CAN MEXICO SET UP IN THE AEROSPACE GLOBAL VALUE CHAIN AS A HIGH VALUE ADDED PLAYER?

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1. INTRODUCTION

World trade has notably accelerated in the past 30 years due to the fragmentation of the productive processes of multinational companies. Production has been organized globally (Robert Feenstra 1998; Arndt and Kierzkowski 2001) and there has been a shift away from vertically integrated multinational firms towards 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 in their home turf they compete in a global market hence; traditional industrial organization analysis must evolve to fully grasp the nature of global value chains (GVC´s)

Modularization, which consists of the separation and recombination of systems components (Melissa Schilling, A 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 Colin 2001).

For the last twenty years insights on the concept of the “global value added chain” (GVC) have lead to very different issues than the issues originally covered by traditional sector analysis theory. The focus has shifted to: i) the activities that are bundled in one node of the chain or split among various nodes: ii) the way in which knowledge information and materials are passed from one node to the next; iii) on the geographical location of nodes(Timothy J Sturgeon 2008); and crucial iv) the ways in which each chain is coordinated or governed (Gereffi, Humphrey and Sturgeon 2005).

GVCs are comprised by hundreds or thousands of transactions around the world, therefore understanding a firm's capability to manage complex information, transfer technology, control producers or the distribution of power among firms. Important variables in this analysis refer to the role of institutions (government, MNC´s and local firms), and the distribution of power among firms and other actors (Raphael Kaplinsky 2000).

Sturgeon (2008) identifies five governance modalities in the GVC (market, modular, relational, captive and hierarchy) depending on the level of the firms'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 GVC´s and the obstacles faced by firms once they have been immersed in it. We have focused on one particular GVC´s: the aerospace GVC

Some might wonder why we selected the chain we did, we therefore hereby advance some of our motivations: Firstly, we were interested in the impressive growth of employment and exports of the aerospace[1] industry in comparison with the poor macroeconomic performance of the Mexican economy. Secondly, even though Mexican firms are not a part of the knowledge economy as some authors consider as 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. Thirdly, we were also interested by the degree by which this industry growth rates were determined by the close collaboration between government at federal and local levels, private sector and academia (Carrillo and Hualde 2007; Mónica Casalet 2011; Hualde and Mochi 2008; Clemente Ruiz Durán 2007), Finally, we discovered interesting initiatives from 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. But we will continue to use this term because the global value chain is mostly known in this fashion.

Through the case studies we analyzed the nature of inter-firm linkages and how they affected the potential of scaling up in the value added chain by local suppliers. W chose three firms in the Queretaro aerospace cluster. 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 that explain 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 MNC´s subsidiaries and to create the conditions for the entrance and scaling up of local firms in the value chain.

This GVC has unique elements particularly useful to 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 suppliers experience drives buyers to get involved in the assessment of the “fitness for transfer”. This assessment takes into consideration multiple factors including the “home fitness to transmit”, “technology fitness for transfer” and “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 *adhoc* machinery and equipment and obtain industry specific certifications. Entry barriers are high.

This GVC has had certain success in Mexico. However, this paper is not a success story; it is rather an account describing an uphill battle and the red flags that lie ahead. For example, the aerospace gvc strives 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 its industry participants which means that firms must continually invest in capacity building. We discovered that Mexican firms have engaged in this particular GVC mostly as suppliers with a minimal role in product design activities which implies that much effort on their side has to be made to scale up in order to get a higher share of income in the GVC.
This paper has three sections. The first section covers the aerospace industry’s global value chain. In the second section we analyze 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 the aerospace GVC we have prepared three case studies of companies with different roles within the chain.

1. AEROSPACE VALUE CHAIN

2.1 THE AEROSPACE GLOBAL VALUE CHAIN

Estimates for the aerospace and defense (A&D) industry global market in 2008 range anywhere between US$675 billion (Michaela Platzer 2009) and US$920 Billion (Aerospace and Defence Datamonitor's 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 (Michaela Platzer 2009) 2009). Even though both corporations slowed their production lines in 2009[2], 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 the airplane's total value was outsourced. The original equipment manufacturers (OEMs) exerted firm control over their thousands of small suppliers. In Gereffi et al (2005) terms it was 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 the airplane's aggregate value.

A 2008 A&D survey revealed (Wipro Council for Industry Research 2009) that the four most important reasons for outsourcing were: i) reducing operating costs, ii) avoiding capital investments, iii) gaining access to technology not in the company and; iv) 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 do final assembly in France or the case of Bombardier which uses North American and most of the final assembly is carried out in Montreal. Finally Boeing 787 is being built by a consortium of local Japanese companies including companies like 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 the above subsections i, ii, and iv. Market offsets are not important as yet. The most critical reasons for not out sourcing include loss of

[2](S. o. O. D. Airbus 2009)

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 ranging from design and main assembly of airplanes and engines by OEM´s, assembly of hydraulic, pneumatic, fuselage and electronic systems (tier 2), to assembly of subsystems (tier 3) and the lower level manufacturing of interior components, tires and other parts.

Building a commercial jet takes about a year on average. 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[3]. As Kaplinsy (2000) notes the pattern of governance is one in which the major buyers(the assemblers or first tier suppliers in relation to the second) set the standards with regard to cost, quality, delivery and so on. This suggests in terms that third tier firms like one of the firms we interviewed must utilize global designs and as Schmitz (1999) has shown even if the acquire 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. These chains have become global innovation networks. It is no longer possible – or practical – for one corporation to develop, design, manufacture, assemble, test and sustain a major A&D platform or system (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 tolling for industry participants[4]. Second, third tiers and

[3] Life cycle may go to 30 to 40 years.
[4] Cited requirements in the literature are Sarbanes- Oxley in the US 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 (PLM Software Siemens 2011)

subcontractors are subject to the 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 (PLM Software Siemens 2011). This value chain collaboration goes on throughout the product's life cycle. Companies in this sector must upkeep and enhance complex products with life cycles ranging from 30 to up to 50 years (Wipro Council, for Industry Research 2009).

If the "supplier switching cost" for the buyer of airplanes is low then buyer power in the market place is increased. Interestingly, sub component manufacturers who have carved a niche for themselves have the best margins in the value chain (Wipro Council, for Industry Research 2009). This suggests that the later may have developed design capabilities and are involved in cooperative design, thus supplier switching costs are high. 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.

The transition of knowhow is carried out by project managers. OEMs rarely have codified knowledge which can be relied on and repeated consistently over multiple transfers (PLM Software Siemens 2011). Often the transferring site has tacit skills in areas like tooling and problem solving, thus the need of frequent visits from and to suppliers as can be seen in our case studies. The "fitness for transfer" assessment has to be carried out. This assessment evaluates multiple factors including the home fitness to transmit, technology fitness for transfer and host fitness to receive.

Historically, the US 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 a catch up. Datamonitor estimates that the top five emerging countries (Brazil, China, India, Mexico and South Africa) total output of A&D products and services will reach approximately $260 billion by 2014 (PWC)

2.1 INDUSTRIAL ORGANIZATION AND ACTORS

The characteristics of industrial organization in the A&D sector vary along the value chain.

Firstly, the global commercial aerospace market has few large-scale aircraft OEM`s. Secondly, economic concentration in this industry is very high due to the elevated capital commitments required to design and produce an aircraft. Thirdly 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, which 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, a 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 recentlyBombardier is positioning itself as a replacement for Fokker100's and MD-80's 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 RJs 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 GA 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, Cesna* and *Gulfstream*. On the other hand the most relevant engine exclusive manufacturers include, *General Electric, United Technologies, Snecma, Rolls- Roys* and *Honneywell International.*

The first tier of the industry of large engines is dominated by the so called Big Three (*General Electric Aircraft Engines*, *Pratt and Whitney* and *Rolls-Royce*) who are in exclusive contracts with

OEM´s. The small and medium sized engine segment is characterized by a greater number of firms, among we can find: *Allied Signal Engines*, *Williams International*, *CFM International and International Aircraft Engines (Brusoni and Prencipe 2001)*. The second tier of the industry is mainly constituted by middle-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 among 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. The study Industrial Products Aerospace & Defence (Waterhouse Price, Coopers International 2011) reveals the impact of the Council for Aeronautics Research in Europe (ACARE) on the research agenda in the European aerospace sector which has accomplished ambitious goals for reductions in CO2 and NOX emissions (Waterhouse Price, Coopers International 2011) among others.

2.2 THE AERONAUTIC INDUSTRY IN MEXICO

Mexico as many other semi-industrialized economies was considered an outsourcing post of lower value added for the A&D global value chain (GVC). However, during the last six years, 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 60 A&D firms in Mexico subcontracting for US firms with approximately 15 000 employees and US$ 600 million in exports (Carrillo and Hualde 2007). In 2010 there were 199 firms registered in Mexico employing approximately 30 000 workers with export in excess of US$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 5 years and many of their aircrafts are leased. But

given 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 which have multiplied by three in five years from 2002 and 2008, and a trade balance surplus in the sector which has been sustained through the 2009 economic downturn.

Production in the Mexican segment of the chain is highly diverse. Clients range from 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 Queretaro as a result of the arrival of many A&D MNC´s 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: i) manufacturing and assembly (77%); ii) engineering, design and R&D (8%); and iii) maintenance, repair and overhaul (MRO), 16%. Two thirds of manufacturing activities lie in the following categories: electrical cable accessories / harnesses (20%), aerostructure components fuselage (14%), aeroengine & aerostructure subassemblies (14%), raw material supply / material manufacturer (12%), aeroengine components: propellers / rotors (10%), standards parts (8%), avionics (6%),aircraft Interiors equipment furnishings (6%), hydraulic systems and equipment (6%), safety and survival equipment (6%) (ProMexico, 2011).

Mexican firms were once at the very base of the supply chain with total output of approximately US $40 000-$60 000 per employee as measured in the value added index compared to output of US$350,000 per employee in OEM´s and Tier 1 firms (Promexico, 2001). In Tijuana for example, according to Carrillo and Hualde (2007), the majority of the companies in this sector in the Maquiladora 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 in the suppliers market.

The most relevant A&D firms with investments in México 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) *(*ProMexico*,* 2011*).* In 2006 Bombardier was the first ever OEM to arrive to Mexico in this industry. Their objective was to establish a low cost supply base and catch the geographical advantages of Mexican industry. Today there are seven other OEM´s including *CESSNA*, *Honneywell* and *Bell Copter* amongst others.

2.3 GOVERNMENT POLICIES

Mexico spearheads important initiatives in the aereonautic industry. Pro Mexico's initiative to secure investment commitments by foreign companies has been crucial. One example of this is the case of 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 firstly, the main goods imported by OEM companies; and secondly, 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 Brazil's (Banco Nacional do Desenvolvimento) (BNDES) substantial credit line 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 SMEs in this industry as mentioned in (Fabrizio Cafaggi 2011).

At the same time, governments at state level have aimed to create the necessary conditions for the establishment of high-tech clusters as part of their economic development strategies. Queretaro 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.

There are several supplier development programs in Mexico; one example of these programs is the supplier development program jointly executed between 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 have 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 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 later provides integral consulting services which include 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 comprised by 35 firms.

Other strategic institutional efforts for the development of this chain in Mexico include the signing of the Bilateral Aviation Safety Agreement (BASA) with the US 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 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 (MIP) that enable the MRO projects to be completed. Last year Promexico (2011) reported 200 certification processes, 55 in the northern western region, 40 in the Central region and 19 in the east northern region; 81 certifications belong to the AS100 and AS9199.

The government's position regarding the aeronautic industry is published in the corresponding ProMéxico report. This document distinguishes Baja California and Queretaro 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. The later firms have links with educational and research institutions and have and established a support system provided by state and federal agencies. The Queretaro cluster has grown very quickly since its inception in 2005 with the arrival of *Messier Dowty* and *Messier Bugati* from *Safran, Aernnova, ITR (Industria de Turborreactores).*

2.4 AERONAUTIC CVG: CASE STUDIES

We have selected three companies with 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, the other one had no plans to break into the industry however, 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.

Bombardier Queretaro (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 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 why the arrival of industry leader *Bombardier* to the Queretaro cluster has been of the utmost importance to the development of supply capacity in Mexico.

Bombardier is a Canadian highly diversified firm. In its early stages it produced snow mobiles and trains. However, aerospace products now account for over 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. In 1992 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 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 which continues to produce jets under the iconic Learjet name (ProMéxico, 2009)

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 US, China and Mexico.

Bombardier Aerospace started operations in 2006 in the city of Queretaro in central Mexico. The plant produced electrical harnesses and was in charge of some structural assembly. The estimated initial investment of this operation was US$200 million with a workforce of 900 workers. They established operations in China around the same time they established in Mexico. However, their focus in both countries has been rather different. In China their production caters the domestic market where *Bombardier* sells licenses of the productive processes since they have many suppliers in this country and airplane parts, while in Mexico production is destined towards 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 from 37 to 43 days, while transportation from Queretaro takes only 7 days. Secondly, 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 industry expert were the compatibility of characters and working schedules. These similarities have allowed the bi-national team to operate under extremely flexible and changing productive processes that can change on short notice, with sometimes 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.

According to our industry expert, Pro Mexico's negotiations with Bombardier in connection with the latter's entry were clear and transparent. Pro Mexico, the federal and state governments have all been very supportive of Bombardier's Mexican venture. The startup was not easy. The aeronautic park was relatively unfinished when they arrived and different logistic details had to be worked in a joint effort. However, due in large part by 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 Queretaro. Our specialist has told us that, regarding the relocation of production, *Bombardier*'s upper management's position 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 harnesses production was a complete success, since then this plant provides 90% of *Bombardier´*s world demand for this product. After harnesses they moved to 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 the project to produce aircraft back elevators which in turn created the opportunity to supply the half back fuselage of the executive plane production.

The learning process has required back-and-forth visits of 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 capitalization in excess of US$250 million (in addition to the first US$200 million) to manufacture the complete fuselage and the electrical system of their iconic Learjet 85 which was previously manufactured in Wichita[5]; 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 categories 1 and 2. This plant employs more than one thousand workers. The Learjet is finally assembled in Wichita where the cockpit is installed (as required by US 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 CSeries which is Bombardier´s largest jet and doors for Airbus. According to Bombardier's executive their arrival has resulted in the relocation of the industries suppliers. For example *Safran* a firm which previously had several plants in the northern part of Mexico increased its investment by threefold with its new Queretaro operation.

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

The *BMQ* operation is the main wheel in a complex network of suppliers. *Bombardier* executives, executives from other foreign firms as well as government officials have visited select SME´s 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 4 years and before its coming to life FAA provided the corresponding certifications. According to our interviewee approximately 40 firms are applying 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 Queretaro in charge of identifying local manufacturing opportunities. This team has identified 10,000 items that can be produced locally and is travelling around Mexico searching for suitable suppliers eligible for obtaining the corresponding certifications.

Our interviewee suggests that it is a feasible goal for Mexico to become the 10th global supplier with total yearly exports in excess of US$20 million in the near future. However, substantial investments are required for this goal to materialize. For example, several firms are asking Pro Mexico to participate as co-investor in order to create a Center of aerospace design in northern Mexico. This institution would provide service to SME´s in the chain. Apparently, BMQ is keen on participating in said investment. He 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 the certification related regulation. However, more support is still required in order to certify local SME´s 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 pay taxes for example. On his opinion the lack of reforms is not the only impediment for the arrival of foreign investment. There is potential to be three times larger, but communication infrastructure needs more development with high impact projects, such as the creation of railroads routes to improve logistics around the country.

a) *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 *adhoc* 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 US$4000 to US$40,000. An additional barrier of entry is the large amount of capital investments. As this case study shows the 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 the adequate support from governmental institutions as described in this last section.

This second firm has an interesting trajectory in other sectors. The company 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 distributer company in Mexico). They have reached a prominent status in the manufacture of parts, subassembly and assembly as well as the overhaul of complete turbo compressors. They hold a joint patent with a public innovation center in the state of Queretaro (CIATEQ) for the dry sealing of low power turbines. This new product reduces pollution, avoids steam leakages and increases the life of the turbine from 11 to 18% more years.

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

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

They were approached by a first tier landing gear designer and systems integrator about the manufacture of parts for the 767 and 777's landing gear. However, this was not possible as they needed a very heavy investment in security systems to 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 and adequate infrastructure and the corresponding certifications. This alliance is beneficial for both parts at this initial stage since the firm did not have the capital for the required investments and the contractor increased their product line.

Lengthy inspections and audits were undertaken in order to satisfy its customer's needs. At the moment of this interview they had obtained the first approval by the customer after the try outs and were 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).

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

Currently, their industrial 18 month plan (introduced at the end of 2010) aims to create the conditions in order to manufacture the complete family of landing gear components. This plan is spread throughout three stages: manufacture, material-manufacture and special processes. The objective is to build their supplier chain for thermal and special treatments which right now is carried out by the contractor firm with local firms. *Goodrich* has already approached five local firms which are on 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, Messier*.

One of the major challenges of increasing product lines consists in increasing expertise stocks and specializing in the handling and operation of titanium. This is a five year project which required an alliance with CIATEQ in order to handle and processes titanium and to understand its

markets. The goal is to manufacture propulsion engines. Strict industry requirements and the supplier's bargaining power makes the OEM's learning curve very steep and makes them vulnerable to particularities of the aeronautic market which may have many indirect costs which are hard to identify. As an example of this the firm has shared an interesting experience with us. They were approached initially by a *Honneywell* supplier 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. Their conclusion was 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, they analyzed this case and realized that these products were not suitable for the firm's capabilities and trajectory in the 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 from 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 has helped them decide where their GVC niche lies.

In addition to TECHBA's valuable advisory, *ET* stressed the importance of the Canadian consultants in advising their upper management on issues ranging for the manufacturing package to other aspects like the delivery of the documentation system, the planning of budgeting and logistics.

The project was initially funded with their own capital; however they have now applied for technological development CONACYT funds. The verdict is yet to come, but they are optimistic since 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. They also expect to get support from the Secretary of Sustainable Development of the state of Queretaro. The interviewee stressed the importance of the availability governmental funding. Conacyt´s financing has been crucial in their innovations; our interviewee complained

about the excessive amount of documentation and the time consuming red tape and particularly about the lack of competitive long term financing.

b) *Maquinados Especiales* (ME)

While it can be considered as a fluke, ME's arrival to the aeronautic GVC would not have been possible without the 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 20 employees: two engineers in charge of product design, one in charge of metrology and one in charge of quality assessment. Their most important clients are General Motors whose engineers once visited the plant and praised them for their good practices.

At the onset of the Queretaro aerocluster *Aernnova*, a Spanish firm approached them about the manufacture or repair of deteriorated Spanish tools. *Aernnova* manufactures components sold to a first tier supplier of Boeings´s tails for *Bombardier*. They also manufacture helicopters and turbines components. ME delivered the contract successfully.

Back then ME was not certified, it did not even hold a ISO9000 certificate. But the firm's track record in the autoparts industry was well known. *Aernnova* encouraged them to apply for the aeronautic suppliers development NAFIN-PNUD program. This program lasted six months through which the company passed many evaluations and changes. At some point a PNUD expert visited them and made several suggestions which included the installation of a metrology laboratory, 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. They are planning to undertake the certification process to get AS 9100 which would be indispensable to obtain global contracts in the aeronautic industry. But they are aware that certification is only the first step. Their decision to enter fully as supplier in the aeronautic market is definite. They

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 CIO did not know anything about the different funds offered to SME´s by the government.

3. POLICY IMPLICATIONS

Our case study shows that Mexican aeronautic firms participate in this chain as suppliers of parts of subsystems. It also documents that these firms play a minimum role when it comes to product design which is carried out by systems integrators in developed countries. We discovered that firms 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. We did not find enough conditions to characterize the type of governance in the nodes located in Mexico as modular on the cases we analyzed. In the cases when capabilities are high the governance can be characterized as relational which implies a great learning potential for our companies. When capabilities are still limited (ie, the supplier company is starting a new field), the governance of the chain must be considered captive. Thus much effort on their side has to be made 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 Queretaro´s aeronautic cluster. Geographical proximity gives Mexican firms an advantage over Chinese firms due to: i) reduced transportation costs, ii) reduced time differences, iii) immigration benefits provided by NAFTA (expedited visas for example); and iv) the commitment of the Mexican government's commitment to WIPO'S trips agreements. In general we found that NAFTA sets a good framework for international business and that proximity with the US market gives a competitive edge that enables swift interaction with clients.

These advantages are only part of the reasons explaining the insertion of Mexican industry to the aerospace GVC. In our opinion, this could not have happened without an effort of public policy at different levels to attain this goal on the side 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 the initial negotiations in which the government communicated their intention of creating favorable conditions for investment. ProMexico role in securing investment commitments by foreign companies was deemed decisive by Bombardier who recalls that negotiations were clear and transparent. In depth strategic analysis was carried out (Plan de Vuelo 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 upmost importance. The proactive engagement of government in these efforts in comparison to the past was fundamental. One example of this was the call upon local firms by government officials which lead to the mobilization of other industry participants.

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 later could not have been possible in the aeronautic industry without the accumulation of technological capabilities in other chains like the automotive or the metal mechanic industries in earlier stages.

From 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 that helps firms approach their global potential clients in Canada and the United States. Techba's role considered as a milestone for the firm. This advisory seems to be a precondition in order to build not only regular business capabilities, but international marketing capabilities which local firms tend to lack.

In the past criticisms has 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 the government who lead the institutional coordination efforts to generate the models and scale economies that engaged suppliers with different programs. This has been confirmed by other analysts (Mónica Casalet 2011). We are therefore of the opinion that public policies that establish goals and provide coordination among all industry participants is an important ingredient to overcome the

obstacles and barriers of entry to new high tech niches, As we will explain below this these initiatives are not sufficient to secure success.

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From a public policy point of view we also find that reducing governmental burocracy is fundamental. The amount of paper work to access to Conacyt resources is extremely cumbersome particularly for small sized firms. 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 were 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 insufficient forgery companies was a problem to the value added chain as a whole. Additionaly, there is a need for new industrial parks with appropriate infrastructure. They also believe that the negotiation with different government agencies in order to improve the regulatory framework for certifications is long due. Additionally more support in order to certify local SME´s is needed if Mexican authorities are serious about launching the chain of local suppliers into the global chain and, this is why more CONACYT´s and the Ministry of Economics resources will be needed.

There is a notorious unbalance between efforts to secure investment from foreign firms and certification and long term financing initiatives. In our view the later has not been properly addressed and should de considered as a market failure. The evidence about 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 supplier but if up to now the initial investment came from internal funds in the future competitive credit will be indispensable to succeed in the scaling up and developing of their own chain of suppliers.

We believe entrepreneurs must evolve as well. The prevalence of very small firms in the 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.

In conclusion, there are general traits of economic policy that have been conducive for the growth. Lessons from our case studies and the experience of other countries point to the need of some specific programs to address the specific needs of this GVC. Mexican aerospace firms 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 participate as captive suppliers or in the low range of value added, however, there is room to move up in the value chain in both GVCs.

Government initiatives in the early stages give the possibility to local firms to participate in product design and greater value added in manufacture in the future. But in order to achieve these companies must continue to invest in capability building, certifications and 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´s 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. This challenges will require the fostering of high impact projects that provide i) physical infrastructure; ii) improve logistics and communications conditions; but iv) most importantly that foster innovation and learning capabilities among the pioneers of the new chains.

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