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Can Mexico Set Up in the Aerospace and the Software and IT Global Value Chains as a High-Value-Added Player?

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Abstract

This study is an effort to identify the process by which firms venture into GVCs and the obstacles faced by firms once they have been immersed in it. We have focused on two particular GVCs: the aerospace GVC and the software and IT services GVC. Through the case studies, we analyzed the nature of inter-firm linkages and how they affected the potential of scaling up by local suppliers in the value-added chain, the particular role of firms in the value chain in Mexico and the achievements and limitations of governmental policies as tools to facilitate the entrance of MNCs' subsidiaries and to create the conditions for the entrance and scaling up of local firms in the value chain.

We found that geopolitical factors were important, in particular NAFTA, but these advantages are only part of explanation for the insertion of Mexican industry in both GVCs. In our opinion, this could not have happened without an effort of public policy at different levels to attain this goal on the part of the Mexican government. Nevertheless, there is a notorious unbalance between efforts to secure investment from foreign firms and certification and long-term financing initiatives. In our view, the latter has not been properly addressed and it is a major problem for the scaling up of local firms in the value chain.

JEL: F14, F23
Key Words: Global Supply Chains, International Fragmentation of Production, Suppliers

1. Introduction

World trade has notably accelerated in the past thirty years due to the fragmentation of the productive processes of multinational companies (MNCs). Production has been organized globally (Feenstra 1998); (Arndt and Kierzkowski 2001) and there has been a shift away from vertically integrated multinational firms toward global outsourcing and the use of external supplier networks. At the same time, better and cheaper IT technologies have evolved dramatically and emergent countries have improved their capabilities in this sector. The above-mentioned fragmentation allows multinational companies to specialize in their core capabilities such as design, marketing, or product development of advanced technology components and services, while their subsidiaries or local firms in semi-industrialized economies produce components or complete processes of lower value added. Firms no longer compete on their home turf; they compete in a global market. Therefore, traditional industrial organization analysis must evolve to fully grasp the nature of global value chains (GVCs).

Modularization, which consists of the separation and recombination of systems components (Schilling, 2000), intensified this new trend in the productive process, thanks to advances in the codification of knowledge and market-led standardization of the interfaces between separate stages of production through better technical standards and design rules (Sanchez and Collins 2001).

For the last twenty years, insights on the concept of the global value-added chain have led to very different issues than the issues originally covered by traditional sector analysis theory. The focus has shifted to: (1) the activities that are bundled in one node of the chain or split among various nodes; (2) the way in which knowledge information and materials are passed from one node to the next; (3) the geographical location of nodes (Sturgeon, 2008); and, most important, (4) the ways in which each chain is coordinated or governed (Gereffi, Humphrey, and Sturgeon 2005).

GVCs are composed of hundreds or thousands of transactions around the world, therefore there is a need to understand a firm's capability to manage complex information, transfer technology, and control producers. Important variables in the global value chain

analysis refer to the role of institutions (government, MNCs, and local firms) and the distribution of power among firms and other actors (Kaplinsky, 2000).

Sturgeon (2008) identifies five governance modalities in the GVC (market, modular, relational, captive, and hierarchy), depending on the firm's ability to codify transactions, the capabilities of the supplier base, and the complexity of transactions. When linkages are characterized by superior transactions codification, evolved capabilities in the supplier base, and highly complex transactions, the governance modality is modular. On the other hand, if the firm's ability to codify is low, and the other characteristics are high, then the governance modality is relational. A captive governance modality is when capabilities in the supplier base are low.

This study is an effort to identify the process by which firms venture into GVCs and the obstacles faced by firms once they have been immersed in it. We have focused on two particular GVCs: the aerospace GVC and the software and IT services GVC.

Some might wonder why we selected the chains we did; here are some of our motivations: First, we were interested in the impressive growth of employment and exports of the aerospace[1] industry and of software and IT services in comparison with the poor macroeconomic performance of the Mexican economy. Second, even though we don't agree with some authors who speak of the Mexican aerospace industry as part of the knowledge economy (Ruiz Durán, 2007) because these firms do not engage in design and higher value-added activities, we were interested by the fact that they do employ a higher proportion of qualified labor and/or are capital intensive in comparison to other chains. Third, we were also interested by the degree by which both of these industries' growth rates were determined by the close collaboration between government, private sector, and academia (Carrillo and Hualde, 2007); (Casalet, 2011); (Hualde and Mochi 2008); (Ruiz Durán, 2007). Finally, we discovered interesting initiatives by the stakeholders of these chains to develop and support clusters inserted in global value chains.

[1] Although there may be some aerospace exports in the Mexican economy, most of them are aeronautic. We will, however, continue to use the term "aerospace" because the global value chain is mostly known by this term.

Through the case studies, we analyzed the nature of inter-firm linkages and how they affected the potential of scaling up by local suppliers in the value-added chain. Special attention was given to the analysis of the particular role of firms in the value chain in Mexico in order to assess the suitability of their respective strategies and examine the reasons for the depth of their insertion relative to other firms. Lastly we investigated the achievements and limitations of governmental policies as tools to facilitate the entrance of MNCs' subsidiaries and to create the conditions for the entrance and scaling up of local firms in the value chain.

Both GVCs have unique elements particularly useful to the GVC analysts. The Mexican aerospace GVC is ruled by complex transactions. This chain is organized by tiers, and participating firms must comply with high security requirements, obtain certifications, and comply with traceability along the product life cycle. All of the above are prime elements of a modular governance. The aerospace GVC nodes in Mexico are also characterized by a collaborative effort between customers and clients. In this regard, the lack of supplier experience drives buyers to get involved in the assessment of the fitness for transfer, including both the home fitness to transmit, and the host fitness to receive. Thus, depending on the component, governance may lie between relational and captive. To become suppliers, local firms need to invest in facilities development, purchase ad hoc machinery and equipment, and obtain industry-specific certifications. Entry barriers are high.

The Mexican software and IT services GVC has become increasingly interrelated to its global value chain. Shrink-wrapped software is mostly imported, and Mexico's role in the value chain consists of providing customized solutions. In this case, software usually requires ad hoc tailoring to address the specific needs and requirements of the end user. This industry-specific quality explains the need for close coordination of multiple suppliers of software applications. Thus, codification is low, transactional complexity is high, and capabilities in the supplier base are also high. In terms of classifying the shrink-wrapped-software sector from a governance modality perspective, we could speak of a relational governance. In the sector of tailored or client-specific integration of IT systems, Mexican firms have reached a different level within the IT service chain. The most important one is

reported as outsourcing by Select,[2] which accounts for near 35% of the IT market. In this segment, information is mostly codified and operations mostly follow standard routine, the capabilities of the supply base are adequate (although they do not need to be high), and transaction complexity is high. Hence, in this sector, we can speak of a modular governance.

These two GVCs have had certain success in Mexico. However, this paper is not a success story; rather, it is an account of an uphill battle and the red flags that lie ahead. For example, both GVCs struggle to fill positions in their workforce due to the lack of qualified professionals available in the workforce, and local companies are still in the initial phases when it comes to certification of industry participants, which means that firms must continually invest in capacity-building. We discovered that Mexican firms have engaged in these particular GVCs mostly as suppliers with a minimal role in product design activities, which implies much effort must be made on their side to scale up in order to get a higher share of income in the GVC.

This paper has four sections. The next section covers the aerospace industry's GVC; the third covers the IT services GVC; and the fourth section is dedicated to policy issues. Within each section we analyze the characteristics of the global value chain, the structure and evolution of the industry, and the corresponding government initiatives in Mexico. Finally, in order to analyze the challenges and success stories of each GVC, we have prepared three case studies of companies with different roles within the chain.

2. AEROSPACE VALUE CHAIN

2.1 The Aerospace Global Value Chain

Estimates for the aerospace and defense (A&D) industry global market in 2008 ranged between USD 675 billion (Platzer, 2009) and USD 920 billion (Datamonitor, 2008). This industry has experienced an important expansion. Boeing and Airbus, the industry's main players, have been building substantial backlogs of orders on their books since the beginning of 2003 (Platzer, 2009). Even though both corporations slowed their production

[2] We are using this source because official information is scarce and Select consulting firm has built the first database on the IT sector.

lines in 2009, market projections still indicate an average annual fleet growth of 3.2% and a cargo growth rate of 5.4% for the 2009–2028 period.

Thirty years ago, the industry was vertically integrated and a very clear hierarchy could be observed along the value chain. Only about 20% of an airplane's total value was outsourced. The original equipment manufacturers (OEMs) exerted firm control over their thousands of small suppliers. Gereffi, Humphrey, and Sturgeon (2005) call it a hierarchical system. In contrast, it is estimated that the amount of manufacturing outsourcing in the aerospace industry today is somewhere close to 80% of an airplane's aggregate value.

A 2008 A&D survey (Wipro Council for Industry Research, 2009) revealed that the four most important reasons for outsourcing were: (1) reducing operating costs; (2) avoiding capital investments; (3) gaining access to technology not in the company; and (4) increasing flexibility and responsiveness. According to Kimura (2007), offsets are a big driver for international outsourcing in commercial aircrafts. This is exemplified by the case of EADS, which uses European suppliers and carries out final assembly in France, or the case of Bombardier, which uses North American suppliers while most of the final assembly is carried out in Montreal. Finally, Boeing 787s are being built by a consortium of local Japanese companies, including Mitsubishi, to fulfill Japanese government orders (Wipro Council for Industry Research, 2009). The reasons to outsource in Mexico, as will be seen, are related to reasons (1), (2), and (4) mentioned above. Market offsets are not important as yet. The most critical reason for not outsourcing include loss of control (72% of respondents). A similar reason was adduced to explain why Bombardier preferred Mexico to China, as will be seen next.

Different levels of manufacturing are normally identified: design and main assembly of airplanes and engines by OEMs; assembly of hydraulic, pneumatic, fuselage, and electronic systems (tier 2); assembly of subsystems (tier 3); and subsequently the lower-level tiers of manufacturing of interior components, tires, and other parts.

Building a commercial jet takes, on average, about a year. It takes an OEM an average of five years to design a completely new model. In today's A&D industry, OEMs like Boeing and EADS have concentrated their efforts in their core capabilities and act

more as large-scale system integrators rather than acting as manufacturers as they did in the past. They retain full control over final assembly, testing, and perpetual service and support during a life cycle that may last thirty or forty years. As Kaplinsky (2000) notes, the pattern of governance is one in which the major buyers (the assemblers or first-tier suppliers in relation to the lower tiers) set the standards with regard to cost, quality, delivery, and so on. This suggests that third-tier firms like one of the firms we interviewed must utilize global designs and, as Schmitz (1999) has shown, even if the firm acquires design capabilities, it would be difficult to scale up to design activities. A consequence of this relationship is the possible erosion of local ownership and local technologies in developing countries (Wipro Council for Industry Research, 2009).

Both OEMs (systems integrators and assemblers) and first-tier suppliers are subject to aeronautic regulations for the proper certification of the products. The risks of non-compliance with industry and governmental regulations can be especially high for both commercial and military aviation companies. In recent years, this industry has seen a proliferation of regulations ranging from quality control to environmental standards, and the corresponding compliance has become increasingly expensive and takes its toll on industry participants.[3] Second, third tiers and subcontractors are subject to approval by the manufacturing firms of primary systems and components.

OEMs' end goal is to strategically outsource to their partners as much as possible while concentrating on product assembly, marketing, and long-term strategies (Siemens PLM Software, 2011). This value chain collaboration goes on throughout the product's life cycle. Companies in this sector must keep up and enhance complex products with life cycles ranging from thirty up to fifty years (Wipro Council for Industry Research, 2009).

If the supplier switching cost for the buyer of airplanes is low, then buyer power in the marketplace is increased. Interestingly, subcomponent manufacturers who have carved a niche for themselves have the best margins in the value chain (Wipro Council for Industry

[3] Cited requirements in the literature are Sarbanes-Oxley in the United States and adherence to OEM. In addition, aerospace and defense companies must comply with Contract Data Requirements List/Subcontract Data Requirements List (CDRL/SDRL), ITAR (International Traffic in Arms Regulations), RFID (Radio Frequency Identification Device), UID (Unique Identification), and an array of specifications and industry standards (Siemens PLM Software 2011).

Research, 2009). This suggests that the latter may have developed design capabilities and are involved in cooperative design, leading to high supplier switching costs. But in the case of small firms in emerging countries, this may not be the case. Thus the margins for these firms in the A&D GVC are low, as was mentioned by our interviewees.

Knowledge transfer is carried out by project managers. OEMs rarely have codified knowledge that can be relied on and repeated consistently over multiple transfers (Siemens PLM Software, 2011). Often the transferring site has tacit skills in areas like tooling and problem-solving, thus requiring frequent visits from and to suppliers, as can be seen in our case studies. Historically, the United States and some European countries—notably the UK, France, Germany, Italy, and Spain—have dominated both research and manufacturing in the A&D industry. But emerging countries are starting to catch up. Datamonitor estimates that the top five emerging countries (Brazil, China, India, Mexico, and South Africa) have a total output of A&D products and services that will reach approximately USD 260 billion by 2014 (PricewaterhouseCoopers, 2011).

2.2Industrial organization and actors

The characteristics of industrial organization in the A&D sector vary along the value chain. First, the global commercial aerospace market has few large-scale aircraft OEMs. Second, economic concentration in this industry is very high due to the elevated capital commitments required to design and produce an aircraft. Third, but of no lesser importance, is the fact that as systems integrators they have accumulated technical and coordination knowledge. These capabilities range over a wide spectrum of fields and take decades to achieve (Brusoni and Prencipe, 2001).

For many decades, the U.S. large commercial jet manufacturing industry was dominant worldwide, but European firms caught up, and today, the world market is characterized by the Airbus and Boeing duopoly. This does not mean absence of competition; Boeing and Airbus complaints filed with the WTO reveal that there is an intense rivalry between firms (Platzer, 2009). Additionally, new competition from China's state-owned Commercial Aircraft Corporation of China, Ltd. (COMAC) is coming in 2016 with its C919. Japan and Russia also have aircraft under development. Fokker has been a

distant competitor, and most recently Bombardier is positioning itself as a replacement for Fokker100s and MD-80s with its new C Series commercial jet (seating 100–149), which may also gain some market share from the traditional narrow-bodies as well.

The regional jets' main competitors are Canadian Bombardier and Brazilian Embraer. These firms represent an important market for the U.S. industry, which provides them with engines, landing gear, avionics, and a wide range of other components. There is also increased potential competition from three new entrants into the regional jet market: COMAC, with its ARJ21; Japan's Mitsubishi Heavy Industries, with the Mitsubishi Regional Jet (MRJ); and Russia's Sukhoi, with its Superjet 100.

Among general aviation business-jet producers are Cessna, Hawker Beechcraft, and Bombardier's Learjet. The global commercial aerospace market has few prime contractors who manufacture aircrafts and engines; the five most relevant companies are Boeing, Airbus, Bombardier, Cessna, and Gulfstream. On the other hand, the most relevant engine-only manufacturers include General Electric, United Technologies, Snecma, Rolls-Royce, and Honeywell International.

The first tier of the large-engine industry is dominated by the so-called Big Three (General Electric Aircraft Engines, Pratt and Whitney, and Rolls-Royce), who are in exclusive contracts with OEMs. The small- and medium-sized engine segment is characterized by a greater number of firms, among them Allied Signal Engines, Williams International, CFM International, and International Aircraft Engines (Brusoni and Prencipe, 2001). The second tier of the industry is mainly composed of medium-sized firms who supply components and subsystems, and even smaller firms are found in the third tier.

Governments play a major role in the A&D sector, both as a customer and as a regulator of the A&D industry. Governments are also increasingly influential when it comes to setting the technological agenda for the sector. An example of this influence can be seen in European governments who have driven research priorities in the sector through the Clean Sky Joint Technology Initiative and other initiatives. This combined effort shouldered by the European Commission and the A&D industry has funneled an estimated 1.6 billion euros to the research of breakthrough developments across the entire aeronautic

supply chain. Pricewaterhouse Coopers (2011) reveals the impact of the Council for Aeronautics Research in Europe (ACARE) on the research agenda in the European aerospace sector, which has included ambitious goals for reductions in CO_2 and NO_x emissions, among others.

2.3 The aerospace industry in Mexico

Mexico, like many other semi-industrialized economies, was considered an outsourcing post of lower value added for the A&D global value chain. However, since 2003, Mexican A&D firms have experienced considerable growth and development. This boom brought not only new firms to the Mexican market, but it also brought investment that expanded the Mexican A&D industry's geographical footprint into regions of the country that until then had not hosted this industry. In 2005, there were sixty A&D firms in Mexico subcontracting for U.S. firms, with approximately 15,000 employees and USD 600 million in exports (Carrillo and Hualde 2007). In 2010, there were 199 firms registered in Mexico, employing approximately 30,000 workers and with exports in excess of USD 3.26 billion, the highest amount to date in the Mexican A&D industry export record (Grupo de Trabajo de la Industria Aeroespacial Mexicana, 2009).

Mexico's share in the worldwide A&D market is less than 1%. In contrast with competing countries in Asia like China and India, Mexico does not have a strong local demand, since airlines have been in trouble for the past five years and many of their aircrafts are leased. But the availability of human capital and the competitive costs derived from a strong dollar, in addition to the learning process taking place in the local industry, has contributed to greater export volumes that multiplied by three from 2002 to 2008, and a trade balance surplus in the sector which was sustained through the 2009 economic downturn.

Production in the Mexican segment of the chain is highly diverse. Clients include both military and civil entities and products span from aviation to helicopters. Until 2004, most firms were located in the northern states of Baja California, Sonora, and Chihuahua. However, as the corresponding case study will show, a new cluster was created in the state

of Querétaro as a result of the arrival of many A&D MNCs in conjunction with joint government efforts which led to the subsequent arrival of first- and second-tier suppliers.

Mexico's aerospace sector is driven by three main activities: (1) manufacturing and assembly (77%); (2) engineering, design, and R&D (8%); and (3) maintenance, repair, and overhaul (MRO, 16%). Manufacturing activities lie in the following categories: electrical cable accessories and harnesses (20%), aerostructure components fuselage (14%), aeroengine and aerostructure subassemblies (14%), raw material supply and material manufacture (12%), aeroengine components: propellers/rotors (10%), standard parts (8%), avionics (6%), aircraft interiors equipment furnishings (6%), hydraulic systems and equipment (6%), and safety and survival equipment (4%) (ProMéxico, 2011).

Mexican firms were once at the very bottom of the supply chain with total output of approximately USD 40,000–60,000 per employee as measured in the value-added index, compared to output of USD 350,000 per employee in OEMs and Tier 1 firms (ProMéxico, 2011). In Tijuana, for example, according to Carrillo and Hualde (2007), the majority of the companies in the aerospace sector in the Maquiladora (offshore) industry corresponded to the fourth tier and there were only two second-tier firms. Today, the industry is evolving toward the production and export of products with higher levels of complexity and higher added values, as will be clear from our case studies. Foreign firms are currently upgrading their facilities, and some have relocated their subsidiaries to Mexico. New local firms are upgrading their facilities to enter the suppliers market.

The most relevant A&D firms with investments in Mexico are Bombardier Mexico, Cessna, Textron, and Labinal (airframe structures, subassemblies, and components); ITR and Goodrich (engines and components); General Electric (propulsion systems); Honeywell (airframe, assembly, and sales); and Gulfstream (fuselage and components) (ProMéxico, 2011). In 2006, Bombardier was the first-ever OEM in this industry to arrive in Mexico. Their objective was to establish a low-cost supply base and capitalize on the geographical advantages of Mexican industry. Today there are seven other OEMs in the country, including Cessna, Honeywell, and Bell Copter.

2.4 Government policies

Mexico spearheads important initiatives in the aerospace industry. ProMéxico's[4] initiative to secure investment commitments from foreign companies has been crucial. One example of this is the Transnational Company Alliances (ACT) model. The ACT seeks to leverage the strong interest of various multinationals established in Mexico to increase their local supply capacity and transferring operations. The objective of the ACT is to integrate the A&D sector supply chain through the identification of the main goods imported by OEM companies and the national suppliers properly qualified and certified to produce these goods.

Mexico's National Council of Science and Technology (CONACYT) and the Ministry of Economics are promoting private investment in innovation through programs like Innovapyme, Proinnova e Innovatec. However, Mexico does not have a specific financial initiative devoted to the aeronautic industry, unlike the substantial credit line Brazil's Banco Nacional do Desenvolvimento (BNDES) has created for this sector. Brazil also has a specific financing initiative called Pro-aeronáutica, which provides low-interest-rate financing for the implementation, expansion, rehabilitation, modernization, and development of Brazilian small- and medium-sized enterprises (SMEs) in this industry (Cafaggi, 2011).

At the same time, state governments in Mexico have aimed to create the necessary conditions for the establishment of high-tech clusters as part of their economic development strategies. The State of Querétaro, for example, supported the creation of the National Aeronautic University.

The National Council of Tractor Companies (CNET), created in order to coordinate institutions, companies, and agencies for supplier development, has been crucial in this stage. The idea is to generate coordination models and economies of scale to develop and attract suppliers. The end goal is that "tractor" firms (big buyers) incorporate the participation of small firms as suppliers.

[4] ProMéxico is the government agency in charge of attracting foreign investment to Mexico.

There are several supplier development programs in Mexico; one example is the program jointly executed by the Ministry of Economics and Mexico's development bank, Nacional Financiera (NAFIN), with the technical assistance of the United Nations Development Program (UNDP). We interviewed one of the companies participating in this program.

As we mentioned in the first section of this study, security control and certification are essential for firms to be able to participate in this particular GVC. The Training and Development Center for the Aeronautic Industry (CEDIA) and the Technology Business Accelerator (TECHBA) grant consulting and training services to firms willing to update business and managerial systems in order to obtain relevant industry certifications. The latter provides integral consulting services, including assistance delivered through their Montreal office to firms that wish to break into this GVC. As of the publication of this work, TECHBA's portfolio was composed of thirty-five firms.

Other strategic institutional efforts for the development of this GVC in Mexico include the signing of the Bilateral Aviation Safety Agreement (BASA) with the U.S. government. This agreement regulates the industry's minimum standards regarding design and manufacturing processes. The execution of BASA was fundamental for the certification of local suppliers and therefore enhanced Mexico's profile as a production venue. Bombardier mentioned that the execution of this treaty was a crucial factor in their location decision. The next natural step will be to continue developing implementation mechanisms for maintenance activities that enable the MRO projects to be completed. ProMéxico (2011) reported two hundred certification processes for 2011, among which eighty-one certifications belonged to the aerospace standards AS9100 and AS9199.

The government's position regarding the aeronautic industry is published in the corresponding ProMéxico report. This document distinguishes the Baja California and Querétaro clusters as the strategic sources of innovation. Bombardier has established a presence in both states. These clusters concentrate some of the most important A&D firms in the country. These firms have links with educational and research institutions and have established a support system provided by state and federal agencies. The Querétaro cluster

has grown very quickly since its inception in 2005 with the arrival of Messier-Dowty and Messier-Bugatti from Safran, Aernnova, and Industria de Turborreactores (ITR).

2.5 Aerospace GVC: case studies

We have selected three companies for the purpose of illustrating different echelons in the value chain. The first company is a multinational systems integrator. The other two companies are up-and-coming local suppliers; one of them established itself through a well-planned and -executed strategy, while the other one had no plans to break into the industry until the demand for its products opened a unique window of opportunity for its entrance. These cases evidence the efforts required to remain competitive as a supplier in the market and the necessary financial backing for a long-term operation.

2.6 Bombardier Querétaro (BMQ)

The aeronautic GVC has a complex industrial organization model in which the network of local suppliers is linked to a leading company, also known as an anchor company, that is in charge of product design. The nature of the relationship between anchor companies and suppliers determines the transfer of the industry's technology. This is one of the reasons the arrival of industry leader Bombardier to the Querétaro cluster has been of the utmost importance to the development of supply capacity in Mexico.

Bombardier[5] is a Canadian firm that is highly diversified. In its early stages it produced snowmobiles and trains, but aerospace products now account for more than half of the company's revenue. Today, the company has grown into the world's third-largest civil aviation manufacturer for the business, commercial, specialized, and amphibious aircraft markets. Bombardier's incursion into the A&D industry was not an organic process but one triggered by a series of corporate acquisitions. In 1986, Bombardier acquired Canadair after the Canadian government-owned aircraft manufacturing company had recorded the largest corporate loss in Canadian business history. The bankrupt Belfast-based company Short Brothers was acquired in 1989. The acquisition of Lear Jet Company of Wichita, Kansas, followed in 1990, and finally in 1992 they acquired Havilland Aircraft of Canada, a Boeing subsidiary. Bombardier's most popular aircraft currently include its

[5] www.bombardier.com

Dash 8, CRJ100/200/440, and CRJ700/900/1000 lines of regional airliners. It also manufactures the CL-415 amphibious water-bomber and the Challenger business jet. Learjet is still a Bombardier subsidiary and continues to produce jets under the iconic Learjet name.

Most Bombardier airplanes are designed in Montreal, where 50% of the Canadian aerospace industry workforce resides, as well as in Toronto and Ontario. Bombardier production sites outside of Canada are found in Northern Ireland, the United States, China, and Mexico.

In 2006, Bombardier Aerospace started operations in the city of Querétaro in central Mexico. The plant produced electrical harnesses and was in charge of some structural assembly. The estimated initial investment of this operation was USD 200 million with a workforce of nine hundred workers. They established operations in China around the same time, but their focus in each country has been rather different. In China, their production caters to the domestic market, where Bombardier sells licenses of the productive processes because they have many suppliers and airplane parts in this country. In Mexico, production is destined toward the global market.

According to our interviewee, Bombardier's justification for their Mexican operation is manifold. Wage differences between China and Mexico do not seem to be as important as geographical location. For example, the transportation of a fuselage from China to Montreal can take between thirty-seven and forty-three days, while transportation from Querétaro takes only seven days. In addition, Mexico has a very satisfactory regulatory and legal framework for intellectual property rights protection, including the incorporation of the BASA agreement. Other aspects mentioned by our interviewee were the compatibility of personalities and working schedules. These similarities have allowed the binational team to operate under extremely flexible and shifting productive processes that can change on short notice, sometimes with less than three days' notice. This, we are told, has not been possible in China, where the approach is more process oriented and cannot absorb the quick changes that customers sometimes demand.

Our interviewee states that ProMéxico's negotiations with Bombardier in connection with the latter's entry were clear and transparent. ProMéxico and the federal and state governments have all been very supportive of Bombardier's Mexican venture, but the start-up was not easy. The aeronautic park was relatively unfinished when they arrived and different logistic details had to be worked out in a joint effort. However, thanks in large part to the cooperation of all levels of government, these problems were overcome.

The firm was also able to take advantage of funds from CONACYT and the government of Querétaro. Our interviewee told us that the position of Bombardier's upper management regarding the relocation of production was that no decision would be made solely on the basis of a country's fiscal advantages rather on the general characteristics of a particular country.

Bombardier's role in the Mexican aerospace GVC has been evolving through a learning process in the firm. In a very short time span, Bombardier has acquired manufacturing experience along the global value chain. The first stage of harness production was a complete success, and since then this plant has provided 90% of Bombardier's world demand for this product. After harnesses, they moved to producing a part of the fuselage. Later on, elevators and stabilizers were introduced. In 2009, in a competition against a Mitsubishi plant in Japan, Bombardier Mexico won a project to produce aircraft back elevators, which in turn created the opportunity to supply the half back fuselage for executive plane production.

The learning process has required visits by engineers from and to Bombardier Canada as well as multiple training programs. Under the leadership of our interviewee, the firm has been able to build a world-class workforce: 8% of the workforce is dedicated to design engineering. In 2010, Bombardier Mexico received additional capital in excess of USD 250 million (in addition to the first USD 200 million) to manufacture the complete fuselage and the electrical system of their iconic Learjet 85, which was previously manufactured in Wichita;[6] this is Bombardier's third plant in Mexico and is also Bombardier's most important plant outside Toronto. The new plant was launched in 2010 and received the corresponding FAA authorization to manufacture airplane parts in

[6] This technology is based on carbon fiber developed in the Belfast plant.

categories 1 and 2. This plant employs more than one thousand workers. The final assembly of the Learjet takes place in Wichita, where the cockpit is installed (as required by U.S. regulation) and the airplane is dressed and tested.

BMQ's integration in the GVC comprises other activities, including the manufacture of some parts for the C Series (Bombardier's largest jet), and doors for Airbus. According to our interviewee, the company's arrival in Mexico has resulted in the relocation of the industry's suppliers. For example, Safran, a firm that previously had several plants in northern Mexico, increased its investment threefold with its new Querétaro operation.

The BMQ operation is the main wheel in a complex network of suppliers. Bombardier executives and executives from other foreign firms, as well as government officials, have visited select SMEs to encourage them to enter their network of suppliers. Even though the number of local suppliers is increasing, our interviewee was careful to point out that certification of suppliers is a long-term process, and that there is still a long road ahead in terms of creating an ideal environment. BASA's inception took almost four years, and before its coming to life, FAA provided the corresponding certifications. According to our interviewee, approximately forty firms are applying for or have obtained certifications. An interesting example of a newly certified supplier is Quo, a successful auto parts producer turned Bombardier supplier. At the beginning, Bombardier's supply came exclusively from Montreal, but this is gradually changing as Bombardier now has a project manager and a staff of ten people in Querétaro in charge of identifying local manufacturing opportunities. This team has identified ten thousand items that can be produced locally and is traveling around Mexico searching for suitable suppliers eligible to obtain the corresponding certifications.

Our interviewee suggests that it is a feasible goal for Mexico to become the tenth global supplier with total yearly exports in excess of USD 20 million in the near future. However, substantial investments are required for this goal to materialize. For example, several firms are asking ProMéxico to participate as co-investor in order to create a center of aerospace design in northern Mexico. This institution would provide service to SMEs in the chain. Apparently, BMQ is keen on participating in said investment. Our interviewee

went over a list of challenges overcome through joint action of the industry's participants and government in order to build up the aerospace value chain in Mexico. One of the most pressing challenges is the construction of new industrial parks with appropriate infrastructure and the negotiation with different government agencies in order to improve certification-related regulation. However, more support is still required in order to certify local SMEs if they are to be included in the chain of suppliers.

Our interviewee was emphatic that in order for the Mexican A&D industry to receive more foreign investment, additional fiscal and labor reforms will be needed. Mexico is still a country where it is difficult to pay taxes, for example. Our interviewee's opinion is that the lack of reforms is not the only impediment for the arrival of foreign investment, however. The aerospace industry has the potential to be three times larger, but communication infrastructure needs more development with high-impact projects, such as the creation of railroad routes to improve logistics around the country.

2.8 Especialistas en Turbopartes (ET)

Becoming a supplier of the GVC chain is not easy. It requires changes in a firm's infrastructure and considerable investments. Our case studies will detail the requirements that a supplier of the aerospace chain must comply with in order to get due certification. These requirements range from the construction of ad hoc facilities to the purchase of the necessary equipment. Certification fees (which in some cases may be co-financed with federal or state funds) range from USD 4,000 to USD 40,000. An additional barrier of entry is the large amount of capital investments required. As this case study shows, successful entry into the GVC can depend on the convergence of two virtues. The first virtue is the firm's adequate technological track record and its disposition to take the necessary risks in order to enter into a new sector; the second virtue is adequate support from governmental institutions as described in the previous section.

This second firm has an interesting trajectory in other sectors. ET was incorporated in 1991 as a turbo compressors manufacturer for the energy industry. Its most relevant customers include companies like Pemex and CFE (energy producer and distributor in Mexico). ET reached a prominent status in the manufacture of parts, subassembly, and

assembly, as well as in the overhaul of complete turbo compressors. They hold a joint patent with a public innovation center in the state of Querétaro (CIATEQ) for the dry sealing of low-power turbines. This new product reduces pollution, avoids steam leakages, and increases the life of a turbine by 11–18%.

The company was approached by several foreign firms in the region, including Bombardier, and finally became part of the recently formed aerocluster in Querétaro as a Bombardier supplier. They arrived at the conclusion that their new status required an expansion of their plant, the purchase of new machinery, additional qualified labor, and the corresponding certification. Their first hire was a project manager qualified turbo machinery engineer with business studies—to lead the new unit.

TECHBA played the required advisory role in the initial stage. ET agreed to the necessary terms and conditions in order to be approved as suppliers. The plant was finished in 2010 and the firm acquired the AS9100 certification, which is now on revision "B"; they expect to obtain revision "C" next year. In 2011, the company set up camp at TECHBA Montreal for a month in order to prepare for a marketing and public relations campaign in order to secure clients.

ET was approached by a first-tier landing-gear designer and systems integrator about manufacturing parts for the 767's and 777's landing gear. However, this was not possible, because they needed a very heavy investment in security systems in order to become direct suppliers, and there would be no way to get competitive credits from Mexican banks. Instead they were subcontracted by a landing-gear producer who is an authorized supplier with experience, adequate infrastructure, and the corresponding certifications. This alliance was beneficial for both parties at this initial stage; the firm did not have the capital for the required investments and the contractor wanted to increase its product line.

Lengthy inspections and audits were undertaken by ET in order to satisfy the customer's needs. At the time of our interview, ET had obtained the first approval by the customer after the tryouts and was about to deliver the first samples. Before final delivery,

ET is required to complete a first run with the original material. For the second approval they will have to undertake investments in IT (hardware and specialized software licenses).

ET is optimistic about growth potential, but is aware that this requires the management and development of their capabilities. When asked about increasing production lines, our interviewee categorically answered that they want to consolidate. To take on new projects would mean focusing solely on manufacture, and that would put the firm at risk of having its capabilities stagnate.

ET's industrial eighteen-month plan (introduced at the end of 2010) aimed to create the conditions needed in order to manufacture the complete family of landing-gear components. This plan, divided into three stages—manufacture, material-manufacture, and special processes—had as its objective to build their supplier chain for thermal and special treatments, which at the time of the interview was carried out by the contractor firm with local firms. The systems integrator company had already approached five local firms that are in the process of certification or that already have the necessary certification to be part of the chain of supply of such clients as Bombardier, Eaton, and Messier.

One goal of the company is to manufacture propulsion engines. The major challenge is increasing capabilities and specializing in the handling and operation of titanium for which the company created a five-year project in alliance with CIATEQ in order to handle and process titanium and to understand its markets Strict industry requirements and the supplier's bargaining power make ET's learning curve very steep and make them vulnerable to particularities of the aeronautic market, which may have many indirect costs that are hard to identify. As an example of this, the firm shared an interesting experience with us. ET was initially approached by an important customer to provide a quote for the production of specific parts in high volumes. Their quote was approved, and thus they went ahead with the design of prototypes with trial materials. It only took them five runs to realize that they had made a mistake, and they came to the conclusion that they would not be able to deliver as promised. They assessed tolerance levels, volumes, and costs, but determined that they had not considered all costs, particularly those related to aeronautic traceability. Therefore, they did not continue with the project.

In a joint effort with TECHBA, ET analyzed this case and realized that these products were not suitable for the firm's capabilities and trajectory in turbo compressors. The project involved parts of relatively small size in large volumes; however, they determined that their capabilities should be defined by the manufacture of large-size parts in small volumes and with very low error tolerance, which they had achieved with the turbo compressors for the energy industry. In other words, this contract was a disruptive force that was pulling them away from their core capabilities and competitive advantage. Our interviewee considers that this failure helped ET decide where their GVC niche lies.

In addition to TECHBA's valuable advisory role, ET stressed the importance of the Canadian consultants in advising their upper management on issues such as the manufacturing package, delivery of the documentation system, and the planning of budgets and logistics.

The project was initially funded with ET's own capital; however, they have now applied for technological development CONACYT funds. The verdict is yet to come, but they are optimistic because they are the first firm in Mexico producing these types of parts with composed materials for an entirely new market. They have also applied to the Gazelle firms program of the Ministry of Economics, and expect to get support from the Secretary of Sustainable Development of the state of Querétaro. The interviewee stressed the importance of the availability of governmental funding. CONACYT's financing has been crucial in their innovations; our interviewee complained, however, about the excessive amount of documentation and the time-consuming red tape, and particularly about the lack of competitive long-term financing.

2.9 Maquinados Especiales (ME)

While it might be considered a fluke, ME's arrival in the aeronautic GVC would not have been possible without their previous development of manufacturing capabilities and accreditation in the automobile industry.

ME was incorporated in 1993 as a scantlings manufacturer for the auto parts industry. They are currently manufacturers of tools and dies used in the production of lids and separators for silencers. The firm has twenty employees, including two engineers in

charge of product design (one in charge of metrology and one in charge of quality assessment). Their most important client is General Motors, whose engineers once visited ME's plant and praised them for their good practices.

As the Querétaro aerocluster began to take shape, Spanish firm Aernnova approached ME about the manufacture or repair of deteriorated Spanish tools[7]. ME delivered the contract successfully.

Back then, ME was not certified—they did not even hold an ISO 9000 certificate—but the firm's track record in the auto-parts industry was well known. Aernnova encouraged ME to apply for the aeronautic supplier's development program, NAFIN-PNUD. This program lasted six months, during which the company passed many evaluations and changes. At some point, a PNUD expert visited ME and made several suggestions, including the installation of a metrology laboratory and a conference room, administrative improvements, and certification issues. They were all carried out, and the production process was finally fully documented.

In order to get the certification, two employees took the course at CEDIA, and it was decided that the first step was to get the ISO 9000 certification, which they obtained recently. ME is planning to undertake the certification process for AS9100, which would be indispensable for obtaining global contracts in the aeronautic industry, but they are aware that certification is only the first step. The decision to enter fully as a supplier in the aeronautic market is definite. ME has already invested in the building of a separate plant with new machinery for the aeronautic market exclusively, as will be required by their future customers.

Until now they have financed their new operations with their excess cash flow, as is frequent among Mexican firms. More recently, they have applied to the above-mentioned supplier program. We were puzzled to hear that the interviewee did not know anything about the different funds offered to SMEs by the government.

[7] Aernnova manufactures components sold to a first-tier supplier of Boeing's tails for Bombardier. They also manufacture helicopter and turbine components.

3. The Software Value Chain

Software is an important part of the global value chain of information technologies (IT), which include computing and telecommunications hardware and telecommunications and IT services. Software production can be classified into the following four categories:

Software as a product—that is, the shrink-wrapped software programs developed for use in the mass market, sold as packaged programs by distributors or distributed as freeware. These include operating systems, tools, and applications.

Embedded software, which is built into the electronics of cars, telephones, audio equipment, robots, appliances, toys, security systems, pacemakers, televisions, and digital watches.

Customized software solutions—these may be generated in-house by the systems department of a firm, or they may be outsourced to third-party contractors (software factories). Applications for enterprise resource planning (ERP) and customer relationship management (CRM) are examples of the customized software segment. These applications may be sold as plug-and-play products, but they usually require specific tailoring to address the specific needs and requirements of the end user (López, Ramos, and Torre 2010).

Cloud software, also known as cloud computing, is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet).

Modular design is an essential characteristic of software as a product that is standardized and codified. Packaged-software vendors structure their products into componentized product families developed and maintained using software product lines or as software suites that promote seamless integration (Schilling, 2000). This makes it possible to change and add software modules while still keeping oversight in one central database. An example of this is System Analysis and Program Development (SAP), which was created as an ERP program; over time, more functions were added in the fields of finance, CRM, and human resource management (HRM). This gave rise to software

factories. A software factory systematically captures knowledge of how to produce the units of a specific product family. It then makes it available in the form of assets like patterns, frameworks, models, and tools, and then systematically applies those assets to automate the development of the family units, reducing cost and time, and improving product quality over one-off developments (Greenfield and Short, 2003). Customized software, on the other hand, is not modular, because producers create software according to the needs of customers, so it is not standardized.

Software and IT services have become increasingly interrelated. IT services include planning, integration, implantation, operation, support, and maintenance of computing and telecommunication systems. Planning activities, carried out by the final users of these systems, may be assisted by consulting, design, and engineering services. Integration and implantation go together because the hardware supplier firm is responsible for starting the IT system. This may imply the coordination of several suppliers of software applications and the corresponding tailoring to the specific firm's needs. Operation traditionally rested in the systems departments of firms, but increasingly is carried out by outsourcing companies or by cloud-computing utilities. Outsourcing may include the management of equipment, the operation of data centers, and application and monitoring services, as well as remote management, including security (Hualde and Mochi 2008; Zermeño 2011; Leamer and Storper 2001; Lall 2000).

India has been the pioneer in offshoring services and software factories. Indian firms started concentrating on software programming, with the majority of their workers being "body-shopped"[8] to the United States and Europe, according to Dossani and Kenney (2006). At the same time, MNCs searching for low-cost white-collar workers established small subsidiaries for software coding and transaction-processing services. Offshore services have become more complex as Indian firms have entered offshore IT services as systems integrators or as integrated circuit designers.

Today, other emerging economies have entered this market; as a result, strong forces for geographical dispersal characterize the software market. However, in spite of this, forces toward geographical concentration coexist in the sector because software firms,

[8] Subcontracting of labor services.

like firms in other knowledge-intensive sectors, tend to be clustered in specific cities or regions, such as Silicon Valley in California, Route 128 in Massachusetts, Dublin, Bangalore, and, in Mexico, in Guadalajara and Nuevo León. Firms in the first cluster interact with clusters in Bangalore and Taiwan, and firms on Route 128 with the Irish cluster in Dublin and the Israeli cluster (Saxenian and Hsu, 2001). Therefore, the software industry is characterized by a global dispersion around specific cities and regions (Domaas Wibe and Narula, 2002); (Arora and Gambardella, 2004); (Heeks and Nicholson, 2002).

3.1 Taxonomy of exporting countries

Carmel (2003) elaborates a four-tier taxonomy of exporting countries, based on three criteria: maturity, clustering, and export revenues. Maturity refers to the number of years that firms of a specific country have been exporting (this criteria evaluates a multitude of firms during a specific period, not just two or three scattered firms); clustering refers to the critical mass of enterprises participating in the software export industry and maturing agglomeration of secondary services, such as marketing consultants to aid local firms in foreign market penetration, and export revenues are revenues from products and services.

Tier 1 nations are the Major Software Exporting Nations. The United States leads the way with sixty-three companies, followed by Japan with ten companies, France with six companies, Great Britain with four, Germany with three, and Sweden and Finland with one each (Software Top 100 2011). The new members in this group are the celebrated cases of the three *I*s: Israel (Kaplan, 1998), India (Moitra, 2001), and Ireland. This is confirmed by their presence with one or two companies in the top one hundred in 2011.

Tier 2 nations are Canada and Korea, with several companies among the top hundred and faster-growing software firms in recent times. Also in this tier are the Transition Software Exporting Nations, China (Ju, 2001) and Russia (Terekhov, 2001); (Makarov, 2003).

Tier 3 nations are the Emerging Software Exporting Nations. These nations already have significant software export industries (most are in the USD 25–200 million range). They also have one or more small geographic clusters of successful SMEs; a limited

number of Tier 3 nations also have a few large enterprises. The larger Tier 3 nations are Brazil, Mexico, and the Philippines.

Tier 4 nations are Infant Stage Software Exporting Nations like Cuba, El Salvador, Jordan, Egypt, Bangladesh, Vietnam, Indonesia, and Iran.

The factors behind the success of India, Ireland, and Israel as software exporting countries were global demand; the excess supply of human capital in the 1980s and early 1990s, particularly an excess supply of engineering and technology graduates (Arora and Gambardella, 2004); (Heeks and Nicholson, 2002); and, finally, the role of certain MNCs that have relocated in order to tap into different resources.

Some, for example, have gone to Israel to embark on R&D, others to India looking for low-cost qualified labor, and still others have gone to Dublin to take advantage of tax incentives and to gain access to the European market (Arora and Gambardella, 2004). All three first-tier software exporters have had a national strategy to promote their software industries generally and software exports particularly (Heeks and Nicholson, 2002). Government incentives have proved important because of the active steps taken to encourage the high-tech sector in general or the software industry in particular. Such policies have been given many labels: industrial policy, science and technology policy, and innovation policy (Salmenkaita and Salo, 2002). These policies channel national resources into sectors that the government considers of strategic importance to future economic growth, such as infrastructure, industrial and technological parks, and telecommunications.

The software industry is very dynamic and is characterized by continuous acquisitions, but the countries involved has not varied that much. Although Carmel's taxonomy by countries dates from the early 2000s, with some exceptions, it is still valid up to the present, following recent software trends, as will be seen next.

3.2 The industry leaders

The largest software companies in the world together generated software revenues of over USD 220 billion in 2010 (Software Top 100 2011).The top ten companies accounted for over 60% of that huge amount. Microsoft is by far the largest software

company in the world. The top ten largest companies are: Microsoft, IBM, Oracle, SAP, Ericsson, Nintendo, HP, Symantec, Nokia-Siemens Network, and Activision Blizzard. The new arrivals to the top one hundred in 2010 were: Informatica, Tibco, Emerson, Blackboard, Micro Focus, and Constellation Software. Among the departures are Sun Microsystems and Sybase after being acquired by Oracle and SAP respectively. Competition between technology giants has increased as Microsoft, Google, and Apple have started to challenge each other on their traditional terrains.

The fastest-growing software companies are: NCsoft, Nexon Corporation, Intel Corporation, Square Enix, TOTVS, Autonomy, Shanda Interactive, Kaspersky Lab, Capcom, and Sopra Group. Intel, one of the largest hardware companies in the world, entered the Software Top 100 after buying Wind River, a producer of embedded software. Apart from Intel, all of the fastest-growing companies mentioned are from outside the United States. This could signal a trend of companies in upcoming markets catching up with the United States. TOTVS (Brazil), Shanda (China), and Kaspersky (Russia) are all leading software companies growing at high speed.

The above-mentioned companies are all in different areas of software business, including games, ERP, CRM, and security. In the games field, Japan leads with Nintendo and three other companies (Sony, Konami, THQ). In the ERP market, the United States has four companies (Activision Blizzard, Oracle, Sage, and Infor) and Germany one (SAP). In the CRM business, the leaders are SAP (Germany) and U.S. companies Oracle and Microsoft Dynamics. In the security category, there are two American companies (Symantec, McAfee), and the other four are from Japan (Trend Micro), Israel (Check Point), Russia (Kapersky), and the Czech Republic (AVG).

3.3 Characteristics of the Mexican software and IT services GVC

Since 2003, the software industry in Mexico grew substantially, with outputs reaching USD 415 million in the year 2010, and a yearly average growth of 20% for the 2000–2010 period. Mexico hosts a large variety of IT services firms specializing in customized software solutions, systems consulting, integration, technical support, maintenance to data centers, Business Process Outsourcing (BPOs), and others. These products, including

imports of software packages, are sold by local companies (at the national and international levels).

Embedded software firms as well as cloud-computing firms are still a novelty in Mexico; therefore, it is hard to obtain reliable data on production and sales. The share of software as product accounts for 80% of the Mexican software industry, while customized software solutions account for the remaining market share. In this market there is a concentration in the large international companies. However, concentration appears to be declining; for example, in 1995, the share of large transnational companies in the software package market was greater than 80%; however, by 2005, this ratio dropped to 60% (Hualde and Mochi 2008). There is no information for 2011 yet, but it is safe to assume that the larger firms have continued losing market share to smaller and more dynamic local start-ups.

Revenues for customized software products have grown at a yearly average rate of 9.6% between 2000 and 2011, from USD 148 million to USD 406 million, as illustrated in Table 1. In 2004, the year in which PROSOFT[9] funds were first disbursed, yearly growth rates rose far above the average rates of the rest of the economy, with a 12.05% increase in the case of customized software and 12% in the case of package software. The share of software in total IT services passed from 43% to 47% with only a 1% increase in the share of customized software.

[9] PROSOFT is the government program for the software industry, as will be seen below.

Table 1 Software Market (in million dollars)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011*	Growth rates
Software as product	606	602	671	665	719	816	1036	1215	1328	1205	1376	1590	9.20%
Customized software solutions	148	147	161	116	180	202	239	289	296	273	346	406	9.60%
Total software	754	749	832	781	898	1018	1275	1504	1624	1478	1722	1996	9.30%
IT services without customized software solutions	1625	1679	1768	1908	2007	2152	2416	2927	2989	2759	3296	3868	8.20%
Total IT services*	1774	1827	1928	2024	2187	2354	2655	3216	3285	3032	3642	4274	8.30%

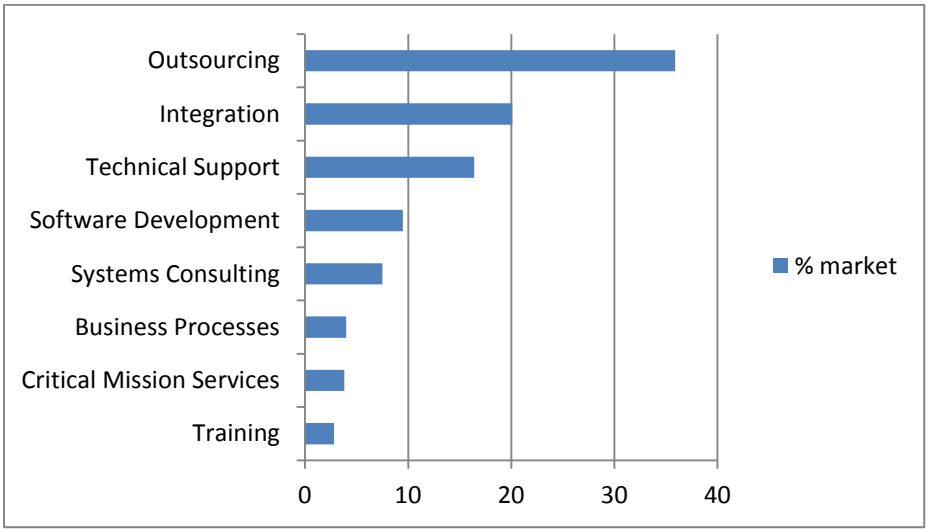
Source: Select company 2011.

IT services have also increased at very fast rates (an 8.3% increase for the entire period and a 10% increase from 2004 to 2011). These services are either provided in-house or outsourced. According to our interviewee at Select, the cost of internal IT services is 20% higher than if these services were outsourced. There is a growing trend for IT services to be outsourced through outsourcing managed services and/or cloud computing.

By "outsourcing," we mean those services subcontracted to third parties, which may include the operation of the data center and applications, monitoring, and remote management systems. Website creation, database analysis, testing, and marketing services may be other activities to be outsourced. Finally, manpower services have become increasingly important business among large software firms. The latter is the activity with less value added.

In the 2007–2010 period, it is estimated that, on average, outsourcing accounted for 37% of total IT services. The outsourcing industry's income drivers in 2007 were data center services (USD 235 million), the application management sector (USD 193 million), and security services (USD 193 million). In terms of market share, after outsourcing follow IT services such as integration, technical support, and software development. The distribution of IT services can be observed in Figure 1.

Figure 1 IT Services (% of market, 2010)



Source: Select company 2011.

The Mexican IT industry is characterized by many small companies and a segment of large firms that can be classified in several groups. According to data compiled by the National Foreign Trade Bank (Mochi and Hualde 2009), by the end of 1999, 257 programming companies were operating in Mexico. Only fifteen of these firms had international operations. In 2002, there were 2,098 firms with 269,620 employees. In 2010, this number increased to 2,785 firms with around 500,000 employees. With the exception of a few companies, most of the firms are SMEs (50–150 employees each and selling less than USD 1 million annually). A recent survey of forty-two firms (Mejía, Ania, and Gamboa, 2006), which account for 75% of the total industry in terms of revenues, shows that these firms are extremely young. Productivity was related to size: firms selling less than USD 10 million a year had lower productivity. The result was a relatively concentrated market structure: 40% of companies account for 95% of the sales in their sample.

The main industry players in the software-as-product sector are global firms like Microsoft, Oracle, SAP, HP, IBM, Accenture, CapGemini, and EDS, which sell to the domestic market and operate offshore facilities to provide bespoke services to their customers in developed nations. According to Mullan, Kenney, and Dossani (2008), in Mexico, a second category of foreign firms includes Indian firms led by the giants—TCS, Infosys, and Wipro—that are expanding their global footprint to better compete with the

service firms in developing nations. A third category consists of independent Mexican IT companies such as Softtek, Neoris, and Hildebrando.

While there is significant supply of these firms in both quantitative and qualitative terms in the Federal District, Jalisco, and Nuevo León, other regions lag behind. As Mullan, Kenney, and Dossani (2008) mention, the concentration of IT activities in Mexico City does not necessarily reflect any specific promotion strategies or synergistic clustering; rather, it likely reflects the size and importance of the economic activity in Mexico City. Guadalajara is the most successful case of IT services. Although it only accounts for a small percentage of the IT service firms in Mexico, it has much larger revenues than Monterrey, which has a greater number of firms. This success combines the presence of large MNCs located there, such as IBM and HP, with an efficient implementation of PROSOFT, as was confirmed by interviews in the state of Jalisco.

3.4 Government programs and industry regulations

During 2001, the Mexican government decreed the strategic importance of the local software industry in terms of its potential for the economic development of the country. The PROSOFT initiative was launched in October 2002 with the objective to raise competitiveness by strengthening the Mexican IT sector. Initially it focused on the software industry, but since 2004 has been expanded to cover the entire IT sector. PROSOFT is part of a general policy of shifting from labor-intensive assembling into high–value-added services.

The PROSOFT fund became operational in 2004 with government funding of USD 12.8 million. This figure increased in 2008 to USD 65 million, which mobilized resources in excess of USD 180 million. PROSOFT funding delivers 25% of the total investment committed by the federal states and the companies (García 2011). This initiative funds a variety of activities such as education and development of human resources, technological innovation and development, processes capacity and quality, and productive projects, as well as promotion and marketing, among others.

The program was advertised among chambers, companies, and local governments. Some Mexican states have developed significant industrial policymaking, with Nuevo León

and Jalisco having the greater success in encouraging IT companies. The importance given to the IT industry by local governments determines the efficiency with which the policy is implemented and the amount of funds dedicated to it. As we have mentioned, the state of Jalisco is a good example of this.

Particular effort has been devoted to the funding of projects geared toward the certification companies. Application for a particular certification can be time consuming and requires expensive training and consulting efforts; hence, applicants incur great costs. Due to the expensive nature of this process, PROSOFT developed an ad hoc norm for certification (MoProsoft) that may be very useful for small firms that usually do not have the resources.

Important advances have been made in connection with the certification of technology companies. According to our official sources at the National Bank of Foreign Trade (BANCOMEXT), in 1999, only five companies had obtained an ISO 9000 certification, and only five held CMM (Capability Maturity Model) certification. In 2010, Mexico had over seventy companies with CMM-certified personnel, ranking Mexico in eighth place globally together with France. As for other certifications like PSP (personal software process) and TSP (team software process) or MoProsoft, our interviewee from the National Chamber of Electronic Industry (CANIETI) estimates that around 350 companies have the above-mentioned certifications.

Mexico First is another initiative lead jointly by PROSOFT and the World Bank. Funds from this initiative are aimed toward training and certification costs. Under this initiative, companies may receive up to 60% of the project's total cost. IT LINK is an initiative originating in Singapore that aims to certify the business processes of firms in order to help them search for clients among multinational firms. This initiative conveys information via a solid operational network, allowing firms to respond to commitments through an alliance or partnership of suppliers. Through IT LINK, associated firms can easily get in touch with a vast network of potential clients.

Finally, it is important to mention TECHBA, a subsidiary of the Mexican-American Foundation for Science, which acts as a firm accelerator and as a highly specialized

consulting bureau. TECHBA's services are funded by the SMEs program of the Ministry of Economics. TECHBA's initial target market was companies in the high technology market. However, in recent years they have become specialized in specific value chains, particularly the IT and aeronautic chains. Their services have several stages, ranging from the basic business level to international advisory service, aiming to provide firms with a solid operational structure in order to establish themselves in the global GVC. They have offices in Silicon Valley, California; Austin, Texas; and Madrid, Spain. They have documented around two hundred success cases of IT firms.

Scholars have identified structural weaknesses in IT companies. Mullan, Kenney, and Dossani (2008) identified the lack of scale in Mexican companies vis-à-vis their Indian peers as a major industry obstacle. In India, large firms have more than 30,000 workers (some have as many as 100,000), with many medium-sized niche firms (5,000–29,999 employees) and many more small firms (< 5,000 employees).

Another limitation is the lack of market specialization that should be expected given the small size of companies. It is very common in Mexico for companies in the industry to focus on more than one core service. Mejía, Ania, and Gamboa (2006) found that only 30% of the companies surveyed had one service that accounted for at least 50% of their business, and in some of these cases, said focus was attributable to one very important client to whom they sell the service.

Using Indian IT offshoring companies as a reference, Mullan, Kenney, and Dossani (2008) identify the great potential of Mexican companies due to: (1) an overwhelming geographical advantage over nations in Asia and even others in Latin America, as proximity to the U.S. market substantially facilitates interaction; (2) lower telecommunications costs versus those in India; and (3) Mexico's superior infrastructure over India's infrastructure, which has a deficit in terms of airports, public transportation, and hotels, which is an obvious impediment to business. Although Indian wages are lower, Indian workers receive an extra payment for transportation—a burden that Mexican software firms do not have.

However, these advantages by themselves are insufficient for Mexican IT firms to compete with their Indian competitors. First, telecommunications costs might be a significant expenditure for call centers, for example, which require significant bandwidth, but these costs are not necessarily the most relevant of expenditures for most IT firms. Moreover, telecommunications costs are becoming an ever smaller portion of overall operational costs and they are declining in the long run, so this advantage will erode. Most importantly, while demand for engineering careers has stagnated or even decreased in Mexico, there has been impressive growth in demand in India, resulting in a many times larger pool of engineers with English-speaking proficiency, many of which are H-1B visa holders who have migrated to, or, at a minimum, have previously lived or studied in, the United States. This explains the large size and competitiveness of Indian companies and explains the difficulties the large firms mentioned in our interviews have in recruiting qualified labor in the quantities needed.

3.5 Software Value Chain: case studies

We mentioned before that modularity is a characteristic in the case of software as a product, but there may be a need to adapt to the needs of a specific firm. This happens frequently in Mexico, where there is a vast array of small companies catering to smaller market niches that must make this adaptation. This leads us to think that this is a limit to modularity and explains the need for tailor-made software applications of different kinds that large software producers do not necessarily control or have the flexibility or agility to venture into. For example, there are huge opportunities to provide software products and services for the business operations of small firms or for specific requirements of governments and large firms. Moreover, many new products require tailor-made embedded software. As technology changes in the software business, software firms need to adapt to the new concomitant business models.

While in the aerospace GVC there is a great deal of coordination between OEMs and supplier firms in the different tiers, in the software industry this coordination is less apparent, although it still occurs. We have selected three companies with the purpose of illustrating the drivers and obstacles in different market niches in the GVC as well as their differences and similarities. The first company is a leader in the export of IT services in

Mexico offering a broad portfolio of services. The second one is a small firm specialized in Internet-based services (cloud computing). The third company plays an advisory role regarding quality software and industry best practices.

3.6 Softtek (Near-Shore Services)

Taking into consideration that India is by far the world's main provider of IT services among the emergent countries, Softtek illustrates that there are different formulas and options that have allowed the entry of emerging countries into the IT services GVC.

Softtek is now a global provider of process-driven IT services, with 6,400 associates across thirty offices in North America, Latin America, Europe, and Asia. It is the largest Mexican-owned software firm, with a very fast growth rate and a well-diversified service portfolio. The company was incorporated in 1982 by three engineers who had been working in the systems division of Monterrey Group (Grupo Monterrey). Later on, two additional partners joined in the firm. The initial product was software development for large and mid-sized Mexican firms. Since then, Softtek's portfolio has evolved substantially.

Initially, Softtek concentrated on application-related services including application development, software testing, application management, and application security services, and SAP and business intelligence. According to our interviewee, application development now accounts for the largest share of Softtek's revenues. They developed the proprietary Softtek's Software Development Process (SSDP®), a phase-milestone methodology that is the underlying foundation of their application development services (Close-Up Media Inc. 2011). Other services include IT support (user support services, server and datacom services, and IT business process support), BPO (procurement services), and SAP and business intelligence software licensing (SAP, Informatica, IBM Cognos).

Softtek's initial exporting destinations in the early nineties included Peru, Brazil, Argentina, and Colombia. It was not until 1997 that they launched an ambitious export program to the U.S. market. According to our interviewee, the explanation behind this strategy was the following: First, the company realized that if they stayed in the domestic market there would not be enough room for growth and they would not be able to adequately diversify risks. Second, they saw the Y2K problem as a window of opportunity

in the American market. More importantly, they understood that big corporations were looking for outsourcing options other than companies in India or China.

Softtek was willing to bet that proximity would become a compelling advantage for customers in need of swift solutions to business problems, and that an even more compelling advantage would be the more compatible corporate culture. Geographic proximity can be of great help in the scoping of projects and the assessment of client's needs. Everything from easier travel to being in the same time zone substantially improves communication. Last but not least, the benefits of NAFTA's short-term visas and the security granted by the Mexican government's commitment to WIPO's TRIPS agreements were deemed paramount. Thus, even though China and India still have a clear lead, it was evident to Softtek that there was a niche for Mexican firms.

When asked about the kind of capabilities the company had developed in order to break into the U.S. market, our interviewee mentioned that by the time they considered entering the U.S. market, the firm already had a staff of approximately 1,800 engineers with certifications in specific technologies and methodology. The company also has a program named Softtek Academy, through which employees are hired for six months to be trained and that also offers scholarships to students in the last years of college. Another interesting program is referred to in the firm as Team Software Process (TSP), which enables improved project performance, increased speed of product offerings with higher quality, as well as improved work-life balance for employees. Additionally, by creating self-directed teams, Softtek reported increasing productivity and reducing costs through more predictable outcomes (Close-Up Media Inc. 2011). According to our interviewee, around 15% of associates are project leaders, and all of them are certified.

Instead of engaging in direct price competition, Softtek differentiated its products. They registered the concept of Nearshore as a trademark. Nearshore refers to carrying out services in an adjacent or nearby delivery center. With nine global delivery centers in Mexico, China, Brazil, Argentina, and Spain, Softtek offers to improve time-to-business-solution, lower costs of existing applications, deliver better-engineered and -tested applications, and produce predictable outcomes for top-tier corporations in over twenty countries. Under this plan, facilities in Mexico would support the U.S. market; facilities in

Spain would support English and French firms; and Argentina would support South American firms.

Exports account for 75% of reported revenues of the firm, with a reported income of around USD 250 million (Close-Up Media Inc. 2011). Softtek's customers include banking and financial companies and other Fortune 500 companies. Our interviewee stressed that many of Softtek's clients already had ongoing business with Indian firms, which leads us to believe that these clients use Softtek as a complementary alternative, either to diversify their set of suppliers or to address needs unresolved by Softtek's Asian counterparts.

GE is Softtek's flagship customer. GE's initial contract was small, but operations slowly increased, both in sales and in the variety of services rendered. Just as GE Capital International Services had relocated to India a range of corporate activities, such as credit cards, back-office operations, call-center work, internal finance, and accounting, GE sold Ddmesis—a division of GE Capital International Services America specialized in the development, maintenance, management, and integration of software systems—to Softtek (Dossani and Kenney 2006). This acquisition greatly expanded Softtek's portfolio of applications and services. Softtek currently has business relations with several divisions: GE Capital and GE Manufacture.

In August 2007, Softtek acquired China-based I.T. UNITED, expanding its capabilities in the Asian market. Currently, Softtek has three hundred employees in China. According to our interviewee, the strategic importance of this investment is threefold. First, China's local market offers enormous growth potential. Second, certain Softtek clients have operations in China and the company can attend to them through the new facilities. Third, having a base in China offers the possibility to pursue global markets twenty-four hours a day, 365 days a year. The company calls this strategy "following the sun."

Another important market is Brazil—four times larger than the Mexican market. Brazil has a much larger number of medium-sized firms than Mexico, and they have more liquidity to invest in services like Softtek's.

In spite of all efforts to improve capabilities, the main barrier or obstacle for the firm is the insufficient supply of qualified employees that are fluent in English. In an

interview with Universia Knowledge@Wharton, Softtek's CEO, Blanca Treviño, described scalability as one of the most relevant limitations that Softtek shares with other large IT firms in Mexico. She pointed out that there is a limit on the scale of operations that can be reached. India and China can summon thousands of software professionals under short notice; this would be virtually impossible in Mexico. However, the company's global strategy exploits the above-mentioned proximity to and adaptability with their U.S. and Spanish customers (Treviño 2008).

Federal, state, and municipal government agencies are an important part of Softtek's domestic market. These agencies retain their IT contractors through rigorous contests in which contractors compete to satisfy rigorous specifications that normally entail very high investments. Softtek subcontracts several firms (or vice versa) when participating in these contests, because it is very rare that a firm would produce every item or service required. This is the only event in which they subcontract other firms.

When asked about challenging moments, failures, and lessons learned, our interviewee told us that accelerated growth is a blessing, but entails risk. At the beginning of 2000, Softtek was awarded many contracts; however, not all of them were delivered successfully, due to either: (1) lack of qualified staff; (2) inability to deliver on certain promises made to clients; or (3) neglect of profitability aspects. Softtek is constantly forced to remember the lessons learned, especially in their new ventures, which include embedded software and near future provision of services on the cloud.

In our interviewee's opinion, PROSOFT has been successful because it has laid down the foundations for the development of IT services in Mexico. Softtek has taken advantage of the certifications program Mexico First. The help of ProMéxico in export promotion was named as a determining factor for Softtek. Our interviewee was also adamant about the lack of success of the CONACYT innovation programs. These programs are supposedly geared toward the creation of new products; however, the initiative does not have a clear understanding of software and its innovative potential. Our interviewee thinks this lack of understanding explains why Softtek was rejected when applying for financing.

The most important problem still unresolved by the current economic policy is the absence of necessary financing in order to compete in the global market. This is particularly problematic for IT services and software entrepreneurs, because they can only provide intangible guarantees (human capital and knowledge), and traditional investors and banks are prone to reject their financing petitions.

3.7 Scio (Software Services in the Cloud)

As mentioned before, the software market structure in Mexico is characterized by a few shining stars, most of them foreign and many small- and medium-sized local firms. Because of their limited scale, many of the latter exclusively serve the domestic market. The size of this market is limited and thus entails high competitive rivalry. Softtek entered the global market due to entrepreneurial talent, acquired capabilities, healthy financing, high-quality products and reliability, and the provision of a relatively vast array of products. Small- and medium-sized firms have more limited resources, and even if they have similar capabilities, they have had to find a competitive niche to become successful exporters. A clear example of such firms is Scio, a small Mexican firm with no more than fifty associates that serves American, Canadian, and English software companies. An important factor behind Scio's success is that the firm specialized in one area of expertise.

The company was incorporated in 2003 in Morelia, Michoacán. Our interviewee, a Mexican engineer with a master's degree from Austin, Texas, who had previously worked as a systems consultant for four years, realized that there was an opportunity in Mexico to serve firms demanding offshore services. According to him, the first years were harsh, but the firm evolved from a home-based business into a multi-service operation constantly fighting for survival. In 2006, they enrolled in the TECHBA consultancy program in Silicon Valley. One of TECHBA's main recommendations was that they should identify a niche where the company had more experience. They identified the changing trends in the industry and decided to reduce their multi-service efforts and focus on software as a service on the Internet, also known as cloud computing.

Cloud computing involves, among other things, delivering software products and services via the Internet instead of exclusively selling software as a product. Scio offers

three services: (1) innovative consulting that helps companies build a strategy (technical solutions) to go to the cloud; (2) training programs for firms that want to migrate to the cloud and understand all the concomitant changes in business paradigms; (3) software solutions and applications via cloud computing.

Training has been a company priority; employees have entered both public and private programs, including several training programs in cities like Denver, Austin, and San Francisco. These privately sponsored programs receive participants from all kinds of firms who want to get acquainted with cloud computing and the problems of migrating software to the cloud. An example of these programs is one put on by Microsoft (Scio's number-one client, which recently launched its cloud-based Windows Assure) and is a two-stage training program: the first module of the program was given in Richmond, Washington, and the second module was delivered in Mexico with thirty Mexican companies participating.

Even though Microsoft is Scio's most important customer, the majority of their revenues come from mid-sized software firms. Only 5% of Scio's customers are in Mexico; Mexican firms in general cannot afford Scio's services.

The company is trying to make a name for itself in the U.S. market. As they lost some contracts to more expensive firms with less expertise, they realized that price alone would not give them the competitive edge they needed. Scio recently started operations in Seattle in order to deliver a more personalized service.

The first obstacle in the United States was that Mexico was not recognized as a household name in the field of IT services. This is slowly changing, as many of Scio's customers do not want to contract Indian or Chinese firms anymore. Their second obstacle was financial in nature: their growth strategy was cash-flow based, which seriously limited the potential growth of the company. They encountered major difficulties in getting credit because traditional credit providers would argue that they did not have scalability. The third and perhaps most important limitation for Scio, as well as for the rest of the software companies in Mexico, is the lack of an English-proficient workforce with programming capabilities.

3.8 Qualtop (Software Best Practices)

It is not necessary to export in order to be a part of the IT GVC, as can be seen in the case of Qualtop. IT services exporters, as well as government providers, must have high quality standards. The competitive edge of this company lies in being one of the first to understand this need and get all needed certifications.

Qualtop is the subsidiary of an Argentine software applications firm that started with three engineers but now has more than one hundred consultants.

The firm incorporated in Mexico in 2003. Their start-up business model soon changed as they identified opportunities for specialization in software optimization processes and CMM certifications and left software applications behind. Soon after, in 2009, they created a new firm with headquarters in Guadalajara's software cluster where, according to our interviewee, entrepreneurial support is particularly efficient. They also have an office in Mexico City, where most of their corporate clients are based.

Our interviewee narrates the process that led to the identification of their market niche. This story goes back to the Argentine team, who observed a high level of chaos in their client's processes. This prevented them from establishing their requirements and demands. This was the opportunity. Qualtop developed a proprietary tool that allowed them to organize the processes. In order to do this, they undertook an in-house project to get CMM certification. Qualtop has forty associates. PROSOFT funds have been paramount to their operation. It is difficult to recruit qualified consultants with experience in software development and testing and knowledge of Six Sigma. Therefore, the company has used the PROSOFT funds to invest in capacity-building. The staff has taken several introductory CMMI (Capability Maturity Model Integration) courses and the special SEI (Software Engineering Institute) course.

The company has also used PROSOFT to certify in CMMI3 in order to become a consulting firm. They are the only company in Latin America consulting on software processes quality. CMM has become an important certification in order for a company to become a software provider to either MNCs or government.

Qualtop's customers are quite diverse; some of them develop software exclusively, others outsource, and others have a large systems department. Qualtop's mission is to help customers develop their software with high quality and minimum reworks, in line with best practices. Through the consultancy offered by the company, some firms have been certified in top levels. PROSOFT's financing was fundamental in this endeavor. Foreign Direct Investment (FDI) firms account for 50% of total sales. The firm does not export, because their consultancy is interactive and requires consultants to visit the client firm at least twice a week.

Small companies, which are the other 50% of sales for Qualtop, come with complications because they rarely would pay for this service if they did not get the government subsidy; sometimes Qualtop even guides its clients through the cumbersome procedures necessary to obtain PROSOFT financing. The company is aiming to change the mix of customers toward larger firms, which is why they recently obtained the IT LINK certification.

In their opinion, PROSOFT is a good instrument, but its performance depends on the efficiency of local (state) governments, which must contribute with 25% of the total project. Jalisco's authorities have understood the advantages of specializing in software clusters in the capital city (Guadalajara). The Council of Science and Technology of Jalisco, the chambers, and the universities all work toward this end. PROSOFT initiatives in Jalisco are very efficient. The Mexico First initiative in Jalisco aims to simplify procedures for smaller firms to access funds and to obtain certifications. This is not the case in Mexico City, nor in Michoacán, where Scio is located. Scio was not able to take advantage of PROSOFT funding.

In our interviewee's opinion, as well as the opinion of the other industry participants we talked to, Mexico cannot compete directly with India; rather, it must develop niches based on its comparative advantages in software architecture services, project management, and requirements analysis. In other words, in spite of the success of some companies, the possibilities of offshoring (mainly manpower) on a large scale are not possible; therefore, high-value-added software activities should be the goal of Mexican firms.

4. Policy implications

Our case studies show that Mexican aeronautic firms participate in this GVC as suppliers of parts of subsystems. The studies also document that these firms play a minimal role when it comes to product design, which is carried out by systems integrators in developed countries. We also show that software firms specialize in customized software solutions, systems consulting, integration, technical support, maintenance to data centers, and BPOs. We discovered that both groups have a great deal of interaction between customers and suppliers. This means that in spite of standardization and certifications, there is a need for exchange of tacit knowledge. In the cases we analyzed, we did not find enough conditions to characterize the type of governance in the nodes located in Mexico as modular. In the cases where capabilities are high, the governance can be characterized as relational, which implies a great learning potential for our companies in the case studies. When capabilities are still limited (i.e., the supplier company is starting in a new field), the governance of the chain must be considered captive. Thus, much effort must be made on their side to scale up in order to get a higher share of income in the GVC.

It is true that geopolitical factors were important in the relocation of the new FDI firms in Querétaro's aerocluster. Geographical proximity gives Mexican IT firms an advantage over Chinese firms due to: (1) reduced transportation costs; (2) reduced time differences; (3) immigration benefits provided by NAFTA (expedited visas, for example); and (4) the Mexican government's commitment to WIPO's TRIPS agreements. In general, we found that NAFTA sets a good framework for international business in the Mexican IT services, and that proximity with the U.S. market enables swift interaction with clients that gives Mexican firms a competitive edge.

These advantages are only part of explanation for the insertion of Mexican industry in both GVCs. In our opinion, this could not have happened without an effort of public policy at different levels to attain this goal on the part of the Mexican government.

In the case of the aerospace industry, this public policy consisted of convincing global aerospace companies to invest in Mexico by engaging with them in initial negotiations in which the government communicated their intention of creating favorable

conditions for investment. ProMéxico's role in securing investment commitments by foreign companies was deemed decisive by Bombardier, whose representative recalls that negotiations were clear and transparent. In-depth strategic analysis was carried out (Grupo de Trabajo de la Industria Aeroespacial Mexicana, 2009) to define the technological road map, and the design of the corresponding policy included the participation of federal and local government authorities, universities, and research centers with the aim to achieve cluster interactions and external economies. In our opinion, the institutional efforts to make industry certifications possible, as well as the availability of funding, training courses, consultancies and certifications, were of the utmost importance. The proactive engagement of government in these efforts in comparison to the past was fundamental. One example of this was the government officials' calling upon local firms, which led to the mobilization of other industry participants.

Regarding the software and IT services, during 2001, the Mexican government recognized the strategic importance of the software sector to Mexico's economic development, and in 2002, the government announced the availability of the PROSOFT initiative, which became fully operational in 2004. This initiative has devoted a substantial amount of resources to finance the obtainment of certifications. We believe that the MoProsoft standard regarding certification is crucial, and even though none of the interviewed companies used it, we believe it is potentially useful for small firms that have more modest resources to devote to certification.

A large firm like Softtek was able to take advantage of the Mexico First program for the building of capabilities and of the ProMéxico initiative for export promotion. Even though the IT LINK certification is still in an early stage, it has important potential, as seen in the case of Qualtop.

We found an increasing presence of entrepreneurial talent with the willingness to take risks and invest in capacity-building and innovation in both sectors. The latter would not have been possible in the aeronautic industry without the earlier accumulation of technological capabilities in other chains like the automotive or the metal mechanic industries. On the other hand, firms in the software industry do not come from other sectors

and are very young. We believe that these firms must invest in their human capital at a greater rate.

Based on the experience of one of the local aerospace companies in our case study (ET), the efforts around the development of suppliers' programs have been very useful. They are even more useful when accompanied by TECHBA's advisory support, which helps firms approach their potential global clients in Canada and the United States. TECHBA's role was also decisive in the case of one IT firm we studied (Scio). In some cases, TECHBA's assistance is so important as to be considered a milestone for the firm. This advisory support seems to be a precondition in order to build not only regular business capabilities, but the international marketing capabilities that local firms tend to lack.

In the past, criticisms have focused on the supposed lack of coordination among programs and institutions (Brown and Domínguez, 2010). Regardless of the merits of this critique, we were surprised to find that in the specific case of the aerospace industry, it was the government who led the institutional coordination efforts to generate the models and scale economies that engaged suppliers with different programs. This has been confirmed by other analysts (Casalet, 2011). We are therefore of the opinion that public policies that establish goals and provide coordination among all industry participants are an important ingredient to overcome the obstacles and barriers of entry to new high-tech niches. As we will explain below, however, these initiatives are not sufficient to secure success.

In the case of the software industry, coordination is not evident. Our interviewees praised PROSOFT as a very good instrument, but added that its performance heavily depends on the local governments. This can be seen in the different levels of success witnessed in different areas of the country. While its performance in Guadalajara is highly regarded, it is not so in other states, as can be observed from the experiences of Qualtop and Scio. This might strongly suggest that software is not a priority everywhere in Mexico.

CONACYT's innovation initiatives seemed to perform better for the aeronautic firms than for software firms. Both Softtek and Scio mentioned that CONACYT programs seem to be oriented toward new product creation, but that there was insufficient understanding of the role of software and its innovative potential. This suggests that special attention to the

software industry is needed, because there may not be enough clarity among evaluators or referees of what innovation means in terms of software. In fact, the design of specific programs (directed to characteristics of value chains) may be needed. As we have mentioned, other countries competing with Mexico do have these industry-specific programs in place, as is the case in India and the mentioned case of the aerospace industry in Brazil.

From a public policy point of view, we also find that reducing governmental bureaucracy is fundamental. The amount of paperwork required to access PROSOFT resources is extremely cumbersome, particularly for small-sized firms, which are in greatest need of ad hoc certifications like MoProsoft in the case of software. This aspect has to be improved.

Funds for certain programs seem to be insufficient to achieve more ambitious goals. In the case of the Mexican aeronautic industry, our interviewees suggested there are empty spaces in the Mexican value chain that if adequately filled would improve the competitive position of the sector in general. As examples, BMQ mentioned the establishment of the Center of Aerospace Design, and TECHBA's consultant mentioned that an insufficient number of companies that perform forging activities was a problem to the value-added chain as a whole. Additionally, there is a need for new industrial parks with appropriate infrastructure. TECHBA also believe that negotiation with different government agencies in order to improve the regulatory framework for certifications is long overdue. More support in order to certify local SMEs is needed as well if Mexican authorities are serious about launching the chain of local suppliers into the global chain, and this is why more CONACYTs and the Ministry of Economics resources will be needed.

The overall opinion of the software industry participants is that PROSOFT funds are insufficient. This is also mentioned in Mullan, Kenney, and Dossani (2008), who say that initiatives in this sector should be freed from governmental bureaucracy and should be spearheaded by the private sector, as is the case of Nasscom in India, which is funded entirely by its corporate members and is an independent lobbying organization.

There is a notorious unbalance between efforts to secure investment from foreign firms and certification and long-term financing initiatives. In our view, the latter has not been properly addressed and should be considered a market failure. The evidence of the deficiencies of the Mexican credit system is dramatic: despite the national guarantee system established in 2003, 97% of credit funds are destined for working capital; in other words, long-term credit is virtually absent (De María y Campos, Domínguez, and Brown, 2010). As the experience of ET shows, certification was a first step to entry as a supplier, but if up to now the initial investment came from internal funds, in the future, competitive credit will be indispensable to succeed in scaling up and developing their own chain of suppliers.

In the case of software, the access to funds is even harder. Due to the fact that they can only provide intangible guarantees (human capital and knowledge), traditional investors and banks are easily inclined to reject financing petitions. Whereas this problem may be endemic of software companies in other countries like Taiwan, the lack of risk capital and long-term financing from the Mexican development bank constitutes a competitive disadvantage in comparison, for example, to Brazilian and Korean companies. Creative policies and mechanisms must be established to induce banks to channel a significant part of their resources to finance equipment and technological development. It is also important to change the policy of the Mexican development bank (NAFINSA), which nowadays emphasizes suppliers credit via factoring (for 60% of portfolio) to incorporate programs in finance projects of the type needed in the A&D and software industries. We believe that the promotion of tractor firms—foreign or local—through the PYME FUND PROGRAM and certification funding is insufficient. Without competitive credit and risk capital, the insertion of Mexican firms in the GVCs may stagnate.

We believe entrepreneurs must evolve as well. The prevalence of very small firms in the software industry makes us wonder if Mexican entrepreneurial idiosyncrasy has become an insurmountable obstacle to achieve strategic alliances and mergers among small firms in order to achieve growth. There appears to be some awareness among entrepreneurs of the need to join efforts in order to compete in the international arena, as can be observed in the association of thirty-eight IT firms (the Monterrey IT Cluster). This cooperation is

supported by the Software Industry Council of Nuevo León. Unfortunately, these initiatives are far from typical.

In conclusion, there are general traits of economic policy that have been conducive for the growth of these two very different GVCs. The aerospace GVC is a highly regulated capital-intensive industry, and the software GVC is a white-collar labor-intensive industry with radically different industrial structures. Lessons from our case studies and the experience of other countries point to the need for some specific programs to address the specific needs of each GVC. Mexican aerospace and software industries do not seem to stand out in global competition, but it is clear that the entry conditions are being set and that Mexican companies are standing up to the challenge. Until now, most firms have participated as captive suppliers or in the low range of value added; however, there is room to move up the value chain in both GVCs.

In the case of the aerospace GVC, government initiatives in the early stages give local firms the possibility to participate in product design and greater value added in manufacture in the future. IT firms can advance also to produce higher value-added services. In order to succeed, these companies must continue to invest in capacity-building and certifications, and must have ambitious goals to get international clients and find new niches.

Finally, it is important to mention that in order to break into a high-tech GVC similar to the GVCs studied in this paper, governmental agencies will need to overcome developmental challenges that go beyond the traditional bridging of market failures. These challenges will require the fostering of high-impact projects that provide physical infrastructure, improve logistics and communications conditions, and, most importantly, foster innovation and learning capabilities among the pioneers of the new chains.

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