Was NAFTA Behind Mexico's High Maquiladora Growth?

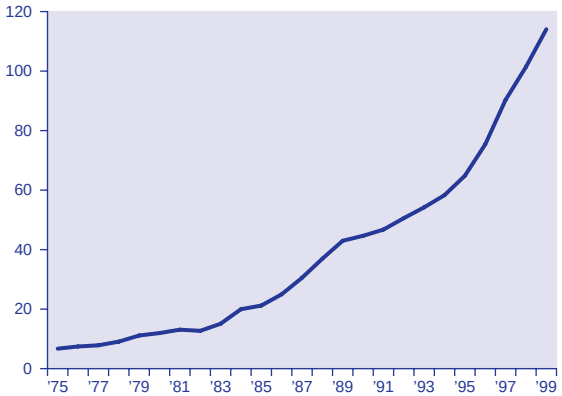
William C. Gruben

Despite the consensus of commentators who otherwise typically disagree, there are at least as many reasons to suspect NAFTA did not cause the maquiladoras' growth as there are to suspect it did.

Among the most striking industrial phenomena in the wake of the North American Free Trade Agreement has been the rapid growth of plants that operate under Mexico's maquiladora program. In its simplest organizational form, a maquiladora plant imports inputs—typically from the United States—processes them, and then ships them back to the country of origin, perhaps for more processing. The maquiladora program permits the inputs and the machinery to process them to enter Mexico tariff-free. On the goods' return, the shipper pays duties only on the value added by manufacture in Mexico.[1]

Although maquiladoras have operated in Mexico since the 1960s, their output and employment growth began to accelerate markedly with the advent of NAFTA in 1994 (*Figure 1*). Over the first six years after the onset of NAFTA, maquiladora employment grew 110 percent, compared with 78 percent over the previous six years. NAFTA opponents and supporters as well as others have concluded that the trade agreement was the cause of this sharp acceleration. Balla (1998, 55), for example, claims that "without doubt, NAFTA has resulted in a dramatic increase in activity in the maquiladora industry." San Martin (2000, 32A) maintains that "NAFTA continues to drive the growth of the maquiladora industry." Carrada-Bravo (1998, 8) argues that "the acceleration of foreign direct investment under NAFTA also contributed to the creation of more than a half-million new employment opportunities in the U.S.–Mexico border region.…These new jobs, tied to the expansion of the maquiladora industry, [pay more] than those not related to international trade." A post-NAFTA report produced jointly by the Economic Policy Institute and the U.S. Business and Industry Council Educational Foundation (1997)

Figure 1
Mexican Maquiladora Employment
Number of workers (in thousands)



SOURCE: Instituto Nacional de Estadística, Geographía e Informática.

William C. Gruben is director of the Center for Latin American Economics and a vice president in the Research Department of the Federal Reserve Bank of Dallas.

claims that "as new and expanded plants are completed in the maquiladora zone…the bilateral trade deficit should soar ever higher." Even before NAFTA took effect, Perot and Choate (1993) declared that "the flow of U.S. companies voluntarily moving factories to Mexico under the maquiladora program threatens to become a flood under NAFTA."[2]

MAQUILADORAS ARE NOT NEW AND NEITHER IS THE CONTROVERSY SURROUNDING THEM

Despite the consensus of commentators who otherwise typically disagree, there are at least as many reasons to suspect NAFTA did not cause the maquiladoras' growth as there are to suspect it did.[3] Certainly, maquiladoras have seen other episodes of sudden acceleration, albeit unlike the recent one.

Mexico developed the maquiladora program in response to the 1964 cancellation of a U.S. program that, starting during World War II, had admitted Mexican agricultural workers into the United States for temporary employment. Maquiladoras were to provide an employment alternative in the manufacturing sector for *braceros*, the agricultural workers who had lost their jobs when the U.S. program ended.

The maquiladora plants in Mexico became controversial in the United States as quickly as they appeared. Some commentators complained that while most of the braceros had been men, most of the newly hired maquiladora workers were women. However, the crux of the controversy was not so much jobs for women in Mexico as it was jobs for anyone in Mexico.

Maquiladora opponents argued that the program helped U.S. and other firms take advantage of low Mexican wages. As firms that had employed low-skilled workers in the United States set up operations in Mexico, opponents argued that maquiladoras were "taking American jobs."

Maquiladora supporters contended that if these assembly plants had not located in Mexico, they would have gone to other low-wage countries—in many cases, in Asia. Indeed, it was pointed out, lower-wage Asian countries had served as export platforms for U.S. manufacturing operations before maquiladoras came on the scene.[4]

More to the point, the maquiladoras of Mexico reflected a broader phenomenon, the globalization of manufacturing. Although the maquiladoras were creatures of Mexican law, similar operations could be found across the globe, thanks to decades of falling communication and transportation costs. These cost reductions facilitated the development of a far-flung network of assembly plants early on in Taiwan—and later in Guatemala, Mauritius, and Vietnam—whose products were marketed in the industrialized world in general and in the United States in particular (Grunwald and Flamm 1985; Romer 1993).

This globalization process was not a result of NAFTA. If anything, NAFTA was a result of this globalization process. If the reductions in communication and transportation costs that motivated globalization had not occurred, the political pressures that permitted NAFTA would not have been so strong.

HAS NAFTA MADE MAQUILADORAS ANY DIFFERENT?

While NAFTA may have motivated companies to start or expand operations in Mexico, it is also possible it discouraged maquiladora expansion or even discouraged maquiladora operations in general. This is because NAFTA allows U.S.–Mexico production-sharing operations in the maquiladora mode but without the maquiladora program.

By 1999 the majority of imports that had been processed under the maquiladora program and then entered the United States could enter duty-free outside that framework. The Automotive Products Trade Act and duty-free treatment of certain products from most-favored-nation suppliers, as well as tariff eliminations under NAFTA, made entry as easy as it was under the maquiladora program (Watkins 1994). And because of the additional paperwork the maquiladora program required, using it as a vehicle in the age of NAFTA might seem unnecessarily costly.

Another disincentive to operating under the program involved environmental restrictions. In some cases, waste-handling and treatment regulations may be interpreted as stricter for maquiladoras than for other Mexican plants making the same products. Under NAFTA some of these plants could export to the United States under levels of protectionism no higher than what the maquiladoras enjoyed, making maquiladora participation an unnecessary expense.[5]

Beginning January 1, 2001, moreover, NAFTA became the only basis for duty-free treatment of imported inputs to Mexican maquiladoras, effectively ending the maquiladora program as it related to trade among North American countries. As of that date, NAFTA provisions phased out unconditional duty-free treatment for imported components and equip-

ment for maquiladoras. They also imposed rules requiring North American content minimums (50 percent or, in some cases, more) for duty-free movement of products between Mexico and the United States or Canada.

On the other hand, although NAFTA began lowering tariffs on goods shipped into the United States from Mexico upon its inception on January 1, 1994, the full reductions were not instantaneous. To the extent that other tariff schedules resulted in lower duties on Mexican imports than NAFTA did, the maquiladora could have remained attractive.[6]

Some NAFTA-related changes unequivocally encouraged maquiladoras. Echeverri-Carroll (1999) notes, for example, that NAFTA eliminated all Mexican programs that favored specific industries. When this occurred, some firms switched to the maquiladora program to continue importing inputs duty-free to Mexico.

In sum, some factors suggest NAFTA may have affected maquiladora growth a great deal. Other factors offer reasons to suspect NAFTA had little impact, and still others suggest the trade agreement discouraged maquiladora growth. Whether NAFTA significantly contributed to the acceleration of maquiladora employment growth is not easy to divine without econometric testing. Nevertheless, the maquiladora expansion rate during the six post-NAFTA years is two-fifths again as high as during the six pre-NAFTA years.

IF THE MAQUILADORA PROGRAM HAS BEEN PHASED OUT, WHY ARE THESE QUESTIONS WORTH ASKING?

Analysts commonly credit NAFTA for all post-NAFTA changes in U.S.–Mexico trade. (See, for example, Council of the Americas 1999 and Rothstein and Scott 1999.) Some econometric evidence suggests that NAFTA explains a significant portion of trade increases but that non-NAFTA factors have been responsible for much of the U.S.–Mexico trade fluctuation since the agreement took effect (Gould 1998). Other modeling efforts find that Mexican export growth cannot be explained by NAFTA and that the agreement's role in Mexican import expansion is unclear (Garces-Diaz 2001).

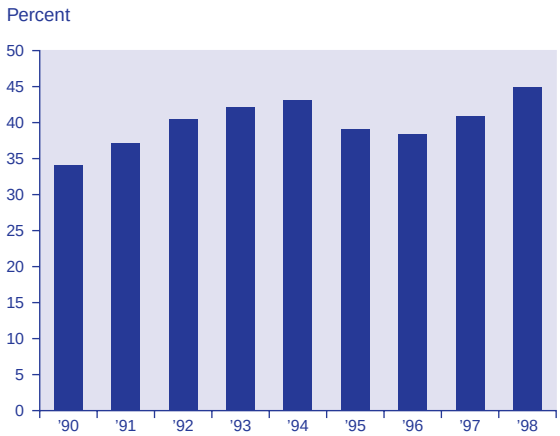
In any case, large blocks of economic activity related to U.S.–Mexico trade—such as maquiladora production—have not been shown to be either connected or unconnected to NAFTA. Why is this important? If maquiladora production and trade were linked to NAFTA, the implications for modeling NAFTA's impacts would be markedly different than if NAFTA did not influence a large portion of U.S.–Mexico trade. For example, if maquiladora activity were unaffected by NAFTA, perhaps estimates of the agreement's impact on U.S.–Mexico trade ought to exclude data for maquiladora trade.

This issue becomes clearer if we consider the broader context of Mexico–U.S. trade. Mexican shipments of crude oil to the United States represent a significant portion of total Mexico–U.S. trade, but they are clearly unconnected to NAFTA. It may be possible to identify other such goods. If it turns out that the portion of NAFTA-affected Mexico–U.S. trade is rather limited, the research focus on NAFTA would also warrant greater limitations than are currently typical.

Suppose, however, that NAFTA has affected maquiladora activity. Another interesting aspect of examining the connections between maquiladoras and NAFTA would involve assessing not only whether NAFTA affected maquiladora activity but how. For example, might NAFTA have only directly influenced maquiladora activity? Or might it have had indirect effects?

Finally, even though maquiladoras have been phased out as a phenomenon separate from NAFTA, the implications of such plants for trade liberalization related to NAFTA may deserve very different modeling and policy consideration if NAFTA motivated some kind of behavior from them that the old maquiladora rules did not. We can only measure these links while it is still statistically possible to consider maquiladoras as separate entities. Figure 2, which shows the ratio of maquiladora to total Mexican exports, demonstrates how important these im-

Figure 2
Maquiladora Exports as a Percentage of Total Mexican Exports



SOURCE: Instituto Nacional de Estadística, Geographía e Informática.

plications may be. Note that maquiladora exports accounted for more than one-third of all Mexican exports every year of the last decade.

MODELING MAQUILADORA BEHAVIOR, WITH AND WITHOUT NAFTA

To test for NAFTA's impact on maquiladora fluctuations, I apply a variant of a model designed to explain maquiladora employment (Gruben 1990). This model addresses influences on fluctuations that would occur in the presence or absence of NAFTA. The model includes adjustments for statistical problems inherent in examining such relationships (Hernandez and Navarrete Vargas 1988; Gruben 1990) and then adds a dummy variable for all periods from 1994 on.

The virtue of this model is that it is very parsimonious, yet accommodates both demand- and supply-side explanations for maquiladora employment fluctuations. To account for the demand side, I use U.S. industrial production, as Hernandez and Navarrete Vargas (1988) do. The rationale for this is that maquiladoras are essentially a segment of the U.S. manufacturing sector. When U.S. industrial production increases (falls), maquiladora employment would also be expected to increase (fall). (I also constructed a version of this model using U.S. real gross domestic product, since it is a broader measure of both supply and demand. I do not report these results because regardless of the configuration of lag lengths or of the other variables in the model, U.S. GDP never offered as much explanatory power as industrial production.)

A second category of variable involves relative wages, although, as explained below, such variables require statistical adjustment before they are suitable for a regression equation. Mexican maquiladora employment may be expected to expand or contract inversely with the ratio of Mexican manufacturing wages to comparable wages in countries that compete with Mexico in supplying products to the United States, including the United States itself. In the typical maquiladora model (Hernandez and Navarrete Vargas 1988; Gruben 1990; Truett and Truett 1993), the maquiladoras' competitors are plants in the United States and in newly industrializing Asian countries. *Ceteris paribus*, as Mexican manufacturing wages fall relative to U.S. or Asian wages, Mexican maquiladora employment is expected to grow.

I express all wages in dollars so as to characterize relative costs from the point of view of a U.S. producer or customer. This detail is important. Why denominate foreign wages in dollars when the workers will be paid in their national currency? The reason is that maquiladoras are operated chiefly by U.S. firms or by foreign firms that use maquiladora products as inputs for their U.S. operations. In either case, these firms are selling to the U.S. market. They attempt to hold down production costs in dollar terms, regardless of where the actual production takes place. So even though workers in a company's foreign plants may be paid in the local currency, the dollar value of these payments is what's important to producers trying to decide whether to produce in Mexico, the United States, or, for example, Hong Kong.

As an illustration, suppose workers in a particular country received 200 pesos per day yesterday and suddenly must receive 300 pesos per day today. However, suppose also that this increase is accompanied by a currency devaluation such that while 10 pesos purchased a dollar yesterday, 20 pesos must be exchanged for a dollar today. This would mean a reduction in the dollar cost of wages from $20 per day yesterday to $15 per day today. Naturally, U.S. firms selling in the United States will suddenly find operating in the peso-issuing country more cost-attractive—even though workers now receive 300 pesos per day instead of 200.

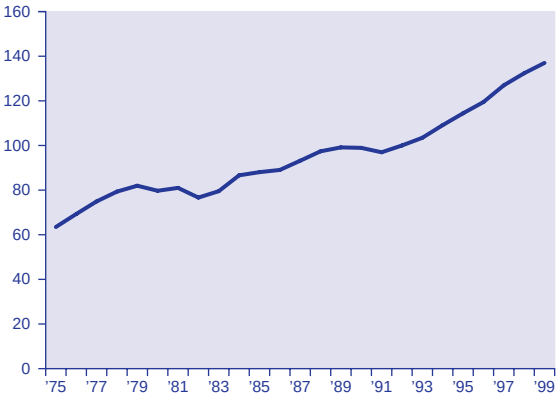
Some may wonder why I (and all other economists who econometrically model maquiladora behavior) use dollar-denominated relative wages rather than some measure of output per wage unit in dollar terms. For a maquiladora owner, the output per wage unit a nonmaquiladora firm can generate may not be relevant. This is because maquiladoras bring management skills and economies of scale that may result in much higher worker productivity than an average Mexican manufacturing plant employing workers of the same skill levels—but without paying wage differentials for the higher productivity.[7] Despite some skilled-labor shortages, Mexico still has an abundance of low-skilled labor whose productivity can be increased through efficient management practices and plant design. Unit labor costs offer little explanatory power in maquiladora models, while simple relative wages have much explanatory power.

IS POST-NAFTA MAQUILADORA ACCELERATION TIED TO NON-NAFTA VARIABLES?

An inspection of the three explanatory variables discussed so far offers insight into why maquiladora employment accelerated after NAFTA's inception. Figure 3 displays U.S. indus-

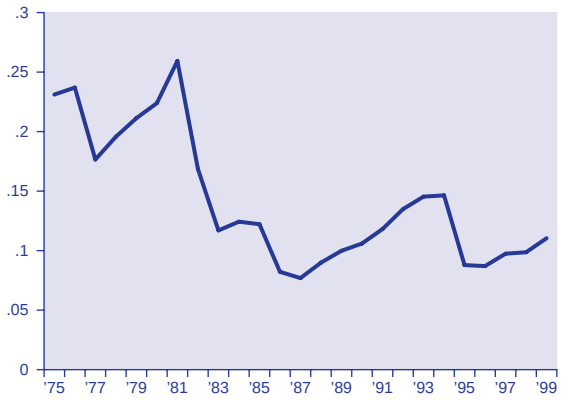
Figure 3
U.S. Industrial Production

Index, 1992 = 100



SOURCE: Federal Reserve Board.

Figure 4
Ratio of Mexican to U.S. Manufacturing Wages



SOURCES: Bureau of Labor Statistics; author's calculations.

trial production for 1975–99. Note the acceleration in 1992 and in 1995. Over the first six years of NAFTA, U.S. industrial production grows 32 percent, compared with 11 percent over the six years before NAFTA.

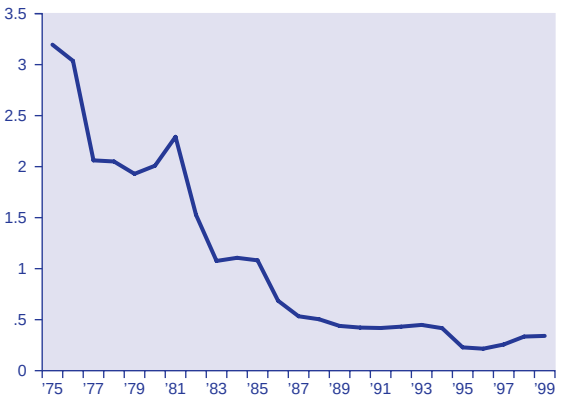
Figure 4 shows the ratio of hourly Mexican to U.S. manufacturing wages, both including benefits and both expressed in dollars. Note the sudden reduction in this ratio in 1995, one year after NAFTA began. Although this ratio edges up in succeeding years, it never goes above its levels of 1991–94. According to the literature, these lower wage ratios may be associated with higher maquiladora employment.

Similarly, the ratio of hourly Mexican manufacturing wages to hourly manufacturing wages in a sample of Asian countries (Hong Kong, Korea, Singapore, and Taiwan) also falls suddenly in 1995 (*Figure 5*). Like the Mexico–U.S. ratio, the Mexico–Asia ratio increases slightly after 1995. But unlike the Mexico–U.S. ratio, the Mexico–Asia ratio never rises to any value reached before 1995. As with the Mexico–U.S. ratios, lower Mexico–Asia ratios may be associated with higher maquiladora employment.[8]

The most recently published econometric models of maquiladora behavior use data series ending in 1988. Eleven years' data are available since the last model was estimated, so it is possible that relations between the independent variable and dependent variables could have changed.[9]

Finally, to test for NAFTA's impact on fluctuations in maquiladora employment, I use a dummy variable with the value of 0 for pre-NAFTA years and the value of 1 for post-NAFTA years. This variable is the most important of this modeling effort. A positive and significant estimated value for the NAFTA coefficient would mean that San Martin (2000), Balla (1998), Carrada-Bravo (1998), the Economic Policy Institute and the U.S. Business and Industry Council Educational Foundation (1997), and Perot and Choate (1993) are correct that NAFTA drives maquiladora growth. A negative and significant estimated value for the NAFTA coefficient would signify that NAFTA discourages maquiladora growth. This result would suggest that the maquiladora-discouraging aspects of NAFTA may dominate the maquiladora-encouraging aspects of NAFTA. If the estimate for the NAFTA coefficient is insignificant, we cannot reject the null hypothesis that the actual value of the coefficient is zero, and so perhaps NAFTA had no impact on the maquiladoras.

Figure 5
Ratio of Mexican to Asian Manufacturing Wages



SOURCES: Bureau of Labor Statistics; United Nations Industrial Development Organization; author's calculations.

Table 1
Maquiladora Employment Equations

	A	B	C	D	E
CONSTANT	.087811*** (.015193)	.077245*** (.015758)	.088691*** (.018936)	.080133*** (.011714)	.080674*** (.011988)
Mex/US Wage (–1)	–.132065** (.060174)	—	–.141554 (.131125)	—	—
Mex/Asia Wage (–1)	—	–.108876* (.059248)	.010268 (.125143)	—	—
Principal Components (–1)	—	—	—	–.014589* (.007566)	–.019336* (.010012)
Principal Components (–2)	—	—	—	–.013934* (.007305)	–.016974 (.012390)
Industrial Production	1.049863** (.395894)	1.131543** (.401794)	1.051087** (.406940)	1.278143*** (.389837)	1.200418** (.484877)
NAFTA Dummy	–.019877 (.025985)	–.010857 (.027943)	–.020874 (.029329)	–.025703 (.022549)	–.025216 (.025341)
R^2	.534362	.504401	.534536	.737014	.747451
Adjusted R^2	.460840	.426148	.431100	.675134	.684314
Standard error of regression	.051558	.053191	.052961	.040064	.040354
Sum of squared residuals	.050507	.053757	.050488	.027287	.026056
Log likelihood	37.75743	37.04029	37.76173	42.39968	—
Mean dependent variable	.118631	.118631	.118631	.121682	.120555
Standard deviation of dependent variable	.070217	.070217	.070217	.070291	.071823
Akaike criterion	–2.935429	–2.873069	–2.848846	–3.399971	—
Schwartz criterion	–2.737951	–2.675591	–2.602000	–3.152007	—
Durbin–Watson statistic	1.548164	1.434754	1.544536	2.027825	1.859293

*** Significant at the .01 level.
** Significant at the .05 level.
* Significant at the .10 level.

NOTE: Standard deviations in parentheses.

PRELIMINARY STATISTICAL EXAMINATIONS SUGGEST THE OLD RELATIONS STILL HOLD

Columns A through C in Table 1 present the results of three simple regression equations, each of which incorporates at least one Mexican wage-ratio variable, plus the industrial production index variable and the NAFTA dummy variable. I use annual data beginning in 1975 and ending in 1999. With the exception of the NAFTA dummy variable, all data are transformed into first differences of their logarithmic forms, so the data will be stationary.[10] Column A reports a regression equation that includes the U.S. industrial production variable (*Industrial Production*) and (following Gruben 1990) one lag of the Mexico–U.S. wage variable (*Mex/US Wage*), together with the NAFTA dummy variable (*NAFTA Dummy*). As expected, the industrial production coefficient is positive and significant. The Mexico–U.S. wage coefficient is negative and significant. Note that the NAFTA dummy variable is insignificant and negative, the implications of which I discuss below.

Column B of the table offers an equation with the same variables, except that the Mexico–Asia wage ratio replaces the Mexico–U.S. wage ratio. The results are essentially the same, however. Industrial production takes on a positive and significant sign. The Mexico–Asia ratio takes on a negative and weakly significant sign. The NAFTA dummy variable coefficient is again negative and insignificant.[11]

Even though the common approach to constructing econometric maquiladora models has been to account for both Mexico–U.S. wages and Mexico-industrializing country wages, an estimation problem usually develops. If I put both wage variables in the same equation, typically neither passes a significance test, even if they do separately. Sign changes also occur. These problems may be seen in Column C of the table, where both the ratio of Mexican to U.S. wages and the ratio of Mexican to Asian

wages appear in an equation with U.S. industrial production and the NAFTA dummy variable. The *t* statistics for the lagged wage-ratio variables fall below the benchmark levels of significance. Moreover, the coefficient on the Mexico–Asia wage ratio takes on a positive sign, even though it is negative when the Mexico–U.S. wage ratio is not in the equation. These weakened results suggest the recurrence "of multicollinearity between the two variables that express relative costs," which appears in a similar maquiladora-related modeling exercise by Hernandez and Navarrete Vargas (1988).[12] Movements in the two wage variables are highly correlated; this correlation substantially reduces the ability of regression analysis to separately attribute variations in maquiladora employment to a wage variable.[13]

We have no direct method for correcting multicollinearity problems beyond increasing the number of observations. A procedure does exist that allows for the weighting of the wage variables to avoid multicollinearity.

Through principal components analysis, the variation of several variables can be compressed into one or more index variables, known as a principal component. The principal component is a linear combination of some collection of variables, such as the two wage ratios in this model. A mathematical procedure is used to maximize the variation of each of the two wage variables that can be captured in one index. This suppresses the contaminating effects of one wage variable's correlation with the other, and multicollinearity ceases to be a problem.

Through this maximization procedure, a coefficient becomes attached to each original variable. In this study, the wage-ratio variables are the two original variables. The values of the coefficients estimated for the variables in this index indicate the relative importance of each original variable in the new, derived component.

It should be noted that principal components estimators are biased. So, unfortunately, are the estimators derived from other procedures to avoid multicollinearity problems—including estimators in ridge regression. However, the focus of this model is to identify NAFTA's impact on maquiladora growth. Since the NAFTA dummy variable has not been converted into a principal component, the estimator bias in the principal component portion of the model will have little effect on the point of this exercise. The relation between fluctuations in U.S. industrial production—also not captured through principal components—and maquiladora employment fluctuations is also unbiased.

DOES NAFTA AFFECT MAQUILADORAS AFTER ALL? MORE COMPLETE RESULTS

Having applied principal components estimation to create an index variable that is free of multicollinearity problems but captures both Mexico–Asia and Mexico–U.S. wage relationships, I use this variable to test for NAFTA's impact on maquiladora employment fluctuations.

The result I present (Column D of the table) is the culmination of a large number of prior estimations in which I tested for the optimal set of lags. In estimating this model, I constructed alternative models that offered all possible combinations of lags from zero (that is, contemporaneous) to three lags for the principal component wage-ratio variable and for the industrial production index variable (which, again, is transformed into first differences of logarithms). "All possible combinations" includes asymmetric combinations.[14] I included up to three annual lags for U.S. industrial production and for the Mexican wage-ratio principal component.

Of all the equations I estimated, this one has the lowest Schwartz criterion value (a model with one and two lags of the Mexican wage principal component variable, a contemporaneous U.S. industrial production variable, and a NAFTA dummy variable).[15] As with the preliminary models in Columns A through C, the results in Column D do not support the claims of San Martin (2000), Balla (1998), Carrada-Bravo (1998), the Economic Policy Institute and the U.S. Business and Industry Council Educational Foundation (1997), Perot and Choate (1993), or of Perot in his television appearances in opposition to NAFTA and maquiladoras. (See note 2.) The same is true for all models that I constructed but do not report here.

The Schwartz criterion offers information about optimal lag length. The criterion punishes overparameterization—or overloading the model with lags of explanatory variables—more severely than other lag-length criteria.

The winning Schwartz criterion model offers an interesting picture of the dynamics of maquiladora operation and management. First, with the exception of the NAFTA dummy variable, the Schwartz winner has no coefficients with significance levels worse than .0735. Coefficients are at least weakly significant, a substantially better result than the previous equations and a commentary on the ability of principal components to capture collective variations. More interestingly, the Schwartz winner has a first and second lag of the Mexican wage-ratio principal component and a contemporane-

ous coefficient of U.S. industrial production.

That this lag configuration is the Schwartz criterion winner suggests that maquiladora management is typically less fretful about demand-side risk than about cost or supply-side risk. As for the demand side, note that the maquiladoras respond within the same year to changes in U.S. industrial production. Other things equal, maquiladoras add employees in the same year in which U.S. industrial production goes up and release them in the same year U.S. industrial production falls. Note also that, according to these results, a 1 percent increase (decline) in U.S. industrial production is associated with a 1.278 percent increase (decline) in maquiladora employment.

The same Schwartz criterion winning lag structure—with its one and two lags of the relative wage variable—suggests that managers take two years to completely respond to shocks to relative wages (supply-side shocks). The lag configuration suggests that maquiladora management takes a good deal of time deciding whether the wage shocks are transitory or will be long-lived, even though responses to changes in demand (that is, industrial production) are relatively quick.

Maquiladora companies may need so much time to adjust to a wage because of their dollar-denominated (rather than peso-denominated) perspective on costs. When we express all wages in dollars, the largest and most sudden shocks to relative wages will involve currency devaluations. The lag structure of the Schwartz winner is consistent with maquiladora companies waiting to see if Mexican wages will adjust to their old levels in dollars immediately after a devaluation or if the adjustment process will be a slow one. As Figures 4 and 5 show, the adjustment was very slow in the wake of Mexico's 1982 and 1994 devaluations. These devaluations not only made the dollar value of Mexican wages fall hard and fast (compared with U.S. or Asian wages), but Mexican wages in dollar terms remained depressed for years.

However, this peso-wage stickiness may not be a certainty. First, it need not persist after every devaluation. McLeod and Welch (1991) show that in many countries this stickiness is not typical and that relative wages return to their old relations far more quickly than in Mexico.

Second, the same investor pressures that trigger Mexican devaluations can simultaneously trigger exchange-rate pressures elsewhere. When a Mexican devaluation lowers wage costs in dollar terms, maquiladora owners may wait to see if devaluations will follow in other countries where they own plants, eroding the Mexican wage advantage. Mexico's last exchange rate crisis, in 1994–95, sparked capital outflows elsewhere in Latin America and in the Philippines and Poland. The Russian devaluation of third-quarter 1998 created financial pressures in Brazil and Argentina, as well as in Mexico. Russia's crisis triggered fears about Brazil that were sufficient to cause large reserve losses (Treuherz 2000). In the wake of these losses, political events within Brazil incited further capital outflows until Brazil devalued the *real* in January 1999. The lag structure on wage ratios is consistent with the time firms may wait to see how these exchange-rate relations sort themselves out.

With respect to the NAFTA dummy variable, the conjectures of the authors who claim NAFTA drove maquiladora growth are unconfirmed. The coefficient value for this variable proves insignificant in every one of the scores of equations I constructed in preparation for building the model I present here. For the authors mentioned, these insignificant coefficient values would offer cold comfort, in and of themselves. However, the NAFTA dummy variable coefficient also takes on a negative sign. This, and the fact that every form of this model gives a negative sign to the dummy variable coefficient, means a coefficient value significantly different from zero would reject those authors' claims even more soundly than insignificance would. It should be reiterated that this negative sign appears in every estimation I performed, ranging from three lags of one variable and no lags of the other, all the way to no lags of the one variable and three lags of the other.

INSTRUMENTAL VARIABLES APPROACH

One last refinement is to deal with the possible problem of simultaneity bias, which arises because employment and wages are jointly and simultaneously determined.

Accordingly, a final step in estimating this model is to substitute an instrumental variable for the lagged principal components originally included to adjust for the multicollinearity problems in the wage ratios.[16] A Hausmann test shows that the instrumental variables model uncorrected for heteroskedasticity is not statistically significantly different from the ordinary least squares model. So from a statistical point of view, there is no need to construct an instrumental variables equation. Nevertheless, in Column E of the table, I present results for instrumental variables estimation because of theo-

retical reasons to suspect simultaneity bias, even if testing does not bear them out. As can be seen, the first lag of the instrumented principal component (wage-ratio variable) is negative and significant, while the second lag is negative and insignificant. As before, the industrial production variable is positive and significant, while the NAFTA dummy variable is negative and insignificant. These results are so consistent with the ordinary least squares results in Column D that they add little to this narrative aside from offering assurances the OLS results are quite robust.

SUMMARY AND CONCLUSIONS

In response to widespread arguments that Mexican maquiladoras' rapid growth after NAFTA was a result of NAFTA, I have performed extensive econometric tests of its effect on maquiladora employment. The results of these tests are resoundingly negative. NAFTA did not make maquiladoras grow faster. Such effect as NAFTA had was negative, not positive, albeit statistically insignificant. So we cannot say that NAFTA had any effect on maquiladoras.

Instead, the acceleration of maquiladora employment growth from NAFTA's inception through 1999 can be explained by changes in demand factors (as expressed by changes in the U.S. industrial production index) and in supply-side/cost factors (as expressed by changes in the ratios of Mexican to U.S. manufacturing wages and to manufacturing wages in four Asian countries). Growth in the U.S. industrial production index over the six years following NAFTA was roughly three times as rapid as during the six previous years. Likewise, Mexico's 1994 devaluation meant that during the first six years of NAFTA, the ratio of Mexican manufacturing wages to their counterparts in the United States, Hong Kong, Korea, Singapore, and Taiwan was far below these ratios during the six years before NAFTA.

The basic equation this article presents is the culmination of many estimations. I present the first- and second-lag configuration equation because it has the optimal lag structure, based on the Schwartz criterion. After adjusting for degrees of freedom in the ordinary least squares version, this equation captures 67.5 percent of all variation in maquiladora employment; an estimated 73.7 percent of variation is captured before adjusting for degrees of freedom. After adjustment, the instrumental variables version captures 68.4 percent of total variation.

The lag length has interesting implications for how maquiladora owners handle risk. These companies respond relatively quickly to changes in demand (as expressed by changes in the U.S. industrial production index), while the response to shifts in relative wages does not occur during the same year as the shift in relative wages (as expressed by changes in the ratios of Mexican to U.S. and Asian wages). Instead, these responses mainly occur one and two years after the shifts, as if maquiladora operators wait to see if the wage shocks are going to be permanent. It is telling that in 2001, following the period I model, maquiladora employment has fallen significantly as U.S. industrial production has slid—validating my model.

While some evidence suggests NAFTA has affected trade between the United States and Mexico (Gould 1998), the effects were not expressed through Mexico's maquiladora system. Trade is a complicated process, and so are changes in trade policy such as NAFTA.

NOTES

I wish to thank Eric Millis for his careful econometric work and his valuable judgment and advice, Ana Prats for organizing Table 1 and the figures, and Monica Reeves for editing this article with great care.

1 Note that the return trip is not under the jurisdiction of the maquiladora program. The tariff arrangements involve U.S. law, not Mexican law.

2 One of presidential candidate Ross Perot's television props was a blowup of an ad inviting maquiladoras to locate in the southern Mexican state of Yucatán. This, Perot said, was what NAFTA would result in.

3 Balla and Carrada-Bravo are pro-NAFTA. Perot and Choate and the Economic Policy Institute and the U.S. Business and Industry Council are anti-NAFTA.

4 The Border Industrialization Program, under which Mexico's maquiladoras began, was introduced by Mexico's secretary of commerce and industry after a trip to East Asia. The program was his policy response to what he had seen—labor-intensive assembly operations, with East Asian workers employed in plants that belonged to U.S. corporations and the same import tariff arrangements that were later applied to maquiladoras (Fernández-Kelly 1987, 151).

5 See Boyer (1997) for a detailed characterization of Mexican environmental law and its significance for maquiladoras.

6 Three general categories of U.S. tariff policy have been applied to maquiladora products imported into the United States. The first—Harmonization Tariff Schedule 9802.00.60—permits the importation of fabricated but unfinished metal products processed abroad. Duties are assessed on the value added in Mexico, rather than on the product's total value. The products must be processed in the United States

before being sent abroad and further processed in the United States upon their return. The second category—HTS 9802.00.80—makes an article assembled in Mexico from U.S.-made components exempt from import duties on the components. These products need not have metal components. The third category, now moot, was the most generous. If the goods assembled or manufactured in Mexico had at least 35 percent Mexican content upon import into the United States, they were eligible for duty-free treatment under the U.S. Generalized System of Preferences, or GSP. Mexico was removed from the list of GSP-eligible countries when it joined NAFTA, but NAFTA allows products the same immediate, duty-free entry as they had under the GSP.

As a result of NAFTA, an additional Harmonization Tariff Schedule was created. HTS 9802.00.90 allows for the duty-free treatment of textile and apparel products assembled in Mexico from U.S.-formed and cut fabric. Textile and apparel products have historically entered the United States under special trade restrictions, so liberalizations of such trade have had to be product-specific. For apparel that had entered under 9802.00.80, only the value of U.S.-cut fabric and U.S.-made fasteners such as buttons and zippers came in duty-free. Under 9802.00.90, the value added in Mexico—including labor and overhead—also enters the United States duty-free. For additional discussion, see U.S. International Trade Commission (1999).

[7] On the issue of scale economies, note that the employment and output of the average Mexican manufacturing plant is smaller than that of the average maquiladora or the average U.S. plant. In the wake of Mexico's 1994 devaluation, real manufacturing wages adjusted downward and remained below predevaluation real wages for years. In dollar terms, average overall manufacturing sector wages in Mexico remained below 1994 levels as late as 1999, the most recent year for which data are available.

[8] When I applied augmented Dickey–Fuller and Phillips–Perrone tests to the variables discussed (including the dependent variable, maquiladora employment), none could reject the null hypothesis of a unit root. I accordingly took first differences of logarithms of these variables, which allows rejection of this hypothesis in every case.

[9] All three models cited here—Hernandez and Navarrete Vargas (1988), Gruben (1990), and Truett and Truett (1993)—use a Mexico–U.S. wage variable, a Mexico–other industrializing country wage variable, and a U.S. output variable.

[10] See note 8 for an explanation of why I used first differences. The wage data for all countries—Mexico, Hong Kong, Korea, Singapore, Taiwan, and the United States—are from the International Comparisons of Hourly Compensation Costs for Production Workers in Manufacturing series, on the U.S. Bureau of Labor Statistics web site, ftp://ftp.bls.gov/pub/special.requests/ForeignLabor/supptab.txt. These data go back to 1975. Again, note that the virtue of these data is that they account for benefits as well as salaries. Maquiladora employment data are from the Mexican government's INEGI (Instituto Nacional de Estadística, Geografía e Informática) web site, www.inegi.gob.mx. U.S. industrial production data are from the Federal Reserve Board.

[11] Although I do not report them here, the results are essentially the same with or without the NAFTA dummy variable. This variable does not affect the equation in this configuration.

[12] Hernandez and Navarrete Vargas (1988, 225), my translation. Their model is quarterly, rather than annual, and uses wage data uncorrected for international differences in worker benefits, unlike the U.S. Bureau of Labor Statistics data my model uses. Truett and Truett (1993) avoid results consistent with multicollinearity by using a different dependent variable than other authors. However, the dependent variable they apply has been criticized on other grounds.

[13] Even when the data are transformed into first differences of logarithms, representing growth rates of the Mexico–U.S. and Mexico–Asia wage variables, the coefficient of correlation between the two is .8852. This is substantive evidence of serious multicollinearity. In contrast, the coefficient of correlation between the transformed version of the Mexico–Asia wage ratio and the similarly transformed (first differences of logarithms) U.S. industrial production index variable is only .0935. The coefficient of correlation between the transformed version of the Mexico–U.S. wage ratio and the transformed U.S. industrial production index is .1232. These last two, low degrees of correlation suggest that the multicollinearity in the equations is strictly in the wage-ratio variables.

[14] An example of asymmetry would be a contemporaneous-only U.S. industrial production variable with three lags of the principal components variable, or vice versa. I also ran symmetrically lagged models, with contemporaneity plus three lags of the industrial production variable, along with (in the same equation) the same lag structure for the principal components variable and so on. In so doing, I followed the London School of Economics paradigm of running every possible combination (in this case, up to three annual lags).

[15] The Schwartz criterion is one of the most common tests for optimal lag specification. When testing alternative lag structures for a model, the one with the lowest value wins.

[16] The goal in creating instruments to proxy for the original variable is to find variables that may be correlated with the right-hand-side variable subject to simultaneity bias, but not with the dependent variable. In this case, a linear combination of the contemporaneous peso–dollar exchange rate together with lagged

principal components was considered a reasonable candidate for constructing an instrument for the original component. When the Sargan test of instrument validity was applied, the related *F* value was 0.3048, implying a .9024 level of significance, clearly demonstrating the instrumentation was valid.

REFERENCES

Balla, John A. (1998), "Data Transfer: What's New?" *Twin Plant News*, November, 55–56.

Boyer, Madeleine (1997), "Pending Developments in Mexican Hazardous Waste Law (Paper presented at the 1997 Advanced Environmental Law Course, State Bar of Texas, Houston, December 4).

Carrada-Bravo, Francisco (1998), "Business Education and Joint Enterprise in the NAFTA Countries," Working Paper, Department of World Business, Thunderbird–The American Graduate School of International Management (Glendale, Ariz.).

Council of the Americas (1999), *NAFTA at Five Years* (New York: Council of the Americas, January).

Echeverri-Carroll, Elsie L. (1999), "Industrial Restructuring of the Electronics Industry in Guadalajara, Mexico: From Protectionism to Free Trade" (Austin: University of Texas Bureau of Business Research).

Economic Policy Institute and the U.S. Business and Industry Council Educational Foundation (1997), *The Failed Experiment: NAFTA After Three Years* (Washington, D.C.).

Fernández-Kelly, M. Patricia (1987), "Technology and Employment Along the U.S.–Mexican Border," in *The United States and Mexico: Face to Face with New Technology*, ed. Cathryn L. Thorup, U.S. Third World Policy Perspectives series, no. 8 (New Brunswick, N.J.: Transaction Books).

Garces-Diaz, Daniel (2001), "Was NAFTA Behind the Mexican Export Boom (1994–2000)?" (Mexico City: Banco de México, February).

Gould, David M. (1998), "Has NAFTA Changed North American Trade?" Federal Reserve Bank of Dallas *Economic Review*, First Quarter, 12–23.

Gruben, William C. (1990), "Do Maquiladoras Take American Jobs? Some Tentative Econometric Results," *Journal of Borderlands Studies* (Spring), 31–45.

Grunwald, Joseph, and Kenneth S. Flamm (1985), *The Global Factory: Foreign Assembly in International Trade* (Washington, D.C.: Brookings Institution).

Hernandez, Jose Luis, and Rodolfo Navarrete Vargas (1988), "Determinantes del crecimiento del empleo en la industria maquiladora de exportación en México," in *Maquiladoras: Primera Reunion Nacional Sobre Asuntos Fronterizos*, ed. Arturo Garcia Espinosa (Monterrey: Asociación Nacional de Universidades e Institutos de Enseñanza Superior and Universidad Autonoma de Nuevo Leon), 221–47.

McLeod, Darryl, and John H. Welch (1991), "Free Trade and the Peso," Federal Reserve Bank of Dallas Research Paper no. 9115 (Dallas, July).

Perot, Ross, and Pat Choate (1993), *Save Your Job, Save Our Country: Why NAFTA Must Be Stopped—Now!* (New York: Hyperion).

Romer, Paul M. (1993), "Two Strategies for Economic Development: Using Ideas and Producing Ideas," in *Proceedings of the World Bank Annual Conference on Development Economics 1992* (Washington: International Bank for Reconstruction and Development), 63–91.

Rothstein, Jesse, and Robert I. Scott (1999), "NAFTA's Casualties" (Economic Policy Institute paper presented at "NAFTA: The First Five Years," sponsored by the El Paso Branch of the Federal Reserve Bank of Dallas, El Paso, November 4).

San Martin, Nancy (2000), "Overworked and Underage," *Dallas Morning News*, March 5, A1, A31–A33.

Treuherz, Rolf Mario (2000), *The Crisis Manual for Emerging Countries* (Palo Alto, Calif.: Fabrizio Publications).

Truett, Lila J., and Dale B. Truett (1993), "Maquiladora Response to U.S. and Asian Relative Wage Rate Changes," *Contemporary Policy Issues* 11 (January): 18–28.

U.S. International Trade Commission (1999), *Production Sharing: Use of U.S. Components and Materials in Foreign Assembly Operations, 1995–1998*, USITC publication no. 3265 (Washington, D.C.: U.S. International Trade Commission, December).

Watkins, Ralph J. (1994), "Implications of the North American Free Trade Agreement for Mexico's Maquiladora Industry and the Use of the Production Sharing Tariff Provision," in *Production Sharing: U.S. Imports Under Harmonized Provisions 9802.00.60 and 9802.00.80, 1989–1992* (Washington, D.C.: U.S. International Trade Commission).