Capital Intensity, Technology Intensity, and Skill Development

in post China/WTO Maquiladoras

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ABSTRACT

This study examines how rapidly rising exports from China to the United States is shaping the evolution of Mexico's export processing zone (EPZ) industry. Mexican policy makers frequently state Chinese competition is forcing maquiladoras to exit low-tech, labor intensive industries and evolve towards higher value added, technology intensive sectors. In this study we determine if post China/WTO maquiladoras conform to the predictions of the Mexican government. To do this we collected information through top management interviews and plant tours at 36 startup, rapidly expanding, and premier EPZ producers in Reynosa, Guadalajara, and Monterrey. We find sample firms have uniformly adopted proximity dependent strategies. The capital intensity, technology intensity, and skill development activities of proximity dependent maquiladoras varies from low to very high. We conclude with policy implications for Mexico as well as other countries facing competition from Chinese EPZ producers in international markets.

1. INTRODUCTION

Export processing zones (EPZs) are an increasingly popular initiative utilized by developing countries in order to more fully benefit from today's global economy. In 1975 one million people in 15 countries worked in EPZs. By 2002 these numbers had increased to 43 million people in 166 countries (ILO, 2003). Mexico's EPZ, commonly referred to as the maquiladora industry, maquiladoras, or simply maquilas, represents by far the largest and most successful EPZ initiative in the Americas. There has been considerable debate in the academic literature regarding the contribution made by maquiladoras to Mexican development. During the 1980s many authors were especially critical due to the nature of the work delegated by transnational corporations (TNCs) to their Mexican EPZ plants. Maquilas during this time period generally employed large numbers of young women with little specialized training to perform highly repetitive assembly tasks (Fernández-Kelly, 1983; Sklair, 1993). Researchers began documenting the growth of more complex maquila production systems by the late 1980s (cf. Shaiken, 1990; Carrillo, 1991; Wilson, 1992). Studies over the past two decades find Mexico's EPZ industry is now composed of a mixture of labor intensive, low-tech assembly facilities, medium-tech manufacturing plants, and a significant number of firms utilizing advanced technology and capital intensive production systems to perform complex manufacturing and assembly tasks (Carrillo & Hualde, 1998; 2002; Bair & Gereffi, 2001; Barajas et al., 2004). These latter two maquiladora categories, especially technology intensive producers, are widely regarded as attractive forms of foreign direct investment (FDI) which make a valuable contribution to Mexican development.

Mexico's maquiladoras have recently experienced dramatic changes that may significantly alter the proportion of low, medium, and high-tech plants participating in the

industry. For the first time in its 40 year plus history, beginning in November, 2000 the maquilas suffered widespread aggregate job losses. Maquila employment fell by almost 300,000 from November, 2000 to the end of 2003 before beginning a slow but steady recovery (Table One). A number of factors, such as the 2001 recession in the United States (US) (the destination for almost all maquiladora outputs), the strong Mexican peso, and the implementation of various trade agreements all appear to have played a role in the maquila contraction (cf. Carrillo & Gomis, 2003; GAO, 2003). In addition, many scholars and policy makers argue the rapid expansion of exports to the US from EPZ firms in China represents one if not the most serious threat to Mexico's EPZ program. Aided by the country's ascension to full membership in the World Trade Organization (WTO) in December, 2001, China has rapidly become the world's preferred EPZ location. From 1997 to 2002 employment in Chinese EPZ firms increased from 18 million to 30 million (ILO, 2003). EPZ firms generate over half of all Chinese exports as well as roughly 70 percent of the country's exports to the US (Lemoine & Ünal-Kesenci, 2004). In US market segments where Chinese and Mexican EPZ exports overlap, trade data reveal a consistent pattern (see Table Two). China is gaining and Mexico is losing market share in sectors such as television receivers, computer hardware, consumer electronics, household appliances, and apparel (Watkins, 2003; Banco de México, 2005).

*** Insert Tables One and Two about here ***

China's entry into the WTO and the maquiladora contraction has caused Mexican specialists to reevaluate why EPZ plants continue to produce in Mexico rather than take advantage of lower wage rates in other developing countries. These studies typically conclude proximity to North American customers represents the foundation of maquiladora competitive advantage. For example, Sargent and Matthews (2004) argue the 2000 - 2003 contraction can

best be understood as a time when TNCs shifted the production of goods where proximity advantages are not particularly important from Mexico to China and other lower cost regions. Drawing similar conclusions, Tafoya and Watkins state (2005, p. 13):

> North American companies under pressure to reduce costs to remain competitive in the US market reportedly have to carefully evaluate the Mexican option. Products with a relatively high labor content, long production runs, few style changes, and long lead times are the most susceptible to relocation to lower labor cost countries in Asia . . . . Products most likely to be assembled in Mexico rather than Asia are those with a high ratio of weight to value, a high degree of customization, or with customers that practice just-in-time inventory control.

In the study detailed in this paper we examine whether proximity dependent EPZ investment tends to fit a low-tech assembly, a medium-tech manufacturer, or high-tech production paradigm. To address this question, we conducted managerial interviews and plant tours at maquiladoras located in the Mexican cities of Reynosa, Guadalajara, and Monterrey. We focus our data collection efforts at maquila startups (defined as plants established in 2002 or later) and at established maquiladoras experiencing rapid expansion (defined as maquilas that have added an additional standalone facility since 2002). We argue maquila startups and expanding maquilas provide especially clear examples of the competitive advantages retained by Mexico as a location for EPZ activity even after China's ascension to full WTO membership. The plant level data collected enables us to determine the technology and capital intensity of new EPZ investment as well as the efforts of these plants to develop the skills and abilities of their Mexican employees.

This study is designed to add to the literature examining how China's growth is shaping the prospects for wealth creation in other countries in the developing world. Authors in academia, the popular press, and decision makers in policy circles have all speculated low cost competition from China and elsewhere will cause labor intensive, low-tech maquiladoras to fail at above average rates and accelerate the evolution of Mexico's EPZ industry towards a

technology intensive business model (Gerber & Carrillo, 2003; Carrillo & Gomis, 2003; Lindquist, 2004; Christman, 2005; Rocio Ruiz, 2005). Mexican policy makers, seemingly confident the country's future role is as a producer of technology intensive, high value added goods and services, are increasingly championing initiatives designed to attract these types of industries. This may or may not be an appropriate policy response. International competition and the continuing fragmentation of North American supply chains may create an incentive for TNCs to spin off to their Mexican EPZ plants a wide range of low, medium, and high-tech proximity dependent goods and services. Development strategies based on the assumption that Chinese competition will force Mexico out of labor intensive sectors and up the value chain may be both inaccurate and result in the country missing out on significant flows of new investment.

This article continues as follows. In Section 2 we discuss in greater depth how Mexican policy makers have responded to the Chinese threat as well as the limited number of academic studies utilizing firm level data that have examined the maquiladora response to Chinese competition. Section 3 is divided into four subsections where we present our research methodology and findings in Reynosa, Guadalajara, and Monterrey respectively. In Section 4 we examine the policy implications of this study for countries such as Mexico facing competition from Chinese EPZ producers in third country markets.

2. CHINESE EXPORTS AND THE MAQUILADORA DECLINE

China's emergence as a major force in the international trading system is resulting in new opportunities for some countries as well as disrupting established trading relationships in others. For example, studies by Lall and Albaladejo (2004), Zhou & Lall, (2004), and Lemoine and Üanl-Kesenci (2004) conclude China and its immediate neighbors in East Asia are evolving

towards an integrated production system characterized by complementary rather than confrontational trade relationships. In South America a study by Inter-American Development Bank found China's growth is creating increased demand for agricultural, mining, and energy exports from countries such as Chile, Argentina, and Brazil (IADB, 2005; see also Dussel Peters, 2004; Lora, 2005). The IADB study found exports from South America rarely face direct competition from Chinese producers in international markets and it is unlikely TNCs will divert FDI destined for South America to China.

Compared to South America, studies come to very different conclusions regarding China's effect on Mexican exports and inward FDI. The IADB report notes there has been a rapid increase in US imports of apparel and electronics from China, a drop in US imports of these products from Mexico, and strong enterprise migration of producers in these industries from Mexico to China. A study by the *Banco de México* (2005) found Mexico accounted for 11.5 percent of all US imports in 2001 but only 10.6 percent in 2004. If Mexico had been able to maintain its 2001 import share, the central bank estimated Mexican exports would be $27 billion higher in 2005 than their projected level. China has been able to increase its US import share in each of the 15 sectors where Mexico has experienced its greatest losses. The *Banco de México* study estimates Mexico's GDP would have increased by an additional 2.54 percent over the 2002 - 2005 period if the country had been able to maintain its 2001 US import share. Finally, a study by Garcia-Herrero and Santabárbara (2004) examined FDI from the OECD countries destined for China and the six largest Latin American countries. Their results suggest that for each additional dollar of FDI going to China over the 1995 to 2001 period TNCs headquartered in the OECD reduced new investment to Mexico by 29 cents.

Mexico's declining share of US imports has sparked a debate within academic and public policy circles regarding the steps the country should take to regain its position as the preferred EPZ supplier to North American markets. There is widespread recognition proximity to the US market has been and will continue to be Mexico's unique advantage when compared to other developing country EPZ locations. In addition, Mexican policy has clearly been shaped by arguments stating technological progress represents one if not the most important contributor to economic growth. For example, Lall (2004, p. 190) states "the ability to generate and sustain employment depends on the ability of countries and firms to promptly gain access to, efficiently use, and then keep up with new technologies." Mexican policy makers have embraced this perspective and frequently emphasize Mexican industry must migrate from labor intensive industries towards higher value added, higher complexity activities in order to successfully compete against China. In a document released by the *Secretaría de Economía* in 2004, the Mexican government summarizes how they perceive, and their response to, Chinese competition:

> China's development is a threat to Mexico's current position. The problem of our country is an industrial structure emphasizing the production of labor intensive goods. With China gaining freer access to developed countries, this industrial structure is not sustainable . . . Our strategy is focused on upgrading towards products with a high degree of manufacturability and services with elevated value added.

The Fox administration has implemented a series of policies consistent with its high-tech strategy. For the first time in recent memory the federal government is providing significant tax incentives to firms engaged in research and development (R&D) and created a fund to promote Mexico's software industry. State governments, industry chambers, and universities are also involved in upgrading efforts. The branch of Mexico's largest private university system in Guadalajara recently established institutes designed to accelerate the development of design engineering centers, software development firms, and technology intensive startups in the city's

cluster of electronics firms. The governor of the state of Nuevo León has proposed to transform Monterrey into a *Ciudad Internacional de Conocimiento* (International City of Knowledge) (Carrillo, 2005). The state government is especially interested in attracting new companies engaged in applied research, product and process development, product testing, and high-tech manufacturing in five industries; biotechnology, mechatronics, information technology, health, and nanotechnology.

Investments in science and technology may in the medium and long term accelerate wealth creation in Mexico. At the same time, the goal of attracting knowledge intensive firms places the country in direct competition with other industrialized and developing countries for a finite amount of TNC investment. Furthermore, these initiatives are not closely tied to Mexico's natural comparative advantage. There is little evidence to suggest geographic proximity to the US represents a strategic advantage for firms in industries such as biotechnology, nanotechnology, and software development. In addition, compared to other low cost countries in Asia and Central Europe, Mexico is clearly behind in its efforts to develop the scientific base thought necessary to succeed in technology intensive industries. Mexico fell from 48th to 57th place on a technology index included in the 2005 Global Competitiveness Report and ranked 59th of 117 countries on the UNCTAD innovation capability index (WIR, 2005). The quality of Mexico's educational system represents an especially serious limitation. The OECD's Programs for International Student Assessment recently measured the mathematics, reading, and science knowledge of 15 year olds in 30 OECD and 10 OECD partner countries (PISA, 2003). Mexican students ranked 37th of the 40 countries in all three skill areas. Mexico scored almost one full standard deviation below the OECD average in science. In contrast, students from Hong Kong –

China placed second, sixth, and third respectively on the measures of mathematics, reading, and science.

The limitations of Mexico's technology infrastructure is clearly evident when trends in TNC R&D investment are compared across countries and regions (WIR, 2005). TNCs are clearly delegating more R&D activities from the home country to lower cost foreign subsidiaries. US companies have increased R&D spending in developing Asian countries from $408 million in 1994 to $2.2 billion in 2002 (WIR, 2005). R&D spending by US TNCs in China increased from $7 million to $646 million during this time period. By the end of 2004, 700 foreign affiliated R&D centers representing an investment of four billion dollars have been established in China (WIR, 2005). US TNCs have increased their R&D spending in Mexico (from $183 million in 1994 to $284 million in 2002). However, Mexico's total share of US subsidiary R&D expenditures dropped from 1.5 to 1.3 percent over this eight year period.

The macroeconomic and comparative data indicates Mexico faces serious obstacles in its efforts to compete in technology intensive industries. This evidence, however, clearly needs to be supplemented by research conducted at the firm level. A limited number of academic studies utilizing plant level information have systematically explored the effects of Chinese competition on maquiladoras. Sargent and Matthews (2004) collected information through top management interviews and plant visits at 55 maquiladoras employing roughly 67,000 people in Reynosa and Guadalajara during 2002 and 2003. Maquila managers were asked to respond to questions such as the role played by the plant in the parent's manufacturing strategy and how this role had changed as a result of Chinese competition. Sargent and Matthews (2004) divided their 50 plant Reynosa sample into the following three categories:

1. Maquilas competing in global markets (8 plants, 3,972 employees) - Defined as markets where maquiladoras face direct competition in the US from producers located in China or other lower cost countries. These maquilas tend to produce highly standardized, commodity types items and compete on the basis of price. With few exceptions, low, medium, and high-tech firms in this category were struggling.

2. Maquilas competing in global/regional markets (27 plants, 19,179 employees) - Defined as markets where maquilas have conceded the production of high volume, standardized, low-cost goods sold in North America to producers in lower cost countries. To compete successfully in non-standardized segments, maquilas are pursuing dual sourcing and/or mass customization strategies. Other firms have adopted organizational forms, such as corporate shelters or internal contract manufacturers, consistent with a "high mix, low volume" strategy (i.e. produce a large number of products in low volume).

3. Maquilas competing in regional markets (15 plants, 23,598 employees) - Defined as markets where maquiladoras do not face direct competition in the US from producers located in lower cost countries. These firms tend to qualify as just-in-time producers, zero defect producers, low value to weight producers, or as remanufacturing centers.

Sargent and Matthews (2004) conclude market characteristics rather than the ability to efficiently utilized advanced manufacturing technology was the primary factor contributing to maquiladora success. In fact, the strategies adopted by a limited number of maquilas was not consistent with the assumption Mexican EPZ producers must invest in capital and technology intensive production systems to compete in a post China/WTO world. For example, internal contract manufacturers were specializing in low volume, non-standardized, labor intensive products that customers wanted in a hurry. The need for flexibility in these facilities may result

in the increased use of hand labor (as stated by one plant manager, "Operators are more flexible than machines"). There was also evidence maquilas utilizing technology intensive production systems but lacking clear proximity advantages were vulnerable to the forces of international competition.

Sargent and Matthews (2004) collected information at maquilas established prior to 2002. Since that time many TNCs have continued to reduce their commitment to Mexican manufacturing while others have established new production facilities. Through systematically examining the characteristics of plants established after China's ascension to full membership in the WTO in December, 2001, the goal of the present study is to improve our understanding of how international competition is shaping Mexico's EPZ industry. If, for example, startup maquilas overwhelmingly qualify as technology intensive producers a strong case can be made that low cost Chinese competition is contributing to the upgrading of Mexico's export industry. On the other hand, if startups fit a traditional low-tech assembly EPZ production model, Mexican policy makers and development scholars may need to rethink their assumptions about how medium cost countries such as Mexico can compete in international markets given China's emergence as the world premier EPZ location.

3. RESEARCH METHODOLOGY AND RESULTS

(a) Study Locations and Survey Instrument

To address our research question we conducted field work in the Mexican cities of Reynosa, Guadalajara, and Monterrey. Reynosa is a rapidly growing city of approximately one million people located along the US-Mexican border across from McAllen, Texas. As of December, 2005, Reynosa (93,180) ranked behind only Cd. Juárez (227,255) and Tijuana

(162,437) as the Mexican city with the largest number of maquiladora employees. Reynosa is unique in that it is the only major Mexican EPZ center that has experienced significant job growth since 2000. Maquila employment increased 38 percent from October, 2000 to December, 2005. With the exception of apparel, Reynosa maquilas are well diversified in the major maquila segments and are controlled by a mixture of both large and medium sized firms from the US, Europe, and Asia.

Guadalajara and Monterrey share many of the same characteristics. The second and third largest cities in Mexico, both locations are important educational, governmental, and industrial centers. The capital cities of the states of Jalisco (Guadalajara) and Nuevo León (Monterrey), both cities have adopted high-tech development strategies. Guadalajara is especially well known as a center for technology intensive electronics manufacturing. IBM, Hewlett Packard, Kodak, Intel, Hitachi, and four of the world's largest contract manufacturers (Sanmina-SCI, Jabil Circuits, Solectron, and Flextronics) represent the core of the city's electronics sector. Since 2001 the export industry in Guadalajara has stagnated. Electronics investment fell from an average of $409 million per year from 1996 to 1999 to $123 million per year from 2002 to 2004. In 2005 electronics exports ($9.7 billion) were still below the level reached in 2001 ($10.5 billion). Monterrey is a recognized center for Mexican heavy industry, enjoys a diverse manufacturing base, and maintains a reputation as a attractive location for TNC investment. FDI to Nuevo León averaged $1.27 billion from 1994 to 2000 and $1.21 billion from 2001 to 2005. However, FDI has fallen for five consecutive years (from $2.39 billion in 2000 to $664 million in 2005) (INEGI, 2006).

The goal at the outset of this study was to collect data exclusively at startup EPZ plants in the three cities. We define startups as plants producing goods or services for export, employing

75 or more people, registered as a maquiladora or PITEX company (see Table One for more information on the PITEX program), and that began production in 2002 or after. We further define startups as companies, or divisions of companies, that are establishing operations in a particular location for the first time. Established EPZ producers that add an additional stand alone plant in the same city are referred to as expanding maquilas. We developed a four part questionnaire to guide data collection at startup plants. Section One focused on the general characteristics of the plant and the person interviewed. In Section Two interviewees were asked to describe the circumstances that lead the parent to invest in Mexico, if other countries as well as other locations in Mexico were considered during the site selection process, why a particular city was chosen, the location of competitors' production facilities, the types of startup challenges encountered, the activities in addition to assembly or manufacturing performed on-site, and the products and additional value added functions that might be transferred to the maquila in the near to medium term. In Section Three participants rated on two separate five point Likert type scales (one meaning low, three medium, and five high) the capital and technology intensity of production systems utilized at the plant. Section Four included measures of human resource management (HR) practices such as the educational level required for new hires, the hours of initial and continuing training provided, the plant's pay policy, and turnover rates.

(b) Reynosa Data Collection and Results

We conducted field work in Reynosa from August to October, 2004 and again from August, 2005 to December, 2005. We first identified startups located in the six major Reynosa industrial parks that fit our sample criteria using a directory provided by a local economic development agency. Managers at 15 of the 19 possible plants agreed to participate in the study. In addition, during 2005 a number of established Reynosa maquiladoras had added, or were in

the process of adding, an additional facility. We conducted interviews with top managers at six of these rapidly expanding maquilas. Compared to the data collection approach utilized at startups, interviews at expanding maquilas were less structured with questions focusing on how Chinese competition was affecting the parents' sourcing strategy and comparisons of the capital and technology intensity of production systems at the new compared to the older plants (see Table Three for addition information regarding sample firms in all three cities).

*** Insert Table Three about here ***

Reynosa startups were on average controlled by very large TNCs with extensive international operations (average parent company revenue in 2004 was $5.6 billion). However, 10 of the 15 plants reported to relatively autonomous divisions with few if any non-US production facilities prior to the Reynosa investment. The majority of plant managers stated the parent company/division established the Mexican facility due to intense competition in the US. To remain viable companies were following a strategy of migrating production from high to low wage countries. In 13 of the 15 startups product responsibility had been transferred from the US to Reynosa resulting in plant closures or downsizing at facilities in Texas, Connecticut, Illinois, New York, Tennessee, New Jersey, California, Ohio, and Wisconsin. One plant was established due to growing demand for the company's products and another to provide a new service.

Mexico was the only country considered by the site selection team in 11 of the 15 startups. This was due to the business model followed by the company (i.e. mass customization, product repair/refurbishing, order fulfillment) and/or the transportation costs associated with the final product. For example, one startup produced a very large, heavy, yet hollow kitchen appliance. Another startup planned to produce as many as 300 million, small, very light, awkward to ship, hollow plastic items per year. A third manufactured a strangely shaped,

expensive to ship product that is wider than the average semi-trailer. The four companies that evaluated other low cost countries eventually selected Mexico primarily due to logistics concerns. In one case the parent had considered both Mexico and Thailand. Reynosa was chosen due to the city's proximity to R&D operations and corporate headquarters in central Texas. Maintaining tight control over their intellectual property was another important concern. The parent at another plant fitting the model of a low volume, high mix assembler had considered Mexico and China. The plant manager stated Mexico was chosen because a Chinese facility would have resulted in "a logistics nightmare." At a third plant China and Mexico had again been considered. China was excluded due to the characteristics of the product (very large, heavy, steel items), the difficulties of managing extended supply chains, and customer response concerns. The company's goal was to reduce the time from when a US customer placed an order to final delivery from 10 to 4 weeks.

Based on responses to our questions and plant tours, we divided the 15 startups into three categories; low-tech maquilas (eight plants; 2,200 employees), capital intensive, medium-tech manufacturers (four plants; 1,254 employees), and capital intensive, high-tech producers (three plants; 724 employees). In Table Four we provide summary data on our Reynosa startup sample. Maquilas startups share a number of interesting characteristics. First, these plants were relatively small and employed on average 278 people. Second, there are no plants producing auto parts but a high proportion in the "other" category. Third, there is a relatively low percentage of maquila employees in engineering positions.

*** Insert Table Four about here ***

The eight low-tech firms in our sample fit the stereotypical model of a traditional EPZ plant. Shop floor workers were observed performing such unskilled or semi-skilled tasks as

feeding material into machines, assembling steel products, assembling steel and copper items, assembling plastic items, packing consumer products into boxes, simple product repair, and the shaping and finally assembly of steel items. Low-tech startups had implemented basic HR practices and compensation levels in seven of the eight plants were set at the average market rate. Turnover at the operator level was clearly a problem. Monthly turnover rates stood at 1.5 percent, 4.5 percent, 10 to 15 percent, 13 percent, 15 to 20 percent, and 40 percent. One plant manager stated turnover was high but would not provide a specific number. The final interviewee reported turnover was "17/4" (i.e. turnover in the first 30 days was 17 percent, after that it was 4 percent).

There were four examples of capital intensive, medium-tech manufacturers in our sample. The capital intensity of operations at these facilities was particularly notable. There were several new 15 to 20 foot high, blow molding machines and 38 plastic injection molding machines at one startup. Another interviewee described his plant as "a big machine shop" where they "bash metal." There were three roughly 12 to 15 foot tall, highly specialized metal forming machines on the production floor. At a third plant large rolls of stainless steel entered one end of the facility, was unrolled, cut into sheets, run through a stamping operation, a heating process, another stamping operation, and then several forming, cleaning, and polishing processes. The fourth plant produced customized steel items. Steel sheets were placed in an automated material handling system, feed through computer controlled laser cutters, and then a series of shaping operations. HR systems in medium-tech manufactures were more developed than those at low-tech startups and three of the four plants in this category set compensation levels above the average market rate in order to attract more capable employees. Even with better pay, operator turnover was still relatively high (4.5, 6.0, 7.0, and 9.8 percent per month).

There were three clear examples of capital intensive, high-tech producers in our Reynosa startup sample. One maquila in this category was established by a small electronics firm that began as a "garage type" entrepreneurial startup. On the shop floor capital intensive machinery including robotics, modified solder wave machines, X-ray testing equipment, and a variety of customized equipment was being used. The plant manager described their production process as "technically daunting" and as complex as anything he had seen in Reynosa. A second plant utilized complex, capital intensive production systems to produce a large consumer product. The facility was designed with very little space to store incoming raw materials, work in process inventory, or finished goods. With a number of color, style, and configuration options, the plant had been designed to efficiently manufacture batches of as few as 20 items. The third plant produced expensive to ship, lightweight plastic goods. Each production line included an extrusion process, plastic injection molding, printing, coating, an oven, and additional, highly complex capital intensive stages. The plant manager stated most of their technicians either had or were working towards some kind of engineering degree. If everything went as planned, when the maquila became fully operational the ratio of employees to capital invested in machinery could be as high as 1 to $240,000.

HR systems are all three high-tech startups were very well developed. The compensation policy adopted by one plant put them in the upper quartile in the local labor market. Another interviewee stated pay levels were high and that technicians made as much as engineers did at his prior job. Operator turnover at these two plants stood at 2.7 and 2.0 percent per month and turnover of professional employees was close to zero. At the final plant, pay was set at the average market rate. The plant manager was clearly unhappy with this policy and stated inadequate pay was contributing to 18 percent monthly turnover.

We asked the six interviewees at rapidly expanding Reynosa maquilas to compare the capital and technology intensity of production systems at the new plant to the older, established plant or plants. At one multi-plant maquila (a low to medium tech auto parts supplier) our interviewee stated newer production lines were less capital and technology intensive than those at older facilities. In two plants the new lines were similar to existing operations. These maquilas included a capital intensive, low to medium tech producer of very heavy steel items, and a low capital and technology intensity assembler of customized products. Two maquilas organized as corporate shelters qualified as "mixed." In other words, divisions experiencing growth fell both above and below our interviewees' estimate of "average" capital and technology intensity for the Reynosa operation. At only one plant, a low to medium tech shelter operator, did our interviewee state there was a strong trend towards increased capital, technology, and skill intensity with their newer operations.

(c) Guadalajara Data Collection and Results

As mentioned the goal in all three research sites was to conduct interviews at startup EPZ facilities. With this in mind, we began data collection in Guadalajara in June, 2005. We first interviewed the director of the public/private organization charged with attracting electronics investment to the region. The director stated very few new companies had relocated to Guadalajara since 2002 but established firms, especially the large electronic contract manufacturers (ECMs), were attracting additional work. This individual estimated the four largest ECMs generated 80 percent of all electronics exports from the Guadalajara area. Subsequent interviews with the lead commercial officer at the US Consulate, the recently retired directors of two of the city's major TNCs, and the director of a university institute charged with

attracting additional design engineering centers to the area further confirmed there had been very few recent entrants into the city's electronics cluster.

There are approximately 22 industrial parks in Guadalajara. Three of these, all established since 1998, are formally designated as technology parks. To validate the findings of our initial interviews we collected firm profile information on tenants in the three new technology parks. To do this we first interviewed the marketing director at two of the parks (the same company developed and managed both locations). This person stated construction in the first park began in 1998 during the height of the electronics boom. They had been very successful and 10 of their first 12 clients were electronics manufacturers. Market demand was strong and in 2000 they started construction in the second park. In 2001 demand for new manufacturing space fell dramatically and in 2002 they stopped all new construction. Given low occupancy rates, the company reevaluated their strategy and came to the conclusion there was not a market in Guadalajara for what has traditionally been considered a technology park. However, they believed there were many firms in the area, especially those providing goods and services to the Mexican market, that could benefit from highly secure, Class A space. Now fitting more a business park model, occupancy rates had improved to 95 percent. They had also restarted construction with plans to finish two large buildings by 2007. In the second park one tenant manufactured a product for sale primarily in the Mexican market. There was also one 100 plus employee TNC subsidiary performing highly complex microprocessor testing and validation services. Other tenants included eight companies with warehouse/distribution operations, a Mexican company that utilized their space as both a corporate headquarters and a distribution center, one printer, and one plant performing light assembly. Prospective tenants for the new buildings were primarily distributors for the Mexican market.

We had visited the third and largest of the technology parks in 2003. Largely vacant at that time, we toured the park and recorded the names of current tenets. In addition, signs had been placed at several locations indicating the future occupants of what was at the time of our visit vacant lots. We identified 12 current and 9 future park tenants. We conducted internet searches for each of these companies to identify their primary activities. The majority of the 21 firms were Mexican companies serving the regional market. Established tenants included an auto parts distributor, a printer, a furniture company, an industrial laundry, an importer of medical products, and a developer of resort locations in Puerto Vallarta and elsewhere. Companies that had committed to locating in the park included five producers and/or distributors of pharmaceutical or nutritional products, a tequila company, and a bakery. There was only one tenant, a European medical products company, that fit the profile of an export oriented manufacturer.

We had interviewed managers in 2003 at five of Guadalajara's most prominent TNCs. In June, 2005 we interviewed top managers at the same five TNCs in order to learn more about the evolution of Guadalajara based maquila and PITEX firms and due to the absence of startup firms in the area. From 2003 to 2005 these firms had collectively added 580 jobs and total employment now stood at 20,915. The primary goal of our 2005 data collection efforts was to determine if these producers were experiencing rapid upgrading. The answer to this question was clearly yes. For example, the only non-electronic firm in our sample had added 800 jobs over the last two years as the parent closed factories in a number of countries. As a result of the consolidation the plant now supplied European markets at well as countries throughout the Americas. Another TNC subsidiary performed highly complex microprocessor testing and verification services. The number of employees at this faculty had more than tripled since 2003

and the plant now performed not only product testing but also more complex verification activities (which could include integrated circuit redesign).

The three ECMs in our sample continued to follow proximity dependent strategies and were experiencing rapid upgrading. One interviewee stated their strategy of becoming a "high mix, low volume, high configuration" producer had been very successful. The plant had purchased a new generation of automatic insertion equipment that was much faster, allowed greatly reduced set up times, and significantly reduced costs. The Guadalajara facility had increased the size of their engineering staff and now had test as well as functional design capabilities. The second ECM was following a similar evolutionary path and recently won a major new contract to produce cell phones and other items for a very large telecommunications company. The third ECM was also upgrading production systems and on-site engineering capabilities. Our interviewee stated they had lost products to China in 2001 but they were now seeing the return of a "technological wave." Prior to 2002 they manufactured or assembled consumer products with an average life span of 18 to 36 months (IPC Class 2). Currently with their low volume, high mix, build to order and configure model, quality requirements on several items had been raised to IPC Class 3 or "life sustaining quality." The company planned to create a large design center in Guadalajara to perform product, test, and process design activities. The formation of this technology center was formally announced during the latter half of 2005.

(d) Monterrey Data Collection and Results

In Monterrey we began our data collection efforts by first reviewing information appearing in the local business press and touring several industrial parks. We concluded from this initial effort that a sufficient number of TNCs had established facilities in Monterrey since 2002 to justify our research strategy of focusing on EPZ startups. It was also clear one of the

most popular locations in the greater Monterrey metropolitan area for new FDI was the city of Apodaca. We were unable to obtain an accurate directory of EPZ startups in the city. However, there are four relatively new industrial parks in the Apodaca city limits. We toured these parks (including one technology park) and identified 13 companies fitting the profile of a recently established EPZ producer. We conducted interviews from November, 2005 to January, 2006 at nine of these plants. In addition, we interviewed the plant manager at a TNC that opened a new facility in 2005 in an established industrial park located just outside the Apodaca city limits.

Only two of our sample firms were "pure" startups (i.e. operated by TNCs that did not have any facilities in Monterrey prior to 2002). Six plants were controlled by TNCs that had entered Monterrey for the first time from 1999 to 2001. Particularly notable producers in this category included one Asian TNC that began its first production line in 2001, a second in 2003, and was currently building another facility to manufacture a related product. The large ECM in our Monterrey sample acquired an existing facility in 1999, expanded into two additional buildings as they experienced rapid growth, and then consolidated operations in a multi-building campus. A third TNC established its first Monterrey plant in 1999, the second in 2001, the third in 2003, and a fourth was in the planning stages. Finally, our sample includes two TNCs with a long history in Monterrey that built new plants in 2003 and 2005 respectively.

Nine of the ten TNCs were following proximity dependent strategies similar to sample firms in Reynosa and Guadalajara. The one exception was a TNC that had located in Monterrey in order to be closer to steel producers in the region. This low to medium tech plant received steel in large rolls, stamped it into small pieces, and used those items as the primary input for a simple assembly process. The second startup cut and shaped steel which was used for new building construction (structural steel, metal roofs, etc.). The plant had the mandate to market its

products in the southwest US and all of Latin America. A third plant made its first shipment in December, 2001. This facility received consumer products from several manufacturers, took orders from big box retailers in the US, packaged items according to the color, number, and type requested, and then shipped the packaged product. The parent company of a multi-plant operation in Apodaca was shutting down small factories in the US and Mexico and consolidating production in Asia and Monterrey. As a high mix, low volume producer, Monterrey specialized in very large or very low cost items, customized products, and goods that require some interaction with US production facilities. Two sample plants, including the facility outside the Apodaca city limits, produced very large, heavy, expensive to ship household appliances. A plastic injection molder located in the technology park primarily supplied maquiladoras in northeastern Mexico. The very large ECM in our Monterrey sample was pursuing a similar strategy as its Guadalajara based competitors. The company's portfolio of clients increased from 1 in 1999 to 21 in 2005 as the company implemented its high mix, low to medium volume strategy. The Monterrey plant was also attracting work from clients concerned they would lose control of their intellectual property if production was shifted to Asia. Our interviewee also stressed Monterrey is one or two "technology platforms" ahead of the parent's subsidiary in China.

After extensive review of our field notes, we were unsure of the classification of several firms in our Monterrey sample. This confusion was primarily due to the presence of high capital and technology intensive operations combined with large numbers of employees performing what appeared to be semiskilled tasks at four of the sample plants. Rather than make arbitrary classification decisions, in Table Five we divide our sample into four categories based on the capital and technology intensity of shop floor operations as well as whether or not the Monterrey

plant performed design engineering. Five plants fall in the low to medium capital and technology intensive category while the remaining five qualified as capital intensive, advanced medium-tech or high-tech producers.

Four sample plants had established significant local design engineering groups. The ECM was again following an evolution path very similar to its competitors in Guadalajara and was engaged in a variety of late stage design and testing activities. The Asian TNC in our Monterrey sample employed close to 100 engineers whose primary task was modifying designs from the parent in order to better fit the preferences of consumers in the Americas. The TNC located outside the Apodaca city limits was building two facilities in order to house two engineering groups. The initial design for goods made in the new production facility was coming from Europe and the parent had sent several Mexican engineers to Germany for periods of up to 16 months. The low to medium-tech European TNC in our sample had established a 100 plus person engineering group to perform design work primarily for items made in the US. Mexican nationals at the plant had engineering degrees from MIT, Purdue, University of Massachusetts - Amherst, Northeastern, Université de Montréal, University of Leeds, and a variety of other recognized universities both in and outside of Mexico.

*** Insert Table Five about here ***

DISCUSSION AND CONCLUSION

In this study we explore how China's emergence as the world's premier EPZ is shaping the evolution of Mexico's maquiladoras. Mexican policy makers frequently state Chinese competition is forcing Mexican industry to exit low-tech, labor intensive sectors and upgrade towards higher value added, technology intensive industries. However, Mexico's unique comparative advantage as an EPZ producer is geographic proximity to the US market. Drawing

from top management interviews and plant tours at 36 startup, rapidly expanding, and premier TNCs in three Mexican cities, we first test to determine if post China/WTO maquilas rely upon proximity dependent strategies for their survival. We then measure the capital intensity, technology intensity, and skill development activities of sample firms. Our findings indicate startup and expanding maquilas uniformly follow proximity dependent strategies. Put slightly differently, we found no evidence Mexico is attracting new EPZ investment in non-proximity dependent EPZ production activities. This study also found proximity dependent, post China/WTO maquiladoras utilize a broad range of low, medium, and high-tech production processes.

There were clear differences in the characteristics of proximity dependent maquilas in the three study cities. In Reynosa, a city where maquila employment has increased by 38 percent from October, 2000, to December, 2005, the majority of startups qualified as low-tech producers. Rapidly expanding plants in our Reynosa sample typically utilized low to medium-tech production systems and there was no clear trend towards increasing technology intensity with recently added production lines. Compared to the other study cities, Guadalajara appeared to be at a significant disadvantage given its location 600 miles from the closest US – Mexican border crossing. The city was attracting very little startup EPZ investment but premier TNCs were experiencing rapid upgrading. Employment levels were stable and sample firms were increasing the range of activities performed by on-site engineering teams. In Monterrey, five plants (3,560 employees) qualified as low to medium-tech producers while another five (6,739 employees) fit a medium to high-tech model. Four of the ten had established significant on-site engineering groups to carry out basic design and/or latter stage design/pre-mass production knowledge intensive tasks. Guadalajara and Monterrey based engineering groups were supporting local

operations but several had taken on responsibilities for products manufactured outside of their respective local areas. This suggests that Mexico may have a role to play as a provider of non-proximity dependent, administrative and technical services within TNC networks.

Our research design does not allow us to precisely determine what characteristics of our sample firms are a direct result of lower cost Chinese competition in North American markets and what characteristics are due to other factors. What we can say, however, is that sample firms differ from established maquilas on several dimensions. First, Reynosa and Monterrey startups were relatively small with an average of 323 employees per plant. The comparable figure from the Sargent and Matthews (2004) study of established maquiladoras in Reynosa was 935. Second, there is a high percentage of post China/WTO maquilas in the "other" category. Nationwide, total employment in "other" segments increased from 145,502 in October, 2000 to 170,824 in December, 2005 (INEGI, 2006). Maquilas in this category produced items such as small plastic containers, plastic spa accessories, stainless steel sinks, metal lab furniture, steel cut and welded into various shapes for use in building construction, and steel used to reinforce poured concrete. Maquilas in these "other" industry segments tended to purchase a considerable percentage of their inputs from Mexican sources. For example, sample plants with plastic injection molding operations often used plastic pellets from a GE plant in Mexico. Maquilas utilizing steel generally (but not exclusively) purchased those inputs from suppliers in Monterrey and other locations in Mexico. This suggests post China/WTO maquilas may form stronger backward linkages in Mexico when compared to traditional EPZ firms.

There were two sets of proximity dependent firms that represent especially interesting and relatively new additions to the maquiladora industry. With one exception, the Mexican subsidiaries of the major ECMs qualified as high-tech producers. Sturgeon (2002), Gereffi,

Humphrey, and Sturgeon (2005), and Berger (2005) have charted the role played in the global economy by large ECMs such as Solectron, Sanmina-SCI, Jabil Circuits, Flextronics, and Celestica. Sturgeon (2002) goes so far as to state these producers represent a new American model of industrial production which he labels the modular production network. Future research should examine if the trend towards modularity is a positive or negative force shaping the contributions made by EPZ firms to host country development (cf. Steinfeld, 2004). A second, very interesting group of firms in our sample were the large appliance manufacturers/final assemblers in Reynosa and Monterrey. These firms tend to fit a high capital intensity, medium to high technology intensity, high skill development model, and purchased as much as 82 percent of their inputs from Mexico suppliers (see Ornelas (2006) for additional information regarding the development of large appliance producers in Mexico).

Space limitations prevents us from exploring in greater depth the skill development practices of post China/WTO maquiladoras. However, several points are worth mentioning. Maquiladoras in all three cities preferred to hire relatively well educated workers and to provide significant levels of initial and continuing training. HR practices in Reynosa improved as capital and technology intensity increased. There were, however, several exceptions to this general rule. In Monterrey there was no clear relationship between capital and technology intensity and skill development activities. Our findings provide mixed support for Samstad and Pipikin's (2005) management centered model of human capital development. These authors propose a wide range of factors, rather than technology determinism, explain maquila skill development practices. Plant managers were also asked to identify the primary strategic HR challenges they were encountering with their professional level employees. Our interviewees had a very difficult time responding to this question other than to say they were very satisfied with their professional staff.

Finally, we did find several examples of post China/WTO maquilas that realized they could not operate with high turnover and were willing to compete for highly skilled individuals through higher pay. There were also high complexity maquilas that paid average wages and were suffering the consequences. Our interviewee at one of the engineering centers in Monterrey stated over the last year roughly 20 percent of their staff had left in search of better pay and advancement opportunities.

As shown in Table One, in October, 2000 apparel producers represented the second largest maquila segment. Our study has not addressed maquilas in this sector for two main reasons. First, with the exception of one plant in Monterrey we did not come across any apparel facilities following our research methodology. Second, NAFTA gave Mexican apparel producers duty and quota free access to the US market if they used fabric from the region. Research consistently finds these special trade benefits were primarily responsible for the success of Mexico's apparel producers in the 1990s (Rodriguez-Archila, 2000; Tafoya & Watkins, 2005). The implementation of the Caribbean Basin Trade Economic Recovery Act in 2000 and the end of the Multifiber Arrangement in 2005 gives lower cost countries greatly increased access to the US apparel market and it comes as no surprise maquiladoras in this segment have recently suffered severe job losses. As in other segments, however, research suggests Chinese competition is forcing Mexican apparel exporters to adopt proximity dependent strategies (Abernathy, et al., 2004) and that technology intensive, non-proximity dependent, "full package" approaches are vulnerable to Chinese competition (Bair & Dussel Peters, 2006).

There are several limitations to this study. First, conceptually there are clear differences between low, medium, and high-tech maquilas. In practice, even after interviews with top managers and plant tours it was not always apparent the correct classification of roughly 20

percent of sample firms. To compensate, we provide brief summaries of many of our post China/WTO maquilas and broadened the classification scheme for our Monterrey sample. The proportion of sample maquilas in each of the categories should be considered well informed estimates and not exact percentages (cf. Carrillo & Gomis, 2005). Second, our study fully supports the argument Chinese EPZ competition is an important factor shaping maquiladora evolution. As the same time, additional forces are clearly at work. Mexico's export industry should experience upgrading regardless of external factors as producers gain additional industrial experience. Furthermore, the types of technology available to producers continues to improve. Mexico also faces low cost competition from not only China but several other developing countries in the US market. We are confident China's emergence as a major location for EPZ activity is forcing startup and expanding maquilas to pursue proximity dependent strategies and that post China/WTO maquilas have implemented a range of low, medium, and high-tech production systems. We are less confident that some of the other characteristics of our sample are a direct result of China's success.

The policy implications that emerge from our examination of post China/WTO maquilas as well as the Sargent and Matthews (2004) study are relatively straight forward. The assumption that Mexico can compete against China through adopting a technology intensive development strategy is not supported by our data. Mexico is not an attractive location for non-proximity dependent, technology intensive EPZ manufacturers. Mexico is, however, a very attractive location for proximity dependent low, medium, and high-tech exporters serving the North America market. The Mexican government should continue efforts to develop the country's science and technology infrastructure. To support the maquila industry, however, targeted initiatives to augment the competitiveness of proximity dependent maquiladoras will

likely result in a more immediate return. The Mexican government has proactively taken steps, such as working with the US government to address post 9/11 security concerns and streamlining import/export procedures, to facilitate proximity dependent strategies (Secretaría de Economia, 2004). Further policy measures could include building additional transportation infrastructure, utilizing these resources more efficiently, reducing the very substantial costs of transporting products from the Mexican interior to the border, reducing energy costs for the country's important but clearly underappreciated steel producers, and reforming Mexican labor law to increase the flexibility of the country's workforce.

Companies serving the US market will continue to search for increased production efficiency and profitability. We suspect there remains a broad range of low, medium, and high-tech manufacturing and assembly operations in the US that may be profitably transferred to a lower cost, yet geographically close location. With appropriate policy initiatives, we believe Mexico's EPZ industry is well positioned for a new round of FDI, job growth, higher levels of regional integration, and a host of new opportunities for those in the public and private sector willing to embrace the changes resulting from China's new role in the global economy. Our study may also hold lessons for other developing countries. Blind faith in the idea that technology upgrading is the primary way to succeed when facing Chinese export competition is not a sound basis for policy making. The Mexican experience suggests medium cost developing countries with EPZ programs should focus on what producers in China cannot or do not want to do. Until competitive conditions change, providing incentives for firms to enter technology intensive industries characterized by global competition is a risky, if not foolhardy, policy response.

Table One: *Changes in Maquila Employment: 10/2000, 12/2003, 12/2005*

	10/2000	12/2003	12/2005	Job Losses
City				
Cd. Juárez	264,241	196,933	227,255	36,986
Tijuana	199,428	141,938	162,437	36,991
Reynosa	67,275	72,492	93,180	< 25,905 >
Matamoros	69,989	52,201	56,287	13,702
Mexicali	65,494	49,373	53,388	12,106
Cd. Chihuahua	53,319	45,485	43,065	10,254
State[1]				
Jalisco	27,332	27,968	47,391	< 20,059 >
Nuevo León	72,566	54,208	67,139	5,427
Sector				
Electronic	467,508	330,378	378,061	89,447
Apparel	293,576	195,577	170,226	123,350
Auto Parts	250,635	238,577	267,626	< 16,991 >
Industry Total	1,347,803	1,050,210	1,163,362	184,441

1. The Mexican government's statistical agency reports maquiladora employment in Guadalajara and Monterrey but not the surrounding metropolitan area where the great majority of EPZ activity takes place. Therefore, we provide employment information by state for these two locations. Guadalajara and Monterrey are the capital cities and industrial centers of Jalisco and Nuevo León respectively. In addition, there is a long tradition of EPZ firms in these cities registering as PITEX companies rather than as maquiladoras. The PITEX program provides companies roughly equal import/export benefits as maquiladoras. However, recent changes in tax laws may make the maquila options more attractive and the growth in maquila employment in Jalisco may be due to PITEX firms changing their legal status to maquiladoras. The Mexican government does not separately disclose employment data for PITEX companies.

Source: INEGI, Banco de Información Económico, Industria Maquiladora de Exportación

Table Two: *Trends in US imports from Mexico and China (in billions of US dollars)*

Total US Imports from Mexico and China

	2000	2002	2004	2005
Mexico	134,734.4	134,121.2	154,958.8	169,216.1
China	99,580.5	124,795.7	196,159.5	242,638.0

Electrical machinery and equipment (Tariff Headings 85, 8471, 8473)

	2000	2002	2004	2005
Mexico	44,401.4	41,325.6	44,911.7	46,712.3
China	29,361.9	38,526.7	73,544.6	96,706.2

Apparel (Tariff Headings 61 and 62)

	2000	2002	2004	2005
Mexico	8,617.0	7,638.3	6,843.4	6,229.9
China	6,192.9	7,069.9	10,684.6	16,773.8

Source: United States International Trade Commission (http://dataweb.usitc.gov)

Table Three: *Sample Characteristics*

	Industry Sector			***Parent Nationality***			**Grand**
	Electronic	**Auto**	**Other**	**US/Can**	**Asia**	**Europe**	**Total**
Reynosa Startup Maquilas							
Number of firms	7		8	14		1	15
Total employment	2,399		1,779	4,129		49	4,178
Reynosa Expanding Maquilas							
Number of firms	3	2	1	5		1	6
Total employment	3,035	5,600	3,300	7,975		4,000	11,975
Guadalajara Premier TNCs							
Number of firms	4		1	4	1		5
Total employment	17,315		3,600	13,715	7,200		20,915
Monterrey Startup Maquilas							
Number of firms			2	1		1	2
Total employment			696	540		156	696
Monterrey Expanding Maquilas							
Number of firms	4		4	5	2	1	8
Total employment	9,000		603	5,215	1,788	2,600	9,603

Table Four: *Reynosa Startup Characteristics*

	Low-Tech N = 8	**Medium-Tech** N = 4	**High-Tech** N = 3
Employment Profile			
Average number of employees	275	313	262
Percent Engineering	2.1	1.7	3.2
Production Systems			
Capital intensity	2.62	4.25	4.67
Technology Intensity	2.25	3.75	4.67
Human Resource Practices			
Education requirements	9 or less	9 or less	9
Hours of initial training	24.6	19.7	42.0
Hours of continuing training	28.1	48.5	55.0
Pay policy	At market	Above market	Above market
Average monthly turnover	15.4	6.8	7.6

Table Five: *Monterrey Sample Characteristics*

	Low to Medium-Tech N = 4	**Low to Medium-Tech with Design**[1] N = 1	**Medium to High-Tech** N = 2	**Medium to High-Tech with Design** N = 3
Employment Profile				
Average number of employees	240	2,600	170	2,133
Percent Engineering	2.1	7.7	3.5	7.2
Production Systems				
Capital intensity	3.25	2.5	4.0	4.33
Technology Intensity	2.75	3	3.75	4.33
Human Resource Practices				
Education requirements	9		9	9
Hours of initial training	41.0		12	54
Hours of continuing training	49.3		75	50
Pay policy	Above	Average	Above	Average
Average monthly turnover	2.4		4.5	3.75

1. At this plant we interviewed one of the engineering managers in the company's design group. This individual did not have full information regarding the plant's HR policies.

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