Regional Labor Market Integration: Northern Mexico and Southern USA

Abstract

In this paper, the analysis of co-dependence between the US and Mexico labor markets is carried out by estimating the cyclical component of California's and Texas' manufacturing employment and four US Border Mexican cities through the Hodrick-Prescott filter. We estimated the smoothing parameter following a calibration technique proposed by Guerrero et al (2001) which allows us to obtain the best linear unbiased estimator of the trend component. Our analysis suggests that after 1994 there has been greater labor market integration between Mexico's northern region and US' southern region. This greater integration has implied a change in the nature of the short term relationship of manufacturing employment between Mexico and the US. The change is also significant on the relationship between Mexican real wages and US employment.

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1. Introduction

A number of studies have illustrated the extent by which trade and direct investment liberalization in Mexico fostered some economic sectors while restricted the growth of others. This process of industrial restructuring has implied the relative growth of some Mexican regions and the decline of others.[1] The regional adjustments of production have also implied adjustments in their labor markets. Hanson (2003), for instance, in a recent study about the Mexican labor market, has pointed out the differentiated impact that economic liberalization is having upon regional labor markets; in particular, trade and investment liberalization seem to have accentuated and even increased existing differences across regional wage rates. In particular, regions most exposed to trade and overseas direct investment obtained wage gains. According to these findings, skilled workers living in cities located near the US border were the most benefited (Meza, 2002).

Another conclusion of these studies is that Mexican and US labor markets became integrated (Robertson, 2000). Integration within this context means that a given shock in the US wage rate induces a change in the Mexican wage rate so that the ratio between both wage rates is affected only temporarily. After an adjustment period, the initial wage differential is restored. He further argues that this integration is even stronger between Mexico's northern border and the US economy. However, even though both labor markets are integrated the evidence in favor of convergence is yet elusive (Robertson, 2000; Hanson, 2003).

In Robertson's study, market integration is measured by the responsiveness of wages in Mexico when wages change in the United States. The adjustment mechanism of relative

[1] See for instance, Katz (1998) and Aguayo and Salas (2002).

wages is based on the assumption that labor migrates between both countries in response to changes in relative wages. Within this framework then, an increase in the relative wage of the United States causes labor to migrate north which, in turn, induces the relative wages to return to their initial level.

It is unclear however how overall labor demand in Mexico is responsive to changes in the US wage rate, -even for the US border Mexican region- as Robertson argues. For one thing, the employment distribution in the northern border cities shows that only about 35% of total employed workers work in the sector that is closely tied to the US economy, -the maquiladora sector-. Another 50% is employed in the commerce and service sectors whereas the remaining 15% works in the construction and transport sectors.[2] Second, a key assumption in Robertson's study is that the decision to migrate to the US depends on short run variations of the wage differential between both economies. However, several authors have argued that such a decision to migrate is more due to the lack of employment opportunities than to variations of relative wages. Furthermore, the assumption not only implies that workers have access to information about US labor market conditions but also that although there are restrictions to labor migration, they are not impediments to labor mobility so that relative wages ultimately respond to it.

Due to these limitations we propose an alternative approach to measure integration between Mexican and U. S. labor markets. To the extent that Mexico's northern border region is the center of maquiladora plants and assuming that their levels of production depend on US demand as well as the international demand for products assembled in these Mexican plants, we shall assume that short run variations of labor demand in these northern

[2] These percentages are average of the period 1987-2003 and were taken from the National Survey of Urban Employment (ENEU, several years).

border cities are correlated to fluctuations of the U. S. business cycles, particularly, manufacturing employment. Changes in labor demand, in turn, should induce changes in wage rates, ceteris paribus. Thus we should expect that the behavior of employment and wage rates are somewhat dependent on the performance of the U. S. manufacturing sector.

Given that the Mexican cities located along the US border have been identified as the ones most benefited by trade and investment liberalization and by NAFTA in particular, we center our analysis on them. We depart from previous studies about the integration of Mexican and U. S. labor markets in three important respects. First, we consider the employment and wage rates as time series which after adjusting for seasonality and outliers exhibit two components: a trend and a cyclical. Second, the degree of integration between these cities' labor markets and the US economy is measured by the cross-correlation of their cyclical components. Third, we evaluate the impact of NAFTA upon the short- and long-term components by comparing the results between the pre-NAFTA period (1987:01-1994:04) and the NAFTA period (1995:01-2003:01).

The analysis is carried out by means of the Hodrick-Prescott Filter (Hodrick and Prescott, 1997). Unlike studies that use the Hodrick-Prescott filter however, the smoothing parameter is estimated through a calibration technique that allows us to obtain the best linear unbiased estimator of the trend component (Guerrero, et al, 2001).

The paper is organized as follows. Section 2, builds the case for expecting greater labor market integration between Mexico's northern border region and the US economy. In particular, we stress the role played by foreign direct investment (FDI) in accelerating such a process. Section 3 submits the basic ideas of the Hodrick-Prescott (HP) filter. The use of the HP filter has been subject to criticisms by some authors. A central argument of these critics refers to the possibility that the HP filter can generate spurious cycles. However, we present some evidence that in our case this does not occur. This section also presents the data used for the empirical analysis. Section 4 shows the main results for the short run fluctuations and the long run behavior of employment in both economies, while section 5 concludes.

2. FDI, Maquiladora Plants and Labor Market Integration

For the last two decades, less developed economies and emerging economies have shown a renewed interest to attract Foreign Direct Investment (FDI) as a means to sustain, -even accelerate-, their economic growth.[3] The argument is that by providing external savings to acquire resources, technology and new administration, marketing and distribution techniques, the host country will improve its productivity. If, in addition, these "new" firms have some spillover effects upon the domestic firms, overall efficiency will further accelerate. In the labor market, the increased production of both domestic and foreign firms will induce higher labor demand of skilled and unskilled labor, and so wage rates will increase.

In the Mexican context, recent studies have shown that economic liberalization has increased existing differences across regions. In other words, the expansion of some economic activities and the contraction of others have brought a significant regional restructuring in production and employment. The uneven performance of the Mexican regions is explained not only by their relative abundance of productive resources but also by

[3] Moran (2000) argues that during 1990-1998 the flow of FDI directed to less developed economies went from US 24 billions to US 120 billions.

their access to infrastructure and lower transport and labor costs which attract foreign direct investment (Hanson, 2003; Katz, 1998).

Máttar et al (2002) present some of the most important features of FDI in Mexico. First, it increasingly has been concentrated in manufactures: from 49 % during 1981-93 to approximately 63 % during 1994-2000. Second, the maquiladora plants have been the main receptors. Third, and related to the previous point, it has been directed to highly concentrated industries, with strong multinationals' presence. Fourth, the large majority of the enterprises are of US origin: during 1982-1993 about 60 % of the enterprises were from the US which by the end of 2000 it went up to around 86 %. Fifth, the strong international position of Mexico's exports is strongly determined by the growth of foreign firms' export which was evident a decade earlier than NAFTA.

The distribution of FDI can also be seen geographically. During 1994-2002 a significant percentage of total FDI was directed to all six US-Border states[4]: about 26.7 % on average. This percentage diminishes about 10 points when we exclude Nuevo Leon[5] and declines even further if we consider only Baja California, Chihuahua and Tamaulipas to about 14.2 % on average.[6]

The FDI pattern differs somewhat when we exclude Nuevo Leon ; in particular, 1997, 1998 and 2000 represent years in which FDI in Nuevo Leon followed a different trend than

[4] There are six Mexican States that share limits with the US: Baja California, Coahuila, Chihuahua, Nuevo Leon, Sonora and Tamaulipas.

[5] We exclude Nuevo Leon because it actually shares a small border region with the United States which is no a maquiladora center. Nuevo Leon is an industrial state whose capital, Monterrey, is the second largest city in Mexico.

[6] To the extent that Tijuana, Ciudad Juarez and Matamoros (located in Baja California, Chihuahua and Tamaulipas, respectively) are the oldest and the most important maquiladora centers, we wanted to isolate the percentage of FDI that was directed to this particular region.

the rest of the Border States.[7] The differentiated inflow of FDI between the border regions and the rest of the Mexican regions induced a series of adjustments that included not only their productive apparatus but also their labor markets as well.

Meza (2002), for instance, found that the return to education rose significantly during 1993-1998 in the main cities located along the US border. Not only there was a general increase in the rate of return to education compared to the rest of Mexican regions but also the returns of college graduated enjoyed the fastest growth of all, resulting in a significant increase of wage inequality in these border cities.

The asymmetry in regional performance has also manifested itself in a drastic reduction, even a reversal, of regional convergence of per-capita output since the mid-eighties (Esquivel, 1999).

Despite the fact that for the last ten to fifteen years the growth rate of new maquiladora plants has been larger in non-border regions, a distinguishing feature of the US border region is that it hosts, on average, more than 75 % of total plants and around 82% of total maquiladora employment.[8] This is the reason why Mexican researchers believe that this region's economic performance depends upon the behavior of the maquiladora plants.

Table 1 shows the average employment distribution by main economic sectors (as a percentage of each city's total employment) during the period 1987-2000. The figures are drawn from the National Survey of Urban Employment (ENEU) for the four largest cities in the Mexican northern border region; namely, Tijuana, Ciudad Juarez, Matamoros and Nuevo Laredo.

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[7] The sharp decline of the percentage of FDI in all three estimates during 2001 is explained by the purchase of the largest Mexican bank by Citibank. This transaction was recorded as a FDI that went to Mexico City.
[8] It should be noted however that during 1990 and 2003, the annual rate of decline of the region's share in the number of establishment and employment in the maquiladora sector were 1.04 and 0.98 percent respectively (source: INEGI, http://dgcnesyp.inegi.gob.mx/bdine/bancos.htm).

As can be observed, in the border region as a whole, about a third of employed labor is occupied in the manufacturing sector which is mainly operated through maquiladora plants. In Ciudad Juarez and Matamoros the importance of the maquiladora plants as a source of employment is even greater since they occupy about 41.3% and 38.8% of these cities' labor, respectively. In contrast, its importance in Tijuana and Nuevo Laredo is much lower than the other sectors: 27% and 23%, respectively.

Table 1: Average Employment Distribution, 1987-2000

	Ciudad Juarez	Tijuana	Matamoros	Nuevo Laredo	Border Region
Manufacturing	0.413	0.271	0.388	0.236	0.329
Commerce	0.197	0.259	0.182	0.208	0.212
Service	0.257	0.270	0.262	0.306	0.273
Construction	0.046	0.067	0.079	0.082	0.068
Transport	0.033	0.050	0.042	0.106	0.057

Note: the figures do not add up to one because the table omits workers employed in Mining, Agriculture and other sectors.
Source: ENEU, 1987:01-2000:04.

The Service sector comes second since more than 27% of the region's labor is employed here. Commerce comes third since it generates about 21% of total regional employment. Table 1 also includes Construction and Transport which in the case of Nuevo Laredo occupy a fairly significant percentage of employed workers (i.e., about 10%).[9]

A distinguishing feature of the manufacturing sector in these border cities is that it is mainly composed by maquiladora plants or inbound assembly plants.[10] In other words,

[9] It should be noted that Nuevo Laredo is the main port of entry/ exit of goods transported by trucks.
[10] Actually, there is a debate among Mexican researchers about whether these maquiladora plants are merely assembly plants or not. Some argue that maquiladora plants in Mexico have evolved into plants with research and development facilities (see for instance Carrillo, …). Others less optimistic researchers note that although there are one or two such cases, there are still very little evidence that the entire maquiladora sector is moving towards such a situation. In fact, the large majority of maquiladora plants are still assembly plants. What

maquiladora plants constitute a significant portion of the region's labor demand. Furthermore, given its relative importance as an employment source in these cities, it is no wonder that Robertson (2000) and Hanson (2003) have found that Mexico's northern border region and the US labor markets are integrated despite the wide wage differential that there is between both economies.

To present our ideas of how labor markets might be integrated, let us assume that there are two countries: a foreign country, A and a domestic country, B. Country B is relatively labor abundant so that its average wage rate is lower than in country A. Firms in country A have a choice between producing in their own country and move part, or all, of their production to country B.[11] To capture the essence of the maquiladora plants we shall assume that the majority of plants located in country B are subsidiaries of parent firms located in country A. These plants are not autonomous subsidiaries since their production decisions are taken by the parent firm. Few plants located in country B might be domestically owned but still their decisions on production are determined by the volume of production in country A.[12] Furthermore, production of plants in country B is re-exported to the home or a third country; thus, total output of firms in country B is traded and none is used for country B's own consumption. To the extent that we are interested in analyzing the relationship between labor markets in both countries, we assume that some firms in country A have already taken their decisions to move some, or all, of their production facilities to country B.

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seems to be technological upgrading in the maquiladora productive process, is in reality a reflection of the technological advancement that the different industries are going through.

[11] The decision to locate some, or all, of their production in country B is based on a number of variables such as the expected demand in the chosen location, the factor costs that would be faced in the new location, the number of local and foreign firms active in the same location (which could result in positive or negative externalities), and public policies in country B designed to attract them (Mayer and Mucchielli, 2002).

[12] This might be the case of subcontracting.

There are technological differences between both countries –country A being the more advanced one. In the long run, production in either country further exhibits decreasing returns to Capital (K) and Labor (L) (for a given technological level). All these assumptions are summarized in the following production functions for country A and country B,

(1) $$q_A = f(K_A, L_A)$$

(2) $$q_B = g(q_A, K_B, L_B)$$

Production functions (1) and (2) exhibit the usual properties: homogeneous of degree one, declining marginal productivity of capital and labor. Equation (2) indicates that production in country B depends on production in country A in addition to capital and labor. Decisions about production in country B by the parent firms are introduced as an input that will effectively limit its production.[13]

We shall assume that the contribution of country A's production on country B's output is uncertain, that is, $\partial q_B / \partial q_A >< 0$. A priori we cannot determine the nature of the relationship between production in both countries because it depends on the types of maquiladora plants and/ or on the goods they produce.

We identify three types of maquiladora plants. First, plants arising due to the migration of firms from country A to country B searching for lower production costs, including labor (characteristic of small and medium sized single plants). Second, plants emerging from country A's firms' decision to move a segment of their production chain to

[13] We can think of this as a bounded maximization problem where firms maximize production subject to the restriction that production is determined by the parent firm.

country B. Third, plants emerging due to country A's firms' decision to move production of low value added goods to country B.

If the maquiladora plants are of the first type then one would expect that a decline in country A's employment is correlated with an increase in country B's employment almost contemporaneously. If, on the other hand, the plants are of the second or third type then the association between both labor markets is less clear. They both move in the same direction if the production segment in country B is complementary to the manufacturing production in country A. However they would move in opposite directions if the production in both regions are substitute one to another.

In the short run, technological differences remain constant and production of a "representative" plant in either country depends only on labor so that the short run production function thus becomes $q_i = f_i(L_i) \quad \forall i = A, B$. Changes in production in both countries can be expressed as,

$$dq_A = \frac{\partial f}{\partial L_A} dL_A \tag{3}$$

$$dq_B = \frac{\partial q_B}{\partial q_A} dq_A + \frac{\partial q_B}{\partial L_B} dL_B = \frac{\partial g}{\partial f} \frac{\partial f}{\partial L_A} dL_A + \frac{\partial g}{\partial L_B} dL_B \tag{4}$$

Equations (3) and (4) can be interpreted as equations of labor demand in country A and country B, respectively. From (4) we obtain the relationship between changes in employment in country B and changes in employment in country A,

$$dL_B = \frac{1}{PML_B}(dq_B - \mu\, dL_A) \tag{5}$$

where $\mu = \frac{\partial g}{\partial f}\frac{\partial f}{\partial L_A}$ measures the impact of changes in manufacturing output (employment) in country A on country B's manufacturing output which, as argued, its sign is uncertain. From equation (5) we determine that employment in the maquiladora plants depends inversely on labor productivity, positively on changes in production in country B and on changes in employment in country A. The nature of the relationship between changes in employment in both countries is determined by the sign of μ.

More integration can be expected to lead to more trade; and more international trade will result in more highly correlated employment cycles. But this view, particularly the second part is not universally accepted. For instance, Eichengreen (1992) and Krugman (1993) have pointed out that as trade become more highly integrated, countries specialize more in production. By this logic, increasing specialization will reduce the business cycle correlation. Furthermore, Ricci (1996) using a static model which incorporate both inter-industry and intra-industry trade, found that flexible exchange rates induce specialization compared with fixed rate, since they automatically dampen the effects of industry specific shocks. Therefore, taking in account that almost at the same time that Mexico was signing NAFTA, (that increased significantly trade between Mexico and U.S.A), the Mexican government adopted a flexible exchange rate, Ricci's argument might partially explain the change in the relationship between Mexican wages and the US real output.

A trade agreement between both countries may change the nature of the relationship between both labor markets. If the resulting trade flows between both countries are more intra-industry than inter-industry then one would expect that the change in employment in both countries become positively correlated. However, if as a result of the trade agreement the resulting trade flow derives in an increased specialization between both economies then changes in employment in both countries go in opposite directions.

In other words, if international integration tends to raise the covariance of country specific demand shocks and aggregate productivity shocks, it would increase the international coherence of business cycles. However, if integration tends to rise the degree of industrial specialization, it would lead to more asynchronous business cycles. The importance of this later effect depends on the degree of specialization induced by integration.

Employment's short run fluctuations can be expressed in terms of its deviations from its long run trend. Thus, the correlation between country A and country B employment's short run fluctuations v, over time span τ and de-trended with method a, can be denoted by

(6) $$Corr\,(v,a)_{A,B,\tau}$$

Labor market integration can also be seen through the impact of changes in country A's production on country B's wage rates. From standard maximization behavior, plants in country A and country B will demand labor to the point where the marginal product equal real wage rate. Thus,

(7) $$L_A = L_A(\frac{w_A}{P_A}) \quad and \quad L_B = L_B(\frac{w_B}{P_B})$$

(8) $$q_B = g[L_A, L_B(\frac{w_B}{P_B})]$$

From (8) we can obtain the relationship between changes in real wages in country B and changes in employment in country A.

(9) $$d\left({}^{w_B}\!/_{P_B}\right) = \frac{1}{PML_B\,\theta}(dq_B - \mu\, dL_A)$$

Where $\theta = \dfrac{\partial L_B}{\partial (w/P)_B}$ is the sensitivity of labor demand to real wage rates in country B. As in (5) μ measures the impact of changes in country A's manufacturing employment on country B's manufacturing output. Depending on the size of θ and B's labor Productivity, changes in A's employment might have significant effect on B's real wages.

The purpose is therefore to provide some estimates of (6) and (9) and whether these estimates changed as a result of the trade agreement between USA and Mexico. An additional question posed by the integration of the labor markets is whether there has been any relationship between employment fluctuations, on the one hand, and real wage rates' variations, on the other. One would expect that when employment is above its long term level, real wage rate would also be above its long term level. Using equation (5) we thus investigate if country B's real wage rate's fluctuations are somewhat associated to country A's employment cyclical behavior.

The relationship between changes in country A's employment and fluctuations in country B's real wage rates is less clear cut however. For one thing, wage rates result not only from the interplay of labor supply and demand but also from the institutional settings that regulate wage determination. In particular, the bargaining power of labor to link their wages to the inflation rate and to productivity growth. The association between employment in country A and real wages in country B would provide a direct indicator about whether trade agreement between countries A and B have meant an improvement of country B's labor's living conditions.

3. Methodology

3.1 The Hodrick Prescott Filter

In what follows we treat the employment and wage series as time series which exhibit two components. A slowly changing function known as the trend (or growth) component, g_t, and a cyclical component, c_t. The model is thus,

$$w_t = g_t + c_t$$

It should be noted that the data have already been adjusted for seasonality i.e., it has been removed. To the extent that growth accounting gives estimates of the permanent (or growth) component with errors that are small relative to the cyclical component, computing the cyclical component is just a matter of calculating the difference between the observed value and the growth component ($w_t - g_t = c_t$). The aim is to estimate and extract the components g_t and c_t.

The approach developed by Hodrick and Prescott (1997), is a smoothing method that is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. The method was first used by Hodrick and Prescott to analyze postwar U.S. business cycles. Technically, the Hodrick-Prescott (HP) filter is a two-sided linear filter that computes the smoothed series g_t by minimizing the variance of w_t around g_t, subject to a penalty that constrains the second difference of g_t. That is, the HP filter chooses to minimize:

$$\sum_{t=1}^{T}(w_t - g_t)^2 + \lambda\sum_{t=1}^{T}((g_{t+1} - g_t) - (g_t - g_{t-1}))^2$$

The penalty parameter λ controls the smoothness of the series, σ. The larger the λ, the smoother σ. As $\lambda \to \infty$, g_t approaches a linear trend.

In recent years several authors have criticized the mechanical use of the HP filter because it can generate spurious cycles.[14] To avoid such a problem, it has been suggested that when investigating economic fluctuations an important first step is the analysis of their variance to quantitatively assess their relative volatility and contribution to the constitution of some aggregate series. A second step is to investigate their cyclical properties in the frequency domain by means of spectral analysis.[15]

The popularity of the HP filter is probably based on some its desirable properties, -it is a symmetric filter so that no phase shift is introduced, and it has trend reduction properties, furthermore, it places zero weight at the zero frequency. In fact, compared to a band-pass filter proposed by Baxter and King (1995), the HP filter gives essentially the same results for quarterly data.[16]

Guay and St-Amant (1997), on the other hand, argue that the HP filter performs well in terms of extracting business cycle frequencies of time series whose spectra have a peak at

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[14] See, for instance, Harvey and Jaeger (1993); Cogley and Nason (1995); Baxter and King (1995), Süssmuth, (2003), among others.

[15] Süssmuth (2003) argues that spectral analysis in economics has not been used more often for several reasons. First, it can be applied only to stationary times series. To the extent that most of economic variables contain a trend component, the failure to effectively remove it would lead to the "typical spectral shape" reported by Granger (1966). Second, many economic series are so short that classical nonparametric methods of spectral analysis cannot be successfully used. Third, it emphasizes description rather than testing. Fourth, methods from the time domain, like cointegration analysis still play a predominant role in applied business cycle analysis.

[16] This is untrue however for data with other frequencies (Baxter and King, 1995).

those frequencies. That is, if the series is dominated by high frequency cycles then the HP filter might provide a good approximation of the unobserved cycle frequencies. A preliminary spectral analysis of our employment and wage series suggests that a significant variability of the series occur at the business cycle frequencies and thus the use of the HP filter is warranted.

The HP filter has become the core of the paradigm for business-cycle estimation in short-term economic analysis at policy making institutions. It is a linear filter that requires previous specifications of the parameter λ. This parameter tunes the smoothness of the trend, and depends on the periodicity of the data and on the main period of the cycle that is of interest to the analyst. Nevertheless, the parameter does not have an intuitive interpretation for the user, and its choice is considered perhaps the main weakness of the HP filter.

For quarterly data, there is an implicit consensus in employing the value of $\lambda = 1600$, originally proposed by Hodrick and Prescott based on a somewhat mystifying reasoning. Still the consensus around this value undoubtedly reflects the fact that analysts have found it useful. The consensus, however, disappears when other frequencies of observation are used. For example, for annual data, authors like Baxter and King (1999) recommend the value $\lambda=10$ because it approximates a band pass filter that removes from the cycle periodicities larger than 8 years; while Backus and Kehoe (1992), Giorno et al (1995) or European Central Bank (2000) use the value $\lambda=100$. Concerning monthly data, Dolado et al.'s reasoning would lead to $\lambda=4800$, while the popular econometrics program E-views™ uses the default value 14400. On this paper we follow a method proposed by Guerrero, Juárez and Poncela (2001) to find the appropriate value of λ that yield consistent and more objective results. These authors suggest an alternative interpretation of Whittaker graduation that yields the graduated series as the best linear unbiased estimator of the true series. Through an index called the "index of precision share" attributable to the time series model, they developed a criteria to help reducing subjectivity when graduating a time series (see Appendix A for details).

3.2 Data Sources

The Mexican cities' employment and wage data are from the National Urban Employment Survey (ENEU). These data are used by the Mexican government to calculate unemployment rate in urban areas and are conducted quarterly. These are household surveys conducted in municipalities throughout Mexico. For the Mexican border region, we focus on four cities: Tijuana, Ciudad Juarez, Nuevo Laredo, and Matamoros. The sample period is determined by data availability: 1987:1-2003:1.

Our analysis is based on workers who received an income for their job. We excluded workers who worked less than 16 hours and more than 68 hours during the reference week. We also excluded males and females younger than 12 and older than 75 years. We only consider workers employed in the manufacturing sector. The data analyzed are in natural-logarithms so that changes in the growth components, $g_t - g_{t-1}$, correspond to the series' growth rate.

The wage rates refers to hourly wage rate and is computed by dividing the monthly labor income by the total number of hours worked in a month. We used the (quarterly) National Consumer Price Index (NCPI) to deflate nominal quantities, using 1994 as the base year. In the case the worker had more than one job, we considered the labor earnings of the primary job to estimate wage rates.

We obtained quarterly data for manufacturing employment in California, Texas and overall US manufacturing employment from the US Bureau of Labor Statistics. The strategy of analysis is to evaluate if employment on the Mexican side is integrated to their neighboring US States (Tijuana with California, Ciudad Juarez with Texas, Matamoros with Texas and Nuevo Laredo Texas) on the assumption that production in the maquiladora plants depends on manufacturing output (and hence employment) of these neighboring States. An alternative assumption is that production on the Mexican side depend more on overall US manufacturing production rather than just southern region's output. As shall be argued later on, Mexican manufacturing employment seem more integrated to the regional manufacturing employment rather than to the national.

4. Empirical results

4.1 The cyclical component

Let us start with a discussion of the employment cyclical components between the Mexican cities and their respective neighboring US states. In the case of Tijuana, its neighboring US State is California while the corresponding neighboring US State of Ciudad Juarez, Nuevo Laredo and Matamoros is Texas.

The series' variability is measured by the sample standard deviations, while the covariability between the employment series cyclical components is measured by their cross-correlations. These measures are computed for two sub-periods: 1987:01-1994:04 and 1995:01- 2003:01. We divide the entire period into two sub-periods in order to analyze the stability of our indicators over time and to evaluate if there were significant changes in the nature of the employment relationship as a result of NAFTA.[17]

The first two columns of Table 2 and Table 3 present the variability of manufacturing employment's cyclical component before NAFTA and during NAFTA periods. Few results are worth mentioning. First, California's manufacturing employment became more volatile during NAFTA period compared to the previous one. Texas, on the other hand, became less volatile. On the Mexican side, volatility increased except in Nuevo Laredo. Both effects induced that the relative volatility of Mexican employment with respect to their respective neighboring US State increased significantly during the second period in Ciudad Juarez, Matamoros and Nuevo Laredo (2nd column in table 2 and table 3).

Table 2: SD and CC between US Border Mexican cities and California and Texas: 1987-1994

	Standard deviation (%)	Standard deviation relative to CA & TX ME	Cross Correlation								
			r_{t-4}	r_{t-3}	r_{t-2}	r_{t-1}	r_t	r_{t+1}	r_{t+2}	r_{t+3}	r_{t+4}
CA ME	1.48										
Tijuana	5.74	3.87	0.082	0.119	0.100	0.100	0.039	0.098	0.030	-0.060	-0.145
TX ME	2.11										
C. Juárez	8.09	3.83	**-0.409***	-0.396*	-0.405*	-0.335*	-0.242	-0.107	0.032	0.154	0.219
Matamoros	8.37	3.96	-0.082	-0.236	-0.431*	-0.522*	**-0.577***	-0.561*	-0.511*	-0.426*	-0.334*
N. Laredo	11.09	5.25	0.101	0.091	0.003	-0.037	-0.107	-0.187	-0.190	-0.124	-0.070

* Coefficient different from cero at 95%

Table 2 and Table 3 also show the cross correlation between employment's cyclical component of Tijuana-California, C. Juarez-Texas, Matamoros-Texas, and N. Laredo-Texas, before NAFTA and during NAFTA period, respectively. It can be observed that before

[17] It should be noted however that NAFTA began in January of 1994. Our reasoning for taking 1994:04 as the end point of the first period is that the effects of the trade agreement on wages, if there were any, were not felt immediately but rather it took a few quarters to be felt.

NAFTA Tijuana and Nuevo Laredo show no evidence of correlation with the manufacturing employment in California and Texas, respectively. On the other hand, during the same period there was a strong negative correlation between Ciudad Juarez's and Matamoros' employment's cyclical components, and Texas' (-0.409 and –0.577 respectively).

Table 3: SD and CC between US Border Mexican cities and California and Texas: 1995-2003

	Standard deviation (%)	Standard deviation relative to CA & TX ME	Cross Correlations								
			r_{t-4}	r_{t-3}	r_{t-2}	r_{t-1}	r_t	r_{t+1}	r_{t+2}	r_{t+3}	r_{t+4}
CA ME	2.01										
Tijuana	6.53	3.24	0.023	0.168	0.267	0.377*	0.416*	**0.434***	0.415*	0.371*	0.340*
TX ME	1.31										
C. Juárez	8.07	6.16	0.071	0.162	0.359*	0.500*	0.600*	**0.618***	0.564*	0.514*	0.489*
Matamoros	9.02	6.85	0.050	0.165	0.331*	0.496*	0.618*	**0.669***	0.640*	0.584*	0.514*
N. Laredo	7.89	6.02	0.078	0.214	0.387*	0.489*	**0.497***	0.464*	0.381*	0.392*	0.441*

* Coefficient different from cero at 95%

After 1994, there is a clear change in the cross-correlation between the employment's short run components. Employment's fluctuations in Tijuana and Nuevo Laredo became positively correlated –with a one period lag- to that of California (although in the case of Nuevo Laredo the correlation became contemporaneous). Changes in the employment relationship between Ciudad Juarez and Matamoros, on the one hand, and Texas, on the other, are more dramatic: they moved from being counter-cyclical to being pro-cyclical almost contemporaneously.

There is thus strong evidence that employment in the border region became more synchronized during NAFTA than what existed during the previous period. When we use instead the overall US manufacturing employment and estimate its cross correlation with employment in Mexico's northern border cities, we also find a change in the short run relationship; in all cases, there is a movement towards higher synchronization in the fluctuations and, with the exception of Ciudad Juarez, the positive correlation became stronger (see Appendix B, Tables B1 y B2).

Moreover, the results suggest that US Border Mexican cities' manufacturing employment is more correlated to their neighboring US States' manufacturing employment than to the overall US manufacturing employment. Even though the correlation with the US national aggregate is milder than with the neighboring States, changes in employment are contemporaneous. In any event, there is significant evidence of a dramatic change in the coherence of manufacturing employment fluctuations between the US economy and US border Mexican cities.

To complement the analysis of the cross correlation between the employment's cyclical components, we estimate the impulse response function in order to establish the direction of causality of such changes; in particular, to determine if the direction is in accordance with the relations established in section 2. Figures (2) through (5) show the impulse response function of a standard deviation shock on the cyclical component of manufacturing employment in California and its effect on Tijuana's employment, and of Texas' on Ciudad Juarez's, Matamoros' and Nuevo Laredo's.

The impulse response functions show three features. First, there is a noticeable change in the pattern of response of employment's cyclical components in the Mexican cities after the signing of the trade agreement. In two cities the pattern moved from an initial negative impact to positive (Matamoros and Nuevo Laredo). In another city moved from an almost nil positive effect to a significant negative one (Tijuana), whereas in the remaining city (Ciudad Juarez) went from a U shape pattern to a slowly declining pattern. Second, there is a significant increase in the magnitude of the initial impact (Tijuana and Matamoros). Third, in some cases the initial positive shock in US employment might have some lasting effect on Mexican regional employment (California-Tijuana, and Texas-Ciudad Juarez).

When using the overall US manufacturing employment instead, the change in the pattern of adjustment is also evident. The initial impact of an external shock of US employment is not necessarily very different after 1994 than what it was during the first period of analysis. There are two significant changes in the dynamics of adjustment. First, is observed in the pattern that local Mexican employment follows after the US shock: an inverted U shaped curve. Second, is that the response function after eliminating the initial negative impact, it remains on the positive side (see Appendix B for details). These results indicate that local Mexican employment became positively dependent on the cyclical behavior of overall US manufacturing employment. These results probably corroborate previous findings about integration of the Mexican and US labor market. Unlike those studies though, our findings provide a more solid result about the degree of such market integration.

Figure 2. IR function for Tijuana-California, (employment-employment)
(a) period 1987-1994 and (b) period 1995-2003.

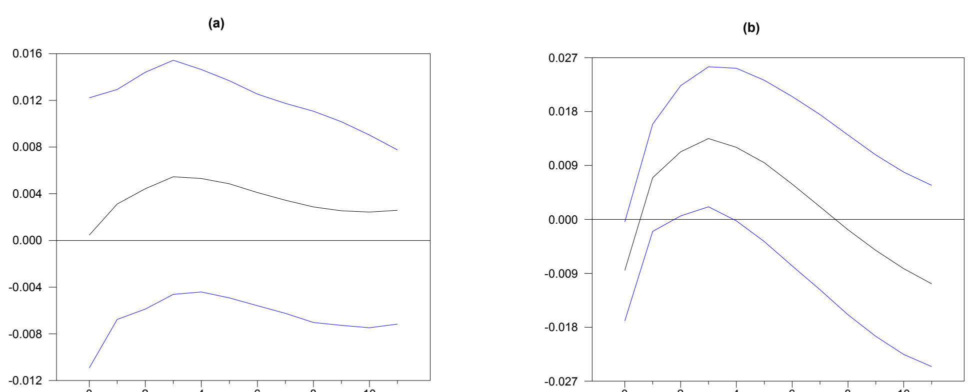


Figure 3. IR function Ciudad Juarez and Texas (employment-employment), (a) period 1987-1994 and (b) period 1995-2003.

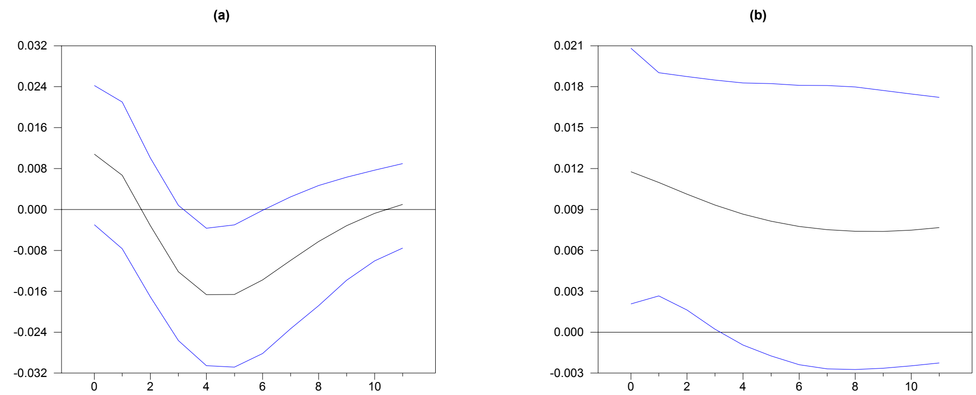


Figure 4. IR function Matamoros-Texas (employment-employment), (a) period 1987-1994 and (b) period 1995-2003.

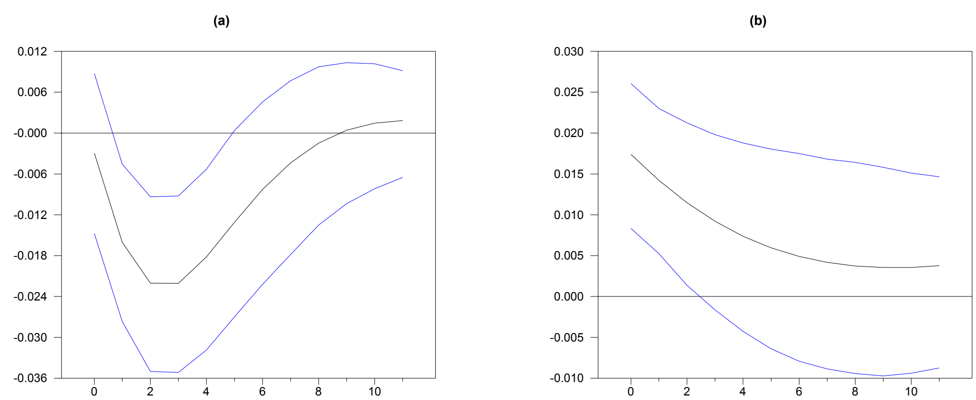
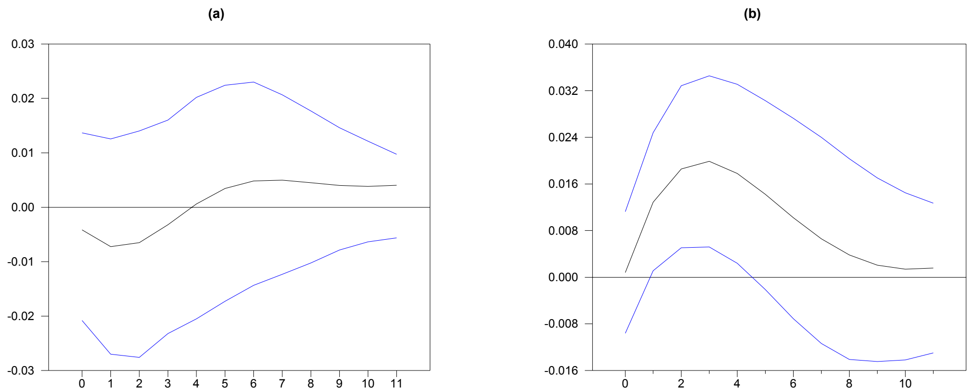


Figure 5. IR function Nuevo Laredo-Texas (employment-employment), (a) period 1987-1994 and (b) period 1995-2003.



Having determined the degree of integration of the labor market in terms of employment, we now assess the impact of changes in US employment on Mexican wages. Figures (6) through (9) show the impulse-response function of one standard deviation in California's and Texas' cyclical component on Tijuana's, Ciudad Juarez's, Matamoros', and Nuevo Laredo's cyclical component of real wages.

As in the case of employment, there is a significant change in the pattern of adjustment of short term real wage due to a external shock in California's and Texas' employment after 1994. The changes include, on the first place, a different initial impact after 1994; that is, during the period 1987-1994 the initial impacts on real wages from a given shock on California and Texas employment were negative. After 1994 they became positive. Second, with the exception of Tijuana, the shape of the adjustment follows an inverted-U curve. Third, in the majority of cases the impact on real wages stay in the positive side of the curve.

Figure 6. IR function Tijuana-California (wages-employment),
(a) period 1987-1994 and (b) period 1995-2003.

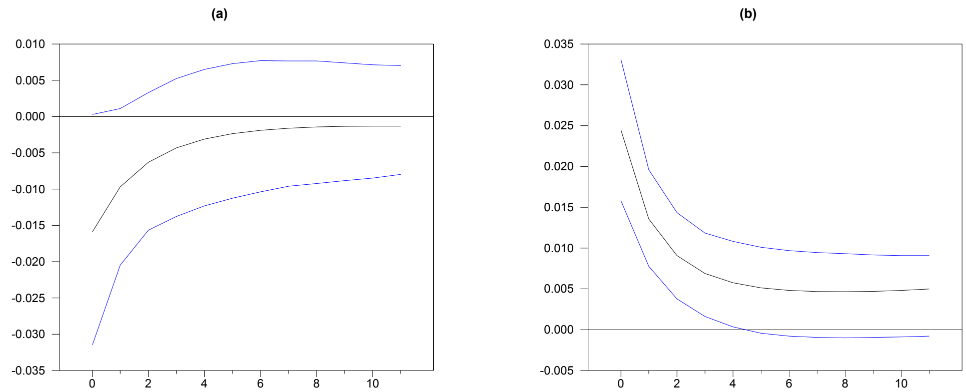


Figure 7. IR function C. Juarez-Texas (wages-employment)
(a) period 1987-1994 and (b) period 1995-2003.

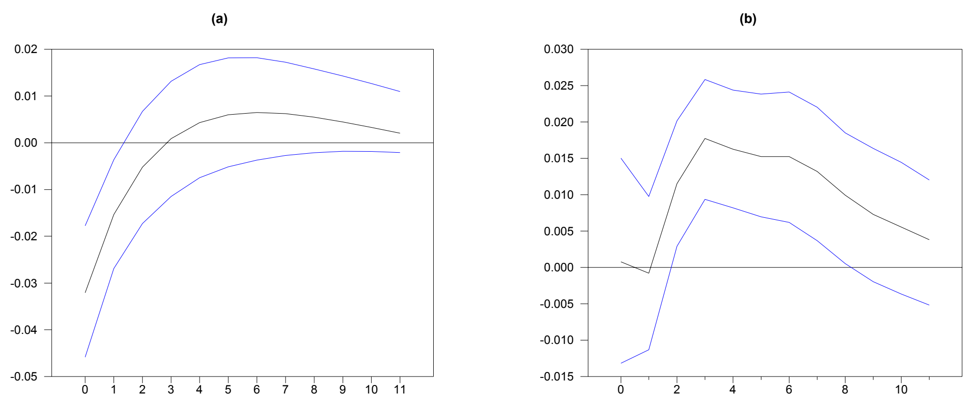


Figure 8. IR function Matamoros-Texas (wages-employment),
(a) period 1987-1994 and (b) period 1995-2003.

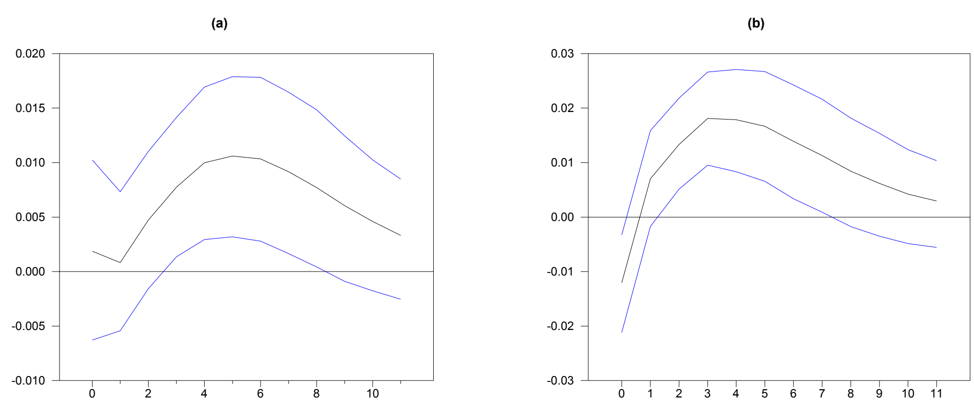
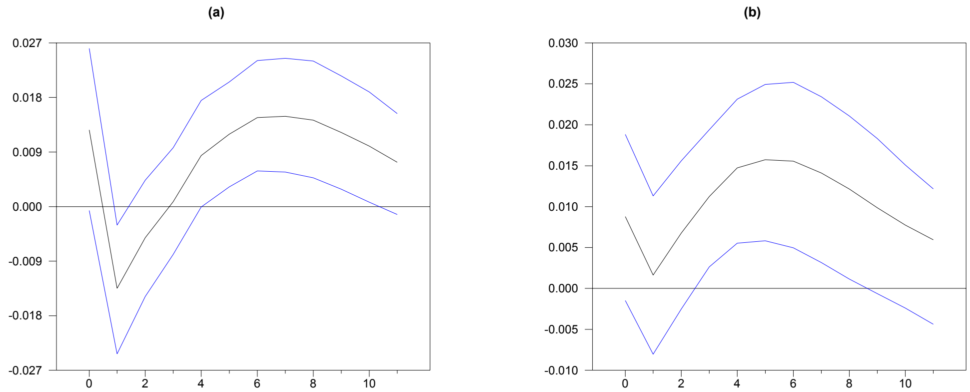


Figure 9. IR function Nuevo Laredo-Texas (wages-employment),

(a) period 1987-1994 and (b) period 1995-2003.



As argued, closer international trade could result in either tighter or looser correlations of employment fluctuations. On the one hand, employment cycles could, in principle, become more idiosyncratic because closer trade could result in countries becoming more specialized in the goods in which they have comparative advantage. On the other hand, if (international) demand shocks predominate, or if intra-industry trade account for most trade, then employment cycle may become more similar across countries when countries trade more. The hypothesis is that both of these relationships are positive.

We can also translate with explanation in terms of changes in the relationship between the parent firms and their Mexican subsidiaries. Our results suggest that the Mexican border region is increasingly used as a specialization center of particular goods. Table 6 presents the employment distribution by main manufacturing sectors as a percentage of total city's employment during the period before and after NAFTA. We observe that between the two periods the main changes in the employment distribution have occurred in the Machinery, Equipment and Metal Products sector. In Ciudad Juarez, Tijuana and Nuevo Laredo there is a significant increase in the percentage of workers laboring in that sector. Matamoros does not exhibit such changes.[18] In other words, an increasing number of maquiladoras plants are assembling more goods classified as machinery, equipment and metal products.[19]

Table 6: US Border Region: Employment Distribution in Manufacturing

	Ciudad Juarez		Tijuana		Matamoros		Nuevo Laredo	
	87-94	95-03	87-94	95-03	87-94	95-03	87-94	95-03
Food, Beb. & Tobb.	2.7	2.2	2.9	2.2	2.5	2.2	2.2	1.5
Textile	2.6	1.2	0.2	0.2	1.0	0.4	0.1	0.1
Clothing	1.4	1.4	1.2	1.9	0.6	2.5	0.7	1.1
Chemical Products	1.9	1.1	5.0	2.1	2.6	2.4	2.1	1.2
Mach Eq. Met Prod.	26.9	35.4	10.2	17.0	29.2	28.0	13.3	16.0
Total	35.4	41.3	19.5	23.4	35.9	35.4	18.5	20.0

Source: ENEU, several years.

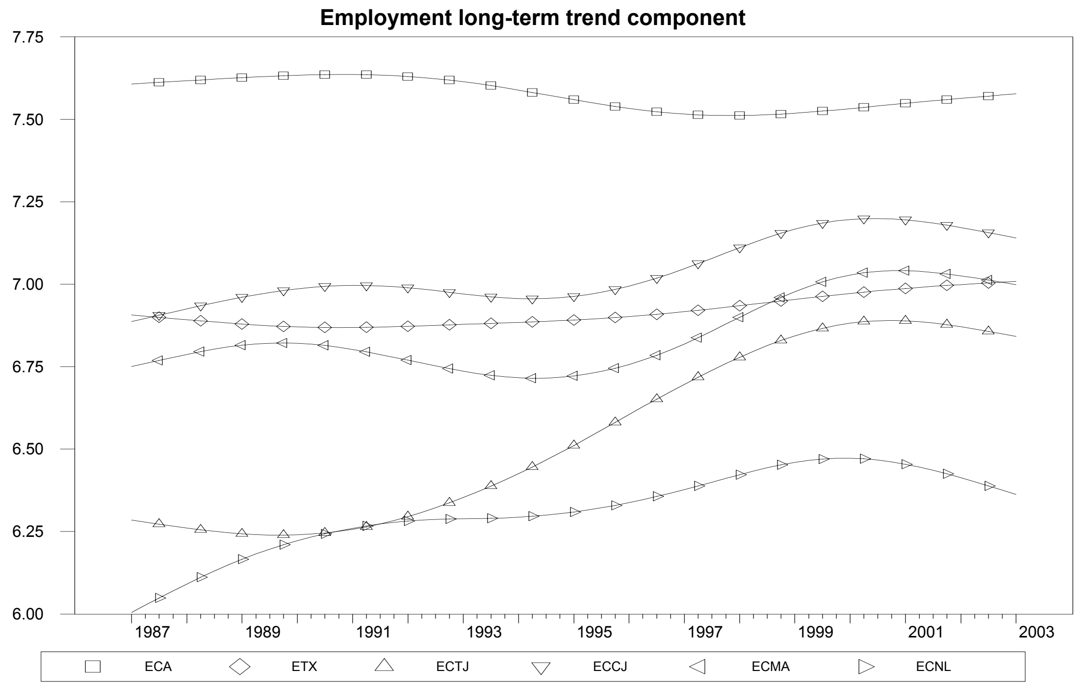
4.2 Growth Component

We now turn to the discussion of the long term behavior of employment in these Mexican cities. Figures 2 and 3 show the long term component of employment in these Mexican cities and that of California and Texas. As can be observed, prior to NAFTA although there was a resemblance in their behavior this was rather weak. in what distinct behavior although after the signing of NAFTA there is a movement toward a long term synchronization of employment in these US border Mexican cities. In fact, the behavior of Tijuana's employment was rather distinct than the other three cities.

This changed significantly after the sign of the trade agreement: all four cities moved toward a greater synchronization of their employment long term behavior, particularly employment in Tijuana, Ciudad Juarez and Matamoros.

[18] We did not include the percentage in the other sectors because the changes that occurred in them were marginal.
[19] Basically as a result of the auto, components and the electronics industries.

Figure 10: Long Term Component: California, Texas and Mexican Cities



5. Conclusions

Since the late eighties and early nineties a key variable in growing industrializing economies has been FDI. It has been recognized as an effective instrument not only for transferring technology to the receiving economy but also for increasing the amount of trade flow among countries. One of the less known impacts of FDI on the receiving country is the degree to which it encourages labor market integration between the receiving and the sending countries.

Some authors have argued that trade liberation in general and trade agreements in particular which accelerate the degree of economic integration among countries could also induce a greater coherence among countries' business cycles. In this later case, one would not be surprised to find out that their labor markets are also integrated. Our argument however is that labor market integration caused by FDI is more direct than integration induced by trade flows.

In this paper, the analysis of co-dependence between the US and Mexico labor markets is carried out by estimating the cyclical component of California's and Texas' manufacturing employment and four US Border Mexican cities through the Hodrick-Prescott filter. Unlike most of the studies that use the filter, we estimated the smoothing parameter following a calibration technique proposed by Guerrero et al (2001) which allows us to obtain the best linear unbiased estimator of the trend component.

We proposed two indicators of labor market integration. First, the cross correlation of manufacturing employment between the two regions. Second, the cross correlation between manufacturing real wage in Mexico and manufacturing employment in the US.

Our analysis suggests that after 1994 and as a result of the trade agreement between Mexico and the United States there has been greater labor market integration between Mexico's northern region and US' southern region. This greater integration has implied a change in the nature of the short term relationship of manufacturing employment between Mexico and the US. The change is also significant on the relationship between Mexican real wages and US employment.

We also found evidence that the long term behavior of employment also changed unmistakably. Previous to the treaty, the growth component of Mexican employment had different behavior. After 1994 there is movement toward a greater parallelism in their growth rates. That is, we observe that there has been a smooth movement towards a state in which their differential growth rates remain constant.

One of the most important policy implications of our results is that to the extent that the receiving economy's labor market outcomes (i.e., employment and wage rates) depends on the performance of sending economy, its labor market policies alone might become ineffective. Much of the labor market outcome would depend on the decisions that parent firms would take regarding production in the receiving country.

The empirical analysis is based on a rather ad-hoc model of labor market integration, we hope that this study would motivate other scholars to develop a more sound theoretical model of labor integration. On the empirical side, data availability has been a major obstacle to extent the analysis to the pre-trade liberalization period which would have given some insights about the whole process of labor marker integration.

Appendix A: The Index of Precision Share

The Hodrick-Prescot Filter, described by Hodrick and Prescott (1997) defines a trend $\{g_t\}$ for a series $\{y_t\}$ as the solution to the problem

$$\min_{\{g_t\}} \sum_{t=1}^{T} (y_t - g_t)^2 + \lambda \sum_{t=1}^{T} (\nabla^d g_t))^2 \qquad \text{(A1)}$$

Fluctuation are defined as deviations from trend, $y_t - g_t$. (A1) can also be written as

$$\min_{\{g_t\}} (\underline{y} - \underline{g})^t (\underline{y} - \underline{g}) + \lambda (s_d \underline{g})^t (s_d \underline{g}) \qquad \text{(A2)}$$

where $\underline{g}^t = (g_1,...,g_T)$, $\underline{y}^t = (y_1,...,y_T)$ and s_d is an *(T-d)xT* matrix whose *ijth* element is $s_d(i,j) = (-1)^{d+i-j} d!/[(j-i)!(d-j+i)!]$ for $i = 1,...,T-d$ and $j = 1,...T$, with $s_d(i,j) = 0$ for

$j < i$ or $j > d+i$. The minimizer of (A1) is given by $\hat{\underline{g}} = (\lambda s_d{}^t s_d + I)^{-1} \underline{y}$ or as it can be derived from Guerrero et al (2001), the BLUE of g is given by

$\hat{\underline{g}} = (\sigma_1^{-2} I + \sigma_2^{-2} s_d{}^t s_d)^{-1} \sigma_1^{-2} \underline{y} = (I + \frac{\sigma_1^2}{\sigma_2^2} s_d{}^t s_d)^{-1} \underline{y}$ [20] with variance-covariance matrix given by

$\Gamma = Var(\hat{\underline{g}}) = (\sigma_1^{-2} I + \sigma_2^{-2} s_d{}^t s_d)^{-1}$. Γ^{-1} is the sum of two precisions, namely

$\sigma_1^{-2} I$ and $\sigma_2^{-2} s_d{}^t s_d$ associated to the cyclical component and the time series model, respectively. As $\sigma_2^{-2} s_d{}^t s_d$ corresponds to the smoothness element in (A2), Guerrero (1993) proposed to measure its precision share in Γ^{-1} by means of a scalar index. Theil's measure of the share of P in $(P+Q)^{-1}$, with P and Q positive definite matrices of size $n \, x \, n$, is given by $\Lambda(P, P+Q) = tr[P(P+Q)^{-1}]/n$. This measure has the following properties: (i) it takes values between 0 and 1, (ii) it is invariant under linear, no singular transformations of the variable involved, (iii) it behaves linearly, and (iv) $\Lambda(P, P+Q) + \Lambda(Q, P+Q) = 1$. The share of $\sigma_2^{-2} s_d{}^t s_d$ in Γ^{-1} is thus measure as

$$\Lambda(\sigma_2^{-2} s_d{}^t s_d, \Gamma^{-1}) = tr[\sigma_2^{-2} s_d{}^t s_d (\sigma_1^{-2} I + \sigma_2^{-2} s_d{}^t s_d)^{-1}]/T = tr[\lambda s_d{}^t s_d (I + \lambda s_d{}^t s_d)^{-1}]/T \quad \text{(A3).}$$

Which is a function of *T, d* and *λ*. (A3) is called an index of precision share attributable to the time series model.

We apply the following steps to calibrate our series:

(i) Obtain the outlier corrected time series

(ii) Obtain the seasonally adjusted time series

(iii) We fixed a desirable precision share and select the λ

(iv) Compute c_t as $w_t - g_t = c_t$

We use a precision share of 93% with λ= 1750 in all series. A procedure for computing trend is available in a MATLAB subroutine developed by Becerra (2003).

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[20] It is important to point out the in this expression $\lambda = \frac{\sigma_1^2}{\sigma_2^2}$ as it was assumed by Hodrick and Prescott

Appendix B

Table B1: SD and CC with overall US manufacturing employment: 1987-1994

	Standard deviation (%)	Standard deviation relative to USA NME	Cross correlations: 1987-1994								
			r_{t-4}	r_{t-3}	r_{t-2}	r_{t-1}	r_t	r_{t+1}	r_{t+2}	r_{t+3}	r_{t+4}
USA NME	1.32										
Tijuana	5.74	4.34	0.134	0.209	0.227	0.266	0.255	**0.286***	0.168	0.001	-0.149
C. Juárez	8.09	6.12	-0.285	-0.153	-0.071	0.055	0.235	0.404*	0.535*	**0.576***	0.496*
Matamoros	8.37	6.34	-0.330*	-0.340*	**-0.344***	-0.305*	-0.230	-0.111	-0.038	0.016	0.041
N. Laredo	11.09	8.40	-0.018	0.041	0.063	0.115	0.138	0.129	0.135	0.132	0.111

*Coefficient different from cero at 95%

Table B2: SD and CC with overall US manufacturing employment: 1995-2003

	Standard deviation (%)	Standard deviation relative to USA NME	Cross correlations								
			r_{t-4}	r_{t-3}	r_{t-2}	r_{t-1}	r_t	r_{t+1}	r_{t+2}	r_{t+3}	r_{t+4}
USA NME	1.04										
Tijuana	6.53	6.27	-0.006	0.069	0.237	0.287*	**0.345***	0.313*	0.263	0.247	0.241
C. Juárez	8.07	7.59	0.394*	0.429*	0.520*	0.522*	**0.543***	0.477*	0.401*	0.342*	0.296*
Matamoros	9.02	8.67	0.309*	0.377*	0.469*	0.520*	**0.526***	0.495*	0.411*	0.310*	0.225
N. Laredo	7.89	7.58	0.342*	0.394*	0.432*	0.408*	**0.438***	0.247	0.212	0.216	0.261

* Coefficient different from cero at 95%

Figure B1. IR function Tijuana-Overall USA (employment-employment), (a) period 1987-1994 and (b) period 1995-2003.

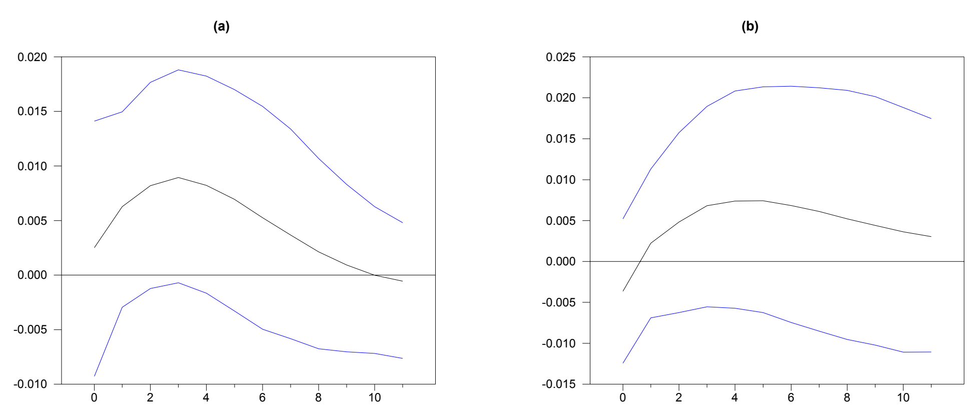


Figure B2. IR function C. Juarez-USA (employment-employment), (a) period 1987-1994 and (b) period 1995-2003.

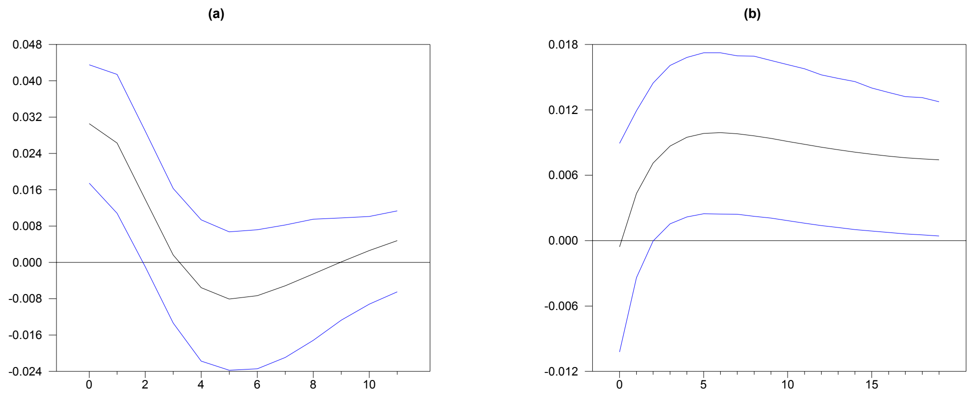


Figure B3. IR function Matamoros-USA (employment-employment) (a) period 1987-1994 and (b) period 1995-2003

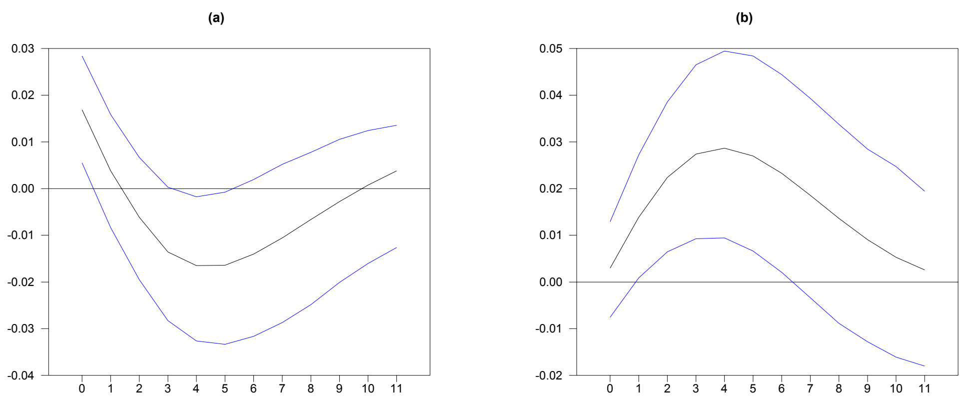
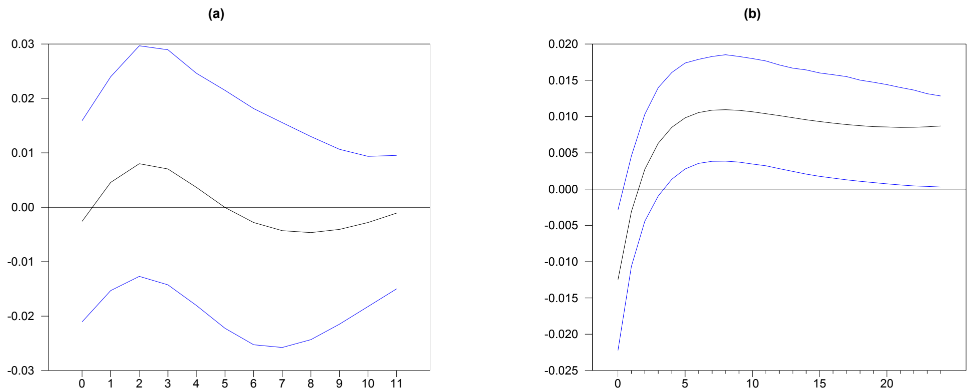


Figure B4. IR function N. Laredo-USA (employment-employment) (a) period 1987-1994 and (b) period 1995-2003.



Appendix C: Impulse-Response Function for the real wage and employment

Figure C1. IR function Tijuana-USA (real wages-employment)
(a) period 1987-1994 and (b) period 1995-2003.

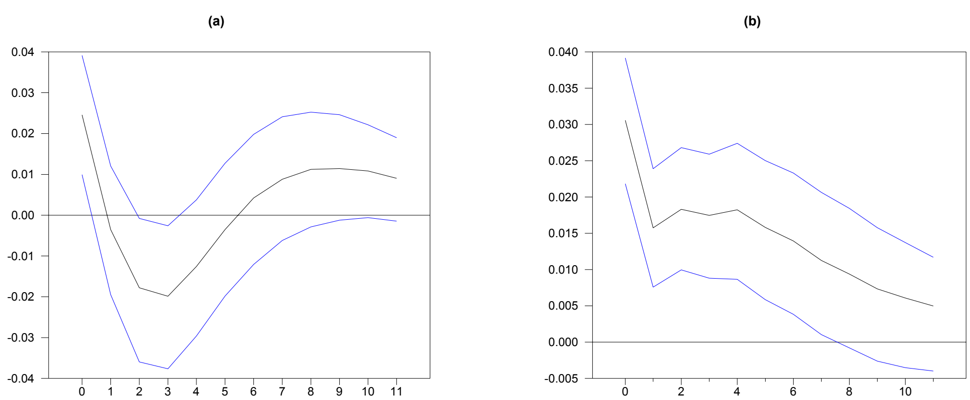


Figure C2. IR function C. Juarez-USA (real wage-employment)
(a) period 1987-1994 and (b) period 1995-2003

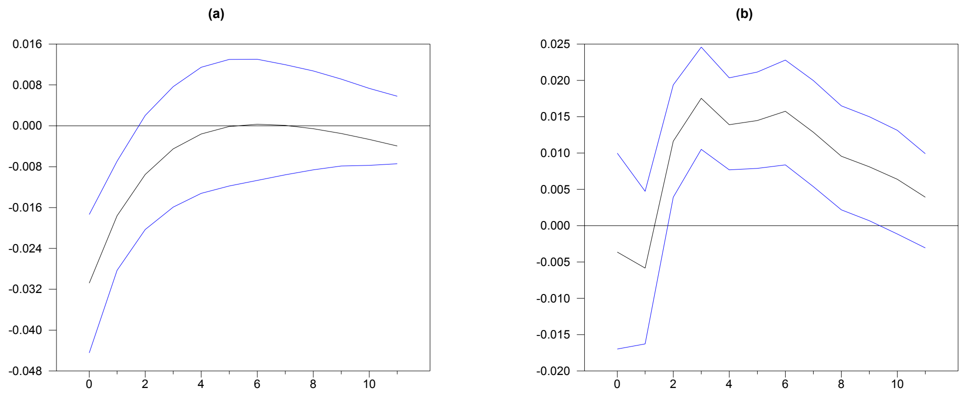


Figure C3. IR function Matamoros-USA (real wage-employment)
(a) period 1987-1994 and (b) period 1995-2003

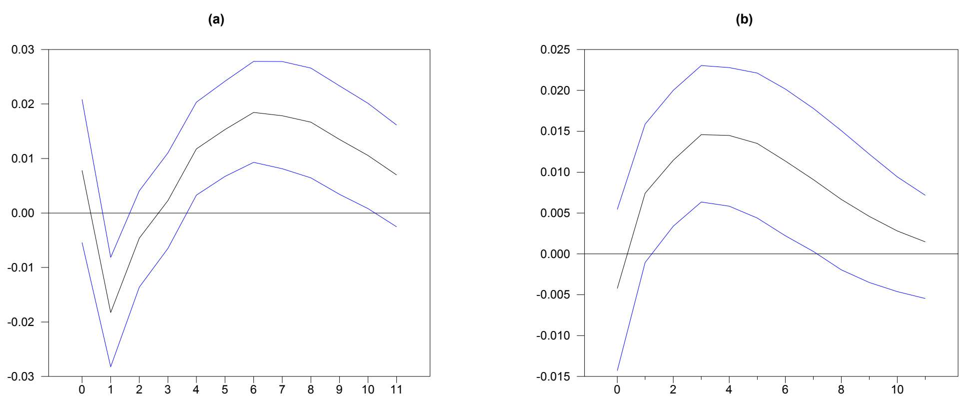
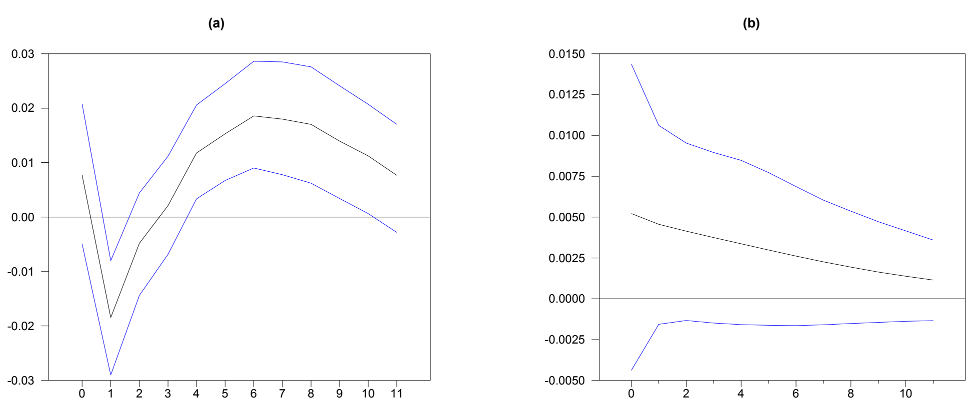


Figure C4. IR function N. Laredo-USA (real wage-employment)
(a) period 1987-1994 and (b) period 1995-2003



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