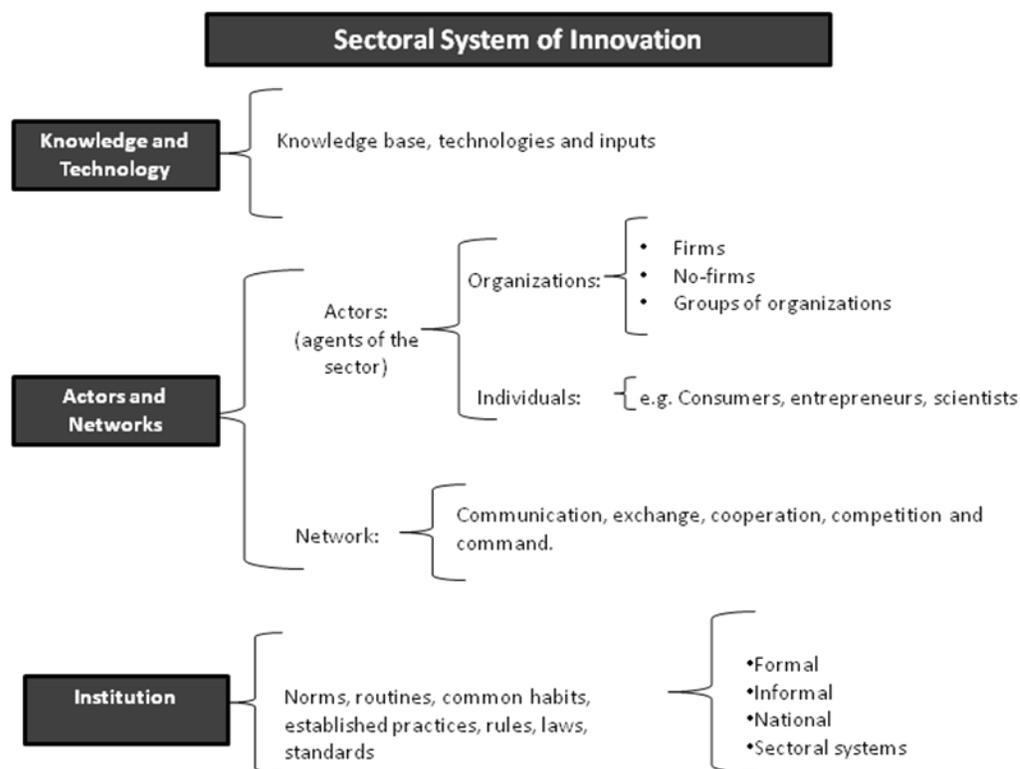
SI, however, is also associated with some conceptual diffuseness. The most notable of these is the absence of a concise specification of boundaries; the distinction between what is inside or outside the system is unclear. This ambiguous limitation of boundaries has created different variants in the SI approach. To start, the National System of Innovation (NSI), which was the first approach related to innovation systems by Freeman in 1987, was embedded in national institutions for the promotion of innovation. Then, the Regional System of Innovations was introduced by Cooke in 1994 and by Howells in 1999; in this approach, geography is fundamental and not incidental to the innovation process. The main argument revolves around the relation of tacit knowledge to geography, in which knowledge transfer within a region is enhanced by relationships of trust due to the physical proximity of local communities (Bjorn, Asheim, Meric, & Gertler, 2005). Finally, the Sectoral Systems of Innovation (SSI) approach emerged from the work of Malerba (2004). SSI focuses on the difference between the types of innovation and the organization of innovative activities across sectors, since most countries, regardless of their level of development, concentrate their innovation activities on a few industries.

The advantage to having different variants in the innovation system is that they complement each other, and their use depends on the scope of analysis. Also, due to the specific components of each system (innovation policies, research universities, public laboratories, and others), it is possible to evaluate and improve the performance of the system. Therefore, the innovation system approach provides a useful, applicable set of policy implications (Niosi, 2011).

2.3.1. Sectoral System of Innovation SSI

According to SSI, each sector involves different types of innovating firms, public policies for learning and innovation, different market dynamics, and technological trajectories, as well as different types of interaction among agents. A sectoral system could be seen as composed by three main building blocks (see figure 2-1)

Figure 2-1 Sectoral system framework



Note: Adapted from Malerba, F. (2005), Sectoral Systems – How and why innovation differs across sectors, in: Fagerberg, J., Mowery, D., Nelson, R. (2005) p. 385, The Oxford Handbook of Innovation, Chapter 14, Oxford University Press.

The value of SSI over other innovation approaches can be summed up in five points: First, it focuses on supply as well as demand and on markets in the innovation process. Second, it examines other types of agents in addition to firms. Third, it places considerable emphasis on non-market as well as market interactions. Fourth, it pays attention to institutions. Fifth, it does not consider sectoral boundaries as given and static, but it focuses on the process of transformation of the system. (Malerba, 2005, p. 67)

2.4. Conceptual Framework

The neoliberal approach has long eschewed state involvement in economic activities due to its limited vision of the state as a provider of macroeconomic stability, giving place to more macroeconomic forces. However, due to a more globalized world economy, the market mechanism and capitalist firms have failed to achieve many economic functions; the influence of the government on the promotion of innovation systems is increasing (Johnson & Lundvall, 2000). The intervention of the state is crucial and strategic for economic growth. Additionally, the determinants of innovation performance have changed in a globalized, knowledge-based economy, partly as a result of recent developments in information and communication technologies. Innovation and diffusion have become relevant in most developing countries. Therefore, for this study, a broad argument considers a structuralist approach which, according to Lall (2003), “puts less faith in free markets as the driver of dynamic competitiveness and more in the ability of governments to mount interventions effectively” (2). Moreover, it considers dynamics, innovation, and economic transformation.

Innovation processes are influenced by many factors, and the increasing dynamics of current competition in recent years has brought a vast number of conceptual frameworks in an effort to analyze the factors of innovation as well as the production and distribution of knowledge in the economy. In the late 1980s, a conceptual framework called the National Innovation System (NSI) responded to the failure to integrate institutions into economic theories and to explain technological gaps and competitiveness (Godin 2007). This framework established that in a research system—part of a larger system composed of sectors such as government, university,

and industry—the main purpose would be to create innovation (Godin 5). However, the NSI approach was relatively general and unable to schematize systems typologically (Cooke 2001). Moreover, the NSI did not consider that innovation systems might have different features and evolutions in different sectors, which explains why some sectors often have different patterns of advancement than others (Malerba 2009).

Therefore, the concept of Sectoral System of Innovation (SSI) was introduced to provide detailed empirical research of firms' capabilities and learning processes to better understand how they contributed to greater innovativeness and competitiveness (Cooke, 2001). The SSI framework involves mapping out the boundaries of the innovation system of specific government agencies dealing with innovation development, policy framework, suppliers, service providers, and regulation agencies. It then tracks the knowledge flows among these various actors within the system.

Considering the particular characteristics of the electronics industry in Jalisco—high-speed of technical change, extreme competitive pressure, and specific role of MNCs as the major drivers of innovation and production—it is necessary to understand strategies for improvement and innovation considering the variety of actors, networks, institutions, and the type of knowledge and technology. The electronics sector of Jalisco has been recognized as a sectoral space that has combined a number of actors and institutions oriented to innovation. That is why this work is based on a “sectoral system of innovation” to examine the process of interaction and cooperation of the electronics industry in Jalisco, as well as the impact of government strategies, in its development of innovative activities that involve product and process innovations. Moreover, understanding the different typologies of innovations, such as incremental or radical innovation, will help to analyze the impact of these innovation activities on the economic growth and productivity of Jalisco.

According to Malerba (2005), every sectoral system of innovation has at least three blocks: (1) knowledge, technological domain, and boundaries; (2) actors, relationships, and networks; and (3) institutions. The focus on knowledge and technology places the issue of sectoral boundaries at the center of analysis while knowledge plays a central role in innovation. Knowledge differs across sectors in terms of domains. The electronics industry of Jalisco analyzes the firms that have been

developing the technological and organizational capabilities because in a SSI, firms are the key actors in the generation, adoption, and use of new technologies; the boundaries of sectoral systems are affected by these knowledge-based technologies.

Second, sectoral systems are comprised of heterogeneous agents. The agents might be firms and non-firm organizations such as government agencies, universities, and local authorities. Additionally, relationships and networks are key elements of the innovative and production processes. As we already mentioned, the knowledge creation process becomes increasingly inserted into various forms of networks. In the case of the electronics sector of Guadalajara, the creation of knowledge was at the regional and international levels. Therefore, it is also important to explore the role of the global production network in the global electronics industry and how, simultaneously, it affected the innovativeness and competitiveness of the electronics firms of Jalisco.

An adequate sectoral system will provide the locus of intersection of numerous networks generating particular kinds of knowledge. Considering that each of these networks has different members and different purposes, it is necessary to have a great ability to manage these network relations so that they can contribute to the innovation process (here, the role of the state to manage the networks). Third, in all sectoral systems, institutions play a major role in affecting the rate of technological change, the organization of innovative activity, and performance. Thus, “in a sectoral system perspective, innovation is considered a process which involves systematic interactions among a wide variety of actors for the generation and exchange of knowledge relevant to innovation and its commercialization” (Malerba 2004). Therefore, this analysis will emphasize the role of the bridge institutions created by the state government in Guadalajara in order to explore the innovative activities to develop regional capacity.

To continue forging a strong system of innovation, a recurrent issue is to identify system failures, knowing the character of the system failure allows policy makers to know whether to influence or change organizations or institutions or the interactions between them (Malerba, 2004).

Thus, this framework analyzes the importance of understanding the implications of government intervention through public policy in co-evolutionary processes. In an

innovation system, it is essential to have the appropriate organizations and institutions to promote innovation. A strong sector of innovation requires the widespread evolution of public innovation support systems along with an even stronger institutional and organizational support system from the private sector.

3. Development of the electronics industry

3.1. Introduction

Competitiveness has always mattered to industrial growth, but its nature has evolved. Rapid technical change, shrinking economic distance, new forms of industrial organization, tighter links between national value chains, and widespread policy liberalization are all altering radically the nature of the environment in which enterprises operate. Competitive dynamics have reshaped the industrial organization of the electronics industry in part because of extremely rapid changes in technology and markets (Ernst, 2000). As a consequence, the electronics industry is one of the most dynamic and globalized industries in the world and is considered by many to be an essential component of modern technology, because it has become relevant to the developmental process of a country. For instance, most of a country's technological progress is determined on the basis of their capabilities in this area (World Bank, 2008).

The transformation of the industrial cycle of the electronics industry has been important for economic growth due to its role in innovation and competitiveness processes. For Mexico, since the mid-1980s, the industry of electronics and computers has been an integral part of the economy. Mexico, like many other developing countries in Latin America and elsewhere, moved in the 1980s toward a liberalized trade regime after a long period of import-substituting industrialization. For the purposes of this paper, it is important to explore the historical context of the national trade and the industrial policy in which the electronics industry has been immersed. Since the transformation of the Mexican economy, manufacturing exports has become a strategic engine of growth in the economy. Within the manufacturing sector, the electrical and electronics industry has become one of the most dynamic in the Mexican economy. In the 1970s, the electronics industry started to consolidate in the metropolitan region of Guadalajara, and the region started to receive its first original equipment manufacturers (OEM) and then contractor manufacturers (CM). By the 1990s, the electronics sector was one of the

better performing branches of Mexico's manufacturing industry and attracted greater foreign investment due to the liberalization of imports and the North Atlantic Free Trade Agreement (NAFTA). However, the electronics industry in Mexico collapsed from 2001 to 2004, mainly because of the global electronics crisis (2001-2002) and the emergence of China as Mexico's main competitor, but also because of some internal weaknesses in the industry, such concentration in the stages of assembly and manufacturing.

This chapter has two purposes: first, to address the industrial cycle of the electronics industry as well as its role in innovation and competitiveness; and second, to explain the origin and growth of the electronics industry in Mexico since the establishment of the world economic structure in the 1980s and 1990s. This review seeks to provide a well-grounded understanding of the perspectives and dynamics of the electronics industry in Mexico before and during its electronics crisis of 2001-2004. This chapter is organized into three main sections. The first section describes the trend of the electronics industry and its role in the global economy. It also explains the relationship between global electronics and competitiveness, followed by a description of innovation in the electronics industry as a major factor enabling competitiveness.

The second section will provide a historical narrative concerning the evolution of the electronics industry in Mexico, focusing specifically on the changes in government interference ranging from import substitution industrialization to neoliberal policies. The third section will present analyses of the development of the electronics industry in the state of Jalisco, covering the nominated "golden era" of electronics during the 1990s to its collapse in 2001. Analyses will concentrate on the main factors that accounted for the failure of the industry, with a central focus on the debate over the benefits of the liberalization strategy in the region. Finally, the fourth, or review, section will point out the most relevant findings regarding future challenges for the electronics industry and delineate the lessons learned from its decline from 2001 to 2004.

3.2. The International trends of the electronics industry

The electronics industry can be tracked through the 1950s and 1960s to the emergence of radio techniques and silicon chips, respectively. Since its origin, the

electronics industry has been re-inventing itself, mostly because of a substantial R&D investment becoming a highly globalized and strategic industry. In the 1970s electronics boomed with the appearance of consumer electronics such as TVs, VCRs, Walkmans, and more. Nowadays the industry involves the production of manufactured products, ranging from consumer electronics such as mobile phones, TVs, DVDs, and MP3 players or PCs to professional electronic equipment such as automotive equipment, IT infrastructure, and electronics used in manufacturing.

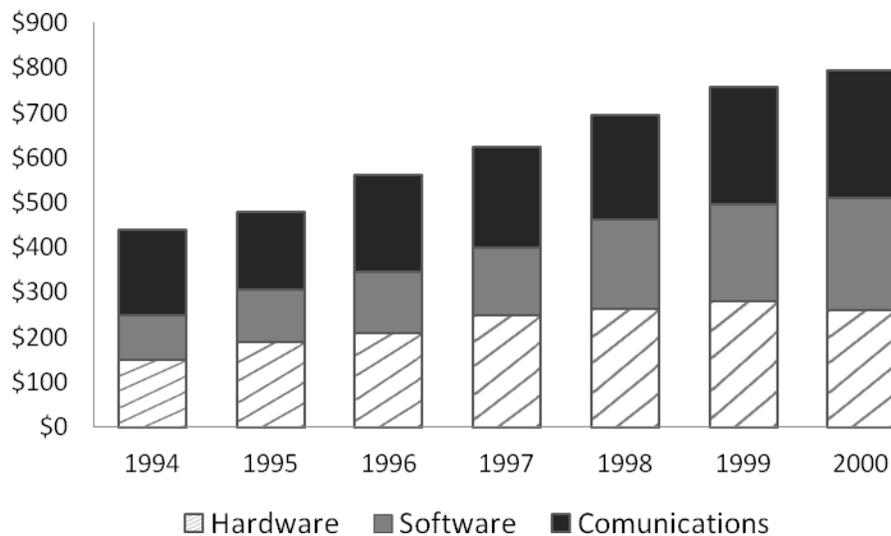
The structure of the electronics industry is integrated from a large technological system that articulates common parts. As a result of its continuing re-invention, is difficult to identify its borders and how it is distinct from other productive sectors that consume large quantities of electronic components, like aeronautics or optical electronics. (Dabat & Ordóñez, 2009) As Ernst (2000, p. 1) states, “Products are insufficient to define an industry when specialized suppliers exist; when there is complex market segmentation and abrupt change in demand patterns; when there is intensive and unpredictable technical change; and when financial institutions accelerate the pace of industrial restructuring and increase uncertainty.

The electronics industry has different subsectors: semiconductors, software, computers, telecommunications, industrial equipment, and consumer electronics. Because all of these subsectors have different levels of exposure to globalization and knowledge intensity, it is easier to catalog them into two main groups, consumer electronics and professional products. Consumer electronics (television receivers, radio receivers, sound equipment) require high volume production and the production of low and mid range components, so they are mainly concentrated in low labor-cost locations. (Dabat & Ordóñez, 2009) On the other hand, professional electronic equipment such as computers, computer accessories, telecommunication equipment, medical equipment, components, and semiconductors are low volume production and at a high-end knowledge intensive stage of the value chain.

The most important subsectors—due to their weight, dynamism in production, and global trade—are semiconductors, software, computers, and telecommunications equipment. As we can see in figure 3-1, these four subsectors were dynamic during the 1990s; communications within electronics has grown exponentially in both industrialized and

emerging countries. This rise was due to the reduction in component prices driven by high productivity, which involved major innovations in specialized software and equipment upgrades and installations

Figure 3-1 Recent global dynamics of large sectors of the SE-I (USD billions)

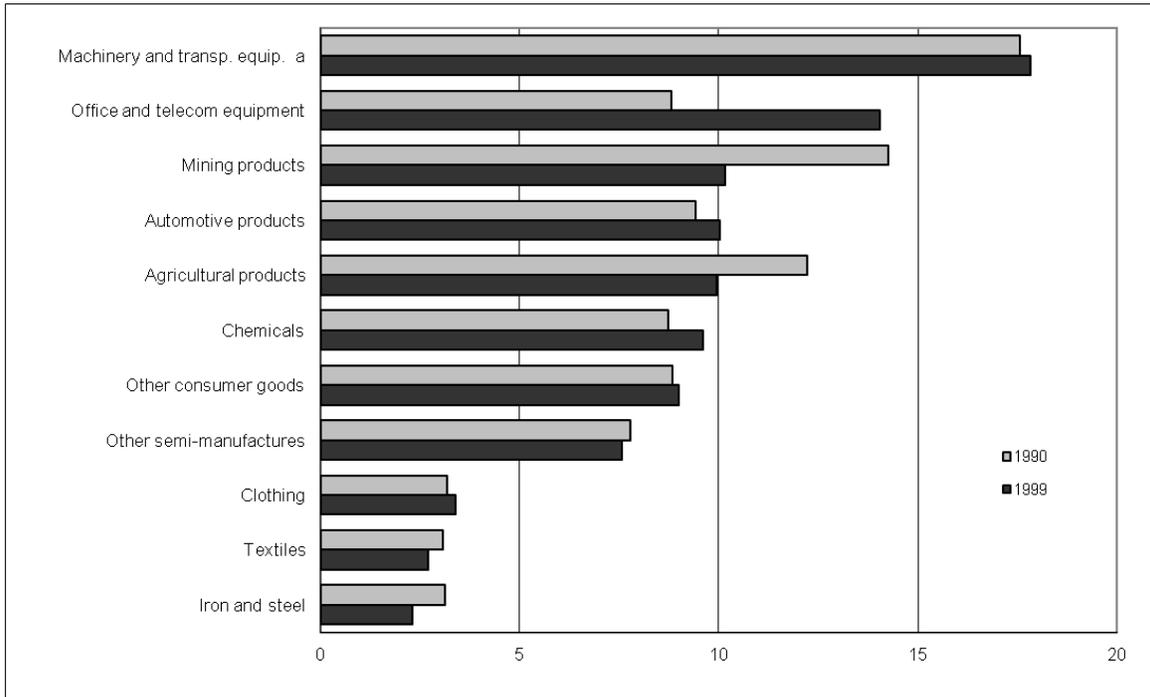


Note. Adapted from: Dabat, A y Ordóñez S. (2009), *Revolución informática, nuevo ciclo industrial e industria electrónica en México*. IIEc–UNAM-Casa Juan Pablos; México, Distrito Federal 2009

3.2.1. Determinants of commercial performance (Global trade)

Not surprisingly, due to its large flows of global trade, the electronics industry is one of the most dynamic and important industries and is of critical importance in enhancing productivity, competitiveness, and long term growth. As we can see in figure 3-2, during the nineties, trade in electronics showed the highest growth rate compared to other manufacturing sectors, such as automotive or chemicals.

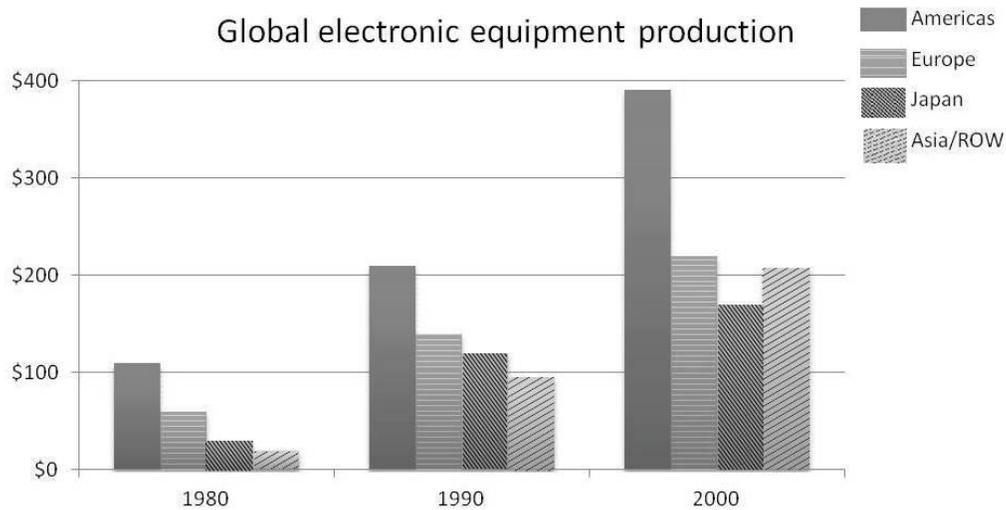
Figure 3-2 World merchandise exports by product, 1990 and 1999



Source: World Trade Organization 2000

The role of electronics as a new axis of world trade and changes in the international division and inter-industrial labor induced an accelerated growth of internationalization, mainly in the United States. The consequences of this new industrial cycle changed the economic balance of power between the major industries like Japan, France, and Germany in favor of the U.S (due to its technological leadership), and similarly brought even more unequal consequences for countries and peripheral regions as is the case of Finland or Asia (Dabat & Ordóñez, 2009) (see figure 3-3).

Figure 3-3 Global electronic equipment production



Note. Shiu-Kao Chiang (2001); used with permission.

This unequal balance is due to highly concentrated, internationally dispersed value chains of the electronics industry, resulting in a spread of global production networks (GPN). This new model of industrial organization indicates that electronics in dominant countries or regions integrate diverse supplier and customer bases of global network flagship companies and therefore have access to lower-cost foreign capabilities that are complementary to the flagship's own competences. As a result, the biggest firms of the electronics industry have a combining cost reduction, product differentiation, and time-to-market (Ernst 2000).

The spread of the value chain led to greater fragmentation and international outsourcing of production and services, with Mexico being a major target due to its geographical proximity and trade liberalization with the U.S. We will explore in chapter three the diverse factors that make Mexico a part of this industrial cycle.

3.2.2. Determinants of competitiveness

In many industries the essential core of competition is the subject of a profound change whose rhythm is relentless and constantly increasing
(Anonymous)

To know the possible sets of strategies that governments can use to incentivize the competitiveness of the electronics industry, it is important to understand the drivers that are affecting its competitive dynamics. The manufacturing process is an aspect of these competitive dynamics, but even more important is the capacity to develop innovative architectural designs to obtain competitive success. According to Ernst (2000, p. 18), “[T]he industry need[s] to develop innovative architectural designs that can provide cost-effective solutions to the manifold trade-offs that exist between size, storage capacity, and access time of these drivers.” Some of these solutions are a high and growing knowledge intensity combined with the rapid pace of change in technologies and markets.

Such has been the case of the North American region, which has a continued growth in electronics production due to its domain in high performance computing, military and industrial electronics, and telecommunications systems. Moreover, they have been trying to improve participation in the industry by focusing on the production of advanced communications and computing hardware infrastructure to support the growth of the Internet (Shiuh-Kao Chiang, 2001).

However, it is also vital to understand that the industrial organization of the electronics industry is shaped by determinants of market structure and firm behavior. Therefore, its continuous transformation is the result of a particularly rapid change in technology and market (Ernst, 2000). In the specific case of developing countries, proximity and local sources of competitiveness need to be used to upgrade the industry to sustain income in the face of increasing competition in these global markets.

For instance, one of the obstacles that producers face in developing countries is the pressure to meet the strict requirements of the export market, which most of the time are not applicable to their domestic markets. When the capabilities of the domestic market are not the same as these requirements, buyers force improvement, demanding consistent quality and supply. If it is not possible to ensure that products and processes

meet the required standards, buyers need to intervene by investing in some suppliers to upgrade the electronics industry (Humphrey & Schmitz, 2000).

We already see in the global production networks of the electronics industry the strategies used by developing countries focused on the manufacture of goods rather than the generation of services while the industrialized countries (United States and Western Europe) specialize in knowledge and the communications industry. However, even though developing countries mainly specialize in manufacturing equipment such as information equipment, computers, and semiconductors, the dynamics of innovation and diffusion are relevant in these emerging economies. They have begun to generate some competitive advantages to participate in the value chain of information technology from the global production linkages (Ham, 2006).

To sum up, the electronics industry is a work in progress. It is important to analyze different periods and understand the relationship between market structure, conduct, and performance in terms of how to move this project forward. The industry can take clear shape over the next ten to twenty years because to foster competitive success, each period requires different sets of strategies and policies (Ernst, 2000). The different sectors of the electronics industry will likely continue maintaining high growth rates worldwide, and it will be possible to push other sub-sectors. However, this boost will depend on the success of the strategies of each country to integrate the supply chains involved in the manufacture and development of new electronic products.

3.3. The Beginning of the Electronics industry in Mexico

The first stage of the electronics industry in Mexico started in the 1940s with the production of radio and television parts and components. By 1970, the industry expanded to communication equipment and apparatuses. During this stage, the industry's market structures were oligopolistic and led by foreign firms, but Mexican firms accounted for 85–95 percent of the value-added content of television production (Gallagher & Zarsky, 2007). Most of the electronic firms were devoted to making parts and components designed almost exclusively for use in consumer goods and destined only for the domestic market, which consisted mainly of state-owned enterprises. By the

late 1970s/early 1980s, the electronics industry was declining. The deficit started to increase since the levels of imports of professional and scientific electronic products grew dramatically. The industry lacked competitiveness (price, quality, and type of product), innovative skill, and the capacity to enter international markets and suffered from insufficient production scales (Peres, 1990). Simultaneously, the Mexican economy was in crisis due to large external debt and dramatic inflation. Between 1982 and 1985, Mexico tried to respond to the crisis with a desperate plan based on the Import Substitution Industrialization (ISI) model. Miguel de la Madrid (president of Mexico from 1982 to 1988) initiated the Program of Immediate Economic Reorganization (PIRE) with the intention to restore financial stability through peso devaluation and a cut in the government's deficit. De la Madrid decided to restrict trade, and tariffs were increased to 100 percent of the value of all imports (Gallagher & Zarsky, 2007). The government decided to create a plan to force the electronics industry to participate in worldwide progress. Thus, the government changed the structure of the electronics industry and created the first electronics industry policy in the country. This industry policy was in the form of protectionist development programs that sought to stimulate import substitutions and raise the amount of locally-produced components. The government protection over the electronics industry consisted of tax incentives, trade protection, and the allocation of import quotas (Peres, 1990). The vision of the government at that time was to create a nationally integrated electronics industry with the following three main goals: 1) to have an industry funded by at least 51 percent Mexican capital; 2) to promote national technological development (it demanded linkages between academia and the productive sectors); and 3) to provide jobs and technical training (Peres, 1990).

By 1986, the electronics industry policy started yielding good results. Mexico started to export mini-computers produced locally, and the industry began to have strong export capacity. For instance, according to the IBM Annual Report for 1987, the company in Mexico was exporting 95 percent of its output and importing just 30 percent of its computer products, while just 6 years earlier, the deficit for computer products was nearly 100 percent of imports. Moreover, Mexico was able to attract major international firms (at only 49 percent ownership) and build a domestic industry (Peres, 1990).

3.3.1. *The exports boom of the electronics industry in Mexico in the 1990s*

By the late 1980s, the failure of the PIRE macroeconomic program was evident as Mexico continued its financial instability. Thus, the Mexican government decided (under pressure from the World Bank and IMF) to adopt neoliberal policies that favored the market over institutions and the international economy over the domestic economy. This tightened fiscal and monetary policy privatized state-owned enterprises and, in general, reduced the role of the state in economic affairs. The expectation was that the new strategy would trigger technology transfer to the country that would automatically spill over into the broader economy (Shafaeddin & Gallagher, 2010)

With the adoption of neoliberal policies, the government changed its vision and policy for the electronics industry as part of its plan to open the economy. Despite the fact that some scholars (e.g., Dabat 2004) state that the electronics industry represents a key element in Mexico's transition from a protected economy to an open structure that concentrated mainly on export manufacturing.

Meanwhile, in the international arena, there were three conditions that fostered the growth and exports of the electronics industry. First, there was a global transformation as the electronics industry became a new axis of global trade dynamic, implying a greater appreciation of the knowledge contained in the production and the imposition of technological standards in competition. Then there was an intense exacerbation of international competition between countries and regions, and finally the implementation of NAFTA (Dabat & Ordóñez, 2009). With the beginning of NAFTA, the electronics industry passed through an extreme process of tariff liberalization from 3.9 percent in the late 1980s to its total elimination in 1994 (Dussel, 2003). Moreover, the government changed the main objectives of the electronics industrial policy implemented in 1982. Because there was a desire to increase FDI inflows and boost exports, the government allowed whole-ownership by foreign investors as an exchange for two types of commitments. First, multinational companies (MNCs) should achieve economic goals by increasing exports. Second, they should promote technical development by transferring technology and investing in R&D (Rivera, 2010). During the nineties, the

electronics industry was one of the most dynamic sectors in the Mexican economy (see Table 3-1).

Table 3-1 Dynamics of the electronics industry in Mexico (1989-1999)

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP (% over total)	0.61	0.63	0.58	0.54	0.56	0.63	0.76	0.89	1.08	1.2	1.17
people employed total (% over total)	0.66	0.66	0.66	0.65	0.67	0.68	0.72	0.8	0.92	1	1.06
Productivity (% over total)	1.02	1.19	1.1	1.08	1.14	1.2	1.14	1.18	1.29	1.34	1.34
Imports/GDP (%) total	13	13.6	13.8	15.1	13.8	15.7	17.8	20.3	21.1	22.4	21.7
	8	9	9	2	2	8		2	7	8	8
Exports/GDP (%) total	10.9	11.0	9.25	8.22	8.06	8.84	17.8	19.4	17.9	16.5	16.4
	8	7					4	5		9	2
Balance trade/GDP (%) total	-2.02	-2.62	-4.64	-6.91	-5.76	-6.94	0.04	-0.87	-3.27	-5.88	-5.35

Source: Dussel, 2003, Empleo: manufactura y electrónica (1995-abril de 2002) [Table 2] La industria electrónica en México: problemática, perspectiva y propuestas/Dussel, E., J. J. Palacios y G. Woo, Universidad de Guadalajara, México

3.4. The electronics industry in Jalisco

Mexico's ability to attract FDI in the post-NAFTA period was impressive. The openness that Mexico experienced at the beginning of the 1990s marked the beginning of the electronics sector in Jalisco, encompassing a vast number of world-class innovative and design corporations, denominated "original equipment manufacturers" (OEMs) (Rivera, 2010). By this time, the central part of Jalisco, including the city of Guadalajara, became known as the Mexican Silicon Valley (Palacios, 2003). In the second half of the 1990s, the electronics industry in Jalisco experienced its major period of prosperity due to the mass arrival of the contract manufacturers (CMs) due to the advantages associated with Mexico's location in the North American market. In addition, Guadalajara has a strategic location in Mexico and a variety of local advantages such as

domestic and continental transport and communications networks, abundant labor supply, friendly worker unions, and a reasonably efficient industrial infrastructure (Palacios, 2003). The metropolitan region of Guadalajara is a preferred destination for investments from national and foreign companies and investors

All of these factors contributed to the performance of the electronics sector in Jalisco, which was spectacular until 2000, when the electronics industry's revenue reached \$10.420 million (Table 3-2). Jalisco increased its participation in the industry to 3.55% in 1996 and to 7.89% in 1999 (Dussel, 2003). The boom years of the 1990s were known as "The Golden Age of the Mexican Silicon Valley."

Table 3-2 General characteristics of the electronics sector in Jalisco (1994–2001), (FDI, employment and exports)

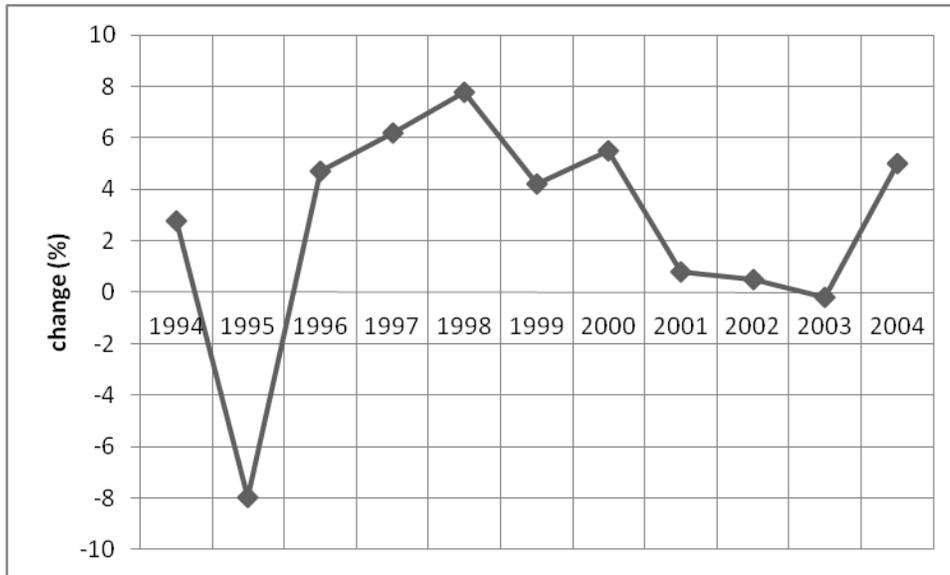
	1994	1995	1996	1997	1998	1999	2000	2001
Employment	12,360	17,250	29,000	50,000	60,000	80,000	70,000	45,000
Exports (M USD)	1,660	2,300	3,500	5,200	6,440	9,029	10,420	9,500

Source: Dussel, 2003, Empleo: manufactura y electrónica (1995-abril de2002) [Table 5] La industria electrónica en México: problemática, perspectiva y propuestas/Dussel, E., J. J. Palacios y G. Woo, Universidad de Guadalajara, México

3.4.1.1. The importance of the electronics industry in Jalisco

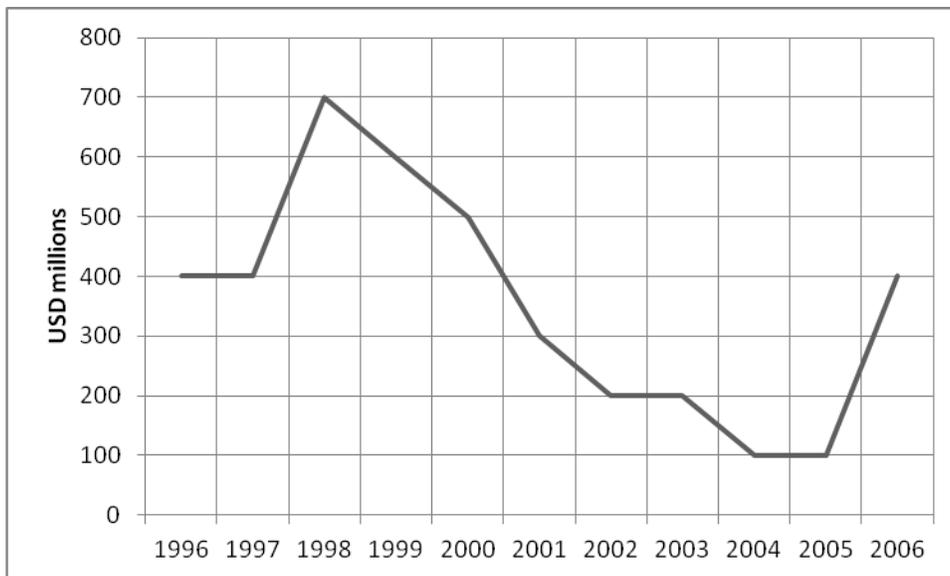
As seen in Table 3-2, the electronics industry has become a major economic sector in Jalisco. For instance, the GDP of Jalisco has been affected by the expansion and crisis of the electronics industry. As shown in figure 3-4, the impact on the GDP was drastic in 1998, when investment in the electronics industry reached a record high (see figure 3-5). Similarly, we can observe in the figure 3-4 a decrease in the GDP from 2001 to 2003, which corresponds to years of the electronics industry crisis (Palacios, 2008).

Figure 3-4 Annual Amount of Investment in Electronics Industry in Jalisco, Mexico, 1994-2006



Note. Palacios (2008); used with permission.

Figure 3-5 Jalisco, Mexico: Annual Gross Domestic Product, 1994-2006



Note. Palacios (2008); used with permission.

However, despite the dramatic growth of the Mexican Silicon Valley, the electronics industry in Jalisco reversed its growth process from 2001 to 2004. This

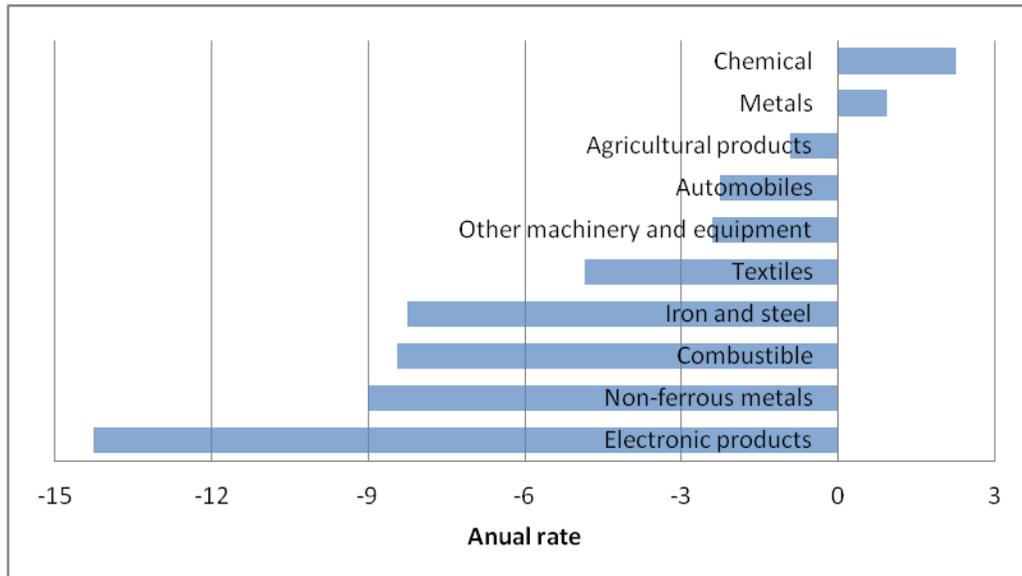
reversal was due mostly to the end of the IT bubble in the United States and the emergence of China as a competitor.

3.4.1.2. The collapse of the industry (2001–2004)

The global economic crisis of 2001 and 2002 led to a radical transformation of the global industrial cycle that reversed the rapid growth of production and international trade in the previous decade, which had been focused on the dynamics and diffusion of the electronics industry of the United States. This economic crisis was caused by an over-accumulation of capital and a decline in corporate profitability, precipitated by the bursting of a huge stock market bubble centered on the most dynamic industry: the electronics industry and the Internet (Dabat & Ordóñez, 2009). According to Dabat (2004, 2009), the global electronics crisis was characterized by 1) a strong increase in the manufacturing costs of new generations of semiconductors; and 2) the increasing miniaturization and complexity of the wafer and the consequent lower unit cost of manufacturing an integrated circuit.

There was a contraction of the U.S. market and production, particularly in the electronics industry: while the sales of all goods and services were reduced by 5.7% and 2% in 2001 and 2002, respectively, the electronics products were reduced by 12.8% and 11.6%. Globally, the contraction of world electronics exports exceeded any contractions occurring in other industries and constituted the center of the contraction of world trade in 2001 (See Figure 3-6).

Figure 3-6 Growth of world exports of major goods, 2000-2001 (annual rate)



Note: WTO-ITS, 2002

As result of this global crisis, Mexico also experienced a period of contraction of electronics exports from 2001 to 2004 (Dabat, 2004). Moreover, Mexico lost its industry position in the international market. As we can see in table 3-3, Mexico lost its position in the U.S. market to China. China, a country with an exporting profile similar Mexico's, became the new emerging electronic-informatics exporter. As a result, Mexico also suffered the loss of the majority position in almost all the subsectors of the electronics industry.

Table 3-3 Electronic Design industry exports from Mexico to China and the United States 2000-2003 (USD billions, percentages and growth rates)

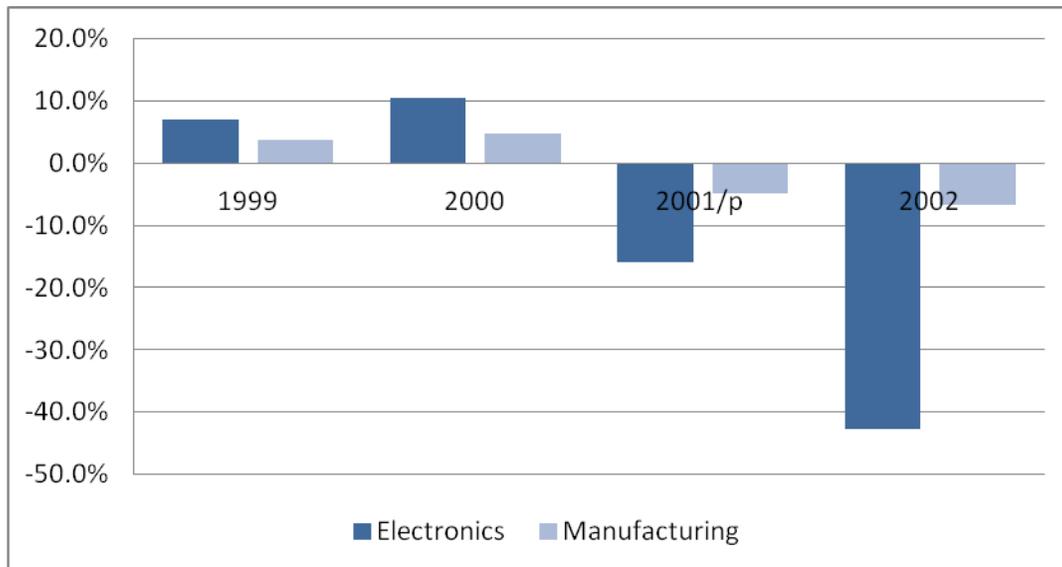
Sectors	Total U.S. imports		Exports from Mexico to United States			Exports from China to United States		
	Amount 2003	Average annual percentage variation 2001-2003	Amount 2003	Average annual percentage variation 2001-2003	% of U.S. imports 2003	Amount 2003	Average annual percentage variation 2001-2003	% of U.S. imports 2003
Components and Semiconductors	25.6	-18.7	1.2	-11.4	4.9	0.9	5.93	3.6
Telecommunications equipment	41.2	-2.17	7.3	-7.43	17.6	8.2	20.37	19.8
Computer complex	82.4	-3.8	7.5	-5.6	9.1	24.3	31.13	30.5
Consumer Electronics	31.3	5.93	7.0	-0.23	22.4	9.3	20.13	29.7
Instruments	15.3	-.01	3.1	6.8	20.6	1.2	-	7.7

Source: Dabat, A y Ordóñez S. (2009), *Revolución informática, nuevo ciclo industrial e industria electrónica en México*. IIEc-UNAM-Casa Juan Pablos; México, Distrito Federal 2009

The electronics crisis also reached the electronics sector of Jalisco. In 2000, the electronics industry in Jalisco faced a number of challenges, such as the emergence of Asian competitors, a new generation of products, global standards, and technological gaps.

Additionally, the electronics industry was extremely dependent on the North American market and therefore very vulnerable. As a result, and without surprise, with the global electronics crisis and the U.S. recession of 2001, the electronics industry in Jalisco collapsed and a vast number of corporations moved their entire line of production to Asia. According to the Suppliers Development for the Jalisco Electronics Industry (CADELEC), in 2001 there was a loss of 25,000 jobs, and the industry's exports rate dropped by 8.8 percent. The negative results of the electronics industry were well above the manufacturing sector. For instance, by 2002, the electronics industry had a loss of 42.7 percent of employment while the manufacturing sector as a whole was down just 6.7 percent. (Figure 3-7)

Figure 3-7 Employment growth in manufacturing and electronics sectors in Mexico (1995–2002)

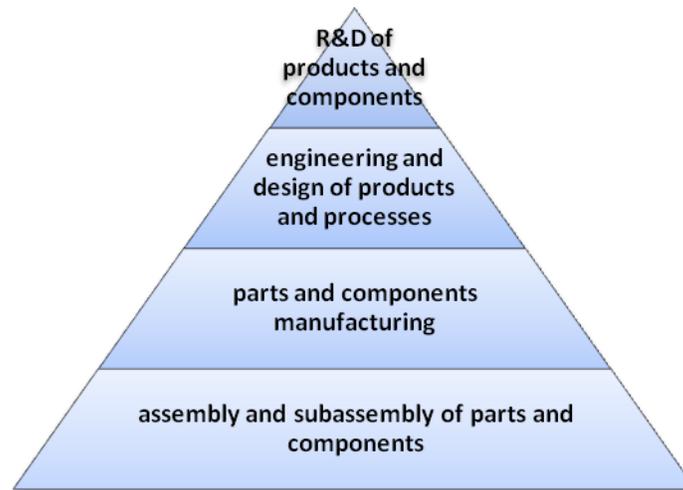


Note: Own elaboration based on INEGI 2012 (classification 322302)

However, the collapse of the industry and the decision of the corporations to move to Asia were not only due to the U.S. recession, but to declining competitiveness in Mexico. The fact that international firms had their own net of foreign suppliers (CMs) created a barrier for new potential local suppliers to participate in the value chain (Dussel, 2003). Competitiveness implies not just the continued pressure on prices but also flexibility, innovation, and skilled workers. The competition between countries to integrate various segments of the value chain in the computing industry is very intense, and many Asian countries, particularly China, had already started to integrate diverse segments of this value chain (Reina & Servín, 2007).

By the end of 2002, the industrial sector in Jalisco showed that the MNCs were not able to connect to the local economy, and as a result, there were important technological and training gaps. The electronics industry in Jalisco continues to be in the first level of the value chain of the electronics industry (Figure 3-8).

Figure 3-8 Representation of the value chain of the electronics industry, decomposed into the following segments, from lower to higher value added



Note: Adapted from Dussel Peters, Enrique, (2003), "La industria electrónica en México y en Jalisco (1990-2002) in La industria electrónica en México: problemática, perspectiva y propuestas/ Dussel, E., J. J. Palacios y G. Woo, Universidad de Guadalajara, México 2003

Rather than spill-overs to local firms through backward linkages, FDI brought the transformation of Jalisco's electronics industry into a foreign enclave dependent on imported inputs. Additionally, the fact that the electronics industry in Jalisco continued to be in the first stage of assembly and subassembly of parts and components affected the spill-over of human capital. According to the neo-classical approach, spill-over in human capital occurs when foreign companies hire local workers and managers and provide opportunities to upgrade their skills on the job or through training programs. But the experience of Jalisco is one in which the vast majority of the workers employed by CMs to assemble electronics products are generally low-skilled and receive only minimal initial training (Gallagher & Zarsky 2007). Therefore, in 2002, there was a necessity to rethink the development model of the electronics industry in Jalisco. Some of the strategies consisted of increasing the level of design (R&D) and the higher incorporation of education and training institutions (Dussel, 2003).

3.4.1.3. Challenges after the electronics crisis: R&D and Technology Transfer

Some scholars affirmed that because Mexico assumed that technology knowledge would cost less and be instantaneously transferred through trade and FDI,

there was not enough government effort aimed at building the capabilities of domestic firms (Shafaeddin and Gallagher 2010). However, Arechavala and Diaz (2007) noted that Mexico recognized the importance of investment in science and technology but was unable to design and implement effective mechanisms for investment.

For instance, spending on research and development by the end of the 1990s accounted for only 0.4% of the GNP, whereas Korea, which had previously been comparable to Mexico in terms of economic development, invested 2.4% of its GNP in the same year (see Table 3-4).

Table 3-4 Research and development spending in relation to GDP)

Country	1993	1999
Sweden	3.27%	3.80%
Japan	2.88%	3.04%
U.S.	2.52%	2.64%
Korea	2.22%	2.46%
Germany	2.35%	2.44%
France	2.40%	2.17%
United Kingdom	2.21%	1.87%
Canada	1.63%	1.66%
Italy	1.13%	1.04%
Spain	0.91%	0.89%
Chile	0.65%	0.63%
Argentina	0.00%	0.47%
Mexico	0.22%	0.43%
Brazil	0.61%	na

Source: CONACYT, Indexes of scientific and technological activities 2000.

In the case of Jalisco, there were some government initiatives to promote technological transfer. Since the late eighties and during the nineties, research and development activities started to be developed in the metropolitan region of Guadalajara. These activities are categorized into two groups: 1) subsidiaries of computing and telecommunications giants, such as IBM, HP, and Lucent Technologies, and 2) academic centers and design companies created by local business and technicians such

as CINVESTAV (Palacios, 2003). According to Rivera (2010), this development process led to the emergence of the triple helix as a public policy measure. The triple helix strategy consists of the funding role of government, its participation in the design of scientific-technological, educational, and industrial policies to increase efficiency, and the assimilation of foreign technology into the national manufacturing system. It also sought to improve competitiveness. Some of the research and design centers that emerged were the Research Center for Advanced Studies (CINVESTAV), the Semiconductor Research Centre (CIS), the CDI of Intel, the CIPIC, and the government-funded Design & Research Centre (CIJALDE). There was, to some extent, an academia-industry relationship that took the form of, for example, “donations of hardware or software sample programs; professional summer study; new course development; research council participation; applied research linkage; and donation of equipment” (Rivera p. 544 2010). The goal was that the relationship would generate employment, classroom interfaces, and internships for current students. However, this academia-industry relationship did not have a significant impact on innovation capacity, mainly because participation was very selective, and only few academic institutions were able to join the programs (Rivera, 2010). Scholars as Shafaeddin and Gallagher (2010) note that government support should strongly and clearly upgrade policies in higher education and on-the-job training and provide more support for university-industry cooperative research and coordination on business incubation.

Reinforcing this perception, some scholars suggest that the Mexican government did not tightly control the upgrading of the industry in Jalisco (Palacios, 2003). Despite the export boom, FDI, and the government’s efforts to transmit technology to the Mexican Silicon Valley during the decade of the 1990s, the application of high technology was not possible (Palacios, 2003).

3.5. Conclusion

After Mexico adopted neoliberalism and applied the liberalization strategy of FDI to stimulate technological transfer and economic growth, most believed that the electronics industry, as one of the most dynamics industries for FDI, would prove the success of the neoclassical economic approach. However, the crisis of the electronics

industry in 2001-2002 helped highlight two main problems. First, FDI did not bring the desired benefits of new technology and new skills that are necessary to compete globally as a higher-value chain industry. Second, the government failed to understand and shape appropriate responses to the global economy and industry dynamics. The collapse of the electronics industry in Jalisco from 2001 to 2004 is evidence of the mixed results of the Washington Consensus and a testament to the statement that there is a need to bring the state back into the development of theory and policy. By the mid-2000s, there was no doubt that the Mexican government had to take a proactive role in building institutions and enacting policies that not only attracted foreign investment but also raised local capacities for production and innovation. Moreover, it was especially important to enact government-sponsored efforts to improve educational capabilities.

4. From Electronic to High Tech industry: the case of Guadalajara

4.1. Introduction

As we saw in the previous chapter, FDI is one of the most significant technology transfer mechanisms, and multinational corporations (MNC) are the players who decide where and when to make this investment. While it is true that the foreign investment that they bring to developing countries has significantly influenced the growth of innovative capabilities, FDI is not a sufficient condition for technology development and competitiveness. In order for FDI to be effective, the government needs to intervene to guide the FDI inflows through the development lanes of the host country (Hira, 2007).

Such has been the case for the electronics industry in Jalisco, which, through the intense process of foreign investment by major transnational companies and OEMs, gave rise to an electronics export industry that made Mexico one of the most important exporting countries during 1990s. However, it also implied that foreign investment alone was insufficient to increase the local capabilities and that the major condition for successful technology transfers through FDI is the appropriate interference of the government (Dabat & Ordóñez, 2009).

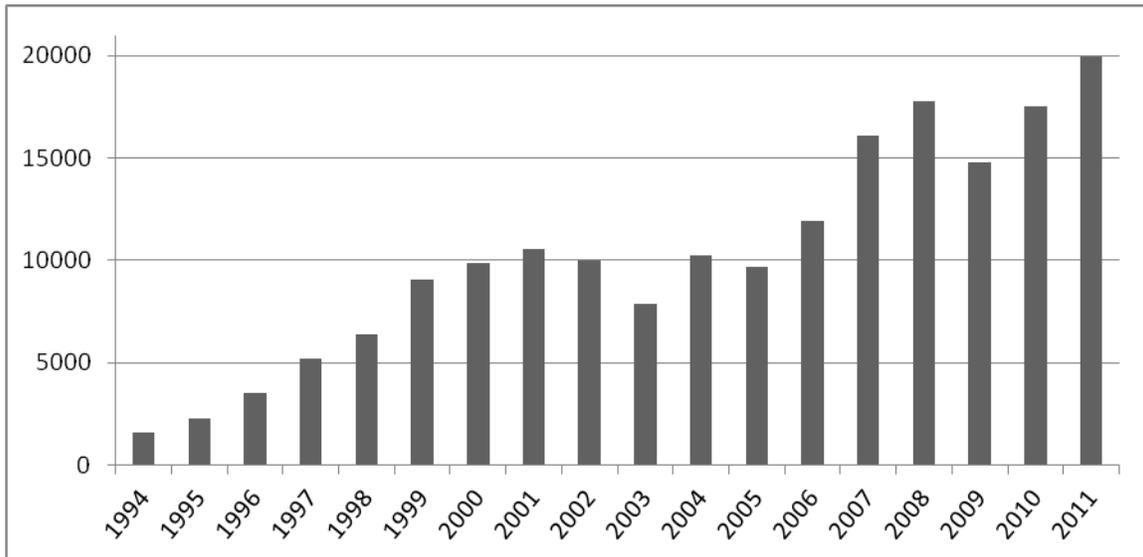
Despite the surge in exports from the electronics industry in Mexico during the 1990s, the collapse of 2001-2004 revealed at least three main concerns in the development of the electronics industry in Jalisco. First, the industry was still in a stage of low technological and business development, at least compared to the major technological powers in East Asia. Second, it was undeniable that U.S. and Asian companies included not only large design companies and brand owners, but also contracting firms. Third, Mexico's electronics industry was concentrated in the stages of assembly and manufacturing, which was encouraged due to the country's low labor costs.

This chapter describes the recovery of the electronics industry in Jalisco after its collapse in 2001-2004. More specifically, it looks into the most important changes in technological and productive processes that allowed an industry based on manufacturing in the 1990s to evolve into a more integrated and diversified industry in the mid-2000s. As discussed in Chapter 2, the driving elements of the analysis are knowledge, capabilities, and a variety of actors, interactions, and institutions. These aspects are key for understanding the innovation, competitiveness, and growth of Jalisco. We examine first the strategies of the sector state government to upgrade the industry in terms of institutional factors. Then, we move to the leadership function of multinational corporations within the overall dynamics of competition and innovative performance. Next, we turn our attention to network complexity, focusing on the collaborations and conditions required for its production. Finally, we apply our conceptual framework to explore the factors affecting innovation and competition in the electronics industry of Guadalajara.

4.2. The upgrade of the industry

As we saw in the previous chapter, the areas most affected by the electronics crisis in Jalisco from 2001-2004 were exports, foreign investment, and employment, the decline of which, in turn, caused a decline in the GDP of Jalisco. However in 2004, exports from all sectors of the electronics industry experienced a recovery. (see figure 4-1), the recovery of the industry was based on the accelerated mode reconversion of targeting development, consisting of a process of industrial upgrading in global value chains and the reorientation of production toward sectors of rapid growth (Dabat & Ordóñez, 2009). Specifically, the process of industrial upgrading in global value chains has the following characteristics: a) improvement of the design, and b) upgrading manufacturing processes toward more knowledge intensive, higher value-added products that require a greater variety of components and the production of smaller series (Dabat & Ordóñez, 2009).

Figure 4-1 Exports of electronics industry in Jalisco, 1994-2011 (USD millions)



Source: SEIJAL 2012

The recovery of the industry also had an impact on employment in the region; from 2005 to 2011, it was the second-largest generator of jobs, just behind the food industry (see Table 4-1). In 2009, at the national level, Jalisco contributed 14% of the personnel employed in the electronics industry, with 42,294 people. Currently, Jalisco is in fifth place, with 43,358 insured workers contributing only 9% percent of workers in the electronics industry (Seijal, 2012).

Table 4-1 Insured workers in the industry of transformation of Jalisco 2005-2011

Industry transformation	2005	2006	2007	2008	2009	2010	2011
Food processing	56886	57863	60291	60838	60979	63445	64464
Manufacture and assembly of machines, equipment, and tools and electrical and electronics parts	30918	32177	33781	36594	42325	47472	43358
Manufacture of metal products, except machinery and equipment	28677	29394	30954	30201	28630	30566	32407
Manufacture of rubber plastic products	22002	23667	24825	24147	24206	24924	26532
Chemical industry	19186	19660	20301	21203	21961	23394	24611
Manufacture of footwear and leather	17333	18102	18163	17162	17057	17527	17505
Elaboration of beverages	17402	17799	17970	17776	16317	16431	16698
Others	110106	114632	113789	103313	93602	99662	105099
Total industry transformation	302510	313294	320074	311234	305077	323421	330674

Source: SEIJAL 2012

4.3. Key actors and main characteristics of the electronic sectoral system in Guadalajara

4.3.1. The role of the government

As the SIS approach suggests, when there is a failure in the market mechanism and firms, state intervention is necessary to solve the problem (Malerba, 2004). In the case of the electronics sector of Guadalajara, to upgrade the previous electronics industry that was based on assembly and manufacture, it was necessary to promote an active industrial policy focusing on the integration of value chains. The government at the state level has played an important role in the generation of an institutional structure of productive and sectoral promotion (Oliver 2009). One of the key strategies of the government to upgrade the industry was the promotion of other tech industries such as design, software development, and digital animation due to their high added value that

could add to the industrial profile of the region. This public policy has been focusing on simplifying the conditions and resources such as financial, human, promotion of investment, and exports relevant to the development of the sector (Oliver 2009).

The guidelines of public policy relating to all activities with potential for regional development were concentrated on initiatives for the construction of both technological and organizational capabilities with the participation of educational institutions. The government of Jalisco, which in this case is represented by the Jalisco State Science and Technology Council (COECYTJAL) and the Productive Chain of Electronics Industry Suppliers (CADELEC), has been playing the role of facilitator and promoter by building up social capital and fostering the business-university relations. As a result, public-private partnerships emerged to promote conditions of intermediation between the main actors of the sector.

The public policy of Jalisco's government established in the "Sectoral Program of Science and Technology for Development 2007 – 2013" is to create institutions for the formation of human resources, while facilitating the formation of Centers of Research and Technological Development and creating institutions for the intermediation activities involved with education and research. Below are the most representative institutions that lead in public policy in Jalisco's government:

- Chain of the electronics industry (CADELEC) : Is a Spin-off from the National Chamber of the Electronics, Telecommunications and Information Technology CANIETI. Founded in 1997 by Solectron, Intel, IBM, JABIL, Lucent Technologies, its function is the development of local suppliers able to cover the needs of the industry and coordination of the industry efforts in this regard. It is supported by Jalisco State Government and CONACYT.
- Research Centre for Advanced Studies (CINVESTAV): CINVESTAV is a research center specializing in the electronics industry in Jalisco founded in 1988 by the National Polytechnic Institute (IPN). This center offers Master and PhD programs specialized in the electronics industry; carries out applied and basic research; conducts collaborative research projects; and provides technical assistance to enterprises in the electronics industry in the region, within Mexico and even in other countries. Several alumni have established their own firms (design houses). According to Padilla (2008) it is a model of what a public research center in a developing country can achieve. As Rivera (2010) states, the creation of this research center represented one of the first public policy measures that tie actors of the three different spheres of government-firm-university. For instance, one example of the important role of CINVESTAV was the firm TD-COM, a local ODM company founded for staff

formed in CINVESTAV, which created design projects for INTEL. By 2000, Intel acquired TD-COM for the quality of its employees, including Jesus Palomino, who became the General Manager of the new INTEL design center¹.

- Information Technology Institute of Jalisco (IJALTI). A civil association founded by COECYTJAL in 2002, its purpose is to form human resources in information and communications technology. Its intermediation activities are the certification and standardization of skills for the development of the IT-C sector, the promotion of technology transfer to strategic sectors of Jalisco's electronics industry, and the promotion of access to infrastructure, both hardware and software, to companies of the State. This institution is key to the government's strategy to develop technological skills as well as a bridge between educational organizations and the business sector.
- The Technology Business Incubator (ETI) Program for the Management of Innovation Technology (Proginnt) of ITESO: Intermediation activities and formation of corporate training through the use of resources provided by State government. In addition to the incubator, this organization provides services such as the Center for Competitive Intelligence and Management Consulting Center of Innovation and Technology. This organization is supported by the Ministry of Economy and the State Council of Economic Promotion. Since its creation in 2004, it has supported more than 45 technology companies in the region; over 85 percent are still active, with sales of more than 20 million pesos a year.

Some of these institutions were created before the collapse of the industry and have evolved. New institutions have been designed, which shows that the government of Jalisco has been able to develop strategies for an ongoing industry transformation. This denotes that within a sectoral system of innovation, organizational and institutional changes are particularly important in situations of rapid structural change (Malerba, 2004). Moreover these institutions coordinate some programs and tools that reflect the vision of turning the region into the hub for design activities in Latin America. (See table 4-2)

¹ In 2000, Intel acquired the design center of TD-COM

Table 4-2 Programs and tools to support local design sector in Jalisco

Programs	Coordinating Institution	Objective
State Software Program of Jalisco PROSOFTJAL	COECYTJAL and CANIETI	To promote the construction of physical infrastructure and telecommunications. To provide education and training of competent and software development.
Advanced Training Program in Human Resources Information Technology (PAFTI)	COECYTJAL	PAFTI is an intensive training program practical design and SW development.
Advanced Program in Human Resources Training for Semiconductors Technology (PADTS)	CINVESTAV	PADTS is an intensive training program emphasizing practical engineering work, specializing in electronic design.
The Software Center	IJALTI	This center provides adequate facilities and an environment conducive to business operations and small and medium software development companies; today it is home to 35 software development companies

Due to these instruments, the government of Jalisco has been a facilitator of the creation of a more high tech sector. As a result, the government has developed a tech industry that started to pay off since 2004, when there were 13 OEMs, 17 CMs, more than 400 SSs, 27 design houses, and 151 small indigenous firms dedicated to software development (Rivera 2010). Table 4-3 shows some of the most representative companies of each category. The IT industry, microelectronics, multimedia and aerospace industry in Jalisco, has an annual revenues of 650 million in 2005, which represented 1.4 percent of the GDP of the state. This is outstanding considering that in 2001 this sector was virtually nonexistent in the state. (Medina, 2007)

Table 4-3 Software sector of Guadalajara

Origin of capital	OEMs	CEMs	Design houses
Foreign	IBM Hitachi Intel HP Siemens VDO	Flextronics Yamaver Solectron USI Telect Mexicor	Global Vantaje Freescale Cadinmex Perot Systems Tata Consulting
National	Pegasus Resser ATR	Loganmex Serie	Medisist ASCI Soltec

Source: Oliver Ruben, (2011) *Innovación y eficiencia colectiva en el sector software en Guadalajara: La experiencia de 14 empresas pequeñas*, Editorial Académica Española

Moreover, the electronics sector of Guadalajara has been working in the higher value added segments (see table- 4-4). There is a clear strategy to achieve international standards in process capability

The state's policy is well defined going forward with respect to additional high technology to increase the competitiveness of the sector of Jalisco, and COECYTJAL has been a strategic actor in making Jalisco a major player in the new economy of information and knowledge (Interviewee)

In addition, the government is strengthening the software industry in terms of quality by the certification of companies under internationally recognized standards and models such as CMM and ISO 15504 (Gonzalez, 2009).

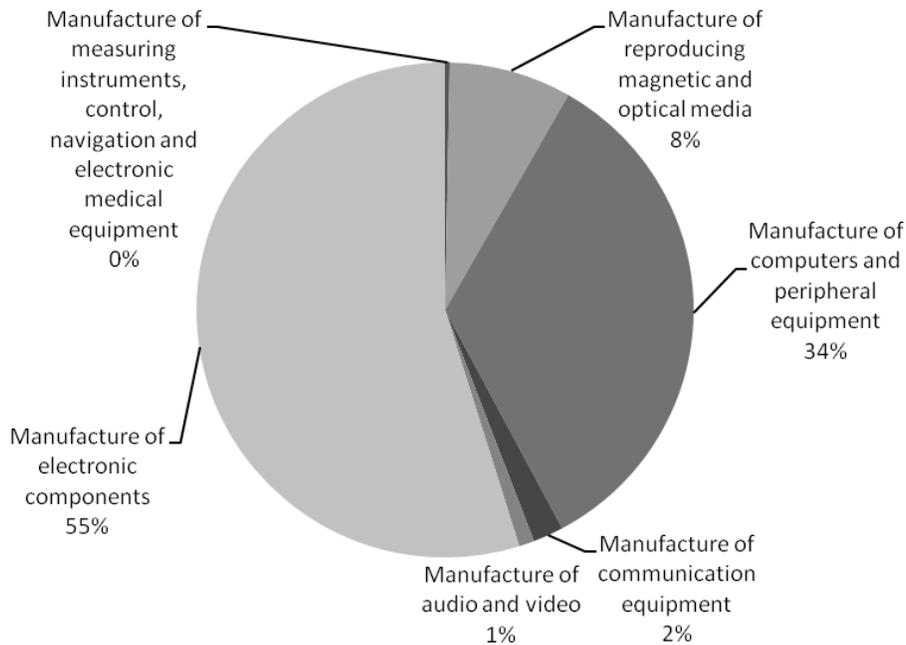
Table 4-4 Jalisco's higher value added segments

Testing software and hardware
Multimedia (animation special effects and 2D-3D)
Management systems-oriented database object
Internet applications (logistics and administration of the value chain)
Firmware and embedded software in microprocessors (Embedded software)
Design of semiconductors

Source: COECYTJAL 2005

According to the census, the gross value added (which represents the gains to be had with respect to production) in the national electronics industry in 2009 was 60,355,166 pesos, representing a share of 12%. The statewide gross value added in 2009 amounted to \$6,946,611, representing 12% percent nationally and constituting a 17% increase above the value added in 2004 (5,916,860). The main activities of the state sector were the manufacture of electronic components (55%) and the manufacture of computers and peripheral equipment (34%) (Seijal, 2012; see Figure 4-7).

Figure 4-2 Percentage of census participation gross value added by branch of the electronics industry, Jalisco 2009



Source: SEIJAL 2012

4.3.2. Universities and design centers

As mentioned, one of the strategies for the industrial upgrade in the global value chain is industrial upgrade to the design. In the electronics sector of Guadalajara, there are some educational and research institutions that aim to participate in the creation of capacities for the sector. In the academic sector, the institutions that engaged in major participation in the formation of human resources are CINVESTAV, ITESO, and the University of Guadalajara. These institutions have engaged in some collaboration between firms in the industry; however, CINVESTAV is by far the institution that responded more efficiently to the demands of the industry. (Palacios, 2008)

In terms of design centres, the number of corporations in Guadalajara with installed research and design facilities grew to eight in 2000 with the establishment of INTEL (Rivera 2010). INTEL Guadalajara Design Center (Intel-GDC) is the most significant design center in Guadalajara's electronics industry, present in the sector since 2001. The center is focused on the design, testing, and validation of computer platforms, chip sets, and other technology hardware and educational software (Intel

2012). The expansion of INTEL after twelve years has been remarkable. Currently, the design center has 700 employees (they started with only 30) and plans to expand to more than 800 employees and 200 interns and contractors by the end of this year. The complexity and the responsibility of the projects have been growing in INTEL, so they are highly engaged with the education institutions of Guadalajara's ecosystem to generate the talent that they will eventually need.

4.3.3. *The role of the firm in the sector*

The literature on systems of innovation notes that the main contributors to greater innovation and competitiveness are the firms' capabilities and learning processes. In the case of Jalisco, we can see this path as well; firms propose policies, programs, and incentive schemes for the development of the industry. Large, foreign private companies currently make up the dominant core of Guadalajara's electronics sector (see Palacios 2008 p. 27) and are the stronger factors guiding the conduct of the State's strategies. Since the creation of Guadalajara's electronics sector, the strategies of industrial restructuring negotiations are conditioned on the interests of big business. If foreign companies continue to have the greatest weight in strategic decisions for innovation and industry development, the sector will remain vulnerable and exposed to tensions between the interests of owners of foreign capital and those of the internal industry. One example was the case of Hitachi Global Storage, which, due to a corporate decision to reduce costs, shut down in Jalisco and moved to the Philippines, costing more than 5,000 employees their jobs (Palacios, 2008).

However, while it is true that the skills and learning processes of companies are contributing factors to the knowledge base of the sector, the beliefs, expectations, and goals of the directors and managers of the main firms, mostly Mexicans, are other key players that have sustained the development of the sector.

The integration of management is indispensable; they have realized that they do not compete with other companies in Guadalajara. They are in alliance with the industry's companies and they even sometimes convince the head offices to follow certain innovation strategies in the area of Guadalajara. (Interviewee)

This group of Mexican managers had implemented a set of initiatives to strengthen the competitiveness of the electronics industry in Jalisco. For instance, as noted by Palacios (2008) and Leon (2004), one of the main actors that promoted a change in the competitive strategies of the electronics industry was IBM under the leadership of Mr. Eugenio Godard. Before the electronic crisis of 2001–2004, Guadalajara’s electronics sector started to perceive the decline of the old system of high volume/low mix that had prevailed in the industry during the nineties, and Mr. Godard was one of the actors that prompted the emergence of new businesses and an organizational change in industry (Leon, 2004). Meanwhile, Dr. Francisco Medina, director of COECYTJAL, was another key player to encourage the change of mentality in the industry and restructure its mix of products. In this way, the electronics sector of Jalisco was able to develop a high-tech complex, in which the shared vision of directors and managers of the main firms and those of other sectoral players, created a network between private and public actors.

4.4. The dynamics and Evolution of Sectoral Systems

4.4.1. *The network*

Evident in the electronics sector of Guadalajara is the atmosphere of cooperation and continued collaboration between all actors and entities involved. As already mentioned, the beginning of this public-private relationship started with the leadership of the government at the state level represented by COECYTJAL, the academic sector represented by CINVESTAV, and the industrial sector represented by multinational corporations such as IBM, HP, DELL, and INTEL. This interaction is important in terms of innovation policy as there should be a focus not only on the elements of the system but also on the relationships among them.

The intermediation processes between education and research institutions with the firm include the relationships among various organizations and institutions. For instance, the intervention of the government bridge’s institutions has worked with corporate actors INTEL and IBM. This relationship between political and economic actors is a feature typical of Jalisco in recent years.

Significant support exists from COECYTJAL and SEPROE, as stated by the directors of the companies, not only at the company but also on a personal level. (Interviewee)

The electronics industry of Jalisco became a sector of high technology which reconverts and upgrades, while responding to an adverse international economic environment. Thus, the sector has become an increasingly dynamic and productive ecosystem. This integration helps firms define a strategy associated with capabilities. In this sense, the external environment becomes an important parameter for the companies looking for a space of action in the context of sectoral performance standards. As a result, the agents interact through processes of communication, exchange, cooperation, competition, and control of individuals. Because the electronics sector instituted a plan to upgrade the value chain of the industry, the industry was able to experience a relatively fast recovery after the collapse of 2001- 2004. For example, in 2003, IBM created a technology center with the consolidation of its Software Development Division, including GPL, and the opening of a new Division of Applications Management Services (AMS). Also in 2004 Flextronics and Solectron began to perform activities of design of prototype printed circuit boards and software (Dabat & Ordóñez, 2009)

4.5. Principal effects in innovation and development

4.5.1. *Factors affecting Innovation*

The activities of innovation in the electronics sector of Guadalajara have been carried out using different strategies and the deployment of technological and organizational activities. The firms are the elements that embark on innovation activities under domestic and external environmental conditions. Among the aspects of innovation of firms are adaptation to business models of firms with a global presence, certification of software engineering standards, capacity building through joint action, and support from public policy (Oliver, 2009).

In terms of technology transfer, the knowledge base in the sector derived partly from the accumulated learning of the firms of the last twenty years of the electronics sector. For example, the current production of software is based on the technological

development of circuits, hardware, networks, and services (Oliver, 2009). Jalisco's government reported that 61 percent of companies carry out activities in their process improvement, 54 percent in innovation of products, services at 25 percent, and 17 percent in the organization. On average, investment in innovation in the electronics sector reached 26 percent of total sales including salaries, technology, and materials.

Additionally, it is possible to see embodied technology as there has been an effect on technological spillover, evident from entrepreneurial initiatives of former employees of national and transnational development companies. This transfer of technology has had a significant impact in terms of existence of human capital entrepreneurs.

Still, no technology transfer is desired, but a more prepared workforce exists that is more sophisticated with respect to the preferences of transnational corporations (Interviewee)

However, this transmission of knowledge is relatively small in terms of academia-industry relationships. Even though there is an indication of interaction through student internships and training at local universities and technical education schools with foreign subsidiaries, there are few research-related activities, reflected in the significantly low number of co-publications or joint efforts in securing patents. While Jalisco has occupied a prominent place in Mexico in relation of the number of patent applications², the COECYTJAL still reports very low intellectual property protection through patents. Although it is important to mention the issue of intellectual property rights at the university-industry interface, it is a problem at a national level because there is a weak enforcement of patent law.

The overlaps between companies and universities in the electronic sector of Guadalajara continue to be insufficient to promote innovation. Educational institutions respond to changes in the industry rather than anticipate them. The scarce cooperation

² From 1996 to 2006, the cumulative figure is was 473, ranking in the fourth place nationally. (OECD, 2008).

of projects in applied research also limited the investment and innovative capacity. This point is of great significance as innovation is the result of evolutionary processes within the system that creates and distributes knowledge.

The government of the State of Jalisco is aware that unless the country has the capacity to generate its own products and processes, the distribution of knowledge to generate innovation will continue depending on FDI. That is why they will continue their efforts linking academia and public research centers with companies. But even more important, they also recognize that the technology transfer acquired through FDI has not been assimilated or adapted to the activity level of engineering, design and innovation. Therefore, with the help of public institutions, research centers, universities and companies, they are trying to develop more mechanisms to disseminate the activities and achievements in scientific research, technological development and innovation (COECYTJAL, 2008).

4.5.2. *Factors affecting competition*

In a sectoral system of innovation, when the state interferes to improve the function of the markets, it is often a matter of increasing the degree of competition rather than increasing the rate of innovation (Malerba, 2004). In the case of Guadalajara's electronics sector, FDI was and continues to be the engine that has allowed a more rapid assimilation of technology skills and management techniques to generate a competitive advantage. However, with the collapse of the electronics industry in Jalisco from 2001 to 2004, it became clear that the attraction of FDI was not a sufficient condition for developing advanced regional technological capabilities. Public initiatives aimed at attracting FDI and fostering technology transfer were necessary.

Moreover, due to the same changes in the inter-company competition of the global electronics industry, in which "manufacturing is becoming more information-intensive: larger parts of value added consist of 'weightless' activities like research, design, marketing and networking" (Lall, 2003, p. 3), the electronics sector of Jalisco could not rely on previous competitive advantages such as lower transportation costs. These previous advantages were insufficient for further development, and the sector opted to develop products that are handled in small series and contain a high number of

electronic components. This process of industrial upgrading in the value chain of the electronics industry applies to products with greater value added that involve a more knowledge-intensive production with low and medium (Dabat, 2009; see Table 4-5).

Table 4-5 Product portfolio in the electronics industry in Guadalajara, 2000 and 2007

2000	2007
Personal Computers	PC's & laptops
Laptops	Servers
Printers	Robotic tape libraries
CDs	Storage Systems
Photocopiers	Sliders
Semiconductors	Actuators
Single-use cameras	Set top boxes
Phones	DVDs
Cellular PCBAs	PCBAs
Answering machines	Jukeboxes
Caller ID	Relays
PDA's	Vending Machines
Amplifiers	Video game consoles
Radio pagers	IP phones
Electronic alarms	Printers
Satellite Jukeboxes	Telecommunication servers
Magnetic Tapes	Routers and firewalls
Tape handler	Docking stations
Electrical metering products	Handhelds
Electronic Toys	Medical Equipment
ABS systems	Cellular Phones
Cards	Digital cameras
Ensembles hard disk	Automotive immobilizers
Entertainment (Xbox)	Security systems
Power Supplies	Automotive airbags
Keyboards	ABS brake systems

2000	2007
Personal Computers	PC's & laptops
Laptops	Servers
Printers	Robotic tape libraries
CDs	Storage Systems
Photocopiers	Sliders
Semiconductors	Actuators
Single-use cameras	Set top boxes
Phones	DVDs
Cellular PCBAs	PCBAs
Answering machines	Jukeboxes
Photo CDs	Paper handling solutions
Scanners	Satellite decoders
connectors	Photo CDs
Battery Eliminators	Internet access boxes
Routers	
Transmitters	
Cables & Coils	
Metal Assemblies	
Electromechanical Parts	

Source: Palacios, J.J. (2008). Alianzas público-privadas y escalamiento industrial. El caso del Complejo de alta tecnología de Jalisco, México. Serie Estudios y Perspectivas 98, Unidad de Comercio Internacional e Industria. México: CEPAL (pp 29)

5. Recommendations and Concluding remarks

This concluding chapter presents the results of the questionnaire as a starting point for the analysis of the factors and agents behind the recovery of the electronics sector of Guadalajara. Then, it presents concluding remarks related to the research questions introduced at the beginning of this paper. Finally, it discusses some recommendations for technological learning and government policies for the promotion of this industry.

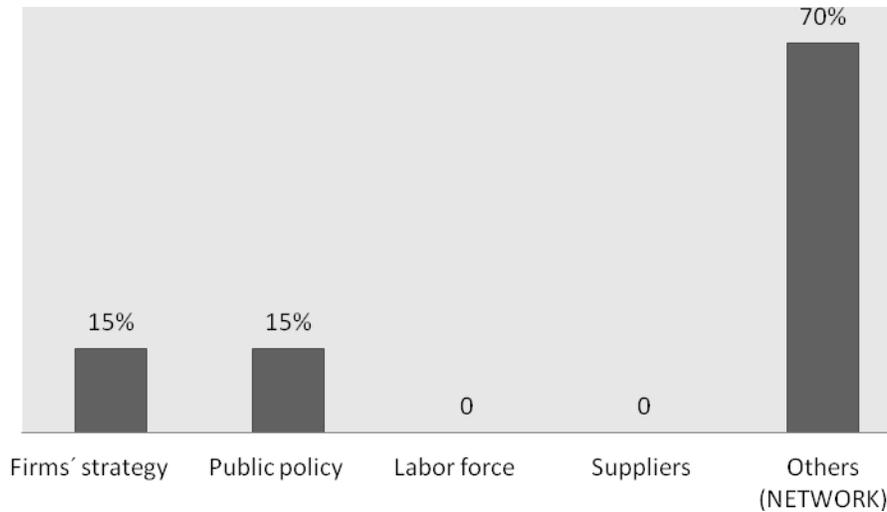
5.1. Questionnaire results: Principal findings

The results indicate that the most important source of transformation and growth for the electronic industry in Jalisco is the strong connection between private and public actors, which has been vital to not only the recovery of the industry, but its continuous development (see table 5-1) This idea is so ingrained that each of the participants referred to the Jalisco sector as an ecosystem.

Table 5-1 Question 1

Question		Number of responses	Percent of total responses
What is the most important source of transformation and growth of the electronic industry in Jalisco?	Firms' strategy	1	15%
	Public policy	1	15%
	Labor force		0
	Suppliers		0
	Others (NETWORK)	5	70%
	Total	7	100%

Figure 5-1 Question 1: Most important source of transformation and growth of the electronic industry in Jalisco

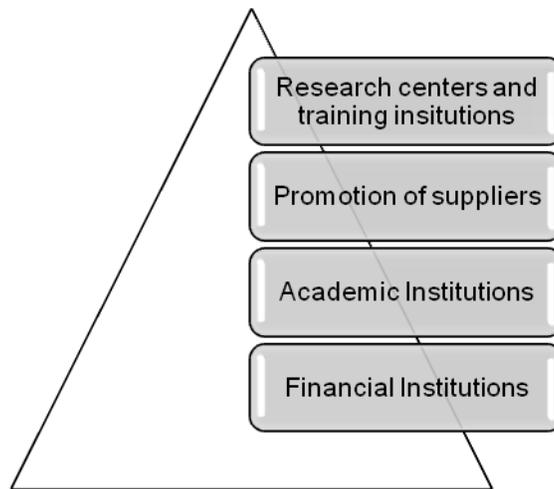


The second question is related to the importance of institutions' shaping actions and interactions in the electronic industry in Jalisco. The results show that the research and training institutions are the most relevant. (See table 5-2) The participants consider Jalisco to have an institutional structure of productive promotion. Two institutions that act as bridge institutions are the basis and support for Jalisco's innovation activities, COECYTJAL and IJALTI, and will be discussed later.

Table 5-2 Question 2

Question		Participant # 1	Participant # 2	Participant # 3	Participant # 4	Participant # 5	Participant # 6	Participant # 7	Total of points
For the institutions mentioned below, please rank each one on a scale of 0 to 5 (0 for no important at all and 5 for essential) on what you believe is important in shaping actions, and interactions in the electronic industry in Jalisco?	Research centers	5	5	5	5	4	4	4	27
	Training	4	4	4	3	5	5	2	27
	Promotion of suppliers	2	3	2	2	2	2	3	16
	Financial institutions	1	1	1	1	1	1	1	7
	Academic institutions	3	2	3	4	3	3	5	23

Figure 5-2 Question 2: Institutions shaping actions, and interactions in the electronic industry in Jalisco



The results show that most of the participants agree that the government at the state level has been able to design a set of sectoral promotion policies to raise the local capacity for production and innovation (see table 5-3). The results indicate the area with most the positive impact on government strategies is the value chain of the industry,

followed by the impact of employment. The area least impacted by government strategies was innovation (see figure 5-4).

Table 5-3 Question 3

Question		Number of responses	Percent of total responses
How do you rank the government strategies for raising local capacities for production and innovation?	Excellent	0	0%
	Very good	4	57%
	Good	2	29%
	Fair	1	14%
	Poor	0	0%
	Total	7	100%

Figure 5-3 Question 3: Importance of government strategies for raising local capacities for production and innovation

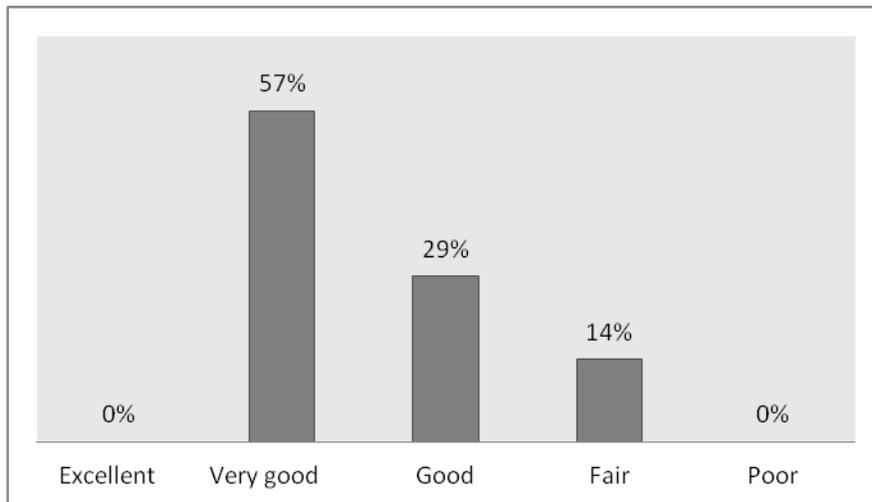
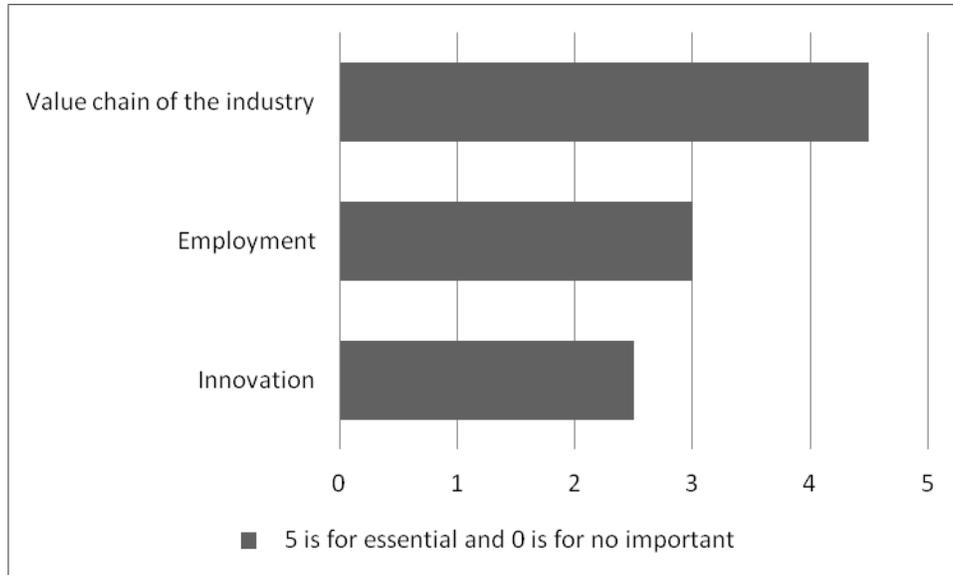


Figure 5-4 Question 4: Impact of the government strategies on upgrading the electronics industry in Jalisco

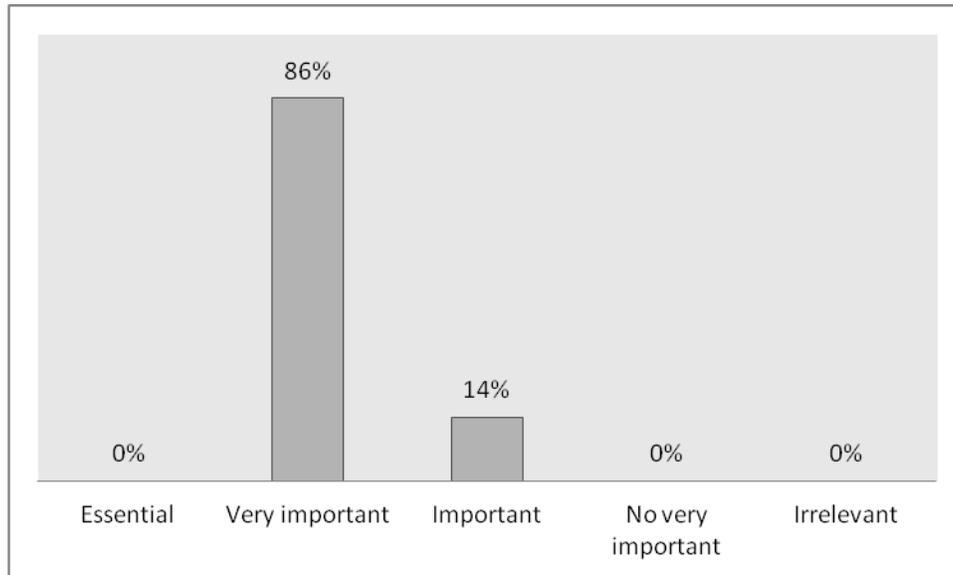


Finally, the majority of the participants agree that the roles of research and academic centers in the innovative process have been very important to bridge institutions (see table 5-4).

Table 5-4 Question 5

Question		Number of responses	Percent of total responses
What roles have research and academic centers played in changes in the innovative process?	Essential	0	0%
	Very important	6	86%
	Important	1	14%
	No very important	0	0%
	Irrelevant	0	0%
	Total	7	100%

Figure 5-5 Question 5: Importance of research and academic centers in the innovative process



5.2. Conclusion

The objective of this paper has been to study the processes of interaction and cooperation in the electronics industry in Jalisco as well as the impact of government strategies on the industry's development of innovative activities. It relies upon the sectoral systems of innovation (SSI) as a theoretical framework to address questions about the relationship between Mexican government strategies and the factors affecting the innovation, commercial performance, and international competitiveness of the electronics industry in Jalisco.

When the electronics industry in Jalisco was established in 1992, it was highly dynamic in the exports area. However, despite the period of high exports, the electronics sector had structural limits, such as the pre-eminence of the manufacturing and assembly phases and a lack of the development and integration of the value chain. These structural limits were one of the reasons for the slowdown of productivity, growth, and competitiveness in Mexico, resulting in the industry's collapse in 2001, which lasted until 2004 and during which the indices of exports, FDI, and employment fell drastically. The other reason for this collapse was the global crisis of 2001-2002 that emerged from

the new structure and dynamics of the global economy, information technology, and telecommunications. This global restructuring created a new pattern in global production that emphasized the valuation and proliferation of digitization and software.

The new dynamics of the global electronics industry together with the structural limitations of the electronics industry in Mexico necessitated an active role for public organizations in recognizing and promoting conditions for industry success. By 2004, the electronics sector in Jalisco had recovered from its collapse of 2001. This recovery implied a full organizational restructuring of the industry, with more emphasis on higher value added segments such as digitization and software.

With regard to our first research question concerning the factors affecting the innovation, commercial performance, and international competitiveness of the electronics industry in Jalisco, we can conclude the following: The factors that contributed to the innovation and technological capabilities of the electronics sector of Jalisco are local human capital, innovation-oriented organizations, a strong network among the actors and agents, and an active public sector.

The major source of transformation and growth of the electronics industry in Jalisco has been collaboration and cooperation among members of the public and private organizations who strongly share a common objective to develop and promote the electronics industry of the state. Simultaneously, they are trying to promote the production and diffusion of technical knowledge in order to realize this objective. The knowledge base of the sector is generated by private firms through their learning experience. The informal transfer of knowledge mainly consists of the skills and learning processes of companies, while a more formal transfer of knowledge is based in the bridge institutions that are created by the government and supported by the private sector. COECYTJAL and IJALTI are the formal research and training institutions that have shaped the actions and interactions in the sector among the government, firms, and universities.

Our second question was related to the strategies that the Mexican government implemented or modified after the electronics crisis of 2001–2004 to increase the competitiveness of the electronics industry in Jalisco. The government, along with the

private sector, identified the need to reconvert the industry and addressed this need by focusing on the production of sectors of rapid growth. More specifically, the new strategic plan of the government consisted of promoting higher value-added sectors such as design, software development, and digital animation, as well as upgrading manufacturing processes with products that require a greater variety of components.

The government (at the state level), represented by COECYTJAL, facilitated the self-organization of innovation systems within the relevant policy domain by creating opportunities and incentives for changes in the production structure. In order to create human capital, the government supported institutions, such as CINVESTAV, which offers masters and Ph.D. programs in the electronics industry, and IAJLTI, which provides human capital in the specific areas of information and communication technology.

The network that exists and continues to evolve in the sector among public-private partnerships has helped to create an innovative dynamic. Part of the success of this network is attributable to the fact that the directors and manager of the main firms are mostly Mexican, and some of them, along with state government representatives, have been involved in the development of the electronics sector since its beginning. Their objectives are focused on promoting and creating the mechanisms that have favored the aggregation of value, the extension value chain, negotiating skills, and the creation of new technological learning mechanisms that create synergistic conditions for innovation and development.

Therefore, the case of the electronics sector of Jalisco confirms that local government can play the role of facilitator in coordinating and networking mechanisms. From the point of view of SSI, this case sustains the argument that relationships and networks are key elements of the innovative and production processes. Moreover, with the support of institutions such as COECYTJAL and IJALTY, the sector proves that institutions play a major role in affecting the rate of technological change, the organization of innovative activity, and performance. Finally, the example of the electronics industry also denotes that foreign firms in Jalisco continue to be a catalyst for the development of technological and organizational capabilities.

Finally, our third question was related to the diverse impacts of the upgrade of the electronics industry in Jalisco. The impacts of these innovation strategies have been most prominent in the value chain of the industry, which is denoted in the adaptation of certain business models in firms with a global presence and the certification of software engineering standards. Moreover, firms started to focus on products with greater value added and that involve more knowledge-intensive production. In terms of employment, thanks to the structural changes implemented after the crisis of 2001–2004, the electronics industry in Jalisco is still considered one of the most important sources of employment for the state. On the other hand, one of the areas less affected by the upgrading of the electronics industry in Jalisco is the capacity of innovation, more precisely in radical innovation. Research-related activities are very limited, and the number of co-publications and patents in the electronics industry of the state remains negligible.

5.3. Recommendations

It is important to emphasize that the electronics sector of Guadalajara is still under development, which means that there are a number of issues to resolve. Probably the most significant weakness of the sector is its limited integration into the scientific-educational sector. In the electronics industry of Jalisco, the “analytical” kind of knowledge base is more prominent, and the university–industry linkages become essential for knowledge transfer. However, the transmission of knowledge between academia and industry is still insufficient for effective knowledge diffusion, which is why there are few research-related activities. Moreover, the distribution of knowledge depends mainly on FDI.

Therefore, it is necessary that the sector focus its efforts on increasing the capacity to generate its own products and processes in order to stop relying solely on FDI as the main mechanism for the distribution of knowledge. In order to do so, it is critical to increase the electronic industry’s links with local universities and technical education schools to foster collaborative research projects. Educational institutions need to anticipate changes in the industry, rather than just responding to them, and to train the workforce according to industry demands in a timely manner.

Another failure of the sector is the low technology transfer that occurs in the region. There is very little participation on the part of domestic capital suppliers. Even though in Jalisco foreign subsidiaries have active relationships with other firms and local organizations, most of suppliers are multinational companies that have been attracted by global standards. This condition supports the statement that the attraction of FDI to high-technology industries is not a sufficient condition for the development of advanced regional technological capabilities. In the case of Jalisco, it remains necessary to incorporate domestic firms into new networks of training providers and service providers, such as original design manufacturer (*ODM*) companies, manufacturers, and service contractors. The government needs to continue to create an even more active innovation and technology design.

The electronics sector of Guadalajara demonstrates that it is possible to recover from a crisis by raising the value chain to more intense activities that require more specialized knowledge. To replicate the experience of the electronic industry in Jalisco and in other regions in Mexico and other Latin American countries with the same export-oriented industrialization model, the major players must have the competency necessary to design explicit instruments of integration into segments of higher value added of the global production chains. Public policy intervention in a market economy is essential when firms and the market mechanism do not have the capacity to deliver the desired outcomes. In this case, FDI alone failed to develop technological capabilities, and the public policy needed to help develop alternative patterns of learning and innovation remains limited.

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Appendices

Appendix A.

Questionnaire

1. What is the most important source of transformation and growth of the electronic industry in Jalisco?

a) Firms' strategy b) public policy c) labor force d) suppliers e) others (please specify)

2. For the institutions mentioned below, please rank each one on a scale of 0 to 5 (0 for no important at all and 5 for essential) on what you believe is important in shaping actions, and interactions in the electronic industry in Jalisco?

- a) Research Center ____
- b) Academic ____
- c) Training ____
- d) Promotion of suppliers ____
- f) Financial institutions ____
- g) Others (please specify) ____

3. How do you rank the government strategies for raising local capacities for production and innovation?

____excellent ____very good ____good ____fair ____ poor

4. What has been the impact of the government strategies on upgrading the electronics industry in Jalisco in terms of?

- a) Innovation: excellent____ very good____ good____ fair____ poor____
- b) Value chain of the industry: excellent____ very good____ good____ fair____
poor____
- c) Employment: excellent____ very good____ good____ fair____ poor____

5. What roles have research and academic centers played in changes in the innovative process?

essential____ very important____ important____ no very important____ irrelevant____

Appendix B

Interview

The following questions will be asked after the participants agree and sign the written informed consent document. The informed consent document stipulates the required time for the interview and survey.

Why you think is important to enact government-sponsored efforts to improve learning capabilities?

What are the factors affecting innovation of the electronic industry in Jalisco?

What are the factors affecting the commercial performance of the electronic industry in Jalisco?

What are the factors affecting innovation international competitiveness in the electronic industry in Jalisco?

Do you think that exist formal institutions that contribute to the innovation and competitiveness of the electronic industry in Jalisco?, if yes,

Which of this intuitions have the potential to shape agents' cognition, actions, and interactions in the electronic industry in Jalisco, and why?

What have been the strategies the Mexican government implemented or modified after the electronics crisis of 2001–2001 to increase competitiveness of the electronics industry in Jalisco?

Do you see a change on the role of design centers and universities in the innovation process of the electronic industry in Jalisco?