# Labor Market Integration between Northern Mexico and Southern United States: an empirical investigation[*]

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**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.

*Keywords*: Vertical FDI, Labor market integration, Hodrick-Prescott filter, Latin America, US-Mexico border.

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**Resumen**

En este trabajo, el análisis de la codependencia entre los mercados laborales de Estados Unidos y México se realiza mediante la estimación del componente cíclico del empleo manufacturero en California y Texas y cuatro ciudades en el norte de México, a través del filtro de Hodrick-Prescott. Se estima el parámetro de suavizamiento siguiendo la metodología propuesta por Guerrero et al. (2001), la cual nos permite obtener el mejor estimador lineal insesgado del componente tendencial. Nuestros resultados sugieren que, después de 1994, la integración de los mercados laborales entre el norte de México y la región sur de Estados Unidos ha sido mayor. Esta mayor integración ha implicado un cambio en la naturaleza de la relación de corto plazo del empleo manufacturero entre México y los Estados Unidos. También se observa un cambio significativo en la relación entre el salario real Mexicano y el empleo en Estados Unidos.

*Palabras Clave*: IED vertical, integración del mercado laboral, filtro Hodrick-Prescott, frontera Estados Unidos-México.
*Clasificación JEL*: E3, J3, O1.

**Introduction**

Since the mid 80s Mexico's economy has been undergoing major structural reforms. Both trade and direct investment liberalizations have induced an industrial restructuring which has implied the relative growth of some regions and the decline of others.[3] These adjustments have also brought changes in regional labor markets. For example, it has been argued that economic liberalization has had differentiated impact on regional labor markets; in particular, it has accentuated, and even increased, existing wage differentials across regions (Hanson, 2003). Moreover, regions most exposed to trade and overseas direct investment seems to have obtained wage gains (Meza, 2002).

It has also been argued that trade and investment liberalization have induced further economic integration between Mexico and the United States. The great majority of these studies have focused on measuring the degree to which Mexico's production is linked to the US industrial production (Garcés, 2003; Cuevas et al, 2003; Torres and Vela, 2002). There are few studies however about the extent to which both economies' labor markets are integrated.

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

One of the earliest analyses about labor market integration between Mexico and the United States is Robertson (2000). In Robertson's study, market integration is measured by the responsiveness of Mexico's wages when there is a shock in the United States' wages. He concludes that shocks on wage differential are temporary and that in the long run the latter remains constant. By the same token, Fragoso, et al (2008) analyze whether there are common movements between both countries' manufacturing sectors. They find that Mexico´s employment in the manufacturing non-maquiladora sector exhibits higher degree of synchronization with the manufacturing employment of the US economy that does the maquiladora sector.

A key element in Robertson's argument is the assumption that an increase in the relative wage[4] induces Mexican labor to migrate north, which, in turn, causes relative wage to return to its initial level. As discussed later on, there are few problems with this view of labor market integration. Instead, we propose an alternative approach based on the analysis of the cross-correlation of the cyclical components of these economies' manufacturing employment and the analysis of the relation between changes in the US manufacturing employment and Mexican wage rates. We depart from previous studies in two important respects. First, to the extent that Mexico's northern border region hosts a large number of US subsidiaries, whose production levels depend on both US demand as well as international demand for these products, we argue that labor demand in this region is closely tied to the US business cycles. Second, recent advancements in the theory of Multinational Corporations (MNCs) include the development of models of vertical Foreign Direct Investment (FDI), which explain not only the emergence of foreign subsidiaries but also the growing importance in the international economy of both intra-firms trade flows and intermediate goods trade. We relate the growing importance of vertical FDI to higher labor market integration of the economies involved.

Due to data availability (or rather restrictions) this study focuses on labor market integration between the four largest Northern Mexican cities and the US economy. Overall, these cities concentrate more than 70% of maquiladora plants in Mexico. We consider the employment and wage rates as time series, which after adjusting for seasonality and outliers exhibit trend and cyclical components.

Further, in order to examine if there have been changes in the relationship between both economies since the beginning of NAFTA we divided the whole sample period into two sub-periods: the first goes from 1987:01 until 1993:04 and the second includes the years 1994:01 -2003:01.

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[4] US relative to Mexico.

It is argued that 1995 represents a turning point in the Mexican economy because of several developments: (i) it is the year in which a major financial crisis took place with negative effects on the real sector of the economy; (ii) the government adopted a flexible exchange rate system which has had some effects on the in bond industry; (iii) the North American Free Trade Agreement was in its first year of being implemented. This trade agreement changed the strategic behavior of many multinational enterprises (MNCs) with strong repercussions on the nature of its relationship with their subsidiaries.

The empirical 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). 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.

The paper is organized as follows. Section 1, reviews some basic models of vertical FDI and 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 the in bond industry in accelerating such a process. It also presents our definition of labor market integration. Section 2 provides some stylized facts about the FDI in Northern Mexico and gives an assessment of the relative importance of the cities considered within their respective States' manufacturing sector. Section 3 discusses all methodological issues. In particular, it submits the basic ideas of the Hodrick-Prescott (HP) filter (Section 3.1), it discusses the data used in the empirical analysis (Section 3.2) and presents the main results for the short run fluctuations and the long run behavior of employment in both economies, Section 3.3 and Section 3.4, respectively. The last section summarizes our main results.

## 1. Foreign Direct Investment and Economic Intergration

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.[5] It is argued that FDI will bring more resources, new technology and management, including novel marketing and distribution techniques. In addition, and to the extent that the new firms have some spillover effects upon the domestic firms, overall efficiency will further accelerate. However, FDI has some collateral effects that not all governments are aware of, but that need to be evaluated to obtain a complete assessment of the likely impacts of FDI on the host country. Higher co-dependence of the business cycles between the home and the host economy is one example. Another example is the higher integration of the home and host countries' labor markets.

In what follows we present the basic ideas behind the different models of vertical FDI. It shows why we shall expect greater labor market integration when vertical FDI emerges.

### 1.1. Models of Vertical Foreign Direct Investment

A formal model of labor market integration is yet to be developed. However, we can infer the nature of the integration from the strategic behavior of the MNCs. Therefore, the purpose of this section is to draw some sketches about the factors that explain the emergence and evolution of the in bond industry. We begin with the early propositions made by Vernon (1966) and continue with models proposed by Markusen (1984), Helpman (1984), Markusen et al (1996) and Yi (2003).

Historically, US firms were the first ones to establish foreign subsidiaries worldwide so that Vernon's (1966) explanation was based on US firms' practices during the 1950s and 1960s. Vernon's theory, known as the product cycle hypothesis, argues that to the extent that both high-income levels and abundance of skilled labor characterized the US market, the latter provided a fertile ground for constant innovations.[6] He also argued that over time, firms would convert new technologies or innovations into common knowledge. Once this occurred, firms would transfer the production of such goods to a different location. In his view, the emergence of FDI was a US

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

[6] A strong domestic market was a source of stimulus for the innovating firm, while the abundance of skilled labor and the technological capabilities allowed US firms to improve new products to the point in which the technology becomes standardized.

firm's response to a real or perceived monopolistic advantage. When such an advantage was absent, the firm would not be willing to take the costs and uncertainties associated with the operation of a foreign subsidiary.

Changes in the international economy made Vernon (1979) re-evaluate his early ideas. In particular, the emergence of Europe and Japan as world economies meant that there were new markets that could sustain innovations and the emergence of large firms capable of FDI. Hence, US firms were not longer the only Multinationals (MNC's) capable of FDI. They now had to compete against European and Japanese firms that were establishing foreign subsidiaries even in the US as a means to gain market share in the international economy. The flow of direct investment across industrialized countries became the leading type of FDI, as opposed to FDI going from the latter to less industrialized economies.

Early analyses on MNCs took Vernon's ideas as a starting point. These studies analyzed different aspects of MNCs operations such as their impacts on the patterns of trade, home and host countries' welfare, transfer of technology in a rather descriptive manner. At that time, formal models of trade were incapable of explaining the existence of foreign subsidiaries. By the mid 1980s, however, Markusen (1984) and Helpman (1984) analyzed the existence of foreign direct investment under the presence of increasing returns to scale (IRS). In effect, while Markusen (1984) relied on multi-plant economies, Helpman's model (1984) was based on differentiated inputs; in particular, he considered a general-purpose input that played a special role in a differentiated product industry. In both cases, IRS emerged as the leading cause of trade (intra-firm trade) and in both cases the firm was able to separate geographically different internal activities.[7]

In Markusen's model, the multi-plant economies are found in firm-specific activities such as R&D, advertising, marketing, and distribution and management services, the so-called "corporate headquarters", *C*. Furthermore, these firm-specific activities, C, tend to be centralized in a particular location, while production activities, *F*, are geographically dispersed. A "national" firm becomes multinational when the sector in which it is located exhibits IRS; that is, when the production involves the product of two activities: corporate headquarters, *C*, and factory, *F*. If increasing returns in the sector are weaker than the effects of factor intensity,

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[7] Both models have some similarities with regards to the assumptions: they are 2x2x2 models, e i, two-countries (home and host), two-goods (one exhibits CRS and the other one presents IRS), two-factors of production. In Markusen these are capital, *K*, and labor, *L*; although in Helpman these are labor, *L*; and a general-purpose input, *H*. In both models firms maximize profits. In both cases, labor is homogeneous and immobile across countries.

then the "national" firm would maintain plants in both countries i.e., would become MNC's. A major drawback of the model however is that it cannot predict the direction of trade; that is, it cannot predict which country ends up with the corporate activities, *C*, and which one with the production activities, *F*.[8]

Helpman (1984), on the other hand, describes the conditions under which firms find it desirable to establish foreign subsidiaries so that trade patterns can be induced from such a decision. Firms produce a single-good and because they maximize profits their location choices are cost minimizing. Contrary to Markusen's model, here MNC's emerge as a result of the tendency of factor price to differ across countries.[9] The IRS sector produces differentiated products, while the CRS sector produces a homogenous product.

For a while, models about FDI explained either horizontal FDI or vertical FDI but not both of them at the same time (Markusen, et al 1996). Horizontal MNCs are those multi-plant firms that produce the same product in several countries; substituting international trade for international production. The main purpose of the MNCs in this case is to penetrate a foreign market protected by high tariffs or high transport costs. Vertical MNCs, on the other hand, separate their productive process geographically, taking advantage of differences in relative factor price across countries. In this case, the objective is not to penetrate the host's market but rather use it to reduce overall costs of production. The first type of models were relevant to explain FDI taking place in advanced industrialized economies, whereas the second type was more relevant to less developed economies.

Recent studies about MNCs have provided new insights about the relative importance of vertical FDI with respect to horizontal FDI and its role in the impressive growth of trade flows that cannot be explained by trade liberalization alone (Hanson et al, 2001; Hanson et al, 2003; Braconier, et al, 2002; Yi, 2003). For example, Hanson et al (2003) show that throughout the nineties US MNCs sent a growing part of their production to their subsidiaries through intermediate exports that need further processing. They also show that employment in subsidiaries located in non-OECD countries - i.e., Asia and Latin America- grew faster than in subsidiaries located in OECD countries, indicating differences in the expansion strategy followed by the MNCs in both groups of countries.

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[8] This result is in part due to the assumption that both countries have the same factors endowments, market size, and tastes and preferences.

[9] The model assumes away transport costs, tariffs and tax advantages.

In the light of the mounting evidence about FDI, Markusen et al (1996) modified some assumptions present in Markusen (1984) to provide a comprehensive explanation of FDI. In particular, differences in labor's skills and relative factors endowments. In this model, the firm would choose between horizontal and vertical FDI depending on differences in: relative factor endowments across countries, trade restrictions in the form of higher costs, and market size of the countries involved. The firm's decision would maximize its overall profits.

Given a set of assumptions, the model predicts that when countries' differences in factor endowments are moderate, then the country that has relative abundance in skilled labor exports *X*. However, if the differences in factors endowments across countries are large, then vertical MNCs emerge. Multinational firms would fragment *X*, and the country with the relative abundance of skilled labor will concentrate headquarters activities and the production would be located in the country with relative abundance in unskilled labor. This decision changes trade direction because now the country with abundant skilled labor would import the good that is intensive in skilled labor.

It should be noted that in this model, vertical multinational dominates production when trade costs are low and the countries differ significantly in relative factor endowments but are of similar size. Horizontal multinational, on the other hand, emerge when countries are of similar size and relative factor endowments and when the trade costs are from moderate to large. National firms dominate when the trade costs are low and the relative endowments are similar, or when trade costs are moderate, relative endowments are similar and the countries differ significantly in size.

The new evidence about the magnitude of vertical FDI helped reconsider two key issues in the discussion: the definition of vertical FDI and whether differences in relative factor costs are more important than differences in relative factor endowments in explaining vertical FDI (Braconier et al, 2002). In effect, early models considered vertical FDI as the practice where foreign subsidiary exports goods only to headquarters, while the evidence suggested that the concept of vertical FDI needed to be extended to include sales from subsidiaries to third countries and sales to the host country. Thus, the picture of trade flows explained by vertical FDI is more complex than initially thought.

The debate about whether differences in relative factors endowments are more important than differences in relative factors prices to explain the impressive growth of trade and the increasing relative importance of vertical FDI has also reached a turning point. Recent empirical studies give more

evidence in favor of the relative factors prices argument (Hanson, 2003; Braconier et al, 2002). Yi (2003), for instance, builds a model that can explain the emergence of vertical and horizontal FDI as a function of labor productivity. The goods consumed and invested by the two countries are produced in sequential stages of production. One of the conclusions of the model is that one country can produce goods of a particular stage, while the other would produce the remaining stage goods. Given the two countries' productivity and their relation with respect to their relative wages, each one of them would produce the stage good for which is better prepared, giving rise to some kind of specialization, but on a particular stage of production.

1.2. Why should we expect increased labor market integration?

As shown in the previous section, a priori we cannot determine the nature of the labor market integration because the latter depends on the role that subsidiary plants play on the overall strategy of the MNCs. Whether we observe a positive (negative) correlation between both countries' employments depends on whether goods produced by subsidiary plants located in the host country are complements (substitutes) of the goods produced by plants located in the home country.

From an international trade theory perspective, more integration can be expected to lead to more trade; and more international trade will result in more highly correlated employment's 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 becomes highly integrated, countries specialize more in production. By this logic, increasing specialization will *reduce* the business cycle correlation *not increase* it. Increased specialization might also result from adopting a flexible exchange rate system since it dampens the effects of industry specific shocks (Ricci, 1996).[10]

From an international trade theory's point of view, a trade agreement between two countries may change the nature of the relationship between both labor markets. If the resulting trade flows were more intra-industry than inter-industry, then one would expect that employment fluctuations in both countries to become positively correlated. On the other hand, if the resulting trade flows were inter-industry, then employment fluctuations in both countries go in opposite directions.

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[10] In the case of Mexico, it is worth recalling that at the same time that Mexico signed NAFTA, -which increased significantly trade between Mexico and US-, the Mexican government adopted a flexible exchange rate. Thus, it is expected that Mexico has become more specialized in the production of specific goods.

Short run fluctuations of employment can be expressed in terms of its deviations from its long run trend. Thus, the correlation between short run fluctuations of home country (A) and host country (M), $v$, over time span $\tau$ and de-trended with method $a$, can be denoted by

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

Labor market integration can also be seen through the impact of changes in home country's employment on host country's wage rates. The relationship between changes in home country's employment and fluctuations in host country's real wage rates is less clear, 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 domestic inflation rate and to productivity growth. The association between employment in country A and real wages in country M would provide a direct indicator about whether trade agreement between countries A and M have meant an improvement on the latter's living conditions.

Our definition of labor market integration is different from other views. Robertson (2000), for example, defines labor market integration between Mexico and US as the responsiveness of Mexican wages to US wage shocks. In Robetson's view the adjustment mechanism of relative wages is based on the assumption that Mexican labor migrates north as a result of changes in relative wages.

This explanation however runs into several problems. First, there is the question about the extent to which labor migration to the US affects overall wage rates in Mexico. Not only the size of labor migration is not large enough to affect overall wage rates but also wages in Mexico is more likely to depend on some institutional settings. Second, several studies show that the decision to migrate to the US depends not only on economic considerations but also on other factors as well. A study carried out by The Mexico/United States Bi-national Study on Migration in 1997[11] identifies two types of factors that drive migration: pull and push factors. Among the pull factors the report identifies: the emergence of new employers, labor brokers, cross-border social networks of relatives and friends. The main push factor, on the other hand, is the lack of employment opportunities in Mexico. Third, relative wages between Mexico and US seem to respond more to variations of the exchange rate rather than to changes in labor mobility

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[11] The Binational Study Group on Migration (1998).

between both countries.[12] Finally, the hypothesis not only implies that Mexican workers have access to information about US labor market conditions but also that although there are restrictions to labor migration, these are not impediments to massive labor mobility so that relative wages ultimately respond to it. For all these reasons, we think the measure of labor market integration based on the analysis of the cyclical components is better suited.

## 2. Foreign Direct Investment in Northern Mexico

In a study about FDI in Mexico, Máttar et al (2002) note some of its distinguishing features. In particular, they note that a large part of FDI comes from US multinationals concentrated in manufactures. To the extent that these multinational firms have subsidiaries in Mexico, the main recipients are the maquiladoras plants. Figure 1 shows the percentage of FDI coming from the United States and the percentage of FDI directed to industrial sector during 1987-2004.[13] It shows that on average more than 60% comes from US firms. Beginning 2001 however the participation shows a steady decline.

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[12] In effect, during 1980-2003 fluctuations in relative wages have been associated to periods of high depreciation of Mexico's currency. Relative wages defined as $\omega = \ln(w^{US}) - \ln(w^{MX})$ where $w^{US}$ is the hourly wage rate of electronics sector and $w^{MX}$ is the average hourly rate of Mexico's maquiladora sector (both are in US dollar).

[13] It should be noted that in 1994 there was a change in the methodology used to estimate FDI. Beginning in that year, FDI includes reports given to the National Registry of Foreign Investment by 2008 and were actually implemented in the year plus imports from maquiladora plants. Since 1999 FDI also includes new investments outside social capital. As a result of these changes, between 1993 and 1994 the amount of FDI went from US $3361 to US $7112.2 (in real terms, deflated by US CPI base year 1982-4).

Figure 1
**FDI in Mexico, Country of Origin and Sector**
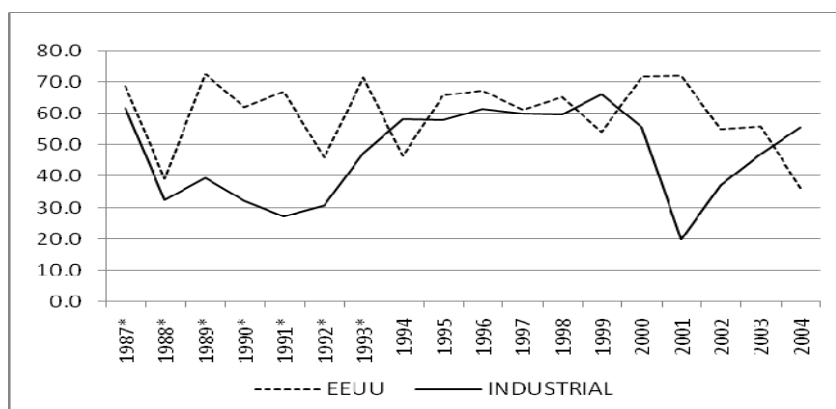


Source: Secretaría de Economía, Dirección General de Inversión Extranjera.

The graph also shows that the industrial sector has been one of the main recipients of FDI. In effect, after 1988-1993, when the amount of FDI going to the sector was below 40%, it increased to 60% during 1994-2000. The year 2001 shows a steep decline in the percentage, explained by the purchase of the largest Mexican bank, but it recovered the following years so that by 2004 it was again above 50%.

Throughout the nineties and early part of the 2000s, FDI as a percentage of Mexico's GDP shows an upward trend. It went from about 2 percent during the second half of the 80s to about 4.7 percent during the second half of the nineties to about 8.9 percent during the first four years of the 2000s.

Analyzing the geographical distribution of FDI in Mexico we find that during 1994-2004 about 26.7 % of total FDI was directed to all US-Border states[14]. To the extent that Tijuana, Ciudad Juarez, Nuevo Laredo and Matamoros are located in Baja California, Chihuahua and Tamaulipas respectively, we focus on the amount of FDI that was directed to them. The amount of FDI going to these three Border States increased from 8.4% in 1994 to about 20.2% in 1998. Since then the percentage distribution shows a declining trend so that by 2004 it was only about 7.9% of total FDI. Moreover, the FDI pattern among these three states differs significantly, i.e, while the amount of FDI going to Baja California and Chihuahua grew at an

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

annual rate of 12.7% and 5.9% respectively, the amount going to Tamaulipas declined by 6.6% annually.

Despite the fact that since the mid eighties the in bond industry has grown faster in non-border regions, a distinctive aspect is that the US border region hosts, on average, more than 70 % of total plants and around 77 % of total maquiladora employment.[15] This is the reason why Mexican researchers believe that this region's economic performance depends upon the behavior of the maquiladora plants.

Due to the lack of information about the distribution of FDI by cities, and in order to assess their relative importance within the flow of FDI going to these States, we measure their relative importance within their respective States' manufacturing sector. In general, the selected cities concentrate most of the manufacturing activities within their respective States. Table 1 shows the participation of these cities' manufacturing sector within their respective States in 1999.[16] Tijuana, for example, concentrated 37.9% of the manufacturing sector's Fixed Assets in Baja California. The city's strong position can also be seen in terms of Gross Capital Formation, Gross Production and Employment.[17]

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[15] 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).

[16] That is, with respect to the state's manufacturing sector.

[17] The second most important city in the manufacturing sector in Baja California is Mexicali. These two cities concentrate more than 90% of manufacturing activity within the State.

Table 1
**City's Relative Importance in their States' Manufactures, 1999**
**(Percentage)**

| City | Fixed assets | Gross capital formation | Gross production | Employment |
|---|---|---|---|---|
| Tijuana, BC | 37.9 | 48.1 | 43.8 | 61.8 |
| Ciudad Juarez, CHIH | 37.2 | 49.6 | 51.2 | 68.3 |
| Nuevo Laredo, TAMS | 5.6 | 2.4 | 7.7 | 13.1 |
| Matamoros, TAMS | 9.9 | 10.5 | 23.3 | 31.6 |

Source: Own estimates using data from the 1999 Economic Census, (INEGI, 1999).

The importance of Ciudad Juarez within the State of Chihuahua's manufacturing sector is also similar to that of Tijuana. More than half of the manufacturing activity (in terms of production, capital formation and fixed assets) occurs in this city. The importance of the city is even higher if we consider the employment in the manufacturing sector since it captures more than 68% of the State's employment in the manufacturing sector.

The relative importance of Nuevo Laredo and Matamoros within the manufacturing sector in the State of Tamaulipas is not as strong as that of Tijuana and Ciudad Juarez. This is explained by the fact that in Tamaulipas there are two other cities that are just as important: Ciudad Madero and Reynosa. In terms of production and employment Matamoros and Nuevo Laredo concentrate 31% and 44.7% of the state manufactures, respectively. In terms of Gross Capital Formation and Fixed Assets their participation is lower however: 12.9% and 15.5%, respectively.

It has been shown the relative importance of these cities in the region´s manufacturing sector. While Tijuana and Ciudad Juarez concentrate more than half of the manufacturing within their respective states, Nuevo Laredo and Matamoros are less important in the performance of Tamaulipas' manufacturing sector. Their importance in the region's manufacturing employment however cannot be underestimated.

## 3. Methodology

In this section we describe the method followed to obtain the trend and cyclical components of the series. We then discuss the data source and carry out the empirical analysis.

3.1 The Hodrick-Prescott Filter

In what follows we treat the employment ( $E_t$ ) and wage series ( $w_t$ ) as time series, which exhibit two components: a trend component (unobserved), $g_t$ , and a cyclical component (unobserved), $c_t$ ; thus, $w_t = g_t + c_t$ . We will assume that the time series $E_t$ and $w_t$ are integrated of order 1, I(1), in such a way that its trend will also be I(1) and the cyclical component will be stationary.[18] The data have been adjusted for seasonality. To the extent that growth accounting gives estimates of the permanent component with errors that are small relative to the cyclical component, the cyclical component is computed as the difference between the observed value and the trend 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) minimize the following expression:

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

where the penalty parameter $\lambda$ controls the smoothness of the series, $\sigma$ . The larger the $\lambda$ , the smoother $\sigma$ is. As $\lambda \rightarrow \infty$ , $g_t$ approaches a linear trend. In recent years several authors have criticized the mechanical use of the HP filter because it can generate spurious cycles.[19]  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

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[18] We present unit root tests for the series in the Appendix. Tables A1 and A2 report unit root tests based on Dickey and Fuller (1979) and Perron (1997). Both tests conclude that the series are I (1) so that their trend components are also I (1) and their cyclical components are stationary.

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

constitution of some aggregate series. A second step is to investigate their cyclical properties in the frequency domain by means of spectral analysis.[20]

The popularity of the HP filter is based on some of 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.[21] 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 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.[22]

The HP filter requires previous specifications of the parameter $\lambda$. This parameter defines the smoothness of the trend. It depends on the periodicity of the data and on the main period of the cycle that is of interest to the analyst. 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. However, the consensus disappears when other frequencies of observation are used. For example, for annual data, Baxter and King (1995) 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 $\lambda = 100$. For monthly data, Dolado et al (1993) propose $\lambda = 4800$, while the popular econometrics program E-views[TM] uses the default value 14400.

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[20] 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.

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

[22] 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.

We follow a method proposed by Guerrero et al (2001) to find the appropriate value of $\lambda$ 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.[23]

3.2 Data Sources

The Mexican cities' employment and wage data come from the National Urban Employment Survey (ENEU). We focus on four cities, -Tijuana, Ciudad Juarez, Nuevo Laredo, and Matamoros-, mainly because data for other border cities are not as complete as for these cities.

Our analysis is based on workers who received an income for their job. The analysis does not include 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 are in natural-logarithms so that changes in the long-term component, $g_t - g_{t-1}$, correspond to the series' long-term growth rate. The wage rate 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.[24] 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, Matamoros and Nuevo Laredo with Texas) on the assumption that production in the maquiladora plants depends on manufacturing output (and hence employment) of these neighboring

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[23] Due to space restrictions the details are available from the authors.

[24] An analysis of the distribution of the manufacturing employment across cities indicates that in the State of California, it is concentrated in the cities of Los Angeles, San Jose, Santa Ana and San Francisco. These cities concentrate about 78 percent of the State´s manufacturing employment. Whereas in the case of Texas, manufacturing employment is concentrated in the cities of Dallas and Houston, which on average concentrate about 78.1 percent of the State´s (Source: Bureau of Labor Statistics, http://www.bls.gov, the period considered is 1999-2004). In both cases, US cities near the Mexican border have small participation in terms of US manufacturing employment.

States. An alternative assumption is that production on the Mexican side depends more on overall US manufacturing production rather than just the 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 manufacturing employment.

Table 2 shows the average employment distribution by main economic sectors for the four largest cities in the Mexican northern border region; namely, Tijuana, Ciudad Juarez, Matamoros and Nuevo Laredo during the period 1987-2000 (figures are percentages of each city's total employment). As can be observed, the four largest cities as a whole, about a third of employed labor is occupied in the manufacturing sector (mainly operated through maquiladora plants).[25] 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 2
**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: National Survey of Urban Employment (ENEU), 1987:01-2000:04.

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[25] It should be noted that 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, Barajas et al, 2004). Other researchers note that although there are one or two plants with R&D capabilities, there is still very little evidence that the entire maquiladora sector is moving towards such a situation (Bendesky et al 2003). In fact, the large majority of maquiladora plants are still assembly plants. What 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.

The Service sector comes second since it generates more than 27% of the region's total employment. Commerce comes third because it occupies about 21% of total regional employment. It should be noted that Construction and Transport in Nuevo Laredo occupy a fairly significant percentage of employed workers (about 10%).[26] In summary, maquiladora plants constitute a significant portion of these cities' labor demand.

3.3 The Empirical Analysis: the cyclical component

We start with a discussion of employment cyclical components of the Mexican cities and their respective neighboring US states; thus we obtain the following pairs: Tijuana-California, Ciudad Juarez-Texas, Nuevo Laredo-Texas and Matamoros-Texas.

The variability of a series is measured by the sample standard deviations, while the co-variability between the employment cyclical components is measured by their cross-correlations. We divide the sample period into two sample sub-periods: the pre-NAFTA period (1987:01-1993:04) and the post NAFTA period (1994:01-2003:01) to examine whether there have been changes in the relationship between both economies' labor markets.

The first two columns of Table 3 and Table 4 present the variability of manufacturing employment's cyclical component before 1994 and after that year. Few results are worth mentioning. First, California's manufacturing employment became more volatile after 1994 compared to the previous one. Texas, on the other hand, became less volatile. On the Mexican side, volatility increased in Tijuana and Matamoros, while decreased in Ciudad Juarez and 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 3 and Table 4).

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[26] Nuevo Laredo is the main port of entry/ exit of goods transported by trucks.

Table 3
**SD and CC between US Border Mexican cities and California and Texas: 1987-1993**

| | 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 | 1.57 | | | | | | | | | | |
| Tijuana | 5.74 | 3.65 | 0.028 | 0.027 | 0.185 | 0.123 | 0.027 | 0.069 | - 0.009 | -0.089 | -0.174 |
| TX ME | 2.24 | | | | | | | | | | |
| C. Juárez | 8.26 | 3.68 | -0.336* | -0.326* | **-0.350***  | -0.308* | -0.248 | -0.090 | 0.055 | 0.137 | 0.174 |
| Matamoros | 8.20 | 3.66 | 0.050 | -0.112 | -0.347* | -0.500* | **-0.631***  | -0.618* | -0.585* | -0.520* | -0.422* |
| N. Laredo | 11.68 | 5.21 | 0.175 | 0.160 | 0.055 | -0.012 | -0.110 | -0.189 | -0.184 | -0.137 | -0.107 |

* Coefficient different from cero at 95%
Source: Own estimates.

Table 3 and Table 4 also show the cross correlation between employment's cyclical component of California - Tijuana, Texas - C. Juarez, Texas - Matamoros, and Texas - N. Laredo, before NAFTA and afterwards, respectively. It can be observed that before NAFTA (Table 3) Tijuana and Nuevo Laredo show no evidence of correlation with the manufacturing employment in California and Texas, respectively. During the same period, short run fluctuations in employment between Ciudad Juarez and Texas and between Matamoros and Texas were strong but negative (-0.350 and –0.631 respectively); that is, employment fluctuations in these Mexican cities were counter-cyclical to employment in Texas; moreover, they were felt first in Ciudad Juarez by almost a year earlier whereas in Matamoros was contemporaneous.

Table 4
**SD and CC between US Border Mexican cities and California and Texas: 1994-2003**

| | 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 | 1.93 | | -0.016 | 0.125 | 0.196 | 0.296* | 0.335* | **0.364*** | 0.351* | 0.324* | 0.320* |
| Tijuana | 6.51 | 3.37 | | | | | | | | | |
| TX ME | 1.27 | | | | | | | | | | |
| C. Juárez | 7.87 | 6.19 | 0.064 | 0.165 | 0.346* | 0.474* | 0.528* | **0.595*** | 0.568* | 0.546* | 0.547* |
| Matamoros | 10.06 | 7.92 | 0.070 | 0.177 | 0.283* | 0.422* | 0.525* | 0.621* | **0.645*** | 0.617* | 0.578* |
| N. Laredo | 7.65 | 6.02 | 0.126 | 0.225 | 0.351* | 0.431* | 0.438* | **0.464*** | 0.417* | 0.450* | 0.513* |

* Coefficient different from cero at 95%
Source: Own estimates.

After 1994, there is a clear change in the (short run) employment relationship between these two regions. First, Tijuana and Nuevo Laredo have become highly correlated to their respective US neighboring States. They both show strong pro-cyclical behavior, -Nuevo Laredo's and

Tijuana's employment fluctuations follow that of California with a one-quarter lag. Second, in the case of Ciudad Juarez and Matamoros the change is more dramatic: they moved from being counter-cyclical to pro-cyclical. Here, Matamoros' employment fluctuations follow that of Texas with two-quarter lags, while Nuevo Laredo's fluctuations follow that of Texas with one-quarter lag.

There is therefore strong evidence that employment fluctuations in the border region became more synchronized after NAFTA. We find similar results when using the overall US manufacturing employment instead. 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.[27] Our results suggest that fluctuations of manufacturing employment in these Mexican cities are more correlated to their neighboring US States' manufacturing employment than to the overall US manufacturing employment. Moreover, the highest correlation between employment fluctuations on the Mexican side and US manufacturing employment occurs when they are contemporaneous. In any event, there is significant evidence of a dramatic change in the coherence of manufacturing employment fluctuations in this case as well.

It is well known that correlation coefficients do not provide information about causal relationships between the series under study. One advantage of VAR models is that it can be used for studying the dynamic response of labor markets to different shocks. For this reason, we performed the impulse response function analysis 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. In what follows we estimate the 2-variable VAR model and the impulse response function with the following ordering: first US states and then the Mexican cyclical components. The optimal lag length was derived from the use of the AIC and BIC criteria, leading to a choice of 2 lags. Even though NAFTA began in January of 1994, the financial crisis that took place in December of 1994 and the rapid recovery in 1996 are shocks that might not be related with NAFTA. Therefore, we include in our VAR model dummy variables for 1995 and 1997 to control for such shocks. Figures (2) through (5) show the impulse response function of one 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, Matamoros and Nuevo Laredo's respectively, from the 1st to the 12th quarter lag.

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[27] The results are available from the authors. They are not included due to space restrictions.

The impulse response functions show that there is a noticeable change in the pattern of response of employment's cyclical components in the Mexican cities after NAFTA. On the other hand, before NAFTA the pattern of adjustment showed an initial contemporaneous positive impact in Ciudad Juarez that become insignificant afterwards and a negative impact in Matamoros ($1^{st}$ – $3^{th}$ quarters) to become insignificant afterwards. In the other two cities there was an insignificant effect: Nuevo Laredo and Tijuana. After NAFTA the pattern of adjustment changes: a positive shock on Texas employment induces a significant positive effect on Ciudad Juarez, Matamoros and Nuevo Laredo's employment. The significant effect for Ciudad Juarez occurs during the first five quarters and for Matamoros occurs during the first two quarters, while for Nuevo Laredo is from the $1^{st}$ to $3^{th}$ quarter. A positive shock on California's employment induces a positive significant effect on Tijuana's employment cyclical component from the $1^{st}$ to the $5^{th}$ quarter.

In short, before NAFTA cyclical components of Mexican (cities) employment and their corresponding US neighbors were not synchronized. After then, they became synchronized: when manufacturing employment in California and Texas were above their long-term trend, manufacturing employment in Mexican cities were also above their long-term trend. When using the overall US manufacturing employment instead, the change in the pattern of adjustment is also evident. First, in the case of Nuevo Laredo the nil effect (of a shock on the US employment) that existed during the first period became positive and almost permanent after the $3^{rd}$ quarter during the NAFTA period. Second, in Ciudad Juarez the initial positive impact that was observed during the first period and despair after the $3^{rd}$ quarter became positive and almost permanent after the $3^{rd}$ quarter during the post-1994 period. Third, the contemporaneous positive effect on Matamoros during the first period became positive from the $1^{st}$ to the $6^{th}$ quarters, reaching its maximum at the $4^{th}$ quarter. Finally, the nil impact observed on Tijuana during the first period continued during the second one. These results indicate that local Mexican employment became positively dependent on the cyclical behavior of overall US manufacturing employment.

Figure 2
**IR function and error band for California-Tijuana,
(employment-employment)
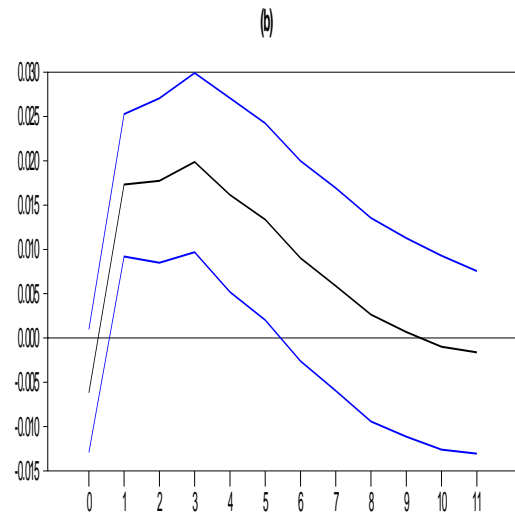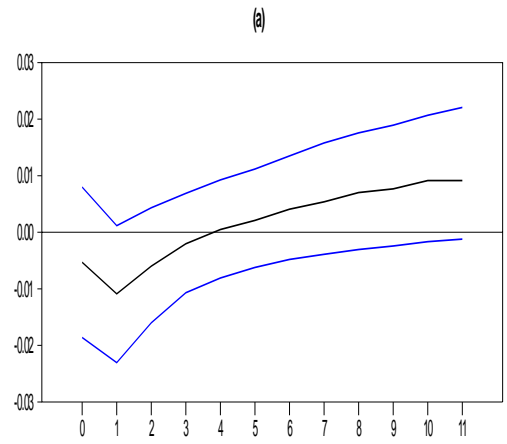(a) period 1987-1993 and (b) period 1994-2003**

**(a)**



**(b)**

Figure 3
**IR function and error bands Texas-Ciudad Juarez
(employment-employment),
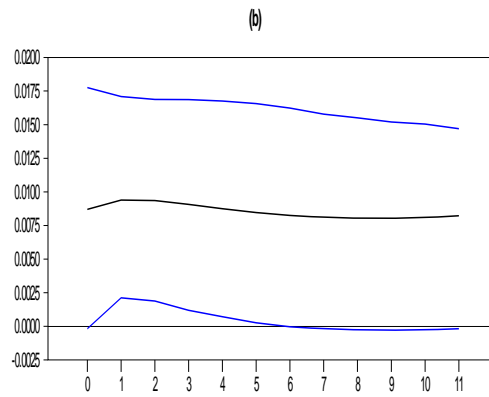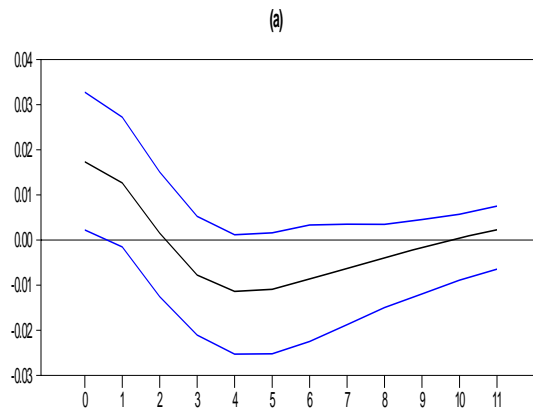(a)   period 1987-1993 and (b) period 1994-2003**

Figure 4
**IR function and error bands Texas-Matamoros
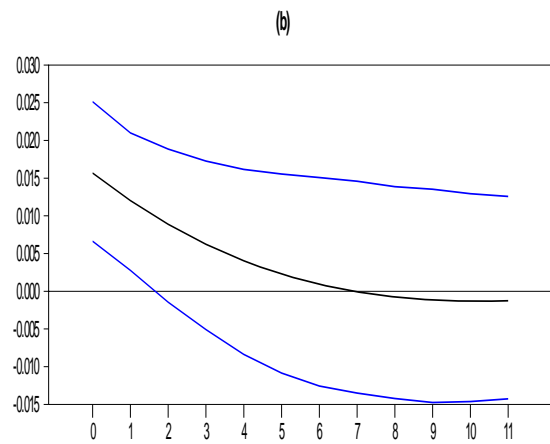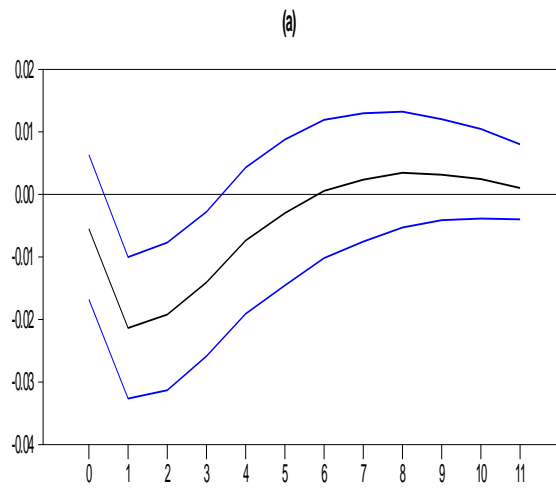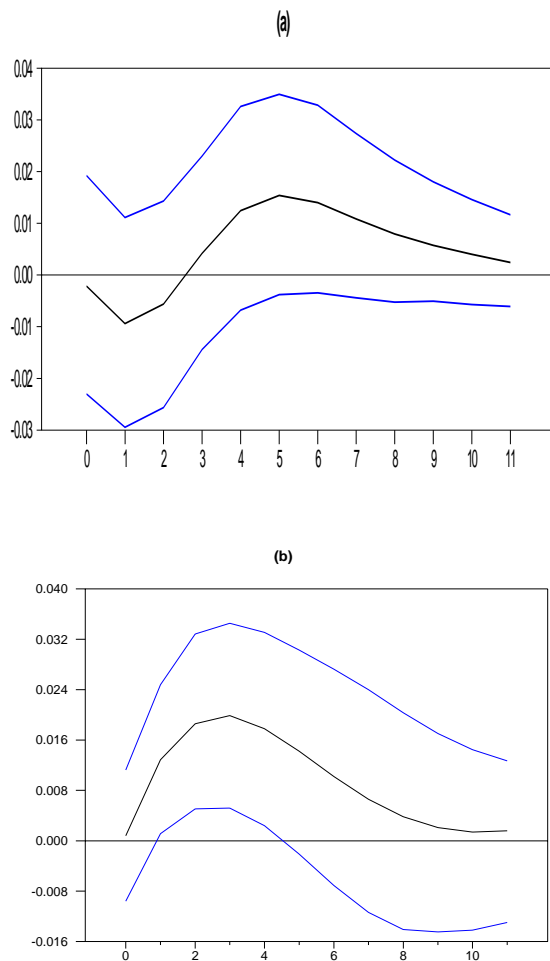(employment-employment),
(a) period 1987-1993 and (b) period 1994-2003**

**(a)**



**(b)**

Figure 5
**IR function and error bands Texas-Nuevo Laredo**
**(employment-employment),**
**(a)  period 1987-1993 and (b) period 1994-2003**

**(a)**



**(b)**



Having determined the degree of integration of the labor market in terms
of employment, we now assess the impact of changes in US manufacturing
employment on Mexican wages. Figures (6) through (9) show the impulse-
response function of one standard deviation in California and Texas'

employment on Tijuana, Ciudad Juarez, Matamoros, and Nuevo Laredo's real wages, respectively.

Similar to employment, there is a significant change in the pattern of adjustment of short-term real wage between the two periods. Manufacturing wages in Tijuana, for instance, were barely affected by a shock on California's employment during the first period. It became positive and declined immediately until becoming insignificant after the 4th quarter during the second period. In the case of Ciudad Juarez, during the first period, a shock on Texas' employment induced a contemporaneous negative effect on short-term wages. It turned positive from the 2nd to 7th quarter, reaching its maximum at the 3rd quarter during the second period. Matamoros' wages, on the other hand, maintained the positive impact throughout both periods. The only noticeable change was the increase in the magnitude of the relationship. Finally, in the case of Nuevo Laredo the positive impact remained throughout both periods.

Figure 6
**IR function and error bands California-Tijuana**
**(employment- wages),**
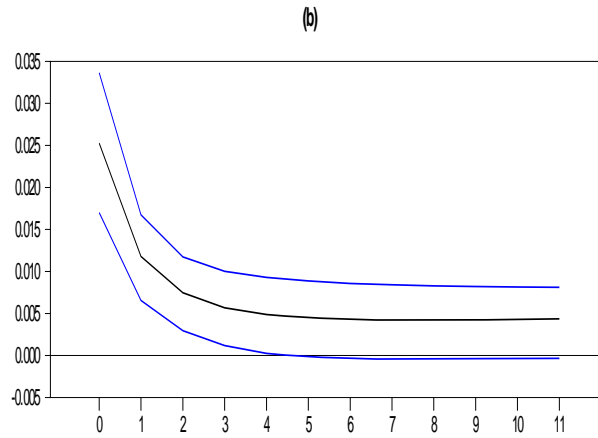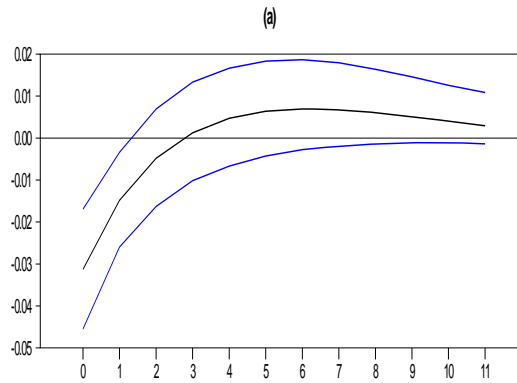**(a) period 1987-1993 and (b) period 1994-2003**



(a)

**(b)**
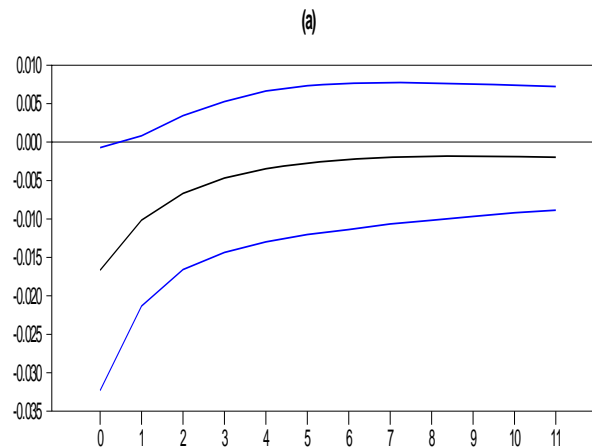


Figure 7
**IR function and error bands Texas- C. Juarez
(employment-wages)
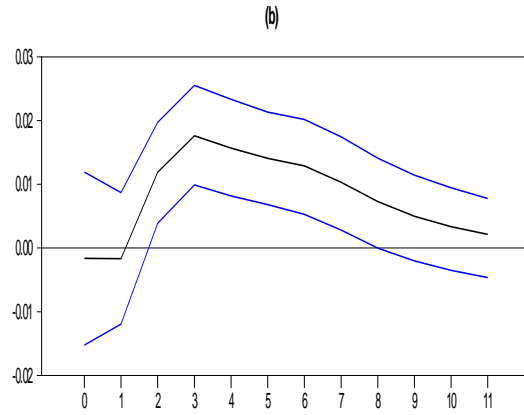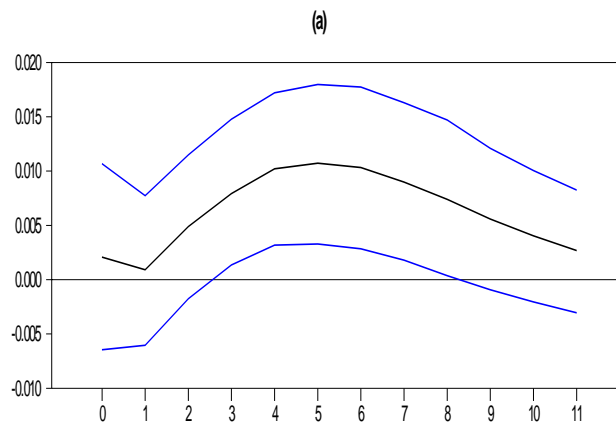(a) period 1987-1993 and (b) period 1994-2003**

**(a)**

**(b)**

Figure 8
**IR function and error bands Texas- Matamoros (employment-wages),
(a) period 1987-1993 and (b) period 1994-2003**

**(a)**

**(b)**


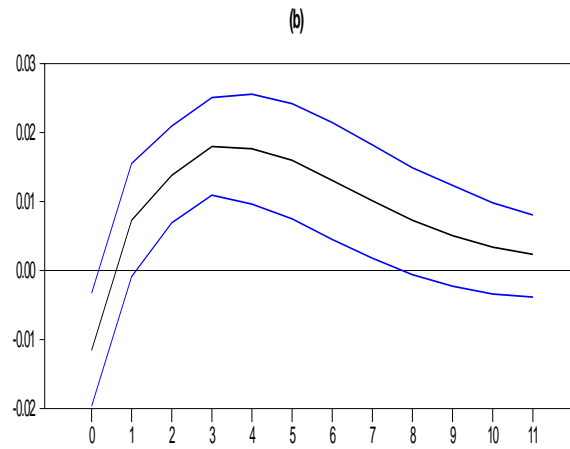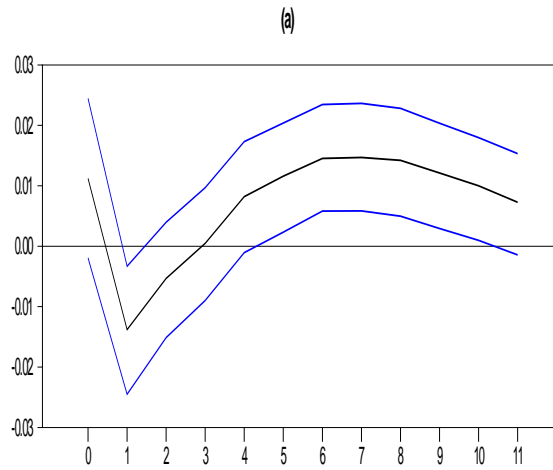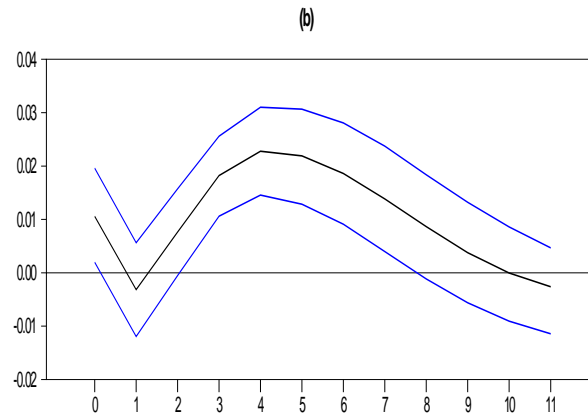
Figure 9
**IR function and error bands Texas-Nuevo Laredo
(employment-wages)
(a) period 1987-1993 and (b) period 1994-2003**

**(a)**

**(b)**



Our results suggest that manufacturing employment fluctuations in Mexican cities have become more synchronized to US manufacturing employment (the results hold when we look at state-wide and nation-wide data) after 1994. One contribution of this study is to measure not only the degree of labor market integration between both economies but also the magnitude of such changes. A possible explanation of such changes is that they are the result of an ongoing restructuring of the in bond industry in Northern Mexico. Table 5 presents the employment distribution by main manufacturing sectors as a percentage of total city's employment during both periods. 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. In fact, Matamoros is the only city that does not exhibit such changes.[28] In other words, the region seems to have enjoyed an inflow of foreign subsidiaries that tied Mexican labor market even more than what previously was; in particular, an increasing number of maquiladoras plants are assembling more goods classified as machinery, equipment and metal products.[29]

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[28] We did not include the percentage in the other sectors because the changes that occurred in them were marginal.

[29] Basically, as a result of the auto-component's industry and the electronics' one.

Table 5
**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.

3.4 Empirical Analysis: Trend Component

We now turn to the discussion of the long-term behavior of employment in these Mexican cities and that of California and Texas. As can be observed in Figure 10[30], prior to 1994 although there was some resemblance in their behavior this was rather weak. After 1994, there is a movement towards a long-term synchronization of employment among these Mexican cities. The long term behavior of Tijuana's manufacturing employment deserves special comments. Prior to 1994, it showed a trend quite different from the other Mexican cities. However, after 1994 it changed significantly and moved closer to path of the other cities.

The performance of California and Texas manufacturing employment, on the other hand, is more stable. We do not observe any significant change in their long term trend throughout the period of analysis.

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[30] The units on the vertical axis are logs of manufacturing employment.

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



**Employment long-term trend component**
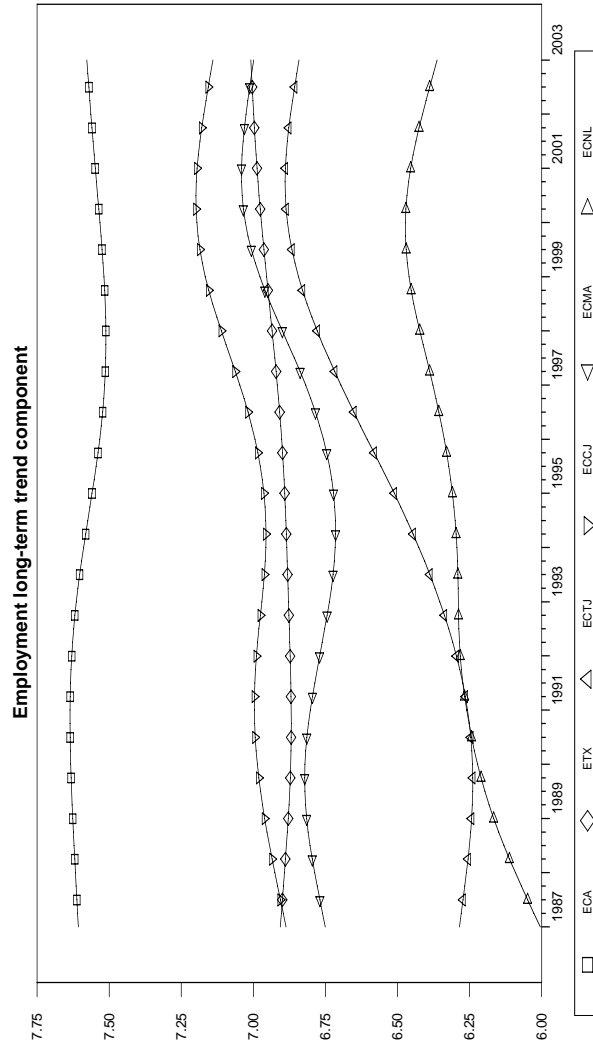
**Conclusions**

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

The literature on FDI identifies two types of FDI: horizontal and vertical. They each respond to a particular set of variables and play a specific role within the overall strategy of the MNCs: It is a fact that the type of FDI coming to Mexico is of the vertical type; that is, investment that responds to differences in relative factor prices between the home and host 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 respect, one would not be surprised to find higher labor markets integration. Our argument however is that labor market integration caused by vertical FDI is more direct than integration induced by increased trade flows.

The analysis of co-dependence between the US and Mexico labor markets was carried out by estimating the cyclical component of California, Texas and overall US' manufacturing employment and of four US-border Mexican cities through the Hodrick-Prescott filter. We measured labor market integration in two ways: (1) estimating the cross-correlation of manufacturing employment fluctuations between the two regions, (2) calculating the cross-correlation between US manufacturing employment and Mexican real wage. 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. We also found evidence that the long-term behavior of employment also changed unmistakably. Previous to 1994, the trend component of Mexican employment had different behavior. After 1994 there is movement toward a greater parallelism in their long –term behavior. That is, we observe that there has been a smooth movement towards a state in which their differential growth rates remain constant.

In general, our results are as expected and consistent with other studies on economic integration between the US and Mexico. However, our study provides a new light about the discussion of labor market integration for we relate labor market integration to the flow of vertical FDI. This represents a step forward with respect to previous analyses where there is not a theoretical explanation about labor market integration as in Fragoso, et al (2008). Here rests one line of future research: to develop a formal model of the role of FDI on labor market integration and to contrast it empirically. Unfortunately, due to the lack of information about the flow of FDI directed to the border cities we did not incorporate FDI explicitly in our empirical analysis.

Another important element of our analysis is that we analyze the behavior of employment instead of wages to measure the degree of labor market integration. As argued the use of wage rates to show labor market integration might not be a good idea because they could respond more to supply, demand and institutional factors (such as labor unions) than to economic integration.

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

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**Appendix**

<div align="center">

Table A1
**Dickey - Fuller Test**

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| Unemployment $\tau(\rho-1)$ | $\phi_z$ | Wages $\tau(\rho-1)$ | $\phi_z$ |
|---|---|---|---|
| California 2.766 | -0.144 | | |
| Texas 5.348 | 1.006 | Tijuana 3.374 | -0.104 |
| Tijuana 1.560 | 0.879 | Ciudad Juárez 1.720 | 0.407 |
| Ciudad Juárez 1.573 | 0.391 | Matamoros 3.003 | 1.728 |
| Matamoros 2.084 | 0.214 | Nuevo Laredo 1.588 | 1.503 |
| Nuevo Laredo 2.968 | 0.333 | | |

Source: own estimates
The results are based on the regression

$$\Delta y_t = a_o + \gamma y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-1+1} + \varepsilon_t$$

$\tau(\rho-1)$ and $\phi_z$, test respectively, the null hypotheses, (i) $\gamma = 0$, (ii) $\gamma = a_2 = 0$. 5% critical values: -1.950 and 6.250 respectively

<div align="center">

Table A2
**Perron (1997) Test**

</div>

| Unemployment | $\tau(\rho-1)$ | Wages | $\tau(\rho-1)$ |
|---|---|---|---|
| California | -4.498 | | |
| Texas | -5.126 | | |
| Tijuana | -3.175 | Tijuana | -4.285 |
| Ciudad Juárez | -4.721 | Ciudad Juárez | -5.418 |
| Matamoros | -4.070 | Matamoros | -5.426 |
| Nuevo Laredo | -2.991 | Nuevo Laredo | -5.742 |

Source: Own estimates

$\tau(\rho-1)$  test the null hypotheses of a unit root. Critical value: 6.250