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Capital Intensity, Technology Intensity, and Skill Development in Post China/WTO Maquiladoras

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Summary. — 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 that Chinese competition is forcing maquiladoras to exit low-tech, labor intensive industries and evolve toward 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 that sample firms have uniformly adopted proximity dependent strategies. The capital intensity, technology intensity, and skill development activities of proximity dependent maquiladoras vary 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.

Key words — export processing zones, maquiladoras, Latin America, Mexico

1. INTRODUCTION

Export processing zones (EPZs) are an increasingly popular initiative utilized by developing countries to more fully benefit from today's global economy. [1] 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. [2] 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; Wilson, 1992). Studies over the past two decades find that 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 (Bair & Gereffi, 2001; Barajas *et al*., 2004; Carrillo & Hualde, 1998). 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 EPZ industry has 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 (GAO, 2003). Maquila employment fell by almost 300,000 from November 2000 to the end of 2003 before beginning a slow but steady

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recovery [3] (Table 1). 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 that the rapid expansion of exports to the United States 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% of the country's exports to the United States (Lemoine & Ünal-Kesenci, 2004). In US market segments where Chinese and Mexican EPZ exports overlap, trade data reveal a consistent pattern (see Table 2). China is gaining and Mexico is losing market share in sectors such as television receivers, computer hardware, consumer electronics, household appliances, and apparel (Banco de México, 2005; Dussel Peters, 2005; Watkins, 2003).

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 that proximity to North American customers represents the foundation of maquiladora competitive advantage. For example, Sargent and Matthews (2004) argued that the 2000–03 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.

Table 1. *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	225,234	39,007
Tijuana	199,428	141,938	162,577	36,851
Reynosa	67,275	72,492	90,616	⟨23,341⟩
Matamoros	69,989	52,201	56,299	13,690
Mexicali	65,494	49,373	53,393	12,101
Cd. Chihuahua	53,319	45,485	44,612	8,707
State[a]				
Jalisco	27,332	27,968	47,659	⟨20,327⟩
Nuevo León	72,566	54,208	67,137	5,429
Sector				
Electronic	467,508	330,378	375,683	91,825
Apparel	293,576	195,577	169,677	123,899
Auto parts	250,635	238,577	263,804	⟨13,169⟩
Industry total	1,347,803	1,050,210	1,156,477	191,326

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

[a] 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. See Footnote Two for additional information about the PITEX and the new IMMEX programs.

Table 2. *Trends in US imports from Mexico and China (in billions of US dollars)*

	2000	2002	2004	2005	2006
Total US imports from Mexico and China					
Mexico	134,734.4	134,121.2	154,958.8	169,216.1	197,055.6
China	99,580.5	124,795.7	196,159.5	242,638.0	287,052.4
Electrical machinery and equipment (Tariff Headings 85, 8471, 8473)					
Mexico	44,401.4	41,325.6	44,911.7	46,712.3	54,138.8
China	29,361.9	38,526.7	73,544.6	96,706.2	110,677.4
Apparel (Tariff Headings 61 and 62)					
Mexico	8,617.0	7,638.3	6,843.4	6,229.9	5,447.6
China	6,192.9	7,069.9	10,684.6	16,773.8	19,864.8

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

In the study detailed in this paper we examine whether proximity dependent EPZ investment [4] tends to fit a low-tech assembly, a medium-tech manufacturer, or a 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 enable 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 that 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 toward a technology intensive business model (Carrillo & Gomis, 2003; Christman, 2005; Lindquist, 2004; Gerber & Carrillo, 2003; Rocio Ruiz, 2005). Mexican policy makers, seemingly confident that 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. [5] 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. 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), Lemoine and Ünal-Kesenci (2004), and Zhou and Lall (2005) concluded that China and its immediate neighbors in East Asia are evolving toward an integrated production system characterized by complementary

rather than confrontational trade relationships. In South America a study by the Inter-American Development Bank (IADB) found that China's growth is creating increased demand for agricultural, mining, and energy exports from countries such as Chile, Argentina, and Brazil (Devlin, Estevadeordal, & Rodrıguez-Clare, 2006; see also Dussel Peters, 2004; Lora, 2005; Moreira, 2007). The IADB study found that 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 that 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 that Mexico accounted for 11.5% of all US imports in 2001 but only 10.6% in 2004. If Mexico had been able to maintain its 2001 import share, the central bank estimated that 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 that Mexico's GDP would have increased by an additional 2.54% over the 2002–05 period if the country had been able to maintain its 2001 US import share. Dussel Peters (2005) also documented a high degree of similarity between Chinese and Mexican exports to the United States and a drop in Mexico's import share. [6] In addition, he argues "... China will probably continue to compete and displace Mexico—and other countries—in additional sectors such as automobiles, chemicals, software, and pharmaceuticals in the near future." A study by García Herrero and Santabárbara García (2005) 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 1995–2001 period TNCs headquartered in the OECD countries 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. [7] There is a widespread recognition that 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 that technological progress represents one if not the most important contributor to economic growth. For example, Lall (2004, p. 190) stated "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 that Mexican industry must migrate from labor intensive industries toward higher value added, higher complexity activities 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 toward 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 (Ruiz Durán, Piore, & Schrank, 2005). 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 United States 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 Program 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% over this eight year period (see also OECD, 2006).

The macroeconomic and comparative data indicate that 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 2002–03. 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 United States from producers located in China or other lower cost countries. These maquilas tend to produce highly standardized, commodity type 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 United States 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) concluded that market characteristics and the adoption of proximity dependent business models rather than the ability to efficiently utilize advanced manufacturing technology was the primary factor contributing to maquiladora success. In fact, the strategies adopted by a limited number of maquilas were not consistent with the assumption that 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 that 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 (90,616) ranked behind only Cd. Juárez (225,234) and Tijuana (162,577) as the Mexican city with the largest number of maquiladora employees. Reynosa is unique in that it is the only major maquiladora center that experienced significant job growth since 2000. Maquila employment increased 35% from October 2000 to December 2005. With the exception of apparel, Reynosa maquilas are well diversified in the major maquila segments (electronics, electrical equipment, auto parts, and ''other'' industry segments) and are controlled by a mixture of both large and medium sized firms from the United States, 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 (Dussel Peters, 2000; Ordóñez, 2006). IBM, Hewlett Packard, Kodak, Intel, 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. In contrast, Monterrey is a recognized center for Mexican heavy industry, enjoys a diverse manufacturing base, and maintains a reputation as an attractive location for TNC investment (Fouquet & Moreno, 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, and that began production in 2002 or after. We further define startups as companies, or divisions of companies, which 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. [8] Section 1 focused on the general characteristics of the plant and the person interviewed. In Section 2 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 3 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 4 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 3 for addition information regarding sample firms in all three cities).

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 that the parent company/division established the Mexican facility due to intense competition in the United States. 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 United States 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

Table 3. *Sample characteristics*

	Industry sector			Parent nationality			Grand total
	Electronic	Auto	Other	United States/Canada	Asia	Europe	
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

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 that 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 4 we provide summary data on our Reynosa startup sample. Maquilas startups share a number of interesting characteristics. First, these plants were relatively small employing 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.

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

Table 4. *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
Capital/technology measures			
Capital intensity[a]	2.62	4.25	4.67
Technology intensity[b]	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

[a] Response to the question "Using a scale where one is low, three medium, and five high, how would you rate the capital intensity of this plant?".

[b] Response to the question "Using a scale where one is low, three medium, and five high, how would you rate the technology intensity of this plant?".

1.5%, 4.5%, 10–15%, 13%, 15–20%, and 40%. One plant manager stated that the turnover was high but would not provide a specific number. The final interviewee reported that the turnover was "17/4" (i.e., the turnover in the first 30 days was 17%, after that it was 4%).

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 15–20 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 12–15 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, fed 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 to attract more capable employees. Even with better pay, operator turnover was still relatively high (4.5%, 6.0%, 7.0%, and 9.8% 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 that most of their technicians either had or were working toward 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/$240,000.

HR systems at 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 that 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% 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% 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 that 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 toward increased capital, technology, and skill intensity with their newer operations.

To summarize, we conducted interviews and plant tours in Reynosa at 15 startups and 6 rapidly expanding maquiladoras. Startup investment was primarily coming from divisions with little international experience of very large United States based TNCs. These divisions were transferring the production of proximity

dependent goods from the United States to Mexico. Startups were relatively small and concentrated in the electronic/electrical equipment and "other" industrial sectors. The capital and technology intensity of operations on the factory floor ranged from low to very high; steel sourced from Mexican suppliers was a major input at several maquilas, and high operator level turnover was limiting the development of organizational capabilities at the majority of sample plants.

(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 that 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 that the four largest ECMs generated 80% 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 that 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 that 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, which could benefit from highly secure, Class A space. Now fitting more a business park model, occupancy rates had improved to 95%. 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 tenants. In addition, signs had been placed at several locations indicating the future occupants of what were 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 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 that 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 setup times, and significantly reduced costs. They 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 that they had lost products to China in 2001 but were now seeing the return of a "technological wave." Prior to 2002 they manufactured or assembled consumer products with an average life span of 18–36 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.

To summarize, we found that there had been very little startup EPZ investment in Guadalajara over the 2002–05 period. The three recently established technology parks were attracting primarily Mexican companies and TNCs distributing products to the local market rather than export oriented, technology intensive manufacturers. Given the absence of new EPZ investment, we conducted interviews at five of the city's premier TNCs. Total employment was similar to the levels reached in 2003 and all of the sample plants were experiencing rapid upgrading. The three ECMs were uniformly pursuing proximity dependent, high mix, low volume, high configuration strategies, and increasing the size and capabilities of their on-site engineering teams.

(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 that 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 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 United States 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 United States, 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 United States 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 United States 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 that 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 5 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

Table 5. *Monterrey sample characteristics*

	Low to medium-tech $N = 4$	Low to medium-tech with design[a] $N = 1$	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
Capital/technology measures				
Capital intensity[b]	3.25	2.5	4.0	4.33
Technology Intensity[c]	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

[a] 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.
[b] Response to the question "Using a scale where one is low, three medium, and five high, how would you rate the capital intensity of this plant?".
[c] Response to the question "Using a scale where one is low, three medium, and five high, how would you rate the technology intensity of this plant?".

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 evolutionary path very similar to its competitors in Guadalajara and was engaged in a variety of early 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 to better fit the preferences of consumers in the Americas. The TNC located outside the Apodaca city limits was building two facilities 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 United States. 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.

To summarize our Monterrey findings, a significant quantity of new EPZ investment flowed into Apodaca during the 2002–05 period primarily from rapidly expanding United States, European, and Asian TNCs. Sample plants were pursuing proximity dependent strategies and the capital and technology intensity of production systems varied from low to very high. Steel, primarily but not exclusively from Mexican sources, was a primary input at the two startups and at three of the eight rapidly expanding plants. Finally, four of the EPZ producers had established or were in the process of establishing large on-site engineering groups.

4. 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 that Chinese competition is forcing Mexican industry to exit low-tech, labor intensive sectors and upgrade toward 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 that startup and expanding maquilas uniformly follow proximity dependent strategies. Put slightly differently, we found no evidence that Mexico is attracting new EPZ investment in non-proximity dependent EPZ production activities. This study also found that 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 35% 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 toward 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 other 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 manufacturing category. Nationwide, total employment in this sector increased from 145,502 in October 2000 to 170,846 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 manufacturing 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 that post China/WTO maquilas may form stronger backward linkages in Mexico when compared to traditional EPZ firms.

In addition to the increased presence of firms in other manufacturing sectors, there are a number of important sectorial trends evident in our data which may represent important areas for future research. First, the electronics/electrical equipment sector continues to represent the largest maquila sector (Table 1). This sector experienced a very significant drop over the 2000–03 period and total employment as of the end of 2005 remains below pre-crisis levels. However, there were two sets of proximity dependent firms that represent especially interesting and relatively new additions in this sector. With one exception, the Mexican subsidiaries of the major ECMs qualified as high-tech producers. Gereffi, Humphrey, and Sturgeon (2005), Berger (2005) and Sturgeon (2002) 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 that these producers are a leading example of a new American model of industrial production which he labels the modular production network. Future research should examine if the trend toward modularity is a positive or a 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 was 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% of their inputs from Mexico suppliers (see Ornelas, 2006 for additional information regarding the development of large appliance producers in Mexico).

Auto parts represents the second largest sector in the maquila program. This study, the employment data shown in Table 1, and research examining mortality rates in Mexican EPZ firms since the mid-1990s all suggest that auto parts has been a very stable sector that is experiencing neither job losses nor strong growth (Fouquet & Moreno, 2006; Sargent & Matthews, 2007). Sargent and Matthews (2004) argue that large auto part producers were shielded from Chinese competition due to the preferences of final assemblers in North America to maintain JIT relationships with their primary suppliers. In contrast, Dussel Peters (2005) proposes that Mexican auto parts producers will become increasingly vulnerable to Chinese competition in the near and medium term. The fate of the Mexican auto parts industry represents an important test of our argument that proximity dependent business models represent an effective shield for Mexican EPZ producers.

As of the end of 2005, apparel represents the third largest "pure" maquila segment. This sector experienced considerable job losses during the 2000–03 period and has continued to decline during 2004–05. Our study has not focused on apparel producers for two main reasons. First, with the exception of one plant in Monterrey we did not come across any apparel facilities following our sampling 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 (Gruben, 2006; 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 that maquilas in this segment have suffered severe job losses. As in other industry sectors, however, research suggests that 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). Studies frequently employed a global commodity chain framework to explain the competitiveness of Mexico's apparel sector during the 1990s (cf. Gereffi, Spener, & Bair, 2002). Researchers may want to reexamine the explanatory power of this theoretical lens in light of the difficulties experienced by this sector during the present decade.

Space limitations prevent 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 provided mixed support for the Samstad and Pipkin (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% of their staff had left in search of better pay and advancement opportunities.

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% 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 that 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 also 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 straightforward. 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 American 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, and reforming Mexican labor law to increase the flexibility of the country's workforce. Also, as mentioned several of our post China/WTO maquiladoras utilized steel from Mexican sources as one of their primary inputs. To deepen these backward linkages the Mexican government should ensure energy intensive suppliers such as those in the steel industry are not burdened by energy costs that are significantly higher than the world average (electricity rates are typically at least a third higher in Mexico than in the United States).

Companies serving the US market will continue to search for increased production efficiency and profitability. We suspect that there remains a broad range of low, medium, and high-tech manufacturing and assembly operations in the United States that may be profitably transferred to a lower cost, yet geographically close location. With appropriate policy initiatives, we believe that 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 that 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 (such as significantly higher wages in China and/or a major revaluation of the Chinese currency), providing incentives for firms to enter technology intensive industries characterized by global competition is a risky, if not foolhardy, policy response.

NOTES

1. The term export processing zone implies that participating firms are physically located in a specific zone such as an industrial park or a particular region of a country. However, it is common practice to refer to EPZ initiatives as programs which offer participating firms regardless of physical location special export promotion incentives such as duty free importation of raw and intermediate materials which then undergo some type of assembly or manufacturing process before being exported (ILO, 2003).

2. Mexico's EPZ industry is composed of companies formally registered as maquiladoras as well as producers operating under other export promotion programs. In the past the most important of these has been the PITEX program (*Programa de Importación Temporal para Producir Articulos de Exportación*). The PITEX program was established in 1985 to allow non-maquila companies the ability to import duty free materials and equipment as long as the final output was exported. In other words, PITEX companies sell their products in Mexico paying all the normal import duties and taxes and at the same time receive nearly identical treatment as maquilas for their export sales. The differences in the maquila and PITEX programs have eroded over time. NAFTA, which mandated maquilas could sell their goods in Mexico, was a major force blurring the differences between the two programs. On November 1st, 2006 the Mexican government issued a decree combining the maquiladora and PITEX programs under a single export promotion scheme entitled the *Programa de la Industria Manufacturera, Maquiladora y de Servicios de Exportación* (IMMEX). The Mexican government has stated that IMMEX companies will be referred to as maquiladoras. Consistent with this policy, throughout this paper we refer to Mexican EPZ firms as maquiladoras. The Mexican government's statistical agency does not separately disclose export or employment figures for PITEX companies. There are, however, scattered measures of their importance. A document released by the Mexican President's office in 2006 estimates PITEX employment at 1.1 million and states that maquiladora and PITEX firms are responsible for 85% of all Mexican manufacturing exports. The reports also states that there are 4,523 firms functioning as sub-manufacturers for maquiladora (2,778) and PITEX companies (1,745). In 2005 the official Mexican import/export figures list the dollar value of temporary imports for maquiladoras ($75.1 billion) and non-maquiladora firms ($88.4 billion) (Bancomext, 2006). In the same year manufactured exports totaled $96.8 billion for maquiladoras and $77.8 for non-maquiladoras. The November 2006 directories maintained by the *Secretaría de Economía* (www.economia.gob.mx/?P=760) list 3,159 maquiladoras and 3,375

PITEX companies. The ratio of maquiladoras to PITEX producers in the following delegations shows EPZ firms tend to register as maquiladoras in border locations and as PITEX companies in the Mexico interior; Cd. Juárez (7.00), Tijuana (5.72), Reynosa (17.40), Matamoros (6.94), Mexicali, (1.87) Cd. Chihuahua (1.71), Guadalajara (.44), and Monterrey (.59). See Dussel Peters (2000, 2003) for additional information regarding the PITEX program.

3. The employment numbers given are for firms formally registered as maquiladoras. As previously stated the Mexican government does not separately disclose data for PITEX firms or for sub-manufacturers.

4. As discussed by Sargent and Matthews (2004) and Tafoya and Watkins (2005), product characteristics and how firms attempt to gain competitive advantage in the market place differentiate proximity dependent from non-proximity dependent business models. Non-proximity dependent products are generally very high volume, highly standardized, easy to ship items that do not experience rapid design changes. Transportation costs tend to be a small percentage of total costs for these products. TNCs frequently manufacture these goods in the lowest cost production location they can find. In contrast, firms pursuing proximity dependent strategies have a compelling reason to be located close to their customers. For example, a firm may manufacture a heavy, awkwardly shaped item such as a full-sized refrigerator that is very expensive to ship. In addition, auto assemblers utilizing JIT systems located in North America often require their primary suppliers to be located in the same region. Uncertain market demand, customers needing products in a hurry, low production volumes, and customized items are additional characteristics of proximity dependent goods. See Abernathy, Dunlop, Hammond, and Weil (2004), Blázquez-Lidoy, Rodrıguez, and Santiso (2006) and Sargent and Matthews (2004) for additional information.

5. It is worth emphasizing that proximity intensive and technology intensive strategies are not mutually exclusive options. Proximity dependent EPZ producers may adopt low, medium, or high-tech production systems. The primary goal of this study is to determine the proportion of post China/WTO maquilas that fall in each of these categories.

6. A study by Freund and Ozden (2006) suggests that Mexico has lost market share to China in not only low value added segments such as apparel but also in higher value added activities. These authors state ''Using bilateral trade data at the 4 digit SITC level from 1985 to 2004, we find that China's export expansion has had a significant negative effect on Latin American exports. The effect is concentrated primarily in industrial exports from Mexico to North America since 1995. We find some evidence of quality upgrading in response to China's emergence, but there is significant evidence that China has put downward pressure on LAC (Latin American and Caribbean countries) export prices. In addition, China is displacing LAC in relatively high-wage export sectors. Thus, China's export surge has limited LAC's ability to move up the export ladder.''

7. The Center for China-Mexico Studies has recently been established at Mexico's premier public university. The Center's website is an excellent source for additional information (http://www.economia.unam.mx/cechimex, see also http://dusselpeters.com).

8. We drew from the maquiladora literature as well as research examining industrial upgrading in developing countries during the survey development process. Gereffi (2003) states that there are four primary dimensions of industrial upgrading; intersectoral shifts (moving from primary products to manufacturers), intrasectoral shifts (the strengthening of forward and backward linkages), economic role shifts (from assembly using imported materials to manufacturing to design and branding), and product shifts (from simple to complex products). This study focuses primarily on the latter two upgrading dimensions. A consistent finding in the literature is that industrial upgrading is positively correlated with increased investments in capital intensive equipment and advanced manufacturing technology. These are not synonymous terms. A large, manually operated, hydraulic press used to bend metal may be very expensive but most maquila managers and researchers would not consider it a technology intensive application. In contrast, in this study examples of technology intensive equipment include robotics, surface mount machinery, X-ray testing equipment, and complex computer controlled machinery integrated into flexible manufacturing systems.

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