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Is the downturn in maquiladora employment cyclical or structural?

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Abstract

Purpose – The purpose of this paper is to examine the effect of cyclical and structural factors on the decline of maquiladora employment. In addition to the US industrial production, the cyclical factors examined are relative Mexican US wages, the Mexican exchange rate relative to the US, and US foreign direct investment (FDI). The paper also explores the effect of competition from China, a structural effect, on the decline of maquiladora employment.

Design/methodology/approach – A vector error correction (VEC) model of maquila employment for the period 1980-2002 is estimated and controlled for US industrial production, FDI flows, relative wage rates of Mexico and USA. To empirically investigate the structural differences of lower costs in Mexico vs China a seemingly unrelated regression (SUR) is estimated across three sectors: apparel and textile, electronic, and transportation.

Findings – From the VEC maquila employment model it is found that, in addition to the strong effect of US industrial production on the maquila employment, there exist significant short- and long-run effects of Mexico US exchange rate and Mexican wages relative to USA on maquila employment. The sectoral (SUR) model shows that competition from China has a bigger adverse effect on relatively labor-intensive good and commodities which are cheaper to transport (such as textiles) over more bulky transportation goods. The transportation sector has a location advantage, though is more sensitive to the cyclical fluctuations in the US industrial production.

Research limitations/implications – Future research should investigate the role of USA and world FDI exclusively into Mexico and maquiladora sector.

Practical implications – Well designed controls, output choice, and location advantage are important for the growth and viability of small scale manufacturing industries.

Originality/value – The VEC model for maquila employment and the SUR framework across main maquila sectors is the first to account for wages, exchange rate, and FDI in addition to the US industrial production in understanding the decline in maquiladora employment.

Keywords Maquiladora production, China, Mexico, United States of America, Pay, Exchange rates

Paper type Research paper

I. Cycle or structure? An introduction

In October 2002, the Mexican maquiladora manufacturing sector entered a sudden downturn in employment, output, and the number of firms. After more than a decade of annual employment growth, the double-digit employment in the maquiladora industry has declined. The relative stagnation in the maquila sector has generated questions about the long-run employment prospects for the maquiladora industry[1]. The failure to return to double-digit annual growth and the unprecedented nature of the decline has created a suspicion that the problems have more than a temporary cyclical component. In particular, there are worries that structural shifts in the world economy,

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such as China's entrance into the World Trade Organization (WTO), or threshold effects from intensifying global competition are at the root of the industry's problems. In addition to the role of the following cyclical factors: US manufacturing, relative Mexican wages and foreign direct investment (FDI) into Mexico, this paper explores the role of important structural factors, competition from China, on the decline of maquiladora employment over the period 1980-2002.

While this paper focuses on maquiladora industry on the border region of USA and Mexico, but the issues of offshoring on the volatility of the domestic employment (Bergin *et al.*, 2009) and competition from China are also faced by many manufacturing firms around the globe. For instance, firms specializing in labor-intensive goods have many such industries located along the Indo-Nepal border. Hong Kong also serves as a huge illegal market for Chinese goods (Venkatiraman, 2001; Tummala *et al.*, 2000; Cheng, 2000 to name a few).

This paper focuses on sorting out a number of issues that are affecting the maquiladora industry. First, it examines the role of cyclical factors, particularly the effect of FDI, wages, and exchange rate, in addition to the US industrial production on the decline in the maquiladora employment. The decline in US industrial production explains about eight or nine percentage points of the employment decline which reached nearly 27 percentage points in February of 2002, indicating that there are other factors in addition to the US industrial production that are an important factor in explaining the maquiladora employment. Given the unusually large and persistent decline in USA and world FDI, it is not surprising that sectors that depend on FDI inflows have been adversely affected. While the impact of the decline in FDI is probably more cyclical than structural, it is a world-wide phenomenon that has not figured in most of the discussion of the maquiladora industry.

The second aim of this paper is to examine the challenge posed by China to the Mexican maquila industry. We estimate a seemingly unrelated regression (SUR) model across the three major sectors of the maquiladora industry, textile, electronic, and transportation to shed some light on the role of this important structural factor. Based on surveys of the maquila in the electronics and automotive industry in the border region, it is argued that a large number of firms are extremely vulnerable to foreign competition from low cost producers such as China, but that many firms are likely to weather the current downturn. The most robust firms are likely to be in areas where location advantages matter, such as the automotive industry, or firms at the technological frontier of their industry where they are deeply embedded in a multinational corporate strategy.

In this paper we also examine the most benign structural factor for the downturn and subsequent stagnation – the idea that an unknown portion of the downturn is purely a statistical artifact. A simple theoretical model is developed to show how a constant rate of attrition in the industry might combine with a reduced set of incentives for manufacturing firms to seek legal status as maquilas and cause a slowdown or a decline in the industry growth rate, even if there is no disincentive to manufacture in Mexico.

II. Outward USA and world FDI and inward FDI in Mexico over 1980-2002

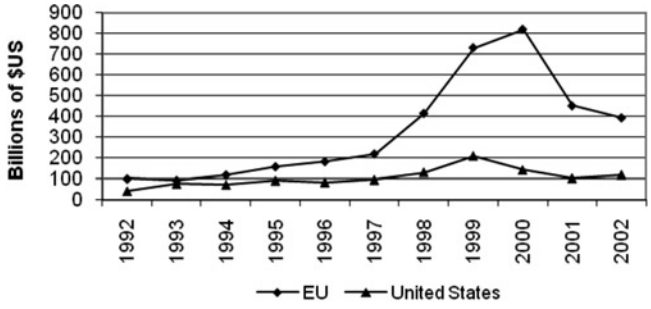
According to the United Nations Commission on Trade and Development (UNCTAD), global foreign direct investment outflows fell by 40.8 percent in 2001 and another 9.0 percent in 2002 (UNCTAD, 2003). US outflows recovered in 2002, but began their decline a year earlier in 2000. The total cumulative decline in US outflows was over

50 percent in 2000-2001. Figure 1 shows the pattern in USA and European Union (EU) outflows over the last several years.

Three factors are cited as reasons for the downturn in world FDI: weak economic growth, tumbling stock markets that led to fewer mergers and acquisitions, and institutional factors, particularly in transition economies and emerging markets, which resulted in fewer privatizations. Mexico and the USA have been characterized by relatively weak economic growth since 2000, and the decline in inward FDI in Mexico is consistent with the trend in overall economic conditions. Figure 2 shows the pattern in Mexico relative to the world pattern, and with the exception of the increase in 2001, there is nothing peculiar about FDI into Mexico. The increase in 2001 reflects the $12 billion purchase of Banamex by the US firm Citicorp.

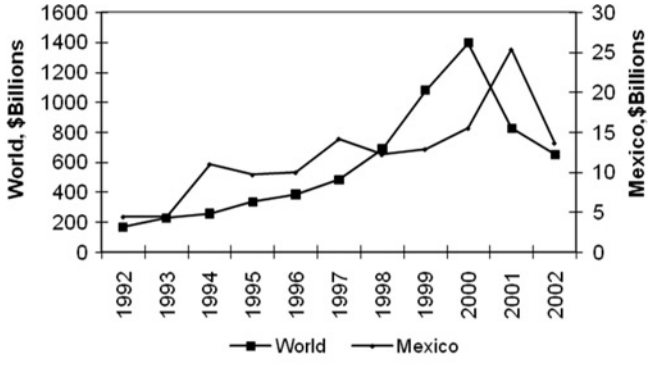
With the exception of 2001, during the years 1998-2002 foreign investment in fixed assets in the maquiladora industry has been between 18 and 25 percent of total inward FDI in Mexico. From their peak in 1999-2002 the decline in the level of FDI flows into the maquiladora industry was 32 percent, nearly identical to the 30 percent decline in overall level of FDI (Secretaría de Economía, 2003).

In sum, the decline in world FDI flows has not had a disproportionately large impact on either Mexico nor on the maquiladora industry. These descriptive statistics are not precise; however, they do argue for an interpretation of the decline that primarily emphasizes cyclical factors over structural.



Source: UNCTAD (2003)

Figure 1.
Outward FDI



Source: UNCTAD (2003)

Figure 2.
World and Mexico FDI inflows

III. Manufacturing employment and maquila employment

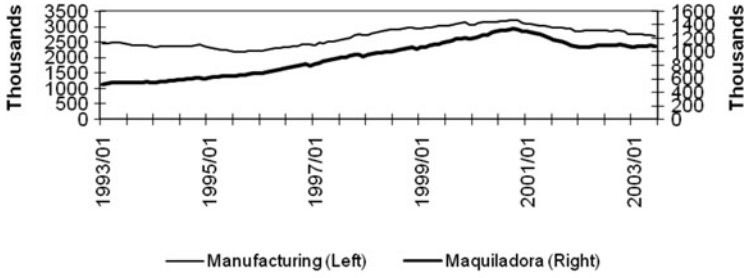
World FDI flows are part of the global economic environment affecting the maquiladora industry. Another factor is the state of Mexican manufacturing. The maquiladora industry is a mirror of overall Mexican manufacturing since only about 3.5 percent of employment is in the service sector (INEGI, 2003). Other than its special tax status, there is no reason why the maquiladora industry might perform differently than the rest of manufacturing.

Employment in manufacturing (IMSS registered, non-maquila) peaked in October 2000, at 3,194,197. The same month, maquila manufacturing reached its peak of 1,347,803. Although both sectors peaked in the same month, the troughs have been significantly different. IMSS registered manufacturing workers have continued to trend down through June 2006, while maquiladora employment reached a trough in February 2002. In spite of the much longer period of decline in the number of formal sector non-maquila manufacturing workers, the 19 percent decline is significantly less than the 26.7 percent peak-to-trough decline in maquila employment. Figure 3 illustrates the movement in the two variables.

Overall, maquiladora employment fared worse than formal sector manufacturing employment, although the continued decline in manufacturing means that it continues to catch up to the maquiladora industry in overall job loss. In June 2003, total cumulative job loss in IMSS registered manufacturing workers stood at 19.2 percent, vs a 24.6 decline in the maquiladora sector from October 2000. The relatively worse performance of the maquiladora sector during this time period argues that the forces causing its decline include non-cyclical factors. This follows from the argument that the maquiladora is essentially the same as Mexican manufacturing, except that it operates under a different set of legal institutions, and consequently, the institutional structure is to some degree different from the rest of manufacturing. The impact of legal and other changes will be considered below. We turn now to a more systematic analysis of the employment data.

IV. An econometric model of maquiladora employment

The role of US industrial production has already been examined in the literature by Gruben (2001) and Gerber and Balsdon (2001). Both the papers estimate that a 1 percent decline in US industrial production causes maquila employment to fall by approximately 1.27 percent. Both papers find that maquila managers react quickly to a downturn in the US economy with Gruben showing that managers make their layoffs within a year of the downturn, while Gerber and Balsdon show it takes around seven months. Although the US economy did not officially enter a recession until March, 2001, industrial production



Source: INEGI (2003)

Figure 3.
IMSS registered and maquiladora manufacturing employment

peaked in September 2000. Between then and December 2001, industrial production declined by 7.27 percent. If the historical relationship holds, it implies a decline in maquiladora employment of approximately 9.23 percent ($1.27 \times 7.27 = 9.23$). The growth rate of US industrial production turned positive at the start of 2002, but the seven month lag between a US downturn and adjustments in maquila employment implies that even if the US economy continued to grow, some of the maquila layoffs were "in the pipeline" and would have continued through June or July of 2002. In fact, employment began to recover sooner than that, and February 2002 turned out to be the trough.

In this paper we consider the impact of US cyclical factors – Mexican wages, relative to the USA, the Mexican US real exchange rate, and total US FDI on the employment growth over and above the US industrial production. Relative Mexican US wages are the ratio of Mexican to US manufacturing wages, and the real exchange rate is equal to the nominal rate adjusted by the ratio of consumer price index in both countries, normalized to 1994. All variables are in log and quarterly values. Data on the maquila employment and wages in Mexico are obtained from INEGI. The US industrial production data is obtained from the Bureau of Economic Analysis and the US wage rate is obtained from the Bureau of Labor. All the series except US FDI have unit root as shown by the augmented Dickey-Fuller (ADF) tests (Table I). A second round of ADF tests show that none of the variables have unit roots when measured as the first differences of their logarithms.

We test if the non-stationary series are co-integrated, or in other words we test for whether there exists a linear combination of the three non-stationary series that is stationary. The logic behind this analysis is that if there exist a long-run relationship between the maquila employment, US industrial production, real exchange rate, and the relative Mexican US wages, then if any shock causes a permanent change in the path of each series they are tied together and cannot diverge from this long-run relationship. The results from Johansen test of co-integration show that there exists at the most one co-integrating vector or the long-run equilibrium for our non-stationary cyclical factors and the maquila employment. Since the maquila employment and US industrial production, real exchange rate, and the relative Mexican wages are co-integrated, we use an error correction model (ECM) to estimate their relationship. The ECM allows estimation of the long-run relationship together with the short-run fluctuations or periods of disequilibrium from the long-run equilibrium (Granger, 1991; Engle and Granger, 1987).

The ECM is specified as follows:

$$\Delta E_t = c + \gamma t + \sum \beta_i(\Delta E_{t-i}) + \sum \theta_i(\Delta US_{t-i}) + \sum \delta_i(\Delta XR_{t-i}) + \sum \emptyset_i(\Delta W_{t-i}) + \gamma(E_{t-1} - \alpha_1 US_{t-1} - \alpha_2 XR_{t-1} W_{t-1}) + \rho FDI_t + \varepsilon_t$$

Variable	Levels	First differences
Maquila employment	−0.942	−3.646**
US industrial production	−2.081	−3.418**
Real exchange rate	−2.865	−3.797**
Relative Mexican wage	−2.781	−3.734**
US FDI	−4.780*	−9.2006*

Notes: The null is that unit root is present; *, **significance at the 1 and 5 percent levels, respectively

Table I.
Augmented Dickey-Fuller unit root test statistics

where E is the maquiladora employment, US is the US industrial production, XR is the real exchange rate, W is the relative hourly wage rate between Mexican and the US adjusted for the exchange rate, FDI is the US FDI to the world, t = 1980-2002, Δ is the difference operator, and ε is the random error term. The lagged term of the maquiladora employment accounts for the problem of autoregressive errors and the lagged terms of the US industrial production, real exchange rate, relative Mexican wages, and the US FDI accounts for the cyclical factors explaining the short-run fluctuation in the employment. The lag is included through the AIC and log likelihood ratio tests. The error correction term, $(E_{t>-1} - \alpha_1 US_{t-1} - \alpha_2 XR_{t-1} - \alpha_2 W_{t-})$, captures the long-run equilibrium effect and the coefficient on the EC terms, γ, captures the speed of convergence to the long-run equilibrium.

The results from the ECM are presented in Table II. The long-run equilibrium shows that a partial effect of a 3 percent increase in the US industrial production increases the employment in the maquila sector by 1 percent. Whereas a larger partial effect is required in the relative Mexican exchange and wage rate to have a similar effect on the maquila employment. A decrease of 65 percent in the relative Mexican exchange rate and a 33 percent decrease in relative Mexican US wages increase employment by 1 percent.

The short-run fluctuations and movement towards the long-run equilibrium is calculated as the adjustment coefficient 0.001 times the first-difference lag terms. A one percentage point increase in the US industrial production in one-quarter increase the employment growth by 0.1 percentage in the next quarter; if exchange rate falls by one percentage point in quarter t then employment goes up by 0.03 percentage points in the quarter $t + 1$ and by 0.02 percentage point in $t + 2$. A similar short-run effect is estimated for maquila employment for relative Mexican wages. In Truett and Truett (1993), they find that the Mexico-US relative wage has a positive impact on maquila output, which is explained by the fact that the hourly wages in Mexico are very low compared to the US wage rate; hence, even if Mexican wages rise relative to the USA, maquila output goes

Co-integrating equation	Model 2 n	Standard error
E_{t-1}	1.0000	
US_{t-1}	3.298***	4.648
XR	−65.978***	22.594
W_{t-1}	−33.772***	17.038
C	6.893	
Error correction: co-integrating equation	−0.001***	0.0005
ΔE_{t-1}	0.453***	0.121
ΔE_{t-2}	−0.168*	0.104
ΔUS_{t-1}	0.625***	0.250
ΔUS_{t-2}	0.169	0.227
ΔXR_{t-1}	−0.264***	0.051
ΔXR_{t-2}	−0.159***	0.060
ΔW_{t-1}	−0.236***	0.046
ΔE_{t-2}	−0.109**	0.051
ΔFDI_t	−0.003	0.003
Constant	0.013***	0.003
$\overline{R}^2$	0.627	

Table II.
ECM for maquiladora employment

Notes: *Significant at 10 percent level; **significant at 5 percent level; ***significant at 1 percent level

up[2]. In our model, we have a stronger result showing that if the growth rate of the relative Mexican-US wage increase, the growth in maquila employment falls.

The one period lag in US FDI remains insignificant, and although the coefficient is positive, it is very small. It may be that the impact of FDI is mainly cyclical and that controlling for US industrial production explains most of the cyclical effects. Nevertheless, given the world and US downturn discussed in the first section of the paper, it is probably worth investigating this further. A more accurate relationship may be obtained by examining US FDI into Mexico.

From the vector error correction model of maquila employment, we find that in addition to the effect of the US industrial production there exist a significant short- and a long-run effect of exchange rate and Mexican wages relative to the USA on maquila employment growth.

V. Structural factor: some statistical artifacts?

In addition to the cyclical factors discussed above there are structural factors that may have an important effect on the maquila employment. Several structural factors have at least anecdotal evidence to support them, as discussed in the introduction. For example, most observers are familiar with specific cases of firms moving to China. While the issue of Chinese competition is treated below, in this section we consider the possibility that some of what might seem like structural change is actually statistical artifact.

In its 1999 report on production sharing, the United States International Trade Commission states:

> Imports that incorporate US-made components can enter the United States either free of duty or at reduced duties under the production-sharing provisions (9802.00.60-.90) of Chapter 98 of the Harmonized Tariff Schedule [HTS]. However, a significant and growing proportion of imports from production-sharing operations do not enter under those Chapter 98 provisions because the goods are already eligible for duty-free treatment under other agreements or tariff-preference programs (United States International Trade Commission (USITC), 1999, p. i).

According to the USITC, these goods accounted for 8.2 percent of US imports ($74.1 billion) in 1998. Value of the US components was about $25.2 billion, or 34 percent of the value of the imports. Later in the same report, the USITC states:

> Firms that import articles free of duty [. . .] under trade preference programs such as the North American Free Trade Agreement [NAFTA] [. . .] have a greatly reduced incentive to enter those articles under the production-sharing provisions (USITC, 1999).

In an update, the same point is made by Watkins (2001):

> When articles are eligible for duty free entry under other provisions, there is little incentive to complete the documents required to declare eligibility for reduced duties under production sharing provisions.

And:

> Official US statistics, however, are increasingly unable to quantify the magnitude and scope of production sharing activity because a significant and growing portion of imports from production-sharing operations does not enter under heading 9802 provisions because the goods are eligible for duty-free treatment under other agreements or tariff preference programs. Examples are goods entering duty-free from Mexico or Canada under NAFTA.[. . .] (p. 28).

All of the above quotes describe the situation on the US side of the USA-Mexico maquiladora relationship. Nevertheless, it seems likely that some share of firms that might

have used maquiladora legal status in the past in order to reduce their tax obligations currently find that it is unnecessary under the provisions of North American Free Trade Agreement (NAFTA). For several years, tariff reductions under NAFTA were phased in, and not until January 2001, did Article 303 eliminate the duty drawback on non-NAFTA imports. The government of Mexico was slow to define an alternative regime for imports incorporated into exported products, which meant that the government created a great deal of uncertainty and hesitancy to go forward with investment. Ultimately, the federal government announced its new export promotion regime which it called Programa Sectoral, or PROSEC. Ultimately PROSEC may be very useful, but most early indications were that it would raise compliance costs since manufacturers must more closely track the imports they incorporate into their products and they must pay duties not based on the import but dependent on the final destination of the product that uses it.

In other words, while the quotes from US sources indicate that many firms are not using production-sharing arrangements in the US tariff code, changes on the Mexican side indicate that there are increased costs to using those provisions. Furthermore, the implementation of NAFTA tariff provisions has eliminated import taxes on most manufactured goods entering Mexico from the USA. Taken together, this implies that there are reduced incentives for seeking a maquiladora designation since it may raise costs and confer no advantages. In that case, some of the decline in the industry as well as employment is simply a statistical artifact.

For example, assume that maquila growth depends on US manufacturing growth (Figure 4): $g_M = f(g_{US})$. Firms leave the industry at rate d, the rate of attrition. As long as US manufacturing growth is above rate g_{US1}, there is positive growth in the industry since f_1 implies that $g_M > d$. After the implementation of various NAFTA-related tariff provisions, assembly firms in Mexico no longer find it necessary to register as maquilas since they can obtain duty-free entry of their inputs from the USA and duty-free entry of outputs to the USA.

As a consequence, the growth rate of the maquiladora industry is less sensitive to the growth rate of US manufacturing, and f_1 shifts to become f_2. Under these conditions, a given growth rate in the USA (g_{US}) will produce less growth in the maquiladora industry and the threshold rate of US growth required for positive maquiladora industry growth rises from g_{US1} to g_{US2}.

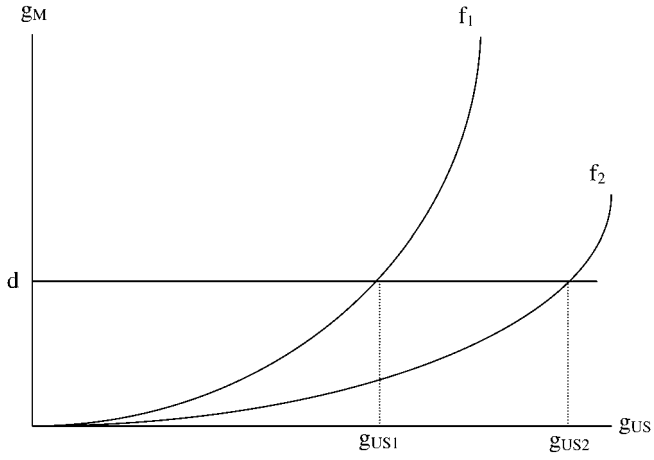


Figure 4.
Sensitivity to US industrial production

VI. Structural factors: China and other low cost producers

According to Luis Ernesto Derbez, Mexico's Minister of the Economy, increased labor costs are not harmful, since they shift the development model away from a reliance on cheap labor and force producers to adopt more technology in order to increase productivity (*Businessweek*, April 29, 2002). After all, what is the point of economic development if it does not result in an increase in wages?

Examining the aggregate maquila employment, Mollick and Vazquez (2006) do not find strong support for Chinese competition on the Mexican maquiladoras over and above the effect of the US industrial production. However, all maquila sectors have shared the same experiences over the last few years. For example, the United States General Accounting Office has noted that there are growing signs of textile and apparel displacement from Mexico to China, but that there is no evidence of displacement in the machinery sector from Mexico to China. In still other cases, for example household appliances, increased imports from China are matched by increases in imports from Mexico. In still other cases such as wiring harnesses for automobiles, Mexican exports fell due to a decline in US auto manufacturing[3].

According to INEGI (2003) the textile and apparel maquilas lost almost 100,000 from their peak. The number of workers peaked in July 2000, at 294,855, but it did not begin a significant decline until the first half of 2001. By August 2003, it stood at 205,180, for a cumulative loss of 89,675. From the peak in July 2000, to August 2003, the cumulative loss of jobs in textiles and apparel is 89,675, or about 30 percent of the total maquila job loss (0.2995). Transportation equipment, on the other hand lost 16,919 jobs, or 6.8 percent of the total. Machinery and equipment account for a similarly small proportion, while electrical and electronic materials and accessories are responsible for 134,171 jobs lost, or 37.3 percent of the total. In other words, job losses in apparel and electronics are equal to 223,846, or 75 percent (74.8) of total job loss.

In both cases, but particularly apparel, China is blamed (or credited) for the job losses. While there is some truth in this, it is also the case that some of the job loss relates to changes in US commercial policy towards the Caribbean and Central America. In particular, the USA-Caribbean Basin Trade Partnership Act (CBTPA), implemented on October 1, 2000, significantly altered market access to the USA for textiles and apparel producers located in the Caribbean and Central America. The CBTPA addressed the problem of competitive disadvantage for the textile and apparel industry that resulted from the implementation of NAFTA by enhancing the Caribbean Basin Economic Recovery Act (CBERA). The former applied to Caribbean and Central American countries and has been operational since 1984, but apparel was excluded until passage of the CBTPA, which created parity between the Caribbean and Central America relative to Mexico in their access to the US market.

Table III shows the top five US imports from four Central American countries, along with growth in the top 2 since the implementation of the CBTPA. For comparison purposes, the top two Chinese and Mexican apparel exports to the USA are included. Table III shows that apparel exports from El Salvador and Guatemala to the USA have outpaced those from China. In addition, the absolute value of the top two apparel exports from four small Central American countries are nearly 80 percent of the value of the top two Chinese apparel exports to the USA. In other words, in a low wage labor-intensive industry such as apparel, Central America is as competitive as China.

According to the GAO (2003), China has specific cost advantages over Mexico, including the cost of labor, electricity, and water. In addition, the GAO cites evidence that the supplier base is deeper and corporate income taxes are lower. On the other

Country and articles		2000	2002	Top 2 2002	Top 2 2000	Growth 2000-2002
SITC	*El Salvador: Top 5 (All 5 are apparel items)*					
845	Articles of apparel of textile fabrics	667	729	980	894	0.0962
844	Women's or girls' coats, capes, knit	227	251			
843	Men's or boys' coats jackets, knitted	231	226			
841	Men's or boy's coats jackets, etc., not knit	180	195			
842	Women, girls coats, not knit	204	154			
SITC	*Guatemala: Top 5 (4 are apparel)*					
845	Articles of apparel of textile fabrics	508	664	1,055	977	0.0798
842	Women, girls coats, not knit	469	391			
057	Fruit and nuts, fresh or dried	249	335			
841	Men's or boy's coats jackets, etc. not knit	266	270			
844	Women's or girls' coats, capes, knit	157	221			
SITC	*Honduras: Top 5 (4 are apparel)*					
845	Articles of apparel of textile fabrics	1,401	1,555	1,850	1,774	0.0428
841	Men's or boy's coats, jackets etc, not knit	373	295			
843	Men's or boys' coats, jackets, knitted	309	280			
844	Women's or girls' coats, capes, knit	194	227			
057	Fruit and nuts, fresh or dried	108	153			
SITC	*Nicaragua: Top 5 (3 are apparel)*					
841	Men's or boy's coats, jackets etc, not knit	166	186	318	256	0.2422
845	Articles of apparel of textile fabrics	90	132			
842	Women, girls coats, not knit	67	79			
036	Crustacean	99	74			
011	Meat of bovine animals	21	33			
Four Central American countries, top two items from each				3,885	3,645	0.0658
SITC	*China: Top apparel are ranked 15 and 16 in exports to USA*					
842	Women, girls coats, not knit	2,335	2,469	4,936	4,616	0.0693
848	Apparel and accessories except textile; headgear	2,281	2,467			
SITC	*Mexico: Top apparel are ranked 13 and 15 in exports to USA*					
845	Articles of apparel of textile fabrics	2,875	2,626	4,775	5,224	−0.0859
841	Men's or boy's coats, jackets, etc. not knit	2,349	2,149			

Source: United States International Trade Administration (2003)

Table III.
Exports to the USA, three-digit SITC top categories and top apparel categories (millions of $US)

hand, Chinese disadvantages include higher transportation and communication costs, longer transit times, a relative lack of intellectual property protection, problems with its regulatory and administrative transparency, and less access third party markets due to the scarcity of free-trade agreements. Watkins (2002) cites similar lists of advantages and disadvantages, but includes the opportunity for technology transfer and the flexibility of Mexico's manufacturing industries and its management.

Gerber and Carrillo (2003) use survey data (COLEF, 2002) to assess the industrial upgrading and technological learning of the maquiladora. Their assumption is that firms on the frontier of industry production and management techniques will survive competitive challenges more handily than firms that are inside the frontier. There is a growing empirical literature in support of this proposition, some of which is

summarized in Lewis and Richardson (2001). Using a set of criteria found in Moran (2001), Gerber and Carrillo estimate that about 40 percent of the electronics plants in the three important cities of Tijuana, Mexicali, and Ciudad Juarez are so-called first-generation plants that compete primarily on the basis of price. These plants may have competitive advantages related to location or they may be part of an industrial cluster with its own industrial labor force and service suppliers, but they are likely to be influenced by labor costs abroad or rising costs at home in Mexico.

VII. Sectoral econometric model: competition from China

In order to empirically investigate the structural differences of lower costs in Mexico vs China across three sectors: apparel and textile (often called textile), electronic, and transportation, we estimate a model using SUR (Greene, 2003; Zellner, 1962; and Berndt, 1991). The data on the sectoral employment and the number of firms are obtained from INEGI. The model is specified as below:

$$\begin{aligned}
\Delta AE_t &= c_C + \beta_1 t + \beta_2 \Delta AE_{t-1} + \beta_3 \Delta US_{t-1} + \beta_4 \Delta FDI_t + \beta_5 (\Delta XR_{MXCH})_{t-1} \\
&\quad + \beta_6 (\Delta W_{MXUS})_{t-1} + \beta_7 \Delta E_{t-1} + \beta_8 \Delta AF + u_{Ct} \\
\Delta EE_t &= c_E + \alpha_1 t + \alpha_2 \Delta EE_{t-1} + \alpha_3 \Delta US_{t-1} + \alpha_4 \Delta FDI_t + \alpha_5 (\Delta XR_{MXCH})_{t-1} \\
&\quad + \alpha_6 (\Delta W_{MXUS})_{t-1} + \alpha_7 \Delta E_{t-1} + \alpha_8 \Delta EF_t + u_{Et} \\
\Delta TE_t &= c_T + \delta_1 t + \delta_2 \Delta TE_{t-1} + \delta_3 \Delta US_{t-1} + \delta_4 \Delta FDI_t + \delta_5 (\Delta XR_{MXCH})_{t-1} \\
&\quad + \delta_6 (\Delta W_{MXUS})_{t-1} + \delta_7 \Delta E_{t-1} + \delta_8 \Delta TF_t + u_{Tt}
\end{aligned}$$

where AE is the employment in apparel and textiles, XR_{MXCH} is the exchange rate defined as peso per yuan[4], AF is the number for firms in the apparel and textile sector, EE is the employment in the electronics sector, EF is the number of firms in the electronics sector, TE is the employment in the transportation sector, TF is the number of firms in the transportation sector, t is the time trend, and the period for the study is 1980-2002.

We use SUR to estimate the above model under the assumption that employment in the three main sectors in maquiladora is correlated. This allows us to share information across sectors about those factors that affect the overall state of manufacturing while separating out the individual effects on each of these three main sectors. The error structure for the system is given by $u = [u'_{At}, u'_{Et}, u'_{Tt}]$ where $E(u_t) = 0$ and the covariance is given by $E(u_t u'_t) = V$. In the above SUR specification, the errors are allowed to be heteroskedastic and contemporaneously correlated; thus, the covariance matrix of the above system is given by

$$V = \begin{bmatrix} \sigma_A I_T & \sigma_{AE} I_T & \sigma_{AT} I_T \\ \sigma_{EA} I_T & \sigma_E I_T & \sigma_{ET} I_T \\ \sigma_{TA} I_T & \sigma_{TE} I_T & \sigma_T I_T \end{bmatrix}$$

In the covariance structure above there is heteroskedasticity since $\sigma_A \neq \sigma_E \neq \sigma_T$. The contemporaneous correlation between employment in the apparel and electronics is given by σ_{AE}, for all t. Similarly, contemporaneous correlation between apparel and transportation is given by σ_{AT}, and the contemporaneous correlation between electronics and transportation is given by σ_{ET}; hence, the model is seemingly unrelated. All series are checked for non-stationarity, while the estimated growth rate model is a drift with trend. Given the error structure specified above, we do a

generalized least squares estimation of the model in Equation (3), and the results are reported in Table IV.

From Table IV we see that the exchange rate between peso and yuan effects the employment in the textile and electronics sector inversely; thus, the cheaper the relative cost of production in China, the more production (employment in the sector) increases in the maquila industry. We find that the exchange rate is significant at the 1 percent level in the apparel sector and at the 10 percent level in the electronics sector. It is statistically insignificant in the transportation sector. These results are highly consistent with the observed changes in these three key sectors. Apparel and electronics suffered the biggest decline in employment, while transportation equipment manufacturing saw almost no decline. This supports our hypothesis that structural factor such as competition from China will have a bigger effect in relatively labor-intensive good and commodity which is also cheaper to transport to the USA from China. Transportation goods are bulky and hence have a location advantage in Mexico over China.

Moreover, we find that growth in US industrial production does not affect employment in apparel and textiles or electronics, but is significant in the transportation equipment sector. This finding from our econometric model shows that after controlling for Chinese cheaper labor cost advantage, the transportation sector is more sensitive to the cyclical downturn in US production than the textile sector.

An increase in the number of firms in all the three sectors significantly increases the growth in the employment. Growth rate of the US FDI to the world is not significant for any sector. It also seems that the growth in the employment in the textile is more sensitive to changes to the total employment in the maquila sector as compared to transportation. This shows that the textile sector might require less skilled workers, but once workers are in the transportation sector, they get more specialized. It is then difficult for them to move within the maquila sectors.

VIII. Conclusion

Explanations for the changing fortunes of an industry are never likely to depend on a single factor unless it is a simple commodity producing industry such as copper or

	Apparel		Electronics		Transportation	
	n	Standard error	*n*	Standard error	*n*	Standard error
ΔAE_{t-1}	−0.0136	0.1022				
ΔEE_{t-1}			0.4008***	0.0987		
ΔTE_{t-1}					0.1363	0.1161
ΔIP_{t-1}	−0.0506	0.3901	−0.3962	0.3980	−1.0880*	0.6037
ΔFDI_t	0.0089	0.0052	0.0027	0.0054	0.0018	0.0075
$(\Delta XR_{MXCH})_{t-1}$	−0.0044***	0.0009	−0.0018*	0.0009	0.0018	0.0013
ΔW_{t-1}	−0.0482	0.0480	−0.0185	0.0495	−0.1536	0.0683
ΔE_{t-1}	−0.4791**	0.1728	−0.3999*	0.1787	0.2973	0.2524
ΔAF_t	0.0008***	0.0001				
ΔEF_t			0.0011**	0.0004		
ΔTF_t					0.0032**	0.0013
Trend	−0.0008**	0.0003	−0.0006*	0.0003	−0.0009*	0.0004
Intercept	0.0873***	0.0166	0.0504***	0.0172	0.0607*	0.0272

Table IV.
Maquiladora three sector SUR employment estimation

Notes: *Significant at 10 percent level; **significant at 5 percent level; ***significant at 1 percent level

cotton. The maquiladora industry in particular is far more complex than a single Standard Industrial Classification or North American Industry Classification industry since it spans the entire range of industrial production and even takes in a small number of service providers. In effect, it is a cross-section of Mexican manufacturing. Consequently, it is misleading to try to analyze its circumstances as if it only produced one type of product.

The econometric evidence, a number of different descriptive statistics, and the narrative of institutional change within the industry paint a picture of multiple causes for the employment decline. Perhaps the greatest single factor, or at least the most quantifiable factor, is the cyclical downturn in the US economy. This paper and others have shown that US industrial production has a strong and consistent impact on Mexico's maquiladora industry.

Other factors are at work as well, however, and it would be incorrect to assume that all of the changes in employment are related to the depression in US manufacturing. If only US manufacturing mattered, then we could expect a return to double-digit employment growth once the US manufacturing sector recovers, but that seems highly unlikely. Other factors beyond the US business cycle are at work, including China's entrance into the WTO and the institutional security it offers foreign investors. In addition to the US industrial production in this paper we show that the relative Mexican US wage rate, exchange rate, and competition from China have a significant effect on the employment growth in the maquila industry.

A sectoral econometric model across textiles, electronics, and transportation sector shows that relatively labor-intensive and relatively cheaper transportable goods such as textiles and apparel are adversely affected by competition from China. We also find that after controlling or the Chinese competition the transportation sector is more sensitive than the electronics and the textile sector to the US industrial production.

Notes

1. "Maquiladora is a Mexican Corporation which operates under a maquila program approved for it by the Mexican Secretariat of Commerce and Industrial Development [SECOFI]. Ordinarily, all of a maquiladora's products are exported, either directly, or indirectly, through sale to another maquiladora or exporter. The type of production may be the simple assembly of temporarily imported parts; the manufacture from start to finish of a product using materials from various countries, including Mexico; or any conceivable combination of the various phases involved in manufacturing, or even non-industrial operations, such as data-processing, packaging, and sorting coupons" (Aureliano Gonzalez Baz (available at: www.bancomext-mtl.com/invest/vox128.htm)).
2. Truett and Truett (1993) raise a concern: whether the increasing maquila output is putting an upward pressure on Mexican wages, something they did not empirically explore in their model.
3. Gruben (1990) finds that Asia and Mexico were substitutable in production in aggregate. Truett and Truett (1993) find that Singaporean and Mexican production are substitutable for most of the goods produced on the border, and less so for goods coming from the interior of Mexico.
4. In order to compare the relative wages between Mexico and China for the time period under study we use the relative exchange rate between peso and yuan. We do this partly out of necessity since quarterly data for Chinese wages are unavailable, but in addition, we argue that short to medium run shifts in exchange rates will convey most of the relevant information about changes in relative labor costs. Data on the yuan to dollar are obtained from the Department of Planning and Finance, Ministry of Labor and Social Security, China.

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