Maquiladora Downturn: Structural Change Or Cyclical Factors?

Jesus Cañas, (E-mail: jesus.canas@dal.frb.org), Federal Reserve Bank of Dallas
Roberto Coronado, (E-mail: roberto.coronado@dal.frb.org), Federal Reserve Bank of Dallas
Robert W. Gilmer, (E-mail: bill.gilmer@dal.frb.org), Federal Reserve Bank of Dallas

Abstract

Mexico's maquiladora industry is currently the focus of much attention in the media, in corporate boardrooms, and among Mexican government officials. After watching the maquiladora industry sustain its biggest ever employment decline in recent years, many observers now question the industry's future in Mexico. The 2001 U.S. economic recession took a heavy toll on Mexico's maquiladora industry, although the size of the industry's contraction during the recent recession—almost 260,000 jobs—suggests there are more factors at work than the mild business cycle. The advantages of operating plants in Mexico, such as low wages and tax incentives, are now offered by a number of developing countries. At the same time, location has become less important for many products, as innovations in transportation and technology lower shipping costs. This paper attempts to estimate how much of the current maquiladora downturn is due to the business cycle and how much is due to structural changes. We use the Branson-Love methodology to estimate structural and cyclical impacts on the maquiladora employment downturn. Results suggest that the 2001 U.S. recession and rising real wages in Mexico account for much of the maquiladora downturn. Historically, these are the two most important factors during maquiladora growth, but new factors such as China's membership in the World Trade Organization, the Caribbean initiative and implementation of NAFTA Article 303 have changed corporate options for plant location or affected the cost structure in Mexico. Although our statistical results strongly suggest a recovery in maquiladora employment, potentially important qualifications are discussed as well.

1. Introduction

Mexico's maquiladora industry is currently the focus of much attention in the media, in corporate boardrooms, and among Mexican government officials. After watching the maquiladora industry sustain its biggest ever employment decline in recent years, many observers now question the industry's future in Mexico.

The 2001 U.S. economic recession took a heavy toll on Mexico's maquiladora industry, with about 260,000 jobs lost since its peak in October 2000. The size of the industry's contraction during the recent recession suggests more factors are at work than the mild business cycle. The advantages of operating plants in Mexico, such as low wages and tax incentives, are now offered by a number of developing countries. Attention has particularly focused on the low-wage competition Mexico is facing from China. At the same time, location has become less important for many products as innovations in transportation and technology constantly lower shipping costs.

Over the past three decades, the maquiladora industry has played a key role in the economic development in Mexico, especially on the northern border. In 2003, there were 2,860 operating plants employing 1.06 million people in Mexico. Further, maquiladora industry employment accounts for about 9 percent of total formal employment in Mexico, equivalent to 3 percent of the country's total labor force. Maquiladora exports represent almost half of Mexico's total exports, and the industry generated more than $18 billion in foreign exchange in 2003, making it Mexico's top source of foreign exchange.

Given the importance of the industry to the Mexican economy, and the large downturn it has experienced in recent years, the following questions arise: How much of the current maquiladora business downturn is due to the business cycle? And how much is due to structural change? This paper attempts to answer these questions. We use the Branson-Love methodology to estimate structural and cyclical impacts on the maquiladora employment downturn. Our results suggest that the recent U.S. recession and rising real wages in Mexico account for most of the maquiladora downturn, while the role of structural factors is small but still statistically significant. This suggests that the maquiladora industry will follow the recent recovery in U.S.. industrial production.

An overview of the literature on Branson-Love methodologies and maquiladora-related research is presented in section 2. Section 3 includes a summary of the data and methodology employed. Section 4 presents the empirical results obtained. Concluding remarks and suggestions for future research are presented in the final section.

2. Related Studies

2.1 Maquiladora Industry Literature

The Border Industrialization Program—enacted in 1965 by the Mexican government after the United States ended the Bracero Program—gave birth to the maquiladora Industry. The main objective of this program was to reduce high unemployment rates and stop growing poverty in communities along the U.S.-Mexico border. According to Ayer and Layton (1974) a number of factors attracted the operating plants of U.S. corporations into the border area. Duty-free import of plant machinery and raw materials, plus low transportation costs due to the proximity of the U.S., played a role. But the most important single factor in the location of these plants was inexpensive labor

In general terms, Mexico's maquiladora program allowed plants to temporarily import supplies, machinery and equipment necessary to produce goods and services duty-free as long as the output was exported back to the United States (Cañas and Coronado, 2002). The U.S. government taxed only the value-added portion of the manufactured product. Maquiladoras can operate under various frameworks such as: subcontracting operations, shelter operations, and wholly-owned subsidiaries (Coronado, 2003). Choice of a particular mode depends upon a number of factors, including the degree of control and ownership of the operation desired by the principal, the risk that the enterprise is willing to assume, and the size of the operation. For example, if a parent company wants to have limited responsibility and control over the production process in Mexico, the best alternative is through a Mexican subcontractor. If the parent company chooses to assume more responsibility over the production process, but with limited control over the administrative portion of the operation, a shelter might be the best option. Wholly-owned subsidiaries, know as twin-plants, are chosen by the parent when it wants full control over the manufacturing processes as well as for the inventory, machinery, equipment, and the facility as a whole.

The maquiladora industry has captured the attention of academic researchers since its inception in the mid-1960s and early 1970s. Several research projects over the last three decades have examined various topics, including but not limited to the following: (1) employment turnover and job training; (2) cross-border job gains; (3) retail sales and cross-border commuter flows; (4) NAFTA and maquiladora employment fluctuations; (5) corporate profitability; (6) sectoral and geographical growth determinants; and (7) maquiladora industry growth and employment dynamics. We will briefly discuss some of these in the following paragraphs.

With respect to employment turnover, English, Williams and Ibarreche (1989) analyzed maquiladora employment turnover in Ciudad Juarez. They concluded that if the management systems used by maquiladoras better reflected the cultural characteristics of Mexico, this might result in lower turnover rates. Lucker (1987) argued that maquiladoras in the mid-1980s were not fully aware of the costs of turnover. His research results indicate that employee turnover costs in the electronics and automotive sectors exceed $17 million per year. Finally, research by Verdugo-Vidales (1990) on maquiladoras in Baja California, concluded that the high prices of housing close to the industrial parks forced workers to live far from their workplace. Given the obsolete transportation systems in place, the maquiladora industry experienced high turnover rates because of lengthy commutes.

Patrick (1989 & 1990) analyzed the cross-border job impacts along the south Texas border. Results indicated that maquiladoras typically demand services (such as legal, customs, engineering and financial services, etc) and purchased a broad range of supplies and materials (such as office and industrial supplies, packaging materials, etc.), stimulating employment on the U.S. side of the border. Silvers and Pavlakovich (1994) assessed the relative magnitude of employment gains and losses across U.S. border regions due to maquiladora industry activity. Results suggest that U.S. border states—with the exception of Arizona—gained jobs as a result of growth in the maquiladora industry. Hanson (2001) further analyzed the cross-border impacts of maquiladora activity along the U.S.-Mexico border-city pairs. His research indicates that the growth of export manufacturing in Mexico can account for a substantial portion of recent employment growth in U.S. border cities.

With respect to border retail sales, Ayer and Layton (1974) estimate maquiladora impacts on employment, value added, and population in the U.S. border region that only result from the consumption expenditures of Mexican maquiladora employees. Using an input-output model for the Arizona-Mexico border economy, they conclude that the expenditures of Mexicans due to growing presence of twin plants increased employment 14 percent and population by 11 percent on the U.S. side of the border. Cobb, Molina and Sokulsky (1989) analyze the impact of the maquiladora industry on commuter flows in the Texas-Mexico border. Their results indicate that increasing levels of maquiladora employment are found to reduce the number of crossing permits issued. Overall, the most consistent factor accounting for changes in commuting activity is the difference in income between adjacent cities.

Gruben and Kiser (2001) attempt to resolve a long-standing controversy as to whether NAFTA has fostered maquiladora growth. Results suggest that three factors account for the majority of maquiladora employment fluctuations: (a) U.S. industrial production; (b) Mexican-to-U.S. manufacturing wage ratios; and (c) Mexican-to-Asian manufacturing wage ratios. Further, these results indicate that factors were equally relevant both before and after NAFTA.

Corporate profitability has also been analyzed with respect to maquiladora operations. Davila (1990) estimates the effect on maquiladoras profitability of the 1982 peso devaluation by using stock-price returns data. Results suggest that the returns of firms with maquiladora investments increased significantly after the 1982 peso devaluation because of reduced costs, which in turn triggered high levels of new investment.

With respect to different sectors within the maquiladora industry, George and Hoffman (1990) assess differences in growth across sectors of the maquiladora industry. Among the factors that were found to promote growth are a declining cost of labor, labor availability, peso depreciation, and continuing pressure on American firms from foreign imports. Factors that tend to impede the rate of growth include high inflation rates in Mexico, rapid deterioration of physical infrastructure systems, and high labor turnover rates.

Brannon and James (1994) conclude that the size of the interior market, wages and labor market conditions, relative infrastructure supply, and ease of international travel can foster a shift in new maquiladora investment to the interior of Mexico. On the other hand, Weiler and Zerlentes (2003) analyzed the future of the northern border maquiladoras in terms of their competition with low labor-cost regions in the interior of Mexico. Results indicate that intensive border-zone production is likely to continue over the long-term due to proximity to both the U.S. market and supply networks attributable to pioneering border firms.

The seminal work on determining maquiladora employment dynamics was conducted by Fullerton and Schauer (2001). They analyzed short-run maquiladora employment dynamics for Ciudad Juarez, the city with the greatest number of maquiladora jobs in Mexico. Results indicate that inflation-adjusted wage rates, factories in operation, U.S. industrial performance, and the international value of the peso play important roles in determining month-to-month fluctuations in borderplex maquiladora payrolls.

Coronado, Fullerton and Clark (2004) extend the Fullerton and Schauer traditional transfer autoregressive-integrated-moving-average (ARIMA) framework by utilizing a more sophisticated methodology for Tijuana maquiladora employment dynamics, the linear transfer function (LTF). The main difference between the traditional

transfer ARIMA and the LTF methodologies arises in the identification procedure. Because it first examines potential correlations between input series and dependent variable, the LTF procedure can handle multiple regressors with relative ease. Similar results to Fullerton and Schauer were found in the Tijuana maquiladora market. However, LTF is proven to be more accurate as a forecasting tool than traditional transfer ARIMA.

2.2 Branson and Love Literature

The 1980s presented a period of challenges to U.S. manufacturing that have striking parallels to those seen today: recession, a strong dollar, strong foreign competition, and wide swings in energy prices (Gilmer and Pulsipher, 1986). In the late 1980's, Branson and Love carried out a series of research projects analyzing the impact of structural changes and cyclical factors on U.S. manufacturing activity. They examined the impact of the 1980's dollar appreciation on manufacturing employment and output (Branson and Love, 1986). A simple model of supply and demand was used to estimate the elasticity of employment or output with respect to movement of the real exchange rate. Empirical results suggest that the dollar appreciation substantially reduced employment and output in U.S. manufacturing. In particular, Branson and Love found that real exchange rate movements had important effects on employment fluctuations, especially in the durable goods sectors. Further, Branson and Love (1987) disaggregated their original model geographically by states and regional results, with similar results found in the different regions analyzed.

Later, Branson and Love (1988) extended their earlier research by introducing Japanese competition into the analysis. In the mid-1980s it was widely believed that the United States was losing competitiveness as the U.S. dollar continued to appreciate in real terms while the Japanese yen depreciated. This created a controversy over the extent to which the Japanese were using the weak yen as a competitive weapon. Branson and Love used a model to estimate the impact of swings in the effective real exchange rate of the dollar and the yen on manufacturing employment and output in the United States and Japan. They found significant and substantial effect of the dollar appreciation on employment and output in U.S. manufacturing, particularly in the durable goods sectors. For Japan, they similarly found significant effects of movements in the yen on employment and output in the durable goods sector.

3. Data and Methodology

3.1 U.S. Manufacturing Data and Model

In this paper, we use the theoretical framework developed by Branson and Love (1986 and 1987). Following the lead of Branson and Love, the dependent variable is manufacturing employment and employment by industry group. We assumed that employment was explained by: the U.S. business cycle, represented by the unemployment rate; the real exchange rate; the price of energy, represented alternatively by the CPI for energy or the price of West Texas Intermediate; and by a trend value. Also included in the regressions was a test for structural change, a single break in the data in 1994:1. The 1994:1 period was chosen because of the implementation of NAFTA, the Mexican peso crisis that followed soon after, and because it roughly marks the point at which U.S. productivity resumed its higher, pre-1973 trend that puts downward pressure on jobs.

The form of the estimating equation for each sector (Table 1) is as follows:

$$y_t = \alpha + \Delta\alpha + \beta_0 t + \beta_1 \Delta t + \sum_{j=0}^{4} \beta_{2j} UR_{t-j} + \sum_{k=0}^{6} \beta_{3k} REX_{t-k} + \sum_{j=0}^{4} \beta_{4j} ENERGY_{t-j} + e_t$$

where,

y_t = the log of employment,
α = intercept term,
$\Delta\alpha$ = the dummy variable to capture change in the intercept term,
T = the trend variable time,

Δt = the dummy variable to capture change in the trend variable time,
UR = the log of the unemployment rate,
REX = the log the real exchange rate,
ENERGY = the log of the relative price of energy,
e_t = the stochastic error term, and the
β's = are the parameters to be estimated.

The data used to estimate this equation are quarterly. The equations are estimated over a period that begins in first quarter of 1980 and ends in fourth quarter of 2002. We used employment data under Standard Industrial Classification (SIC) definitions so that it would allow us to go back to 1980 and we stopped in 2002 due to the change to the North American Industrial Classification System (NAICS). All U.S. manufacturing employment data were divided into a series of SIC codes that have a heavy representation of maquiladora operations in Mexico, plus the rest of manufacturing (see Table 1).

Table 1 SIC industry groups utilized

Sector Name	SIC Code
Food products	SIC 20
Apparel products	SIC 23
Furniture and fixtures	SIC 25
Chemicals and allied products	SIC 28
Leather and leather products	SIC 31
Industrial and commercial machinery	SIC 35
Electronic and electrical components	SIC 36
Transportation Equipment	SIC 37
Toys and sporting goods	SIC 394

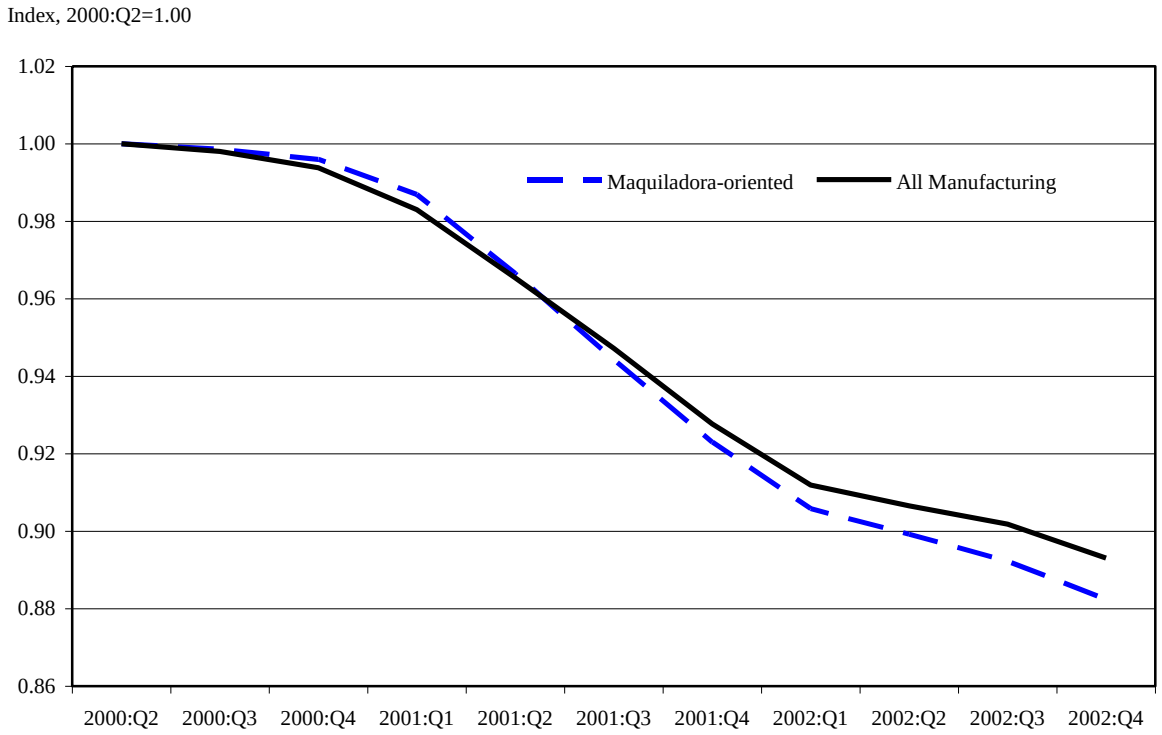
The maquila-oriented industries together make up 52 to 54 percent of U.S. manufacturing since 1980. The peak was at 55 percent in 1983Q1, then fell under 54 percent in 1988Q4, and under 53 percent in 1999Q4. Maquila-oriented industry employment was hurt the most in the recent U.S. recession, but not by much – an 11.8 percent decline from peak (2000:2) to trough (2002:4). Chart 1 shows the similar decline experienced by both maquiladora-oriented employment and total manufacturing employment

The source of the employment data is the Bureau of Labor Statistics (BLS) Employment and Earnings. The dependent variable is the natural logarithm of the number of employed workers. The estimates are for all workers in the manufacturing sector. The exchange rate used here is the Federal Reserve price-adjusted broad dollar index (weighted average of the foreign exchange values of the U.S. dollar against the currencies of a large group of major U.S. trading partners), where an increase in the index is an appreciation of the dollar. Real energy is the CPI-urban index for energy divided by the CPI-urban index for all consumer goods. Alternately, we used the real price of the West Texas Intermediate crude oil. The unemployment rate is for all workers and published by the BLS. The exchange rate variable REX includes the current observation plus six quarters of lagged observations. The real price of energy ENERGY and the unemployment rate UR variables both include the current value plus four quarters of lags.

Since the model is in log linear form, the estimated coefficients have simple economic interpretations. For instance, the coefficient of the trend variable *t* is the estimated exponential rate of growth or decline in employment that occurs due to secular changes in income, tastes, comparative advantage, or technology. The coefficients for the real exchange rate, the real price of energy, and the unemployment rate variables can be interpreted as elasticities.

A possible shift in the intercept, shift in the trend, or a change in the coefficient on the foreign exchange variable represents a structural change. A shift downward in the trend, for example, could indicate downward pressure after 1994 due to productivity gains or improved opportunities abroad. An increase or decrease in the coefficient on the real exchange rate would indicate more or less sensitivity to currency swings.

Chart 1 All U.S. Manufacturing Employment vs. Maquiladora-oriented



3.1 Maquiladora Data and Model

Similar to the U.S. model described above, we applied the Branson-Love methodology to maquiladora industry total employment and by sector. We assumed that the dependent variable (maquiladora employment—total and by sector) was explained by the U.S. unemployment rate which plays the role of the U.S. business cycle (UR); the real exchange rate, pesos per dollar (REX); and the ratio of real maquiladora wages to real U.S. manufacturing wages (RATIO). A trend and intercept variable is also included.

The form of the estimating equation for each maquiladora sector (Table 2) is as follows:

$$y_t = \alpha + \Delta\alpha + \beta_0 t + \beta_1 \Delta t + \sum_{j=0}^{4} \beta_{2j} UR_{t-j} + \sum_{k=0}^{6} \Delta\beta_{3k} REX_{t-k} + \sum_{j=0}^{4} \beta_{4j} RATIO_{t-j} + e_t$$

where,

y_t = the log of employment,
a = intercept term,
$\Delta\alpha$ = the dummy variable to capture change in the intercept term,
T = the trend variable time,
Δt = the dummy variable to capture change in the trend variable time,
UR = the log of the unemployment rate
REX = the log the real exchange rate, pesos per dollar, where *t* restricted to 1994-2002
RATIO = the ratio of real maquiladora wages to real U.S. manufacturing wages,
e_t = the stochastic error term, and the
β's = are the parameters to be estimated.

The data used to estimate the maquiladora model are quarterly between 1980 and 2002. The peak for maquiladora employment was in the fourth quarter of 2000, and it then declined for five consecutive quarters until the second quarter of 2002. We also used maquiladora employment for the various sectors. Table 2 summarizes the sectors used and their respective shares of total employment for 2002. All sectors add up to the total, except for one omitted sector that amounts to about 2 percent of the total. The omitted sector is chemicals, and data were not available for all years for chemicals.

Table 2 Maquiladora sectors, 2002

Maquiladora Sector	Percent Share
Total	100
Electronics, electrical materials, assembly of electrical, electronic machinery, equipment	29.9
Automotive parts, equipment, accessories	21.5
Textiles, clothing	21.4
Wooden and metallic furniture, parts	5.0
Services	3.4
Chemicals	2.1
Assembly, repair of non-eclectic tools, equipment	1.5
Toys, sporting goods	0.9
Foodstuffs	0.8
Footwear, leather goods	0.6
Other	12.9

The source of data on maquiladora employment is the Instituto Nacional de Estadística, Geografía e Informática (INEGI), Industria Maquiladora de Exportación (IME). The dependent variable is the log of the number of employed workers. The estimates are for all workers in the different maquiladora sectors. The exchange rate used here is the Federal Reserve Bank of Dallas price-adjusted peso exchange rate. The ratio of real maquiladora wages to real U.S. manufacturing wages was calculated by the authors from INEGI and BLS data. The exchange rate variable REX includes the current observation plus six quarters of lagged observations. The ratio of real maquiladora wages to U.S. manufacturing wages RATIO and the unemployment rate UR variables both include the current value plus four quarters of lags.

Because the model is in double-log form, the estimated coefficients again have simple economic interpretations. For instance, the coefficient of the trend variable t is the estimated exponential rate of growth or decline in employment that occurs due to secular changes in income, tastes, comparative advantage, or technology. The coefficients for the real exchange rate, the real wage ratio, and the unemployment rate variables can be interpreted as elasticities.

Similar to the U.S. model, in the maquiladora industry model a possible shift in the intercept, shift in the trend, or a change in the coefficient on the foreign exchange variable represents a structural change. A shift downward in the trend, for example, would likely indicate pressure after 1994 due to productivity gains or improved opportunities abroad. An increase in the coefficient on the real exchange rate would indicate greater sensitivity to currency fluctuations. To test for structural change beginning in January 1994 (NAFTA implementation, followed by Mexican financial crisis) the following variables were created, as described above:

$\Delta\alpha$ – intercept shift beginning January 1994
Δt – shift in trend beginning January 1994
Δx – shift in REX post-January 1994.

4. Empirical Results

4.1 U.S. Model Results

In the following sections, we report the empirical results of both the U.S. and the maquiladora models. For the U.S., manufacturing employment within maquiladora-related sectors is disaggregated by nine sectors defined by SIC, as mentioned above. Table 3 summarizes the results of the regressions, indicating which variables were significant at a 95 percent degree of confidence. The U.S. equations are estimated from 1980:1 to 2002:4.

Table 3 Summary of U.S. Model Regression Results

Significant Coefficients in Branson-Love Equations				
	Trend	**U-Rate**	**WTI**	**REX**
Food products	Yes	No	No	Yes
Apparel products	Yes	No	No	Yes
Furniture and fixtures	No	Yes	No	No
Chemicals and allied products	No	Yes	No	Yes
Leather and leather products	Yes	No	No	Yes
Industrial and commercial machinery	No	Yes	No	No
Electronic and electrical components	Yes	Yes	No	No
Transportation Equipment	Yes	Yes	No	No
Toys and sporting goods	Yes	No	No	Yes
All Manufacturing	Yes	Yes	No	No
Maquiladora-Oriented	Yes	Yes	No	No
Not Maquiladora	No	Yes	No	Yes

Table 4 reports the estimates for total manufacturing, maquiladora-related employment, non-maquiladora related, and for the nine manufacturing sectors analyzed on this paper. The table shows the coefficients for each independent variable and a significance statistic. When independent variables are lagged, the coefficient represents the sum of all lagged coefficients. The significance measure (t-stat) is the t-value for the probability that the true value of the sum of the coefficients is zero, using a two-tailed t-test.

The variable TREND is negative in all instances and statistically significant at the 5-percent level in 10 of the 12 regressions. Chemicals and allied products (SIC 28) and toys and sporting goods (SIC 394) were the only two sectors without significant trend parameters. These regression results indicate that there is a continued downward pressure on employment due to secular changes in income, tastes, comparative advantage, or technology, holding other things equal. Only for food products (SIC 20) does the trend variable enter the equation with a small, but positive trend.

The cyclical variable UR measures the impact of cyclical movements in the national economy; the expected sign for this variable is negative, as high sector employment is associated with lower national unemployment rates (Branson and Love, 1986; 1987; 1988). Results in Table 4 show 10 regressions with negative UR coefficients, with only 8 significant at the 5-percent. Apparel products (SIC 23) and toys and sporting goods (SIC 394) have negative UR coefficients, but are not statistically significant.

Table 4 U.S. Model Regression Results

	Trend	*t-stat*	UR	*t-stat*	WTI	*t-stat*	REX	*t-stat*	R^2	DW
All Manufacturing	-0.0024**	-7.08	-0.1900**	-14.47	0.0071	0.93	-0.0063**	-2.06	0.992	0.923
Maquiladora Oriented	-0.0034**	-5.13	-0.1978**	-13.61	0.0123	1.49	-0.0534	-1.52	0.994	0.927
Non-Maquiladora Oriented	-0.0016**	-9.25	-0.1751**	-14.31	0.0008	0.10	-0.0700	-2.72	0.987	1.029
SIC 20 Food products	0.0008**	8.74	0.0040	0.50	0.0089	1.49	-0.0087**	-6.30	0.979	2.041
SIC 23 Apparel products	-0.0366**	-9.18	-0.0104	-0.40	0.0015	0.99	-0.2835**	-4.48	0.999	0.977
SIC 25 Furniture and fixtures	-0.0009**	-2.88	-0.2601**	-11.23	-0.022	-1.49	0.0622	1.33	0.989	1.500
SIC 28 Chemicals and allied products	-0.0001	-0.23	-0.0438**	-3.07	0.0063	0.77	-0.1368**	-4.00	0.977	0.498
SIC 31 Leather and leather products	-0.0152**	-12.55	0.0126	0.29	0.0375	1.51	-0.4715**	-4.66	0.999	1.311
SIC 35 Industrial and commercial machinery	-0.0019**	-2.14	-0.3458**	-10.54	0.0276	1.45	-0.1134	-1.47	0.981	0.743
SIC 36 Electronic and electrical components	-0.0118**	-3.82	-0.3116**	-9.99	0.0541	3.06	0.1314	1.73	0.988	0.913
SIC 37 Transportation equipment	-0.0038**	-4.75	-0.2850**	-8.75	-0.024	-1.29	0.9815	1.29	0.983	1.482
SIC 394 Toys and sporting goods	-0.0002	-0.21	-0.0273	-0.59	0.0286	0.86	-0.6743**	-6.32	0.974	1.735

Notes: ** p<.05, the time period is 1980:Q1 to 2002:Q4

The real price of energy (WTI) was positive in 10 regressions and negative in 2, but statistically insignificant in all cases. Similar results were obtained introducing the energy component of the CPI into the econometric analysis. The predicted sign for this variable is ambiguous since an increase in the relative price of energy increases the cost of doing business, resulting in lower employment. However, some sectors produce outputs that substitute for energy, or are inputs to energy-substitute products (Branson and Love, 1988). Energy did not enter any equation with the right sign and a significant confidence level. Results for the other variables were unchanged, regardless of which energy variable was used.

The real exchange rate variable (REX) is negative for 9 of the 12 equations and statistically significant at the 5-percent level in 6 cases. The exchange rate has its greatest impact on toys and sporting goods (SIC 394) with an elasticity of -0.6, and leather and leather products (SIC 31) with an elasticity of -0.47, apparel products (SIC 20) with an elasticity of -0.28, and chemicals and allied products (SIC 287) with an elasticity of -0.13. Further, results suggest a smaller but statistically significant impact of exchange rates on food products (SIC 20) with an elasticity of -0.008. The REX coefficients for furniture and fixtures (SIC 25), electronic and electrical components (SCI 36), and transportation equipment (SIC 37) are positive, but not statically significant from zero.

In sum, this econometric exercise suggests that sectors generally divide themselves into two groups, those sensitive to exchange rates, and others sensitive to the business cycle. Overall, we don't see maquila-oriented industries in the United States as very sensitive to exchange rates, but the detailed estimates pick up food products (SIC 20), apparel products (SIC 23), chemicals and allied products (SIC 28), leather and leather products (SIC 31), and toys and sporting goods (SIC 394) as maquila-oriented sectors that are sensitive to the real exchange rate. Apparel, toys, and leather are all low-wage industries where China has made significant in-roads in recent years. Furniture and fixtures (SIC 25) and chemicals and allied products (SIC 28) are also subject to the business cycle, along with industrial and commercial machinery (SIC 35), electronic and electrical components (SCI 36), and transportation equipment (SIC 37).

4.2 U.S. Simulation Results

One may ask what happened to manufacturing during the latest U.S. recession? In summary, it was the perfect storm: high energy prices, an appreciating dollar, and a mild recession. So the next question might be what mattered most in pushing manufacturing employment down so sharply? In order to address the above questions, we ran simulation exercises employing the regressions estimated on the last section. We report the simulation results below.

First, results indicate that structural change made a difference in pushing down employment (Table 5). This is apart from our variables – energy, business cycle, the exchange rate. The estimated coefficients show that before 1994 trend factors such as free trade or higher productivity in the U.S. were pushing down total manufacturing employment every year by an average of 0.6 percent. After 1994, the trend declined at a –1.6 percent annual rate. The maquila-oriented downward trend accelerated from annual declines of –0.8 percent to –1.9 percent. The non-maquila trend did not change, but the sector became more sensitive to changes in the real exchange rate.

Table 5 Structural Change Summary

	Manufacturing	Maquiladora-Oriented	Not-Maquiladora
Trend			
Pre-1994	-0.6%	-0.8%	-0.6%
Post-1994	-1.6%	-1.9%	-0.6%
More Sensitive to Exchange Rate	No	No	Yes

One way to look at the role of the recession versus the strong dollar in pushing down employment in manufacturing is to simulate some alternative scenarios over the period 2000Q2 to 2002Q4. Table 6, in the first two columns, shows the course of the unemployment rate and the dollar from 2000Q1 to 2002Q4. The next two columns show two alternative assumptions. One is "no recession," the unemployment rate simply stays fixed at 4.0 percent throughout the period, instead of rising 47 percent to 5.9 percent. Second, instead of rising 9.1 percent, the exchange rate falls back to 100.0 by 2002Q4. Energy is the same in all scenarios. Using these assumptions we built four scenarios:

Base case: What really happened?
Scenario 1: No recession, dollar appreciates
Scenario 2: Recession, dollar declines
Scenario 3: No recession, dollar declines.

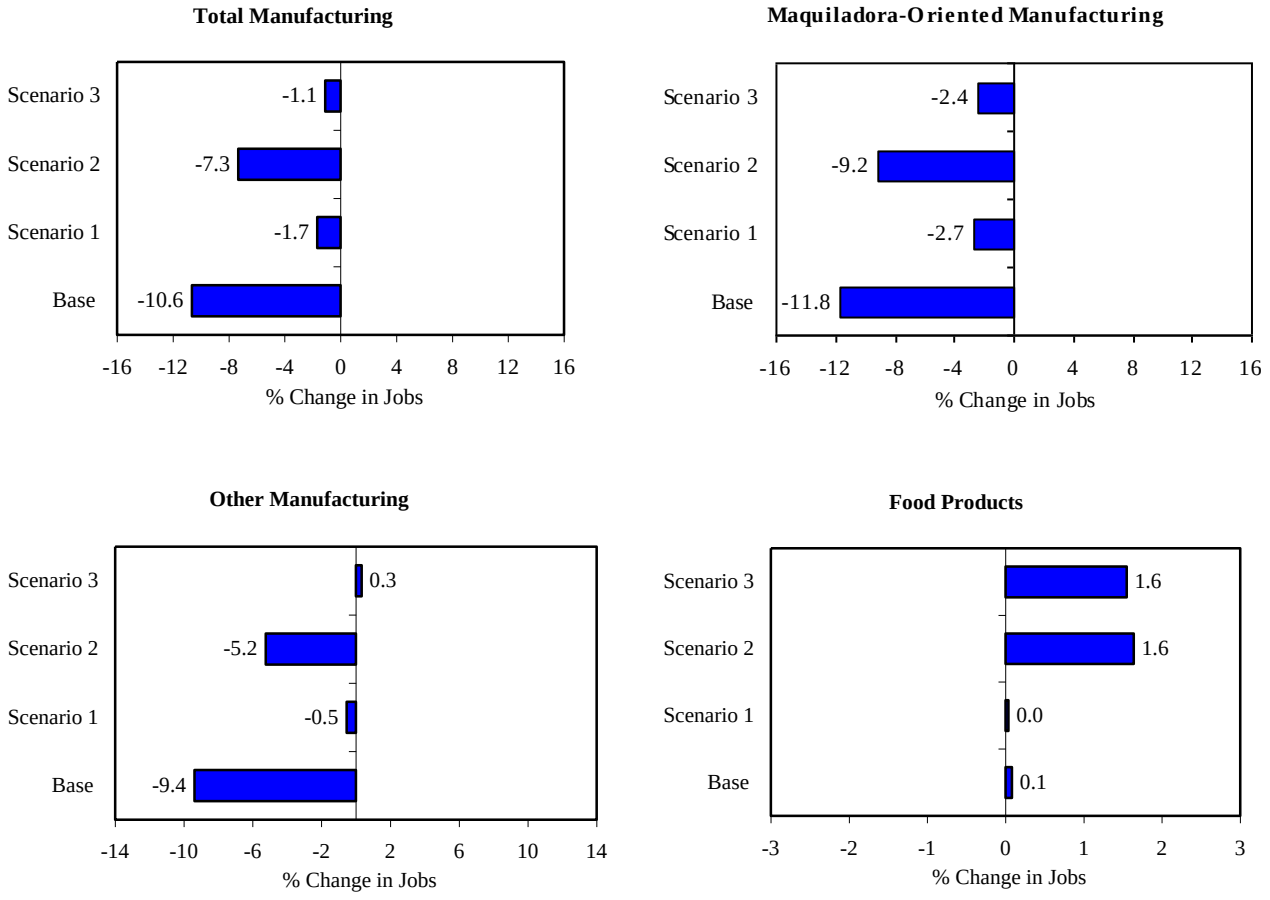
Table 6 Simulation Scenarios

Actual and Assumed Data for Scenarios					
		Actual		Assumed	
		UR	REX	UR	REX
2000	**Q1**	4.0	114.0	4.0	114.0
	Q2	4.0	116.4	4.0	112.7
	Q3	4.1	118.7	4.0	111.4
	Q4	3.9	121.7	4.0	110.1
2001	**Q1**	4.2	122.5	4.0	108.9
	Q2	4.5	124.6	4.0	107.6
	Q3	4.8	125.3	4.0	106.3
	Q4	5.6	125.5	4.0	105.1
2002	**Q1**	5.6	127.1	4.0	103.8
	Q2	5.8	124.5	4.0	102.5
	Q3	5.8	123.8	4.0	101.3
	Q4	5.9	124.3	4.0	100.0

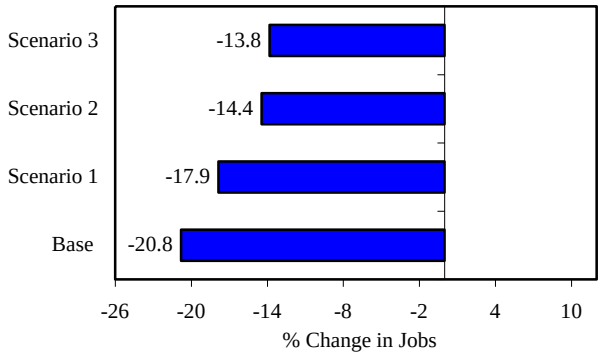
To illustrate better the simulation results, Figure 1 shows the simulation results for all the U.S. manufacturing sectors analyzed in this paper. For example, the chart for toys and sporting goods (SIC 394) shows how this sector is sensitive to exchange rate under these scenarios. Fixing the economy, for example, moves the job losses in the sector from –9.9% to –6.0%. However, fixing the exchange rate moves losses from –9.9 to +4.2 percent. Also, Figure 1 below shows similar results, but for a highly cyclical sector – transportation equipment (SIC 37). Now Scenario 1, fixing the economy, does best. Figure 1 shows the simulation results for all manufacturing employment. A –10.6 percent actual decline; curing the recession reduces it to only –2.2 percent, while fixing the exchange rate reduces it to only –9.6 percent.

Furthermore, Table 7 shows that the same holds for maquila-oriented manufacturing and non-maquila oriented – fixing the economy is a more effective solution in every case. The difference between the behaviors of maquila –oriented does not differ significantly. The exchange rate is the lesser evil.

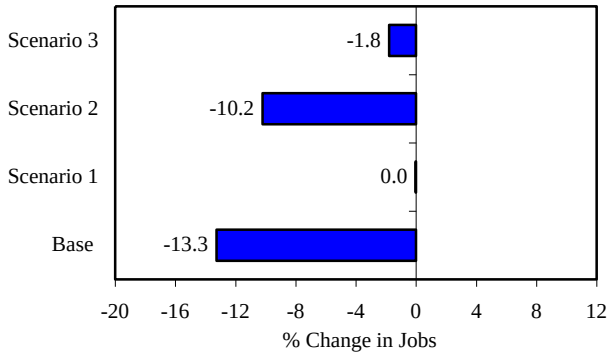
Figure 1 Simulation Results by SIC codes (from 2000:Q2 to 2002:Q4)



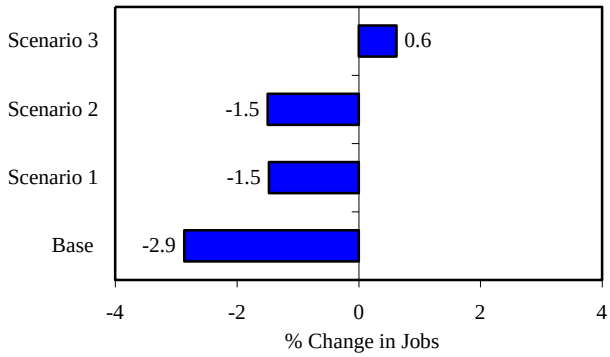
Apparel Products



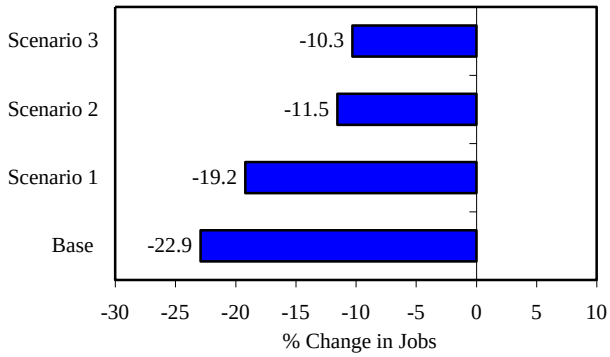
Furniture and Fixtures



Chemicals and Allied Products



Leather and Leather Products



Industrial and Commercial Machinery

Electronic and Electrical Components

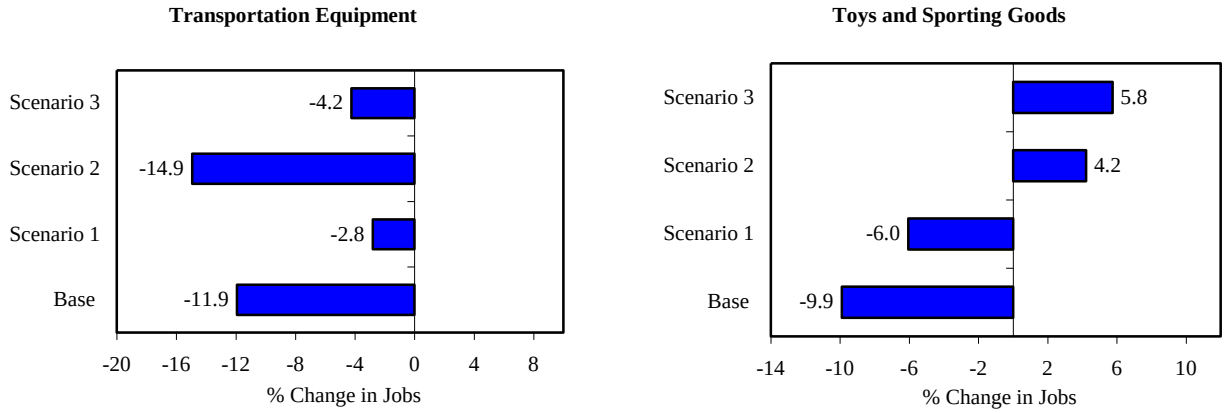


Table 7 Percent Decline in Jobs Under Three Scenarios

	Total	Maquila-Oriented	Non-Maquila
Base	-10.6	-11.8	-9.4
Scenario 1	-1.7	-2.7	-0.5
Scenario 2	-7.3	-9.6	-5.2
Scenario 3	-1.1	-2.4	0.3

4.3 Maquiladora Model Results

In the following sections, we report empirical results on the maquiladora regressions. For the maquiladora model, employment is disaggregated in 10 different sectors, as mentioned above. Table 8 summarizes the econometric results for total maquiladora employment and for each of the 10 sectors we analyzed in this paper. The table shows coefficients for each independent variable and a significant statistic. When independent variables are lagged, the coefficient represents the sum of all lagged coefficients. The significance measure (t-statistic) is the t-value for the probability that the true value of the sum of the coefficient is zero, employing a two-tailed t-test.

The variable Trend is positive for total maquiladora employment and in 7 regressions, while 3 sectors had negative coefficients. More importantly, 9 sectors and total employment show significant Trend coefficients. In general, the Trend coefficients are strong for most variables, especially pre-1994 and especially given these are quarterly growth rate. Total growth in maquiladora employment, for example is 12.7 percent. Expressed in quarterly terms, the fastest growing sectors are food (4.6%), other (4.9%), textiles (5.7%), and furniture (5.8%). Some sectors were negative pre-1994: transportation (6.5%), electrical machinery (-2.4%), toys and sporting goods (-1.0%). There is a slowdown post-1994 in trend growth, from 12.7 to 7.7 percent for total maquiladora employment. The biggest slowdowns at quarterly rates: furniture (-4.9%), food (-4.1%), and other (-3.6%). Acceleration occurs in non-electrical machinery (2.3 percent faster) and transportation (3.2 percent).

The explanatory variable that we used to measure the U.S. business cycle, the unemployment rate (UR), the expected sign is negative, as high employment is associated with lower unemployment rates. Results in Table 8 show negative coefficients for the unemployment rate in all instances including total maquiladora employment. However, only 8 sectors and the total maquiladora had statistically significant coefficients at the 5-percent level. The foodstuffs and automotive sectors have negative coefficients but they are not statistically significant.

Table 8 Maquiladora Regression Results

Sector	Δα							R^2	DW
Total Maquiladora	0.5957**	0.0304**	-0.0115**	-0.4555**	-0.6203**	0.111	-0.194	0.999	0.92
	2.34	*8.10*	*-2.47*	*-6.76*	*-3.01*	*1.30*	*-1.44*		
Foodstuffs	2.189**	0.0464**	-0.0412**	-0.3634	1.115	-0.204	1.129	0.983	2.12
	3.40	*6.72*	*-3.51*	*-0.95*	*0.96*	*-0.39*	*1.36*		
Textiles, clothing	1.052**	0.0571**	-0.0187**	-0.6064**	-0.7509**	0.319	0.0238	0.999	1.06
	2.58	*9.19*	*-2.51*	*-5.90*	*-2.46*	*2.31*	*0.12*		
Wooden and metallic furniture, parts	2.548**	0.0583**	-0.0487**	-0.4313**	-0.3848	0.7288	-0.8168**	0.999	1.2
	6.81	*11.82*	*-7.10*	*-3.48*	*-1.04*	*4.39*	*-3.25*		
Footwear, leather goods	1.181**	0.0173**	-0.0225**	-0.4616**	-0.621	0.0507	-0.3306	0.991	1.67
	3.32	*4.19*	*-3.42*	*-2.64*	*-1.18*	*0.22*	*-0.90*		
Assembly, repair of non-eclectic tools, equipment	-1.319	0.011	0.023	-0.4052**	-0.866	-1.383	-0.219	0.998	1.71
	-1.54	*0.71*	*1.48*	*-2.29*	*-1.66*	*-0.58*	*0.64*		
Electronics, electrical materials, assembly of electrical, electronic machinery, equipment	0.5359	-0.0239**	-0.0101	-0.5061**	-0.7455**	0.1394	-0.3575	0.998	0.94
	1.22	*3.29*	*-1.26*	*-5.06*	*-2.52*	*1.04*	*-1.82*		
Automotive parts, equipment, accessories	-1.826**	-0.0648**	0.0316**	-0.1196	-0.3608	-0.2108	0.0064	0.999	1.21
	-2.01	*-2.39*	*1.94*	*-0.89*	*-0.95*	*-1.17*	*0.03*		
Toys, sporting goods	0.349	-0.0095**	-0.0078	-0.8907**	-0.425	0.2568	-0.2016	0.990	1.71
	0.88	*-2.09*	*-1.07*	*-4.44*	*-0.71*	*0.95*	*-0.48*		
Services	0.2723	0.0251**	-0.0074	-0.2593**	-1.291**	-0.2474	0.1848	0.997	1.61
	0.76	*5.72*	*-1.12*	*-2.00*	*-2.91*	*-1.25*	*0.61*		
Other	1.785**	0.0492**	-0.0355**	-0.712**	-0.1995	0.6758	-0.8734	0.997	1.64
	2.98	*6.57*	*-3.22*	*-3.11*	*-0.29*	*2.21*	*-1.87*		

Notes: ** p<.05, the time period is 1980:Q1 to 2002:Q4, t-statisitcs are shown below the coefficients

Another explanatory variable that we used is the ratio of real maquiladora wages to real U.S. manufacturing wages (RATIO). All sectors, with the exception of foodstuffs, show negative coefficients for the wage ratio. Nevertheless, only three sectors, besides total maquiladora employment, had negative and statistically significant coefficients: textiles and clothing, electronics and services.

The real exchange rate (REX) variable never enters the equations in a statistically significant way. Nor is there any consistent indication that sectors have become more sensitive to REX after 1994. One explanation for the exchange rate not being significant is that the wage ratio (Ratio) probably fills its role on the regressions. If maquiladoras are cost sensitive, they should be sensitive to labor cost. They purchase very few local materials (about 3-5%), and real wages are the primary cost factor. Relative wages would dominate the decision to move to Mexico if it is cost-based. Only two equations are disappointing, in that none of the three variables come in significant. These are foodstuffs and transportation equipment.

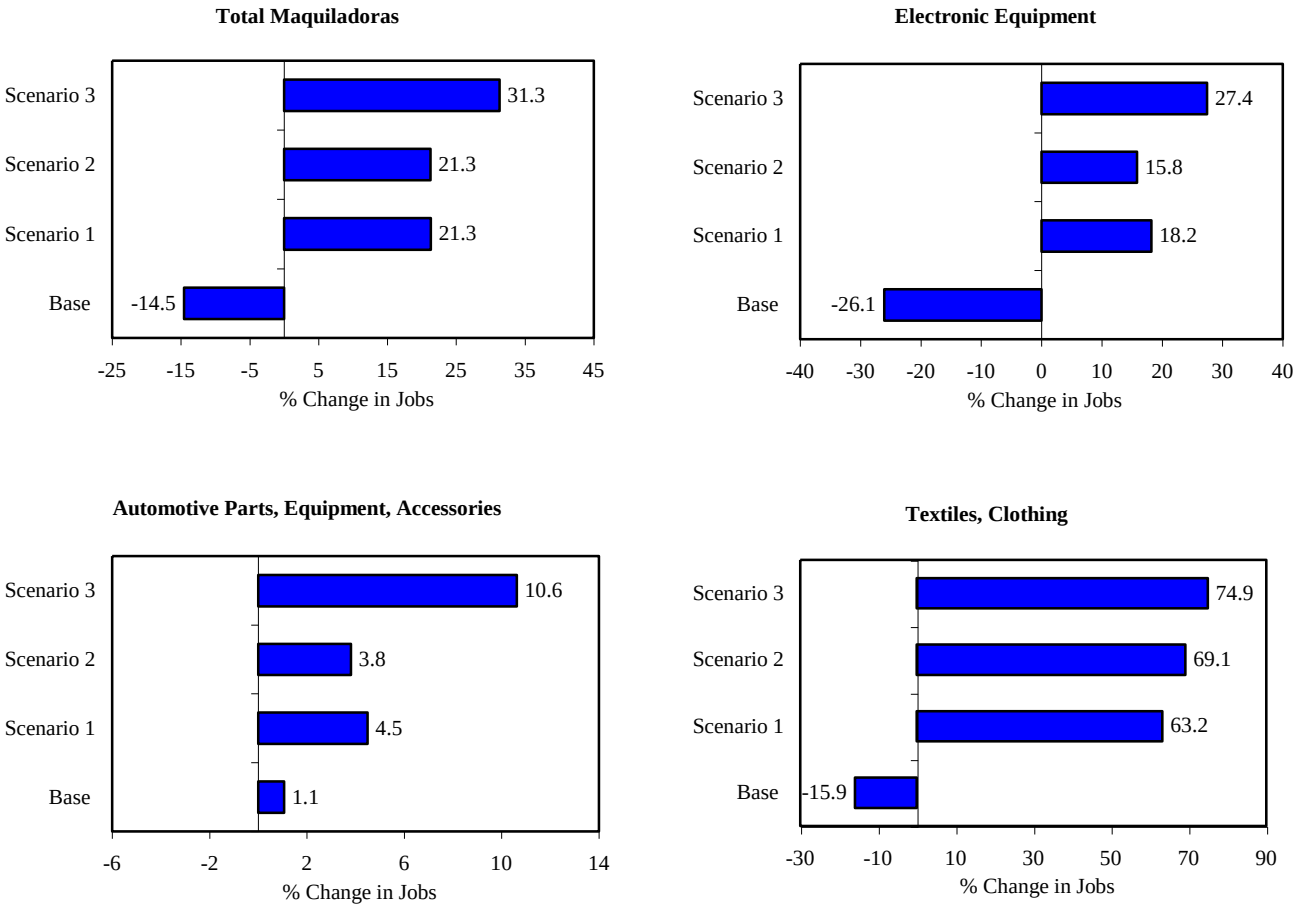
4.4 Maquiladora Model Simulation Results

As we did with the U.S. model, we use the maquiladora econometric model to run simulation scenarios. These simulation exercises assist us in identifying the impacts of different factors during the last maquiladora downturn. Results are clearly useful, not only to understand what happened, but also to understand the extent to which maquiladora employment is likely to recover with industrial recovery and a weaker dollar.

Simulations were done at the total and at sector level. Figure 2 summarizes the simulation results for each of the maquiladora sectors we analyzed on this paper. Each regression was re-estimated through the second quarter of 2000, then the recession period for the U.S. was forecast through the end of 2002. The base period was compared to the following three scenarios:

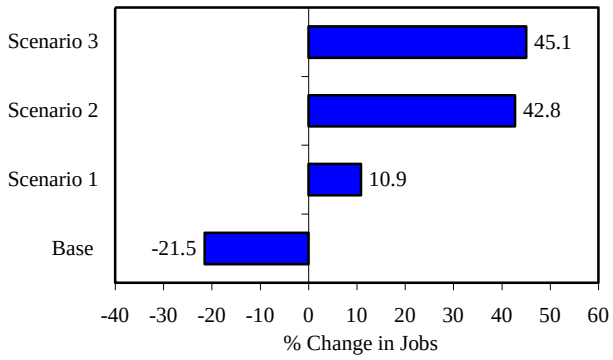
1. First scenario (S1) assumed no recession, and the U.S. unemployment rate held steady at 4 percent;
2. Second scenario (S2) assumed that maquiladora wages fell 6.1 percent after 2000Q2, instead of rising 16.8 percent;
3. Third scenario (S3) assumed that there was no recession *and* falling maquiladora wages.

Figure 2 Simulation Results by Maquiladora Sectors (from 2000:Q2 to 2002:Q4)



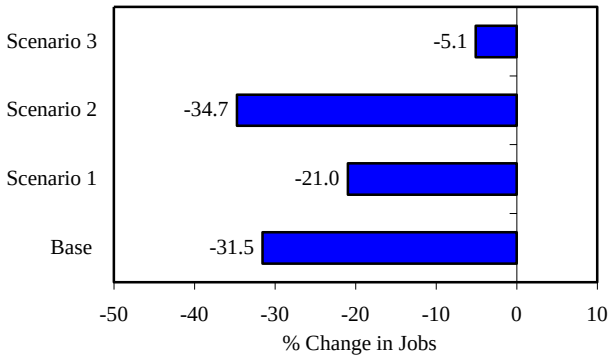
Wooden and Metallic Furniture, Parts

Services

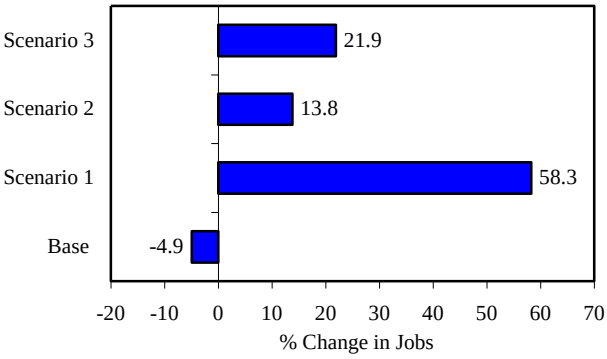


Assembly, repair of non-eclectic tools, equipment

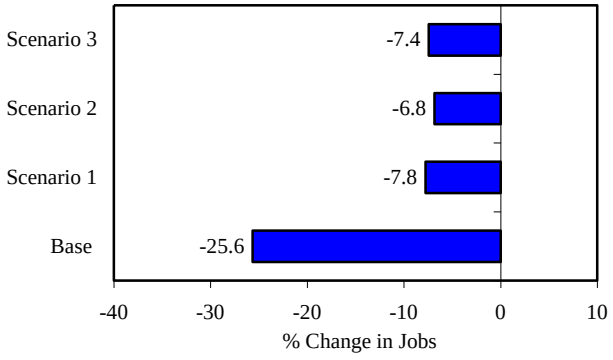
Toys and Sporting Goods

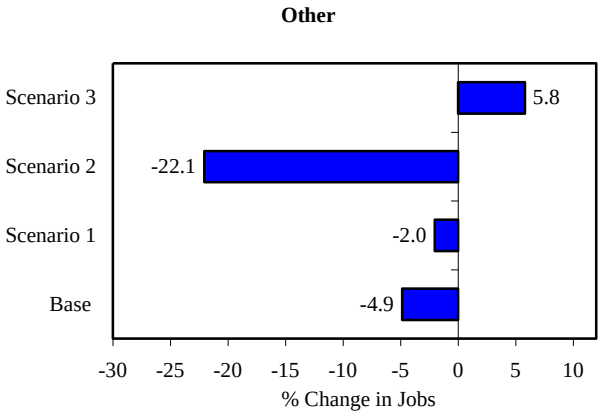


Foodstuffs



Footwear and Leather Goods





The first column in Table 9 shows the results of using only the equation for total maquiladora employment to simulate employment growth. The second column shows the results of adding up all the simulations for the different maquiladora sectors (as described in Table 2), and computing the percentage change in employment from 2000Q2 to 2002Q4 for the base case and each of the three scenarios. The similarity of the results given by the two methods should provide some confidence in our results

Furthermore, the simulation results tell us that maquiladora employment is very sensitive to the US business cycle. Avoiding the recession not only avoids job losses, but adds another 20 percent to employment by the end of 2002. Similarly, the industry is very sensitive to labor costs. Turning maquiladora wages around to the extent that we assumed has the effect of pushing maquiladora employment up by an amount roughly equal to that attained by avoiding the recession. Combining the two effects – no recession, declining wages – adds another 10 percent in maquiladora employment growth..

Table 9 Maquiladora Model Simulation Results

	Total	**Sectors**
Base	-14.5	-14.6
Scenario 1	21.3	20.1
Scenario 2	21.3	17.7
Scenario 3	31.3	31.0

5. Beyond Data

Until very recently, the ratio of real maquiladora wages to U.S. manufacturing wages was a good representation of the choices offered to U.S. corporations. However, in 2000 the Caribbean Basin Trade Partnership Act offered NAFTA-like advantages for apparel and textiles to Caribbean and Central American countries, and in late-2001 China became a member of the World Trade Organization. The number of countries offering low wages has broadened dramatically. Also in 2001, section 303 of NAFTA ended the traditional maquiladora customs and tax regime. The Mexican government has put in place a new customs framework to preserve the operation of these foreign plants, but has wavered on whether the current tax burden borne by the plants will be greater or smaller than before. After several false starts, the most recent October presidential decree has been highly favorable for the industry (Baker and McKenzie, 2003).

Our results from historical data suggest a strong recovery in Mexican maquiladoras will accompany the U.S. recovery. Others have drawn a similar conclusion (Gruben and Kiser, 2001; U.S. GAO Report, 2003). The results are qualified, however, by the rise of foreign competition and Mexico's ability to capitalize on proximity and growing sophistication in its labor force. Rising wages are to a certain extent a symbol of progress for Mexico. Its future manufacturing will increasingly be tied to bulky items (autos, appliances), to goods with a complicated or very short product cycle, or to products where intellectual property must be protected. Rudimentary assembly of toys and bicycles will inevitably move to China, Guatemala or Bangladesh. We think the list of items where Mexico remains competitive is long enough to preserve our conclusion of recovery and growth ahead for Mexican maquiladoras.

6. Conclusion

We attempt in this paper to estimate how much of the current maquiladora downturn is due to the business cycle and how much is due to structural changes. We use Branson-Love methodology to estimate structural and cyclical impacts on the recent maquiladora employment downturn. Results suggest that the recent U.S. recession and rising wages account for most of the maquiladora downturn, while structural impacts are small but still statistically significant. Recent events such as implementation of NAFTA Article 303 or China's entrance into WTO alter our conclusions by suggesting that apparel, textiles, and rudimentary assembly operations may not recover fully. However, we feel that the list of sectors where Mexico remains competitive is long enough to assume recovery and growth ahead.

To some extent rising wages are a symbol of Mexican progress, but our results show substantial sensitivity to labor costs by U.S. companies operating in Mexico. This makes it incumbent on Mexico not to compound the problem of rising operating costs by adding payroll or customs taxes. And to generally work to provide a more competitive economic environment with better infrastructure, energy reforms, and improved telecommunications.

Our simulation results imply better times ahead for maquiladoras. The U.S. economy began to recover in late 2001, and more importantly the U.S. industrial sector began to grow rapidly in 2003. Combined with a weaker dollar, recovery almost certainly lies ahead. How the pace of recovery will be modified by Chinese and other low-wage competition, a new tax and customs framework, or on-going and proposed reforms to enhance competitiveness remains an important and open question for future research.

* Roberto Coronado is the corresponding author. The views expressed here are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of Dallas nor the Federal Reserve System.

References

1. Ayer, Harry; Layton, Ross. "The Border Industry Program and the Impact of Expenditures on a U.S. Border Community," *Annals of Regional Science* 8, 1974, pp. 105-117
2. Baker and McKenzie. "Amendments to the Maquiladora Decree." available at http://www.maquilaportal.com/bulletin/bulletin185.htm, 2003.
3. Brannon, Jeffery T.; James, Dilmus D. "Cometh the NAFTA, Whither the Maquiladora? Reflections on the Future of Industrialization in Northern Mexico," *Journal of Borderlands Studies* 9, 1994, pp. 1-22
4. Branson, William H.; Love, James, P. "Dollar Appreciation and Manufacturing Employment and Output," *National Bureau of Economic Research*, Working Paper No. 1972, 1986.
5. Branson, William H.; Love, James, P. "The Real Exchange Rate and Employment in U.S. Manufacturing: State and Regional Results," *National Bureau of Economic Research*, Working Paper No. 2435, 1987.
6. Branson, William H.; Love, James, P. "The Real Exchange Rate, Employment, and Output in Manufacturing in the U.S. and Japan," *National Bureau of Economic Research*, Working Paper No. 2491, 1988.
7. Canas, Jesus; Coronado, Roberto. "Maquiladora Industry: Past, Present and Future," *Business Frontier*, Federal Reserve Bank of Dallas-El Paso Branch, Issue 2, 2002.

8. Cobb, Steven; Molina, David; Sokulsky, Kariann. "The Impact of Maquiladoras on Commuter Flows in Texas-Mexican Border," *Journal of Borderlands Studies* 4, 1989, 99. 71-88
9. Coronado, Luis. "Permanent Establishment and Taxation: The Maquiladora Case," Maquiladoras *Today Conference Proceedings,* Network of Border Economics-Red de la Economia Fronteriza, 2004, forthcoming.
10. Coronado, Roberto, Fullerton, Thomas M. Jr, Clark, Don P. "Short-Run Maquiladora Employment Dynamics in Tijuana." *Annals of Regional Science,* 2004, forthcoming
11. Dávila, Alberto. "The Impact of the 1982 Peso Devaluation on Maquiladora Profits," *Journal of Borderland Studies* 5, 1990, pp. 39-50
12. English, Wilke; Williams, Susan; Ibarreche, Santiago. "Employee Turnover in the Maquiladoras," *Journal of Borderland Studies* 4, 1989, pp. 70-99
13. Fullerton, Thomas M., Jr.; Schauer, David A., "Short-Run Maquiladora Employment Dynamics," *International Advances in Economic Research* 7, 2001, pp. 471-478
14. George, Edward; Hoffman, Wilma. "Growth Factors in the Maquiladora Industry," *Journal of Borderland Studies* 5, 1990, pp. 87-98
15. Gilmer, Robert W.; Pulsipher, Allan G. "Cyclical and Structural Change in Southern Manufacturing: Recent Evidence from the Tennessee Valley: Note," *Growth and Change* 17, 1986, pp. 61-69.
16. Gruben, William; Kiser, Sherry L., "NAFTA and Maquiladoras: Is the Growth Connected," *The Border Economy*, Dallas: Federal Reserve Bank of Dallas, 2001, pp. 22-24
17. Hanson, Gordon. "U.S.-Mexico Integration and Regional Economics: Evidence from Border-City Pairs," *Journal of Urban Economics* 50, 2001, pp. 259-287
18. Huerta-Macias, Ana. "Workforce Education: Perspectives on Border Issues," *Journal of Borderlands Studies* 15, 2000, pp. 45-56
19. Lucker, G. William. "The Hidden Cost of Worker Turnover," *Journal of Borderland Studies* 2, 1987, pp. 93-98
20. Patrick, J. Michael. "Maquiladoras and South Texas Economic Development," *Journal of Borderland Studies* 4, 1989, pp. 89-98
21. Patrick, J. Michael. "The Employment Impact of Maquiladoras along the U.S. Border," *The Maquiladora Industry: Economic Solution or Problem*, Ed. Khosrow Fatemi, New York: Praeger Publishers, 1990
22. Silver, Arthur L.; Pavlakovich, Vera K. "Maquila Indsutry Impacts on the Spatial Redistribution of Employment," *Journal of Borderlands Studies* 9, 1994, pp. 47-64
23. United States General Accounting Office, "Mexico's Maquiladora Decline Affects U.S.-Mexico Border Communities and Trade; Recovery Depends in Part on Mexico's Actions." available at www.gao.gov/cgi-bin/getrpt?GAO-03-891 July 2003
24. Verdugo-Vidales. "Labor Turnover in Transnational and National Maquiladoras in Mexicali, Baja California." Master's Thesis. University of Texas at El Paso, 1990
25. Weiler, Stephan, Zerlentes, Becky. "Maquila sunrise or sunset? Evolutions of regional production advatanges." *The Social Science Journal* 40, 2003, pp. 283-297

Notes