

WAGES, GAPS AND DERIVED DEMAND:
THE CASE OF UNITED STATES AND MEXICAN PRODUCTION WORKERS

A Thesis

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ABSTRACT

Despite Mexico joining NAFTA in 1994, a manufacturing wage gap between Mexico and United States production workers continues to remain at a considerable extent. Further, it increased as from 2007, systematically measured in dollar terms and adjusted by producer prices. While the Stolper-Samuelson and the Factor Equalization theorems seem not to hold, additional characteristics are analyzed through an error correction model, applied to three continuous and consistent pre and post NAFTA time periods. A positive Mexico-United States manufacturing output ratio and Mexican real exchange rate depreciations widens the wage gap. The manufacturing output ratio growth is found to affect negatively the demand for United States production workers. Meanwhile, Mexican hourly wages appear as a substitute of United States labor demand, with a coefficient approaching an elastic value. Far from any complementariness, wage divergences appear to be instrumental for the incidence of Mexican labor in United States manufacturing production workers.

BIOGRAPHICAL SKETCH

Carolina Carbajal De Nova is submitting the present Master Thesis in partial fulfillment of the requirements for the degree of Master of Sciences in Applied Economics and Management at the Charles H. Dyson School of Applied Economics and Management.

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CHAPTER 1

Introduction

In 1990, the Mexican and United States governments, through their presidents, announced their determination to enter into a fast-track procedure to sign a free trade agreement between their two countries. Mexico became part, along with Canada, of the North American Free Trade Agreement (NAFTA). This agreement seeks to deregulate trade and capital flows, while giving no consideration to labor mobility. It also considers tariff elimination and other trade barriers among the United States, Canada, and Mexico over a 15-year period, which is already over. Therefore, it is expected that integration has been attained to a considerable degree. However, labor flows, Mexican oil operations under a government monopoly and pegging the Mexican peso to the dollar were left out of negotiations. Nearly two decades after the NAFTA was implemented in 1994, a labor migration reform has not been yet established.

As a result of the above mentioned agreement, it was expected that free trade would effectively contribute to reduce any wage gap, as labor is to compete

indirectly, *i.e.* through the price of traded goods. A reduction in the wage gap would imply an equalization or convergence in the income of workers. Ever since Mexico formally joined NAFTA, the subject of wage convergence has been a recurrent topic in the literature. Furthermore, the very NAFTA announcement gave rise to a series of debates, considering the asymmetry, in particular between Mexico and the United States. For example, NAFTA continues to lead expectations of job generation in Mexico, due to prevailing low wage levels and therefore, to the cheapening of goods exported to United States. For the Mexican case, great hopes of attracting foreign direct investment and capital flows to reduce its chronic external deficit still prevail.

This work exclusively envisages manufacturing production and nonsupervisory workers. This segment could be considered as the most important one in manufacturing, both due to its size as well as to its role and skill conveyed. Its relevance is underlined when their higher wages are compared with the compensation received by workers in the retail and wholesale sectors, for instance. Besides, manufacturing is at the heart of any advanced or emerging economy, reflecting its relative strength.

No purchasing power adjustment for final demand is made between wages in both countries, as it is labor as a factor of production and not its welfare as final consumer what is considered here. In other words, the analysis is over product wages, and no regarding real wages.¹ Meanwhile, the present work concentrates itself on the examination of wages as a factor of production.²

Besides, basically all the estimates are done in terms of United States dollars, while price adjustments, when required, are carried out using United States deflators. In other words, Mexican labor is analyzed regarding its incidence through the wage gap, manufacturing output ratio of both countries as well as wage rates, on United States manufacturing production workers. It is important to mention that

¹ Sachs (1983), for instance, correctly distinguishes between product wages and real wages. He makes explicit that it explains the trend of the labor cost to the firm.

² If a comparison of real wages between both types of manufacturing workers were to be made, a totally different approach would have to be followed. This is because there is no common basket of goods and services for both groups of workers, as Mexico has its own currency. Therefore, purchasing power comparisons would have to be introduced, expressing different costs of such final consumption of goods and services for the worker within each country. Such result, as a difference to the approach taken in this work, would bring about well-being differentials, for instance, between workers in both sides of the border. Nevertheless, the importance of considering a welfare differential would suggest the production of a completely different analysis, as it would focus on wages from the point of view of final consumption *i.e.* real wages.

only inland manufacturing is taken into account. In consequence, Mexican *maquiladora* workers, devoted to offshore assembly for export are being excluded.

This work is organized as follows: the first chapter introduces the subject including a brief outline of the content of this work. In the second chapter, the bilateral wage gap among manufacturing production workers is dealt with by descriptive statistics, followed by an estimate of this gap, which is made dependent on the bilateral real exchange rate and the manufacturing output ratio, between Mexico and United States. In addition, the growth rate of the latter ratio is being estimated. In the third chapter, an assessment over wage elasticity is performed. In the fourth chapter the derived demand for labor, incorporating United States and Mexican wages are estimated in terms of employment and the wage bill for the United States, followed by the conclusions, which are briefly presented in a fifth and final chapter.

CHAPTER 2

Wage gaps: an unattained convergence

The analysis for wage convergence could be traced back to the beginning of the 20th century, regarding factor endowments, free trade and price equalization. Ohlin (1967) claimed, alongside Heckscher (1991) who was a pioneer of this concept, that production based on comparative advantage is grounded on factor proportions, leading to the well-known theorem. Specifically, foreign trade could act as a substitute for the flows of labor migration and capital movements.

Afterwards, Samuelson (1948) provides an adequate proof of the factor price equalization theorem. Assuming two goods, the same number of factors of production and countries, the price of factors would be equalized without the need for factor mobility, whether it could be labor migration or capital flows. There are a series of restrictive assumptions, which should be borne in mind.³ Within this theorem, the factor remunerated at a lower price, would tend to become more

³ That is to say, free trade, no transportation costs, perfect competition, cost minimizing firms, constant returns to scale, identical number of production functions and international markets, similar technology and prices, for instance. It is important to note that labor homogeneity is assumed in terms of hours worked and effort per hour, according to Hamermesh (1993), p. 20.

expensive as the two countries trade. At the same time, the factor that is more expensive in one of the two countries will tend to lower its price. If this theorem holds, it would be expected that manufacturing wages for workers in Mexico would rise as a result of NAFTA, while the opposite would be the case for United States. It has been claimed that it was Lerner (1952) who first discovered this theorem back in 1933.

Further, Stolper and Samuelson (1941) produced what is known as the theorem bearing their name, based in turn on the validity of the Heckscher-Ohlin (HO) theorem. According to Haskel and Slaughter (1998), a version of the SS theorem considered that unskilled workers, which produce traded goods in a country where high-skills prevail would be worse off, as foreign trade increases. This is because unskilled labor is a less abundant factor in a high-skilled labor country, *vis-à-vis* capital, which is abundant. Therefore, it could be deduced that it would not be to the advantage of countries like Mexico to produce goods that require a high level of skill.

Bearing in mind the theoretical framework towards convergence outlined before, an attempt to examine the wage gap between both countries is being done. This work does not attempt to test the SS theorem. In other words, it is constrained to analyze wage convergence. In fact, to test the SS theorem constitutes a work on its own. Every reference in the present document regarding FPE is in relation to what is to be expected according to the corpus of such theory. Besides, labor is the only production factor addressed in this work, leaving totally aside what could happen or might have happened to capital, as another factor of production. In this respect, this analysis focuses exclusively on the wage gap convergence of labor.

By means of descriptive statistics, three such sets are reported in Table 1. The first set describes the behavior for the wage gap; the second set describes United States wages, and the third set describes Mexican wages. The purpose of this table is to describe the principal trends depicted by these variables. In order to have continuous and consistent variable sets, three periods were selected,⁴ *i.e.* 1987-1994; 1995-2006 and 2007-up to date.⁵

⁴ These three periods were established on the basis of data available for the Mexican manufacturing sector for four overlapped periods *i.e.* 1987-1994; 1994-2008; 2005-2010 and 2007

Table 1. Manufacturing Production Workers. United States-Mexico. Gap and Wages. Selected periods (Wages at prices of 1982* per hour)

	1987:01-1994:12	1995:01-2006:12	2007:01-2013:02
1. Gap			
<i>Mean</i>	0.15	0.14	0.11
<i>SD</i>	0.04	0.03	0.01
<i>CV</i>	0.29	0.23	0.12
2. United States			
<i>Mean</i>	9.26	10.41	10.17
<i>SD</i>	0.18	0.45	0.31
<i>CV</i>	0.02	0.04	0.03
3. Mexico			
<i>Mean</i>	1.41	1.51	1.11
<i>SD</i>	0.43	0.40	0.14
<i>CV</i>	0.30	0.26	0.12
<i>n</i>	96	144	74

* Adjusted for inflation by the producer price index (finished goods), not seasonally adjusted (nsa).

Note: SD stands for standard deviation and CV for coefficient of variation.

Source: Own estimates based on *Banco de Mexico*, Bureau of Labor Statistics and *Instituto Nacional de Estadística y Geografía*.

In Table 1, Mexican wages are being converted to United States currency in order to make them comparable to United States wages. Besides, United States and Mexican wages are adjusted for inflation through producer price indexes. As a result, wages are measured throughout time from the firm point of view, that is to

up to date on a monthly basis. It was judged convenient to establish a pre NAFTA period, while the last post NAFTA period comprises in full the recent economic recession.

⁵ The same sectors of economic activity that appear in the first period, were maintained with the two following ones, in order to make the three periods consistent in terms of the number of sectors of industrial activities analyzed (see Appendix 6).

say, as product wages. Hence, the wage gap represents the fraction of the average Mexican wage compared to its counterpart in the United States.⁶

For the first two periods, comprising 1987 to 1994 and 1995 to 2006 on a monthly basis, the wage gap has remained basically without change. That is to say, Mexican wages amounted to around one seventh of United States wages.⁷ However for the last period, *i.e.* 2007 to date, the mean wage gap grew to over one tenth, widening the difference between Mexican and United States wage.⁸

The behavior of United States wages throughout time is basically stable with a reported mean of 9.26; 10.41 and 10.17 dollars of 1982 per hour. This stability is also displayed by the coefficient of variation (CV) with values of 0.02; 0.04 and

⁶ By using a producer price index (PPI) as a proxy for a gross value added deflator, a product wage is being estimated.

⁷ As for the two periods mentioned above, a mean value of 0.15, and 0.14 is found respectively. Here, the wage gap is the ratio of Mexico and United States manufacturing hourly wages. A unit ratio would be an absence of gap, while a value towards zero would convey an increasing gap.

⁸ In consequence, the debate between exporting goods or people to the United States claimed by Blecker and Esquivel (2009) does not seem to apply, as a widening wage gap could induce both, and not the first at the expense of the second.

0.03 for 1987-1994; 1995-2006 and 2007-up to date, respectively. This CV stability goes alongside with a modest wage growth rate.

Meanwhile, for the periods 1987-1994; 1995-2006 and 2007-up to date the Mexican wage shows a greater variation, though a diminishing CV of 0.30; 0.26 and 0.12, respectively.⁹ The Mexican mean exposes values of 1.41; 1.51 and 1.11 dollars of 1982 per hour, for each of the subsequent periods. As a result, the fall of the Mexican average wage in terms of United States currency appears to be coincident with the enlargement of the wage gap. Besides, the reduction of the dispersion, in particular during the last period seems to be associated with the wage contraction that production wages experienced in Mexico, suggesting a fall in the wage differentials among skills.

From the above Table 1, United States CV exposes stability along with a modest wage growth rate. For its part, Mexican CV shows considerable fluctuations and a subsiding rate of increase. In this respect, Gandolfi, Halliday and Robertson (2014)

⁹ Esquivel and Rodriguez (2003) address the time period between 1988 and 1994, finding that trade liberalization has reduced the wage dispersion in Mexico, *i.e.* when compared with the pre-NAFTA period. However, no explanation for this reduction is provided.

find that for a US-Mexico integrated economy the variance of log wages has declined due to reductions in variation in wages across education/age cohorts.¹⁰

These authors conclude that the data seem to suggest that Mexican wage dispersion has decreased and that United States wage inequality has steadily increased.¹¹

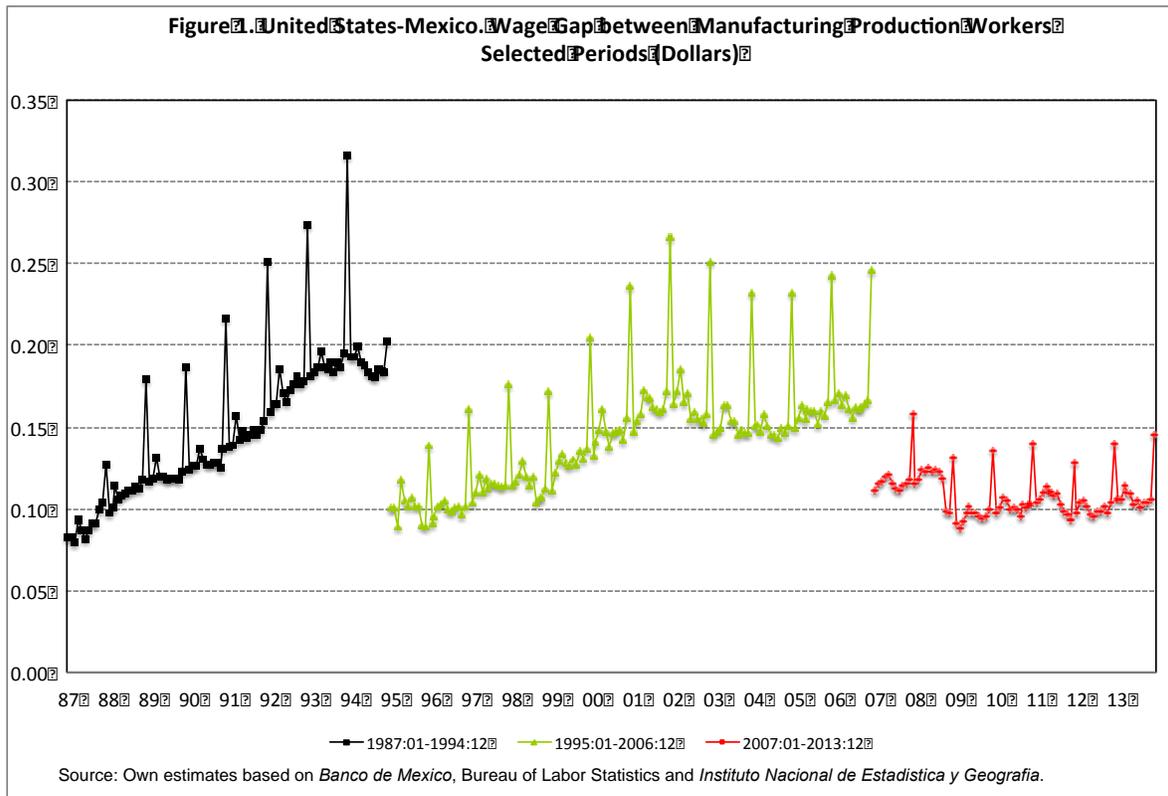
In Figure 1, the evolution of the wage gap through time is presented. The mean of the wage gap,¹² belong to the range plotted for each period. In Mexico every December, there is a statutory annual bonus.¹³ As a result, the wage gap appears to be reduced during the last month of the year.

¹⁰ “Similarly, we also show that in the US-Mexico integrated economy the variance of log wages has declined and that this is due to reductions in variation in wages across education/age cohorts...”

¹¹ “In summary, the data seem to suggest that Mexican wage dispersion has decreased and that American inequality has done the opposite but that this is not consistent with a textbook HOS story.” The time evolution of log wages in the integrated economy is depicted in Table 5 of Galdolfi *et al.* (2014).

¹² Table 1.

¹³ Locally known as *aguinaldo*, which legally corresponds to a bonus amounting two weeks of wages.



The fall in dispersion, particularly during the last period, as well as the increase in the wage gap are confirmed by looking at Figure 1. The wage gap is considerably influenced by the Mexican inflation and the peso dollar exchange rate. These elements are considered in Appendix 7.

Returning to the wage gap results mentioned above and its relation with some literature, Calderon (2006) while resorting to descriptive statistics argues that the

real wage gap between Mexico and United States has been widening, by increasing to an equivalent of 0.10 in 1993, to reach over 0.08 in 2002.¹⁴ Lederman, Maloney and Serven (2005, p.5) concluded that NAFTA does not suffice to ensure economic convergence in North America.

It is conceded that *per-capita* GDP (Gross Domestic Product) of other Latin American and Caribbean countries has evolved more favorably than in Mexico, despite the fact that they did not enter into a trade agreement with United States. The difficulties for convergence as far as *per-capita* GDP is concerned, are expected to remain in the long-term, as the just above mentioned authors envisage institutional gaps, as well as deficiencies in public policies regarding *i.e.* education and innovation in Mexico.

Polaski (2004), for example, reaches similar conclusions by finding that Mexican wages are diverging, rather than converging with the ones in United States. These

¹⁴ In so far as the author estimates the wage gap as a ratio between United States and Mexico, the figures that he produced are 9.6 in 1993, and 12 in 2002. When estimated the other way around, *i.e.* the ratio between Mexico and United States wages, the figures of 0.10 and 0.08 are obtained, which are the ones reported in the present work.

findings are endorsed, *inter alia* by Deva and Sonderfors (2008). In analyzing the real wages ratio between Mexico and United States, by means of a linear regression without stationary variables, these authors conclude that the speed of wage convergence, which took place after NAFTA is below the one achieved before the agreement was established.

Gandolfi *et al.* (2014), resorting to the foundations of neoclassical trade theory, endorse the Heckscher-Ohlin-Samuelson (HOS), predicting convergence on the price of goods and factors. However, these authors report a lack of convergence for the time period of 1988 to 2011.¹⁵

Hanson (2003) finds that there is little evidence on wage convergence between both countries. He reaches this conclusion by analyzing the 1990 and 2000 population censuses. In examining the sensitivity of Mexican wages to wage changes in United States, after controlling for education, Hanson found no significant effect in Mexico *vis-à-vis* United States wages.

¹⁵ Regarding future tasks, an applied general equilibrium model to generate direct predictions related to NAFTA and income convergence is needed, according to these authors.

The empirical evidence for wage convergence seems to wince when Feenstra and Hanson (2003) report that according to their results, it appears that international trade helps in increasing the skilled-unskilled wage gap.

Robertson (2005a), uses the United States Current Population Survey (CPS) National, and its Mexican counterpart, the *Encuesta Nacional de Empleo Urbano* (ENEU). Through an error correction approach, an assessment of NAFTA labor market integration between United States and Mexico is accomplished. In this purpose, he classified wages according to age, and educational groups in four key border locations constrained to *maquiladora* activity,¹⁶ besides Mexico City. This author used three measuring approaches: absolute wage convergence, response of Mexican wages to United States wage shocks, and the rate of convergence between United States and Mexican wages. He finds that Mexican and United States wages expose a long-term relationship, *i.e.* they cointegrate. However, he also reported little evidence of increased integration in NAFTA labor market.

¹⁶ Tijuana, Ciudad Juárez, Matamoros and Nuevo Laredo. According to Hanson (2003), around four fifths of *maquiladora* output is concentrated in three types of goods: apparel, electronics and car parts.

As a continuation of his 2005 wage convergence analysis, Robertson (2005b) assumes that if there is a NAFTA labor market integration, wage shocks could be transmitted from one region to the other one. In order to achieve integration, he says, a long-term wage equilibrium differential should be shrinking between United States and Mexico. However, he reports that the difference between wages in both countries is constant, returning to such long-term wage equilibrium differential whenever they deviate from it. As a result, this author concludes that neither a convergence nor a divergence in terms of long-term wage equilibrium differential is being reached.

Through a different procedure, Hanson (2003) analyzed the wage structure in Mexico, going as far back as the 80's, when the liberalization process of the Mexican economy started. Specifically, this author examines 1986, when Mexico joined the General Agreement on Trade and Tariffs (GATT). He found that wages and demand for skilled workers have risen, as they mirror closely labor wage

fluctuations in United States.¹⁷ At the same time, he noted that regional wage differential among countries have grown. He believes that this effect is due to heterogeneous access to foreign investment, trade and migration opportunities.

Afterwards, Hanson (2004) examines the impact of free trade (NAFTA) in the Mexican labor market. He finds that a greater wage premium is presented in the Mexican border regions *vis-à-vis* the Mexican south. As a consequence, he reports little wage convergence across labor market groups during the 90's at this geographical level. He employs data from the 1990 and 2000 population censuses and synthetic cohorts.

As an exception to the findings mentioned previously, Esquivel and Rodriguez (2003), explicitly claim that they found grounds to confirm the SS theorem. However, they argue that this wage effect was offset by the sizable negative impact of technological progress on the real wage of unskilled workers. For the

¹⁷ Hanson finds that Mexican interior wages rise 1.8%, while Mexican border city wages increase 2.5%. Both increases were the result of a shock coming from United States, where wages increased by 10%.

period 1994-2000, these authors did not find a wage divergence effect, suggesting that even a slight increase in wage inequality was the result of technical progress.

Robertson (2004) finds that prices explain wage inequality in line with the SS theorem. For this purpose, he constructs two sets of price indexes: Laspeyres and Paasche. This author finds that changes in relative good prices are connected to changes in relative wages, a link that emerges in a period of three to five years.

2.1 Wage gaps: determinants

An estimate is done in order to find out which factors contribute to determining a growing wage gap.¹⁸ The Mexico-United States wage gap in dollar terms is presented as a function of a bilateral real exchange index and the manufacturing output ratio. In brief, the existing wage gap between Mexican and United States production workers is assumed to be determined, on the one hand, by the degree

¹⁸ In searching for adequate variables determining the wage gap, several inroads have been examined. Initially, the inclusion of years of education and training ("human capital") was considered. However, the frequency for which data is available (annual) rendered them inadequate. On the other hand, unemployment rates were found to be without significance, as the shadow economy in Mexico, besides being sizable provides recurrent opportunities for local labor, weakening the relevance of this variable.

of appreciation of the Mexican currency *vis-à-vis* the dollar. On the other hand, such gap is to be determined by the manufacturing output ratio of both countries *i.e.*, Mexico and the United States.

$$(1) \quad \log \left(\frac{\frac{W_{mx}^i}{h_{mx}^i}}{\frac{E_o}{w_{us}^i}} \right)_t = c_t + \alpha \log (Er_c)_{t-j} + \beta \log \left(\frac{Q_{man\ mx}^i}{Q_{man\ us}^i} \right)_{t-j} + \varepsilon_t.$$

where W_{mx}^i is the wage bill or payroll for Mexican manufacturing production workers; h_{mx}^i is the number of hours of manufacturing production workers for the Mexican manufacturing industry; E_o is the nominal exchange rate, *i.e.* pesos per dollar; w_{us}^i is the United States average hourly earnings of manufacturing production and nonsupervisory workers; Er_c is the Mexican bilateral real exchange rate computed with consumer prices;¹⁹ $Q_{man\ mx}^i$ is the manufacturing production

¹⁹ In Appendix 1 (Relation of variables and sources), a full definition is provided for these variables as well as for the rest that are being used throughout this work. The differences between E_o and Er_c , is that the former measures the local currency value inside of a country, while the second expresses the relationship between the consumer prices of one country with respect to the other country. The Mexican and United States inflations are linked by their corresponding nominal exchange rate, which serves as a vehicle to compare both inflations.

index for Mexico in local currency;²⁰ $Q_{man\ us}^i$ is the manufacturing production index, North American Industry Classification System (NAICS) for United States expressed in local currency; while ε stands for the error term. The superscript i refers to $i = 1, 2$ and 3 , expressing the time period under consideration, $i = 1$ covers from January of 1987 to December of 1994; $i = 2$ stands for January of 1995 to December of 2006; $i = 3$ considers from January of 2007 to February of 2013. The subscript t refers to the current period of time; j refers to time lags, where $j = 1, 2, \dots, n$.²¹

For the above equation (1), a positive coefficient of the Mexican bilateral real exchange rate with respect to the wage gap is expected. That is to say, an appreciation of the Mexican peso would convey a reduction of the wage gap. Certainly, this reduction implies that wages become closer between both countries.

²⁰ "The production index measures real output and is expressed as a percentage of real output in a base year." Retrieved from <http://www.federalreserve.gov/releases/g17/about.htm>. The nominal manufacturing output in its current currency is deflated to obtain the real output and later it is converted to an index with weights based on annual estimates of value added. The manufacturing output index is computed in its correspondent statistical offices, either in Mexico or United States. Thus, United States manufacturing output index is in dollars and the Mexican one is in pesos.

²¹ Then, j is the lag of the independent variable necessary to obtain a better adjustment with respect to the dependent variable.

If the SS and FPE theorems hold, a contraction in the wage gap is expected. Thus, the effect of manufacturing output over the wage gap is assumed to be positive. Regarding the index of manufacturing output ratio, a negative coefficient is expected. That is to say, the larger the manufacturing output growth in Mexico, a higher wage gap should be observed. This is in so far as a relative manufacturing output growth in Mexico would rebound in a wider gap between the wages of both countries, suggesting a relative lowering of Mexican wages.

Table 2. Manufacturing Production Workers. Elasticity of the Wage Gap with respect to Mexican Real Exchange Rate and Manufacturing Output Index Ratio. Monthly frequency. Selected periods

		Dependent variable: <i>Mexico-United States wage gap</i>		
		1987:01-1994:12	1995:01-2006:12	2007:01-2013:02
Independent variables:				
<i>Mexican real exchange rate*</i>				
Long-term		1.56	1.44	0.93
	lag	t-1		
Short-term		1.67	0.79	1.07
	lag	t-1		
<i>Manufacturing output index ratio**</i>				
Long-term		-0.93	-0.69	-0.66
	lag	t-2		t-3
Short-term		-1.56	-0.68	-0.78
	lag	t-2		t-3
	n	96	144	72

* Bilateral Mexico-United States, on the basis of consumer price indexes.

** Mexican manufacturing production index in relation with the U.S. one, each adjusted for inflation with local implicit price indexes.

Note 1: All reported estimates are significant at a 99%, as reported on Appendix 2.1.

Note 2: The 1995:01-2006:12 time period includes a dummy variable for the last month of December (intercept), due to a statutory annual bonus payment (*aguinaldo*).

Source: Appendix 2.1.

Ostensible long-term elasticity coefficients are obtained for the wage gap with respect to the Mexican real exchange rate for the pre NAFTA period, *i.e.* 1987-1994 and in the first post NAFTA period, *i.e.* 1995-2006 (1.56²² and 1.44, respectively). During the current period the respective coefficient is slightly reduced below the unit value (0.93). The short-term elasticity coefficient is above the unit

²² With one month lag.

value (1.67)²³ for 1987-1994. After falling below a unit value (0.79) in the first post NAFTA period (1995-2006), it exposes an almost unit value (1.07) for the current period (2007-up to date).

As a result, the bilateral real exchange rate becomes a most important variable to influence the wage gap. At the same time, a reduction of this gap would require an appreciation of the Mexican peso, which in turn lies outside the domain of labor markets.

In the long-term, the elasticity of the wage gap with respect to the ratio of Mexico-United States manufacturing index is elastic and negative in the pre NAFTA period (-0.93),²⁴ *i.e.* 1987-1994. While its value tends to be reduced once NAFTA is in place (-0.69 and -0.66²⁵), nonetheless it remains negative and close to being elastic. In the short-term, the coefficients are similar for the first post NAFTA period (-0.68) *i.e.*, 1995-2006, as well as for the current period (-0.78)²⁶ *i.e.*, 2007 to date.

²³ Lagged one period.

²⁴ With two months lags.

²⁵ Lagged three periods.

²⁶ With three months lags.

During the pre NAFTA period *i.e.*, 1987-1994 the short-term coefficient reaches the highest value (-1.56).²⁷ Given the negative sign expressed in these coefficients, a negative relationship is established for these variables. For instance, an increase in the manufacturing output ratio of Mexico-United States would decrease the Mexican-United States wage gap. In other words, a rise in the rhythm of Mexican manufacturing output in relation to the one for United States would derive a greater wage gap. In the next section, the growth rate of manufacturing output ratio is to be measured. This is in order to confirm whether such quotient has been growing. If this is the case, the results from equation 1 and reported in Table 2, would be consistent with Table 1, where the wage gap exposes a systematic growth through time.

2.1.1 An examination of selected tradable sectors

The above equation (1) considers both manufacturing output index ratio and wages in an aggregate fashion. However, it is of interest to consider how specific tradable sectors behave in Mexican manufacturing, while using the functional form previously expressed in equation (1). For this purpose, three tradable sectors are

²⁷ Lagged two periods.

being selected *i.e.*, primary metals, machinery and transport equipment. The relevance of these sectors is attested in so far as they represented 81.7 % of the total manufacturing exports in 2012.²⁸ For convenience, the results are reported in Table 2.A with respect to the Mexican real exchange rate and in Table 2.B regarding the manufacturing output index ratio, as follows:

²⁸ This trade percentage is computed using the Mexican Balance of Payments for manufacturing products for 2012.

Table 2.A Manufacturing Production Workers. Elasticity of the Wage Gap with respect to Mexican Real Exchange Rate.* Monthly frequency. Selected periods and sectors

Independent variables:		Dependent variable: <i>Manufacturing Mexico-United States wage gap</i>		
		1990:01-1994:12	1995:01-2006:12	2007:01-2013:02
<i>Manufacturing</i>				
Long-term		1.66	1.44	0.93
	lag	t-1		
Short-term		1.54	0.79	1.07
	lag	t-1		
<i>Primary metals</i>				
Long-term		1.44	1.25	0.61
	lag	t-1	t-3	t-1
Short-term		2.57	1.12	0.90
	lag	t-1	t-3	t-1
<i>Machinery</i>				
Long-term		1.91	1.26	0.86
	lag	t-1		t-1
Short-term		3.92	1.52	1.56
	lag	t-1	t-1	t-1
<i>Transportation equipment</i>				
Long-term		1.79	2.08	1.12
	lag	t-1	t-1	t-1
Short-term		3.98	2.09	1.27
	lag	t-1	t-1	t-1
	n	60	143	71

* Bilateral Mexico-United States, on the basis of consumer price indexes.

Note 1: All reported estimates are significant at a 99%, as reported on Appendix 2.1.

Note 2: The 1995:01-2006:12 time period includes a dummy variable for the last month of December (intercept), due to a statutory annual bonus payment (*aguinaldo*).

Source: Appendix 2.1.

Considering the availability of data, the first period that has been considered in

Table 2 *i.e.*, from 1987 to 1994 on a monthly basis, has to be restricted in Table

2.A due to the data availability in the United States. The Bureau of Labor Statistics reports hourly wages for these sectors as from 1990.

According to the results, the three tradable sectors expose a coefficient, which is not far away from what is obtained for manufacturing as a whole. It would have been expected that a larger coefficient would be obtained for these sectors. This is the case with transportation equipment,²⁹ exposing a coefficient with a higher value than manufacturing as a whole during the three periods considered. That is to say, for the long-term, the coefficients obtained have been of 1.79, 2.08 and 1.12 for 1990:01-1994:12; 1995:01-2006:12 and 2007:01-2013:02, respectively.³⁰

For the short-term, a higher coefficient for transport equipment is also replicated, *vis-à-vis* manufacturing as a whole. For instance, values of 3.98, 2.09 and 1.27 for

²⁹ This is taking into account Mexican success in the last phase of labor-intensive car manufacturing i.e., assembly.

³⁰ These coefficients contrast with 1.66, 1.44 and 0.93, respectively period wise, for manufacturing output as a whole, also for the long-term.

the former, regarding the three respective periods in transportation equipment were obtained.³¹

In opposition to transportation equipment, primary metals expose a coefficient systematically below manufacturing as a whole in the long-term. For the short-term, the results are mixed. In the case of machinery, in the long-term the coefficients are comparable with manufacturing as a whole. It is in the short-term that they register values well above the entirety of manufacturing production.

Considering the three selected sectors, there is a tendency for a reduction in the levels of elasticity observed as time passes. Therefore, appreciation of the Mexican currency has been loosing impact in driving an increase in the wage gap. That is to say, the fact that Mexico has joined NAFTA reduced the competitive advantage derived from the appreciation of the Mexican peso *vis-à-vis* the dollar, for manufacturing as whole as well as in the three selected sectors.

³¹ Meanwhile coefficients of 1.54, 0.79 and 1.07 were obtained for manufacturing as a whole for the three respective periods.

It should be acknowledged that the coefficients observed in the three tradable activities are basically along the same lines as manufacturing as a whole. That is to say, tradable sectors in Mexico do not expose expected higher coefficients regarding the wage gap with respect to the Mexican bilateral real exchange rate.

Table 2.B Manufacturing Production Workers. Elasticity of the Wage Gap with respect to Manufacturing Output Index Ratio.* Monthly frequency. Selected periods and sectors

		Dependent variable: <i>Manufacturing Mexico-United States wage gap</i>		
		1990:01-1994:12	1995:01-2006:12	2007:01-2013:02
Independent variables:				
<i>Manufacturing</i>				
Long-term		-1.36	-0.69	-0.66
	lag	t-2		t-3
Short-term		-1.62	-0.68	-0.78
	lag	t-2		t-3
<i>Primary metals</i>				
Long-term		0.60	-0.15	-0.45
	lag	t-1	t-2	
Short-term		0.44	-0.42	-0.55
	lag	t-1	t-2	
<i>Machinery</i>				
Long-term		-0.37	0.29	-0.17
	lag	t-1		
Short-term		-0.86	-0.21	-0.45
	lag	t-2	t-2	
<i>Transportation equipment</i>				
Long-term		-0.72	-0.40	-0.33
	lag	t-1	t-2	
Short-term		-0.86	-0.41	-0.65
	lag	t-2	t-2	
	n	60	143	71

* Mexican manufacturing production index in relation with the U.S. one; each adjusted for inflation with local implicit price indexes.

Note 1: All reported estimates are significant at a 99%, as reported on Appendix 2.1.

Note 2: The 1995:01-2006:12 time period includes a dummy variable for the last month of December (intercept), due to a statutory annual bonus payment (*aguinaldo*).

Source: Appendix 2.1.

As for the elasticity of the wage gap with respect to manufacturing output, manufacturing as a whole, exposed negative coefficients below a unit value for the last two periods. This implies that an increase in relative Mexican output *vis-à-vis* the United States, induces a reduction of the wage gap ratio between production workers of both countries. Hence, wage differentials would rise.

It is worth to note that the induction of a wage gap increase as a response of a relative manufacturing growth in Mexico, exposes, basically, negative values for the selected tradable sectors,³² being the rule for manufacturing as a whole. In general, there is a tendency for these negative coefficients to reduce their value within an inelastic range throughout time. Therefore, the wage gap increase as a result of Mexican manufacturing expansion would appear to be losing strength.

What is remarkable is that the elasticity coefficients exposed by the three tradable sectors are even below the ones registered by manufacturing as a whole.³³

³² The exception is for primary metals in the pre NAFTA period, where positive and inelastic values are obtained both in the long (0.60) and short (0.44) terms for 1990:01-1994:12. This is also the case for machinery for the long-term (0.29) with respect to 1995:01-2006:12.

³³ In the previous footnote an exception is mentioned.

Therefore, their exposure to foreign competition appears not to be a factor for a wage gap increase.³⁴

³⁴ From the above, it would be convenient to pursue an analysis comprising the various manufacturing sectors in order to better understand these peculiarities.

2.2 Ratio of manufacturing output: a relative Mexican surge

Once it has been established through descriptive statistics a widening wage gap (Figure 1), it is relevant to measure whether Mexico or the United States has grown to a larger extent. This would be done by measuring the ratio of manufacturing output of the first in relation to the second. Hence, in order to evaluate the pace at which the manufacturing output ratio has evolved in relative terms, the following functional form is proposed:

$$(2) \left(\frac{\frac{Q_{man\ mx}^i - Q_{man\ mx\ t-12}^i}{Q_{man\ mx\ t-12}^i}}{\frac{Q_{man\ us}^i - Q_{man\ us\ t-12}^i}{Q_{man\ us\ t-12}^i}} \right)_t = c_t + \varepsilon_t.$$

where $Q_{man\ mx}^i$ is the manufacturing production index for Mexico; $Q_{man\ us}^i$ is the manufacturing production index, North American Industry Classification System (NAICS), for United States; while ε stands for the error term. The subscript t refers to the current period of time; $Q_{man\ mx\ t-12}^i$ is the manufacturing production index for Mexico with twelve-month lags. The lags in the dependent variable of equation (2), allows obtaining the average annual growth rate for the i period, within a monthly frequency. Here, a positive sign is assumed, which should made itself present

alongside with the aforementioned increasing wage gap observed in descriptive statistics, in Chapter 1.

Table 3 Manufacturing Output. Growth Rates. Monthly frequency. Selected Periods

		Independent variable:	Dependent variable: <i>Ratio of Manufacturing output*</i>
1987:01-1994:12	n=96	<i>constant</i>	1.33
1995:01-2006:12	n=144	<i>constant</i>	n.s.
2007:01-2013:02	n=71	<i>constant</i>	1.26

* Ratio of Mexican manufacturing production index in relation with the one for United States, both in local currencies.

Note 1: All reported estimates are significant at a 99%, as reported on Appendix 2.1.2.

Note 2: n.s. stands for no significance.

Source: Appendix 2.1.2.

Mexican manufacturing output growth has been larger than the corresponding one for United States. This happens with respect to 1987-1994 and 2007 up to date time periods, with a year-over-year percent change of 1.33 and 1.26 respectively, within a monthly frequency. Then, the average annual growth rate for the first period is 1.33% for each year. Although, this is a short-term coefficient, it exposes a larger dynamism of the Mexican output with respect to United States output.³⁵ As from 2007-up to date, the ratio exposes a similar coefficient (1.26).³⁶ So far, this

³⁵ Were Mexico to maintain this surge in the medium term, it would indeed reduce the sizable manufacturing gap that at present has with United States.

³⁶ The 1995 to 2006 period yields results with no significance.

vigorous pace exhibited by Mexico manufacturing output has been translated into a deleterious effect in the wage gap.

CHAPTER 3

Wage elasticity: Mexico with respect to United States

It is relevant to find out whether the wages of manufacturing production workers in United States have any influence in the earnings of their Mexican counterparts. In this purpose, wages of Mexican manufacturing production workers in Mexico are made dependent on United States wages, and the real exchange rate of the Mexican peso per dollar. Therefore, the impact of United States wages of production workers in the corresponding Mexican workers, is being evaluated, on the one hand. On the other, the effect of appreciation or depreciation of the Mexican currency in the wages prevailing in Mexico, is estimated.

$$(3) \quad \log \left(\frac{\frac{W_{mx}^i}{h_{mx}^i}}{\frac{Eo}{pfg_{us}^i}} \right)_t = c_t + \alpha \log \left(\frac{w_{us}^i}{pfg_{us}^i} \right)_{t-j} + \beta \log (Er_c)_{t-j} + \varepsilon_t.$$

where W_{mx}^i is the wage bill or payroll for Mexican manufacturing production workers; h_{mx}^i is the number of hours of manufacturing production workers for the Mexican manufacturing industry; Eo is the nominal exchange rate, *i.e.* pesos per

dollar; pg_{us}^i is United States producer price index for finished goods; w_{us}^i is average hourly earnings of manufacturing production and nonsupervisory workers; Er_c is the Mexican bilateral real exchange computed with consumer prices;³⁷ ε stands for the error term. The superscript i represents three different periods, *i.e.* $i = 1$ covers from January of 1987 to December of 1994; $i = 2$ stands for January of 1995 to December, 2006; $i = 3$ considers from January, 2007 to February, 2013. The subscript t refers to the current period of time considered; j refers to time lags, where $j = 1, 2, \dots, n$.

In estimating the influence of United States wages in Mexican ones, both are adjusted for inflation by means of the producer price index for finished goods of the United States. The use of this deflator is assuming that output decisions regarding manufacturing in both countries are taken in terms of dollars and not of Mexican pesos. Whether the output decision makers are United States firms having plants in the United States and in Mexico, or subcontracting in Mexico, their estimates and adjustment for inflation ought to be done in United States currency.³⁸

³⁷ Defined in Appendix 1.

³⁸ It is not expected that output decisions, particularly dominated by tradables, are to be conducted in terms of Mexican currency.

Regarding the expected signs for equation (3), a positive coefficient of Mexican wages with respect to the ones in the United States is expected. A surge in United States wages would have a positive impact in Mexican wages.³⁹

As far as the elasticity of Mexican wages is concerned with respect to the Mexican bilateral real exchange rate, it would reflect the appreciation or depreciation effects over Mexican wages. It is expected that an appreciation of the Mexican currency would raise prices, at least in a proportional fashion. Therefore, a positive and elastic coefficient is expected.

The above expression (3) is being estimated as a cointegrating equation in order to obtain long-term coefficients. Afterwards, an error correction method is being applied, in order to determine short-term coefficients.

³⁹ It should be borne in mind that considering the wage gap, a stimulus to American wages, even with a proportional increase in Mexico, would imply a far lower increase, due to the prevailing wage gap.

Before Mexico joined NAFTA extremely high coefficients are being observed, as shown in Table 4. The elasticity of Mexican hourly wages, with respect to United States is *i.e.* 2.44 in the long-term, along with 7.32 in the short-term.

Table 4. Manufacturing Production Workers. Elasticity of Mexican hourly wage with respect to United States hourly wages and Mexican real exchange rate. Monthly frequency. Selected Periods

		Dependent variable: <i>Mexican hourly wage</i> *		
		1987:01-1994:12	1995:01-2006:12	2007:01-2013:02
Independent variables:				
<i>United States hourly wage</i> *				
Long-term		2.44	0.88	1.34
	lag			
Short-term		7.32	3.63	2.63
	lag			
<i>Mexican real exchange rate</i> **				
Long-term		1.38	1.42	1.29
	lag	t-1		
Short-term		3.82	1.66	1.54
	lag	t-1		
	n	96	144	72

* United States dollars of 1982 per hour, using producer price index (finished goods), nsa.

** Bilateral on the basis of consumer price indexes.

Note: All reported estimates are significant at a 99%, as reported on Appendix 2.2.

Source: Appendix 2.2.

In reference to the first post NAFTA period, *i.e.* from 1995 to 2006 the long-term coefficient becomes positive and elastic (0.88), exposing a reduced fluctuation of Mexican wages in response to United States wage changes. In the current period (2007-up to date), the long-term coefficient becomes ostensibly elastic (1.34). In

the short-term, the corresponding coefficients fluctuate between 2.63 (2007-up to date) and 3.63 (1995-2006). In a study by Revenga and Montenegro (1998), similar results for workers employed in the same industry are found. These authors obtained point estimates quite large, and a positive association between Mexican and United States relative wages for the period 1984-1990.

Another independent variable of equation (3), reported in Table 4, is the Mexican bilateral real exchange rate. This variable systematically exposes coefficients above the unit value. Its coefficients values are elastic and positive, both in the long and short-term. In the long-term, the elasticity of Mexican hourly wage is systematically above the unit value fluctuating between 1.42 and 1.29, both in the pre NAFTA period and the post NAFTA ones. In the short-term, these coefficients tend to be systematically higher, suggesting an elastic fluctuation of Mexican wages as a result of the appreciation of the Mexican currency. In the short-term, the elasticity reaches a maximum value of 3.82 for the pre NAFTA period.

Hence, the appreciation of the Mexican peso increases the value of wages expressed in United States currency, and *vice-versa* in an elastic fashion.

Robertson (2005b), who stands out for analyzing the wage gap along with the exchange rate, finds that this last variable plays a major role on its determination.

CHAPTER 4

Derived demand for United States labor: United States and Mexican wages

As an alternative way to evaluate Mexican manufacturing wages and its effect in United States manufacturing labor market, the concept of derived demand is used.⁴⁰ That is to say, the demand for manufacturing labor is precisely derived from the demand for manufacturing products.⁴¹ In this case, United States derived demand for labor, *i.e.* employment, would depend on the United States wages that are being paid in the labor market. Also, United States derived demand for labor could be related to the Mexican wages as a substitute or complement. The same type of dependency would happen with the wage bill or payrolls of the United States as regressand, while both United States and Mexican wages became the regressors.

4.1 On production manufacturing workers

In order to evaluate the effect of the Mexican manufacturing average hourly wages, over the derived manufacturing labor demand of United States, the following

⁴⁰ McConnell, Brue and Macpherson (2008).

⁴¹ "The price of the goods a worker buys is the cost of his labor to the employer." Ohlin (1967), p. 146.

expression is put forward. Here, it is measured how do entrepreneurs react demanding labor as a result of United States wages on the one hand and Mexican wages on the other. Besides, the effect in labor demand as a result of relative manufacturing output in Mexico and the United States is also taken into account.

$$(4) \quad \log (L_{us}^i)_t = c_t + \alpha \log \left(\frac{Q_{man\ mx}^i}{Q_{man\ us}^i} \right)_{t-j} + \beta \log \left(\frac{w_{us}^i}{pfg_{us}^i} \right)_{t-j} + \gamma \log \left(\frac{\frac{W_{mx}^i}{h_{mx}^i}}{\frac{Eo}{pfg_{us}^i}} \right)_{t-j} + \varepsilon_t.$$

where L_{us}^i are the production and nonsupervisory employees in United States; $Q_{man\ mx}^i$ is the manufacturing production index for Mexico in local currency; $Q_{man\ us}^i$ is the manufacturing production index, North American Industry Classification System (NAICS) for United States expressed in local currency, w_{us}^i is the average hourly earnings of manufacturing production and nonsupervisory workers; pfg_{us}^i is the United States producer price index, finished goods; W_{mx}^i is the wage bill or payroll for Mexican manufacturing production workers; h_{mx}^i is the number of hours for the Mexican manufacturing; Eo is the nominal exchange rate *i.e.*, pesos per dollar; ε stands for the error term. The subscript t refers to the current period of time considered; j refers to the lag periods of time where $j = 1, 2, \dots, n$.

A negative coefficient is expected for manufacturing output ratio between Mexico and the United States. This would imply that an increase in Mexican manufacturing output *vis-à-vis* the United States, would convey a reduction in the demand for labor in the last mentioned country. This negative sign is assuming that a degree of displacement of United States workers takes place when relative manufacturing output growth in Mexico occurs. Regarding the demand of labor with respect to United States workers, a negative sign is expected, following the rationale by entrepreneurs *i.e.*, the lower the wage, the higher the quantity of labor demanded and *vice versa*. An increase in Mexican hourly wages it is expected to cause an increase in the demand for labor in the United States. Therefore, a positive sign is expected.

Table 5. Manufacturing Production Workers. Elasticity of United States Production and Nonsupervisory Employees, with respect to United States and Mexican hourly wages. Monthly frequency. Selected Periods

		Dependent variable: <i>United States production and nonsupervisory employees</i>		
		1987:01-1994:12	1995:01-2006:12	2007:01-2013:02
Independent variables:				
<i>Manufacturing output index ratio**</i>				
Long-term		n.s.	n.s.	-0.88
	lag			
Short-term		n.s.	n.s.	-0.05
	lag			
<i>United States hourly wage*</i>				
Long-term		n.s.	n.s.	-0.59
	lag			t-1
Short-term		n.s.	n.s.	-0.14
	lag			t-1
<i>Mexican hourly wage*</i>				
Long-term		n.s.	n.s.	0.37
	lag			
Short-term		n.s.	n.s.	0.04
	lag			
<i>Dummy***</i>				
Long-term		n.s.	n.s.	0.03
	lag			
Short-term		n.s.	n.s.	-0.04
	lag			
	n	94	142	70

* United States dollars of 1982 per hour, using producer price index (finished goods), nsa.

** Ratio of Mexican to United States manufacturing production indexes.

*** An annual bonus paid in December (*aguinaldo*) required the introduction of a Dummy variable.

Note 1: n.s. stands for no significance.

Note 2: All reported estimates are significant at a 99%, as reported on Appendix 2.3.

Source: Appendix 2.3.

Statistical results are found to be significant only for the current period *i.e.*, 2007-up to date (Table 5). In the long-term, the elasticity of labor demand for manufacturing production workers in the United States is negative (-0.88) with respect to the ratio

of Mexican-United States manufacturing indexes. In consequence, when the index of United States manufacturing rises more than the one in Mexico, labor demand in the United States grows, in a close to an elastic fashion. However, the fact that manufacturing output in Mexico expands at a higher rate than in United States,⁴² labor demand in this last country falls. This result holds for the current period *i.e.*, from 2007-up to date, as Mexican manufacturing relative growth *vis-à-vis* United States weakens labor demand in the latter. In the short-term, the effect is close to zero. This coefficient suggests that output decisions are operated in the long-term only.

The long-term elasticity of demand for labor in the United States with respect to the hourly wage is negative and inelastic (-0.59).⁴³ This result, for the period from 2007-up to date, is along the lines of labor demand for production manufacturing workers, as reported by Slaughter (1997). In the short-term, the coefficient becomes neatly inelastic (-0.14), losing influence.

⁴² See equation 2, above, holding for the pre NAFTA period and for the current one, *i.e.* 2007 to date.

⁴³ Lagged one period.

Mexican wages expose a degree of substitution *vis-à-vis* United States labor demand for the current period (0.37) in the long-term.⁴⁴ Therefore, this coefficient exposes a degree of substitution of Mexican manufacturing production workers with respect to United States demand for manufacturing production workers, although within an inelastic range.⁴⁵

From the previous results no trace of complementary effect is found in Table 5. However, Robertson (2006) is of a different opinion.⁴⁶ By using a labor demand approach, he claims that Mexican and United States manufacturing production workers behave like complements during the NAFTA period.⁴⁷

Later on Robertson *et al.* (2008) formally test the above mentioned complementariness hypothesis. Econometric results are provided for supporting

⁴⁴ This result holds from January to November. The December slope, dummy, has an almost zero value for the long and short-term.

⁴⁵ These results are in line with the econometric estimates of Armington elasticities. As a further reference, see Reinert and Roland-Holst (1992), and/or Donnelly, Johnson and Tsigas (2004).

⁴⁶ Acemoglu, Gancia and Ziliboti (2012) generalize the complementariness of wages in developed countries *vis-à-vis* emerging economies, encompassing these last ones as offshore production.

⁴⁷ "The finding that U.S. and Mexican production workers are complements brings good and bad news (in the normative sense)." However, this paper does not provide empirical evidence, either in terms of econometric tests or descriptive statistics to support this assertion.

the complementariness between production workers in United States and Mexico.⁴⁸ Their estimates suggest that if United States wages rise, the demand for Mexican workers is reduced. That is to say, assuming a constant output, Mexican and United States workers are p -complements. However, even within the United States Borjas, Grogger & Hanson (2008) did not find evidence to support labor market complementariness between immigrants and United States native employment.

The question as to whether Mexican wages are complements or substitutes with respect to demand for American labor,⁴⁹ has received a degree of relevance in the literature. In the case of Gandolfi *et al.* (2014) a price substitution nature of Mexican and United States workers is being assumed.⁵⁰ However, in Robertson (2006) and Robertson *et al.* (2008) it is claimed and proved respectively, that

⁴⁸ "The main results suggest that, during the NAFTA period, Mexican U.S. production workers (and Mexican and Canadian production workers) are complements, rather than substitutes, suggesting that both countries could benefit from viewing the economies as partners rather than competitors."

⁴⁹ Or *vice-versa*: United States wages with respect to demand for Mexican labor.

⁵⁰ "We assume that Mexican and US workers are price substitutes, such that an increase in the wages of American workers increases the demand for Mexican labor."

binational wages are complements. Peculiarly enough, Robertson is a third coauthor in Gandolfi *et al.* (2014).

4.2. On wage bill or payrolls

Regarding labor compensation as derived demand, the wage bill or payroll was estimated as a function of United States and Mexican hourly wages. Therefore, regarding the United States, the effect of wages and manufacturing output in the wage bill is to be estimated. Besides, the effect of Mexican wages in the United States wage bill, is also to be estimated. Thus,

$$(5) \quad \log \left(\frac{W_{us}^i}{pfg_{us}^i} \right)_t = c_t + \alpha \log \left(\frac{w_{us}^i}{pfg_{us}^i} \right)_{t-j} + \beta \log (Q_{man\ us}^i)_{t-j} + \\ \gamma \log \left(\frac{\frac{W_{mx}^i}{h_{mx}^i}}{\frac{Eo}{pfg_{us}^i}} \right)_{t-j} + \varepsilon_t.$$

where W_{us}^i is the manufacturing wage bill or wage payroll for production manufacturing in the United States; pfg_{us}^i is the United States producer price index for finished goods; w_{us}^i is the average hourly earnings of manufacturing production and nonsupervisory workers; W_{mx}^i is the wage bill or payroll for Mexican manufacturing production workers; h_{mx}^i is the number of hours of manufacturing production workers for the Mexican manufacturing industry; Eo is the nominal exchange rate, *i.e.* pesos per dollar; $Q_{man\ us}^i$ is the manufacturing production index,

North American Industry Classification System (NAICS) for United States expressed in local currency; while ε stands for the error term. The superscript i refers to $i = 1, 2$ and 3 expressing the time period under consideration. The subscript t refers to the current period of time considered; j refers to lag periods of time where $j = 1, 2, \dots, n$.

An increase in United States hourly wages is to bear a positive sign, as they enhance the American wage bill. A rise in manufacturing output in the United States would lead to an increase in the wage bill, also of the United States. Besides, the Mexican hourly wages should bear a positive sign, as its increase should convey an expansion of the wage bill in the United States, due to a degree of substitution between them.

In the long-term, the elasticity of United States wage bill with respect to their hourly wages has been on the rise, growing consistently from 0.58 in the pre NAFTA period (1987-1994) to 1.90 during the current period (2007 up to date).⁵¹ In the

⁵¹ These results are consistent with Rodrik (1997). He found that the more open an economy is, the greater the volatility in earnings resulting from shocks to labor demand (p. 12-13).

short-term, a similar trend is found, although at a lower pace, with coefficients below the unit value for the period 1987-1994 and basically equal to one for the last period. That is to say, in the short-term, coefficients range from 0.62 in the pre NAFTA period (1987-1995) to 0.97 during the current post NAFTA period, *i.e.* 2007 up to date.

Table 6. Manufacturing Production Workers. Elasticity of United States Wage Bill with respect to hourly wages and Manufacturing Production Index of United States and Mexican hourly wages. Monthly frequency. Selected Periods.

		Dependent variable: <i>United States wage bill</i> *		
		1987:01-1994:12	1995:01-2006:12	2007:01 2013:02
Independent variables:				
<i>United States hourly wages</i> *				
Long term		0.58	n.s.	1.90
	lag			
Short term		0.62	n.s.	0.97
	lag			
<i>United States manufacturing production index</i>				
Long term		0.24	n.s.	1.16
	lag	t-1		
Short term		0.18	n.s.	0.47
	lag	t-1		
<i>Mexican hourly wages</i> *				
Long term		-0.07	n.s.	0.14
	lag			
Short term		0.03	n.s.	0.05
	lag			
	n	63		72

* United States dollars of 1982 per hour, using producer price index (finished goods), nsa.

Note 1: n.s. stands for no significance.

Note 2: All reported estimates are significant at a 99%, as reported on Appendix 2.4.

Source: Appendix 2.4.

The manufacturing production index for United States exposes increasing values over time during the short-term. Its coefficients rose from 0.18⁵² during the pre NAFTA period, to 0.47 during the current one (2007 to date). In the long-term, the manufacturing production index is ostensibly inelastic (0.24)⁵³ in the pre NAFTA

⁵² Lagged one period.

⁵³ Lagged one period.

period (1987-1994). However, during the current period, *i.e.* 2007-up to date, this index shows an elastic coefficient (1.16). Therefore, these last results expose a neat elastic influence of the manufacturing production index over the wage bill, in the long-term.

Regarding Mexican hourly wages effect they are close to zero, except for the long-term. This is reported with a coefficient value of 0.14 for the last period. Although this coefficient is positive, it is also close to zero.

While Mexican wages affect the demand of labor in United States,⁵⁴ their remuneration is so scant, that they do not have any incidence. This happens when manufacturing production workers in United States take the form of labor compensation.

⁵⁴ Although with an inelastic coefficient (0.37) in the long term. See equation 4, above.

CHAPTER 5

Conclusions

The wage gap between Mexican and United States manufacturing production workers remained at the same level, *i.e.* 0.15 in the 1987-1995 pre NAFTA period and 0.14 in the first post NAFTA period (1995-2006), when measured in dollars adjusted for inflation. As from 2007 to date, *i.e.* the second post NAFTA period under consideration, far from experiencing a reduction, this gap has widened to over one tenth (0.11). At the same time, there is a downward trend in the variance of this gap, witnessed by a declining coefficient of variation (CV), due to more stability in Mexican wages alongside a contraction of Mexican wages. In brief, a widening gap is being registered as long as wage dispersion is reduced.

These facts would appear to take place independently of whether Mexico has been -or not- a member of NAFTA. That is to say, NAFTA does not seem to make a difference in the behaviour of the wage gap throughout the time periods considered. As a result, the possibility of confirming the Stolper-Samuelson and the Factor Price Equalization theorems appear to be somehow distant. Nevertheless,

there are some peculiarities between manufacturing production workers in United States and Mexican labor, which are being examined.

The Mexican bilateral real exchange rate plays a key role, alongside with the manufacturing output in determining the wage rate. The former displays positive and elastic coefficients over the wage gap, basically above a unit value throughout the three periods under consideration. Therefore, reductions in the wage gap are subject to the vagaries of the exchange rate when appreciation of the Mexican peso could be sustained. The above conclusions hold for manufacturing as a whole as well as considering three key tradable sectors *i.e.*, primary metals, machinery and transport equipment. However, on the whole, there is a tendency for these coefficients to reduce their extent throughout the three periods considered, while they remain exposing elastic values.

The elasticity of the wage gap between Mexico and United States exposes a negative coefficient with respect to the ratio of Mexico and United States manufacturing output, with coefficients ranging from -0.66 to -0.93 in the long-term, for 2007 to date and 1987-1994 periods, respectively. In the short-term, the

coefficient goes from -0.68 to -1.56 for the periods of 1995-2006 and 1987-1994. In this sense, the negative coefficient of the wage gap with respect to manufacturing output constitutes a persistent pattern. When three tradable sectors were added, an increase in the wage gap as a response to a relative output growth in Mexican manufacturing appear to be losing strength throughout time, exposing on the whole, inelastic coefficients.

There has been a substantial dynamism in Mexico *vis-à-vis* the United States regarding manufacturing output. Paradoxically, the relative betterment of the Mexican economy in terms basically of manufacturing output in relation to United States, has affected the wage gap in a negative fashion. The negative effect is confirmed when the ratio of manufacturing output of Mexico with the United States, exposes a positive growth trend for the pre NAFTA and the current period.

In the pre NAFTA period, *i.e.* 1987-1994, the elasticity coefficients of Mexican wages with respect to the ones in United States expose extremely high coefficients, both in the long and short-terms, as reported in Table 4. This is in contrast with the first post NAFTA period and the current one, where while

remaining elastic in the long and short-terms, they expose a reduction in their values.

The appreciation of the Mexican currency has a positive effect in Mexican wages expressed in dollars, with coefficients systematically positive and above the unit value, both for the long and short-terms. The real exchange rate variable is relevant, as NAFTA has not envisaged a monetary union or even a pegging of currencies to the dollar, for instance.

Regarding the empirical results reported in Table 5, the elasticity of labor demand in the United States for the current period, *i.e.* 2007-up to date, with respect to the ratio of Mexico-United States manufacturing output exposed a negative coefficient (-0.88). Considering that this ratio has a positive growth, Mexican relative manufacturing surge brings about a reduction, although in an inelastic fashion, on the demand of United States manufacturing production workers.

The own price labor demand elasticity was within the values (-0.59) found in the literature. The Mexican price labor demand elasticity exposes a degree of

substitution, with a positive coefficient (0.37) although inelastic, for the year around, excluding the month of December where the introduction of a dummy was required. This value suggests that Mexican wages are behaving as a substitute *vis-à-vis* United States labor demand. All the above results refer to the long-term, as in the short-term, *i.e.* the coefficients turn out to be close to zero, except in the case of the own price labor demand elasticity. Besides, only the current period, *i.e.* from 2007-up to date, proved to be statistically significant. These values suggest that the demand of labor involves a planned decision involving the long-term.

Once the demand for labor is expressed as a wage bill and its elasticity is estimated with respect to the United States hourly wage, it proved to be significant for the pre NAFTA and the current period only. This elasticity has been on the rise, growing from an inelastic value both in the short and long-terms in the pre NAFTA period, reaching ostensibly elastic values in the current period. While the elasticity of the wage bill with respect to United States manufacturing index was inelastic in the pre NAFTA period, as from 2007, it exposes a coefficient slightly beyond the unit value in the long-term. The Mexican hourly wage exposes a coefficient systematically inelastic and frequently close to zero in the first and last periods.

The degree of substitution of Mexican wages was confirmed when manufacturing production workers in United States were considered in terms of labor. Once labor in United States is expressed in monetary units the coefficients become zero, due to the wage gap. No degree of complementariness has yet been found.

The FPE and SS are the theoretical references for wage convergence. However there are some elements like labor migration and labor mobility among industries, that are not part of those theorems. The application of these elements conveys some constraints.

When the migration element is taken into account, it would introduce modifications in the FPE and SS theorems for the Mexico and United States case. In this case, labor mobility in a unilateral manner (from Mexico to the United States), could thereby alter the expected outcome.

Controlling for migration in the present econometric models, *i.e.* inclusion of a migration variable would be more suitable for a research, which is not heavily

based in longitudinal series. The present work uses variables with monthly frequency. The inclusion of the migration variable would substantially reduce the degrees of freedom, since it implies reducing the monthly frequency to an annual frequency. This is because border enforcement data is available on a yearly basis for the time period of 1997-2012.⁵⁵

Besides, the inclusion of the migration variable would also diminish the consistency of the estimators given the reduction of the sample size. It is important to underline that the manufacturing production index is used as a *proxy* variable for value added, since the former is available with monthly frequency and the latter is available with quarterly frequency. The use of the manufacturing production index is ideal since the surveys for this sector in United States and Mexico bear monthly frequency. Therefore, the manufacturing production index allows exploring these survey databases, conveying a larger amount of degrees of freedom.

⁵⁵ Homeland Security 2012 Yearbook of Immigration Statistics, retrieved from: <http://www.dhs.gov/yearbook-immigration-statistics-2012-enforcement-actions>

APPENDIX 1. Relation of variables and sources

Data ID	Description	Source	Country
E_0	SF328 <i>Tipo de cambio pesos por dolar para solventar obligaciones denominadas en moneda extranjera</i> (Nominal exchange rate, pesos per dollar)	D	Mx.
Er_c	Mexican bilateral real exchange rate pesos per dollar, consumer prices	$p^*/E_0/p$	
h_{mx}	<i>Horas trabajadas</i> , monthly man hours, manufacturing production, thousands	F	Mx.
L_{us}	CEU3000000006 Production and nonsupervisory employees, nsa., thousands of persons	A	U.S.
p	CUUR0000SA0 Consumer price index-all urban consumers, nsa., United States city average, all items, 1982-84=100	B	U.S.
p^*	<i>Indice nacional de precios al consumidor, base diciembre 2010=100</i> , (National consumer price index)	E	Mx.
$pf_{g_{us}}$	WPUSOP3000 Producer price index, finished goods, nsa., 1982=100	B	U.S.
pp^*	328679 National index of producer prices, June 2012=100	B	U.S.
$Q_{man\ mx}$	Manufacturing production index, 2003=100	F	Mx
$Q_{man\ us}$	IP.B00004.N G17/IP Major industry groups, manufacturing, index 2007=100, not seasonally adjusted, NAICS (North American Industry Classification System)	F	Mx
W_{mx}	<i>Remuneración de asalariados</i> (labor compensation), manufacturing production workers aggregate monthly payroll, thousands of pesos	C	U.S.

APPENDIX 1. Relation of variables and sources (continues)

Short name	Description/Identifier	Source	Country
W_{us}	CEU3000000082 Aggregate weekly payrolls of production and nonsupervisory employees, nsa., thousands of dollars	F	Mx.
w_{us}	CEU3000000008 Average hourly earnings of production and nonsupervisory employees, nsa., dollars	A	U.S.

Sources

A BLS (Bureau of Labor Statistics), CES (Current Employment Statistics), National;

B BLS (Bureau of Labor Statistics). Producer Price Index-Commodities; Consumer Price Index-all Urban Consumers;

C Board of Governors of the Federal Reserve System. Industrial production and capacity utilization;

D *Banco de Mexico* (Banxico), Mexican Central Bank, *mercados financieros* (financial markets);

E *Banco de Mexico* (Banxico), Mexican Central Bank, *precios e inflacion* (prices and inflation);

F *Instituto Nacional de Estadística y Geografía* (INEGI), National Institute of Statistics and Geography, *Encuesta Industrial Mensual* (Monthly Industrial Survey). Four overlapped periods: 1987:01-1995:12, Mexican Catalog of Economic Activities (CMAE *Catalogo Mexicano de Actividades Economicas*) for 129 types of economic activities; 1994:01-2008:12, Mexican Classification of Activities and Products (CMAP 1994 *Clasificacion Mexicana de Actividades y Productos*) for 205 types of economic activities; 2005:01-2010:12, North American Industry Classification System (NAICS 2002) for 230 types of economic activities; 2007:01-2012:10, North American Industry Classification System (NAICS 2007) for 240 types of economic activities.

G BEA (U.S. Bureau of Economic Analysis), NIPA tables.

Note: U.S. stands for United States; Mx. stands for *Mexico*; nsa stands for not seasonally adjusted; SIC stands for Standard Industrial Classification; NAICS stands for North American Industrial Classification System.

APPENDIX 2. Statistic Results

Appendix 2.1

Statistics of Table 2A. Elasticity of the Mexico-United States Wage Gap with Respect to Bilateral Real Exchange Rate. Monthly frequency. Selected Periods

Manufacturing (whole)

Long-term

$$\log \left(\frac{\frac{W_{mx\ 1987:01-1994:12}}{h_{mx\ 1987:01-1994:12}}}{\frac{Eo_{1987:01-1994:12}}{w_{us\ 1987:01-1994:12}}} \right) = 3.90 + 1.56(Er_{c\ 1987:01-1994:12})_{t-1} - 0.93 \log \left(\frac{Q_{man\ mx\ 1987:01-1994:12}}{Q_{man\ us\ 1987:01-1994:12}} \right)_{t-2} .$$

(10.11)*** (17.59)*** (-4.12)**

$R_{aj}^2 = 0.81$ $D.W. = 1.70$ $C.Akaike = -1.31$ $n = 1987:01 - 1994:12$

Note: Values in parenthesis stand for the t-Statistics, whereby ()*** 99% of statistical significance; ()** 95% of statistical significance; ()* 90% of statistical significance.

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx \ 1987:02-1994:12}}{h_{mx \ 1987:02-1994:12}}}{\frac{Eo \ 1987:02-1994:12}{w_{us \ 1987:02-1994:12}}} \right) = 0.0004 + 1.67 \Delta \log (Er_c \ 1987:02-1994:12)_{t-1} - 1.56 \Delta \log \left(\frac{Q_{man \ mx \ 1987:02-1994:12}}{Q_{man \ us \ 1987:02-1994:12}} \right)_{t-2} -$$

(0.03) (1.85)** (-7.02)***

$$0.86(\varepsilon 1)_{t-1}.$$

(-8.19)***

$$R_{aj}^2 = 0.55 \quad D.W. = 2.05 \quad C.Akaike = -1.38 \quad n = 1987:02 - 1994:12$$

Long-term

$$\log \left(\frac{\frac{W_{mx \ 1990:01-1994:12}}{h_{mx \ 1990:01-1994:12}}}{\frac{Eo \ 1990:01-1994:12}{w_{us \ 1990:01-1994:12}}} \right) = 4.48 + 1.66(Er_c \ 1990:01-1994:12)_{t-1} - 1.36 \log \left(\frac{Q_{man \ mx \ 1990:01-1994:12}}{Q_{man \ us \ 1990:01-1994:12}} \right)_{t-2} .$$

(7.93)*** (10.38)*** (-4.57)**

$$R_{aj}^2 = 0.68 \quad D.W. = 2.19 \quad C.Akaike = -1.43 \quad n = 1990:01 - 1994:12$$

Note: Values in parenthesis stand for the t-Statistics, whereby ()*** 99% of statistical significance; ()** 95% of statistical significance; ()* 90% of statistical significance.

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx\ 1990:02-1994:12}}{h_{mx\ 1990:02-1994:12}}}{\frac{Eo\ 1990:02-1994:12}{w_{us\ 1990:02-1994:12}}} \right) = 0.0002 + 1.54 \Delta \log (Er_c\ 1990:02-1994:12)_{t-1} -$$

$$1.62 \Delta \log \left(\frac{Q_{man\ mx\ 1990:02-1994:12}}{Q_{man\ us\ 1990:02-1994:12}} \right)_{t-2} - 1.15(\varepsilon_2)_{t-1}.$$

$$(0.03) \quad (1.08)^{**} \quad (-5.86)^{***} \quad (-7.96)^{***}$$

$$R_{aj}^2 = 0.62 \quad D.W. = 2.01 \quad C.Akaike = -1.40 \quad n = 1990:02 - 1994:12$$

Long-term

$$\log \left(\frac{\frac{W_{mx\ 1995:01-2006:12}}{h_{mx\ 1995:01-2006:12}}}{\frac{Eo\ 1995:01-2006:12}{w_{us\ 1995:01-2006:12}}} \right) = 2.95 + 1.44 \log (Er_c\ 1995:01-2006:12) - 0.69 \log \left(\frac{Q_{man\ mx\ 1995:01-2006:12}}{Q_{man\ us\ 1995:01-2006:12}} \right) + 0.40 D .$$

$$(15.02)^{***} \quad (26.31)^{***} \quad (-3.81)^{***} \quad (17.29)^{***}$$

$$R_{aj}^2 = 0.88 \quad D.W. = 0.33 \quad C.Akaike = -2.29 \quad n = 1995:01 - 2006:12$$

Note: D stands for a December dummy variable.

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx\ 1995:02-2006:12}}{h_{mx\ 1995:02-2006:12}}}{\frac{Eo\ 1995:02-2006:12}{W_{us\ 1995:02-2006:12}}} \right) = -0.03 + 0.79 \Delta \log (Er_c\ 1995:02-2006:12) -$$

$$0.68 \Delta \log \left(\frac{Q_{man\ mx\ 1995:02-2006:12}}{Q_{man\ us\ 1995:02-2006:12}} \right) + 0.43 D - 0.68(\varepsilon_3)_{t-1}.$$

(-3.00) (2.07)^{***} (-2.95)^{***} (11.01)^{***} (-1.17)

$R_{aj}^2 = 0.55$ $D.W. = 2.09$ $C.Akaike = -1.29$ $n = 1995:02 - 2006:12$

Note: When the error term is no significant, it means that it is no significantly different from zero. Thus, the long-term relationship established in the cointegration equation is in equilibrium, Kennedy (1992).

Long-term

$$\log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}{W_{us\ 2007:01-2013:02}}} \right) = 1.02 + 0.93 \log (Er_c\ 2007:01-2013:02) - 0.66 \log \left(\frac{Q_{man\ mx\ 2007:01-2013:02}}{Q_{man\ us\ 2007:01-2013:02}} \right)_{t-3}.$$

(1.95)^{***} (5.78)^{***} (-3.56)^{***}

$R_{aj}^2 = 0.48$ $D.W. = 1.98$ $C.Akaike = -2.07$ $n = 2007:01 - 2013:02$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 2007:01-2013:02}{h_{mx} 2007:01-2013:02}}{\frac{EO 2007:01-2013:02}{w_{us} 2007:01-2013:02}} \right) = 0.0005 + 1.07 \Delta \log (Er_c 2007:01-2013:02) - 0.77 \Delta \log \left(\frac{Q_{man mx} 2007:01-2013:02}{Q_{man us} 2007:01-2013:02} \right)_{t-3}$$

$$(0.05) \quad (3.15)^{***} \quad (-3.21)^{***}$$

$$-1.06(\varepsilon 3)_{t-1}$$

$$(-7.84)^{***}$$

$$R_{aj}^2 = 0.60 \quad D.W. = 1.87 \quad C.Akaike = -2.04 \quad n = 2007:01 - 2013:02$$

Primary metals (331)

Long-term

$$\log \left(\frac{\frac{W_{mx} 1990:01-1994:12}}{\frac{h_{mx} 1990:01-1994:12}}{\frac{Eo 1990:01-1994:12}}}{\frac{W_{us} 1990:01-1994:12}} \right) = 2.87 + 1.44(Er_c 1990:01-1994:12)_{t-1} + 0.60 \log \left(\frac{Q_{man mx} 1990:01-1994:12}}{Q_{man us} 1990:01-1994:12}} \right)_{t-1} .$$

(5.54)^{***} (9.19)^{***} (2.83)^{**}

$R_{aj}^2 = 0.61$ $D.W. = 1.99$ $C.Akaike = -1.48$ $n = 1990:01 - 1994:12$

Note: Values in parenthesis stand for the t-Statistics, whereby ()^{***} 99% of statistical significance; ()^{**} 95% of statistical significance; ()^{*} 90% of statistic significance.

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 1990:02-1994:12}}{\frac{h_{mx} 1990:02-1994:12}}{\frac{Eo 1990:02-1994:12}}}{\frac{W_{us} 1990:02-1994:12}} \right) = -0.003 + 2.57 \Delta \log (Er_c 1990:02-1994:12)_{t-1} +$$

$$0.44 \Delta \log \left(\frac{Q_{man mx} 1990:02-1994:12}}{Q_{man us} 1990:02-1994:12}} \right)_{t-1} - 1.00(\varepsilon 5)_{t-1} .$$

(-0.25) (1.86)^{**} (2.34)^{***} (-7.51)^{***}

$R_{aj}^2 = 0.54$ $D.W. = 1.94$ $C.Akaike = -1.50$ $n = 1990:02 - 1994:12$

Long-term

$$\log \left(\frac{\frac{W_{mx} 1995:01-2006:12}{h_{mx} 1995:01-2006:12}}{\frac{Eo 1995:01-2006:12}{w_{us} 1995:01-2006:12}} \right) = 2.27 + 1.25 \log (Er_c 1995:01-2006:12)_{t-3} - 0.15 \log \left(\frac{Q_{man mx} 1995:01-2006:12}{Q_{man us} 1995:01-2006:12} \right)_{t-2} .$$

$$\begin{array}{ccccccc} (8.00)^{***} & & (14.7-)^{***} & & & & (-1.62)^{***} \\ R_{aj}^2 = 0.79 & D.W. = 1.49 & C.Akaike = -1.96 & n = 1995:01 - 2006:12 & & & \end{array}$$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 1995:02-2006:12}{h_{mx} 1995:02-2006:12}}{\frac{Eo 1995:02-2006:12}{w_{us} 1995:02-2006:12}} \right) = 0.003 + 1.12 \Delta \log (Er_c 1995:02-2006:12)_{t-3} -$$

$$0.42 \Delta \log \left(\frac{Q_{man mx} 1995:02-2006:12}{Q_{man us} 1995:02-2006:12} \right)_{t-2} - 0.75(\varepsilon_6)_{t-1} .$$

$$(0.43) \quad (4.77)^{***} \quad \quad \quad (-3.70)^{***} \quad \quad \quad (9.51)$$

$$R_{aj}^2 = 0.51 \quad D.W. = 2.15 \quad C.Akaike = -2.10 \quad n = 1995:02 - 2006:12$$

Note: When the error term is no significant, it means that it is no significantly different from zero. Thus, the long-term relationship established in the cointegration equation is in equilibrium, Kennedy (1992).

Long-term

$$\log \left(\frac{\frac{W_{mx} 2007:01-2013:02}{h_{mx} 2007:01-2013:02}}{\frac{Eo 2007:01-2013:02}{w_{us} 2007:01-2013:02}} \right) = 0.02 + 0.61 \log (Er_c 2007:01-2013:02)_{t-1} - 0.45 \log \left(\frac{Q_{man mx} 2007:01-2013:02}{Q_{man us} 2007:01-2013:02} \right) .$$

$$R_{aj}^2 = 0.42 \quad D.W. = 1.51 \quad C.Akaike = -2.42 \quad n = 2007:01 - 2012:12$$

(0.04) (4.14)^{***} (-2.82)^{***}

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 2007:01-2013:02}{h_{mx} 2007:01-2013:02}}{\frac{Eo 2007:01-2013:02}{w_{us} 2007:01-2013:02}} \right) = 0.002 + 0.90 \Delta \log (Er_c 2007:01-2013:02)_{t-1} - 0.55 \Delta \log \left(\frac{Q_{man mx} 2007:01-2013:02}{Q_{man us} 2007:01-2013:02} \right)$$

$$(0.26) \quad (3.09)^{***} \quad (-3.76)^{***}$$

-0.86($\varepsilon 7$)_{t-1}.
(-6.53)^{***}

$$R_{aj}^2 = 0.45 \quad D.W. = 1.91 \quad C.Akaike = -2.47 \quad n = 2007:02 - 2012:12$$

Machinery (333)

Long-term

$$\log \left(\frac{\frac{W_{mx \ 1990:01-1994:12}}{h_{mx \ 1990:01-1994:12}}}{\frac{Eo \ 1990:01-1994:12}{w_{us \ 1990:01-1994:12}}} \right) = 4.66 + 1.91(Er_c \ 1990:01-1994:12)_{t-1} - 0.37 \log \left(\frac{Q_{man \ mx \ 1990:01-1994:12}}{Q_{man \ us \ 1990:01-1994:12}} \right)_{t-1} .$$

(6.37)***
(9.02)***
(-1.90)**

$R_{aj}^2 = 0.59$
 $D.W. = 1.81$
 $C.Akaike = -1.01$
 $n = 1990:01 - 1994:12$

Note: Values in parenthesis stand for the t-Statistics, whereby ()*** 99% of statistical significance; ()** 95% of statistical significance; ()* 90% of statistic significance.

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx \ 1990:02-1994:12}}{h_{mx \ 1990:02-1994:12}}}{\frac{Eo \ 1990:02-1994:12}{w_{us \ 1990:02-1994:12}}} \right) = -0.003 + 3.92 \Delta \log (Er_c \ 1990:02-1994:12)_{t-1} -$$

$$0.86 \Delta \log \left(\frac{Q_{man \ mx \ 1990:02-1994:12}}{Q_{man \ us \ 1990:02-1994:12}} \right)_{t-2} - 1.11(\varepsilon 8)_{t-1} .$$

(-0.19)
(2.13)**
(-3.71)***
(-6.98)***

$R_{aj}^2 = 0.54$
 $D.W. = 1.95$
 $C.Akaike = -1.07$
 $n = 1990:02 - 1994:12$

Long-term

$$\log \left(\frac{\frac{W_{mx} 1995:01-2006:12}{h_{mx} 1995:01-2006:12}}{\frac{Eo 1995:01-2006:12}{W_{us} 1995:01-2006:12}} \right) = 2.26 + 1.26 \log (Er_c 1995:01-2006:12) + 0.29 \log \left(\frac{Q_{man mx} 1995:01-2006:12}{Q_{man us} 1995:01-2006:12} \right)$$

$$\begin{array}{ccccccc} (5.10)^{***} & & (9.84)^{***} & & & & (2.41)^{***} \\ R_{aj}^2 = 0.58 & D.W. = 1.47 & C.Akaike = -0.82 & n = 1995:01 - 2006:12 \end{array}$$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 1995:02-2006:12}{h_{mx} 1995:02-2006:12}}{\frac{Eo 1995:02-2006:12}{W_{us} 1995:02-2006:12}} \right) = -0.001 + 1.52 \Delta \log (Er_c 1995:02-2006:12)_{t-1} -$$

$$0.21 \Delta \log \left(\frac{Q_{man mx} 1995:02-2006:12}{Q_{man us} 1995:02-2006:12} \right)_{t-2} - 0.84 (\varepsilon_9)_{t-1}.$$

$$\begin{array}{ccccccc} (-0.09) & & (3.22)^{***} & & (-1.65)^{***} & & (-9.47) \\ R_{aj}^2 = 0.42 & D.W. = 2.01 & C.Akaike = -0.78 & n = 1995:02 - 2006:12 \end{array}$$

Note: When the error term is no significant, it means that it is no significantly different from zero. Thus, the long-term relationship established in the cointegration equation is in equilibrium, Kennedy (1992).

Long-term

$$\log \left(\frac{\frac{W_{mx \ 2007:01-2013:02}}{h_{mx \ 2007:01-2013:02}}}{\frac{Eo \ 2007:01-2013:02}{w_{us \ 2007:01-2013:02}}} \right) = 0.87 + 0.86 \log (Er_c \ 2007:01-2013:02)_{t-1} - 0.17 \log \left(\frac{Q_{man \ mx \ 2007:01-2013:02}}{Q_{man \ us \ 2007:01-2013:02}} \right) .$$

$$\begin{array}{cccc} (1.69)^{***} & & (5.58)^{***} & (-2.82)^{***} \\ R_{aj}^2 = 0.38 & D.W. = 1.88 & C.Akaike = -2.02 & n = 2007:01 - 2012:12 \end{array}$$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx \ 2007:01-2013:02}}{h_{mx \ 2007:01-2013:02}}}{\frac{Eo \ 2007:01-2013:02}{w_{us \ 2007:01-2013:02}}} \right) = 0.002 + 1.56 \Delta \log (Er_c \ 2007:01-2013:02)_{t-1} - 0.45 \Delta \log \left(\frac{Q_{man \ mx \ 2007:01-2013:02}}{Q_{man \ us \ 2007:01-2013:02}} \right)$$

$$\begin{array}{ccc} (0.29) & (4.44)^{***} & (-3.76)^{***} \\ -1.13(\varepsilon_{10})_{t-1} & & \\ (-8.44)^{***} & & \end{array}$$

$$R_{aj}^2 = 0.57 \quad D.W. = 1.92 \quad C.Akaike = -2.13 \quad n = 2007:02 - 2012:12$$

Transportation Equipment (336)

Long-term

$$\log \left(\frac{\frac{W_{mx \ 1990:01-1994:12}}{h_{mx \ 1990:01-1994:12}}}{\frac{Eo \ 1990:01-1994:12}{W_{us \ 1990:01-1994:12}}} \right) = 4.24 + 1.79(Er_c \ 1990:01-1994:12)_{t-1} - 0.72 \log \left(\frac{Q_{man \ mx \ 1990:01-1994:12}}{Q_{man \ us \ 1990:01-1994:12}} \right)_{t-1} .$$

(5.60)^{***} (8.16)^{***} (-4.81)^{**}

$R_{aj}^2 = 0.55$ $D.W. = 1.94$ $C.Akaike = -0.89$ $n = 1990:01 - 1994:12$

Note: Values in parenthesis stand for the t-Statistics, whereby ()^{***} 99% of statistical significance; ()^{**} 95% of statistical significance; ()^{*} 90% of statistic significance.

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx \ 1990:02-1994:12}}{h_{mx \ 1990:02-1994:12}}}{\frac{Eo \ 1990:02-1994:12}{W_{us \ 1990:02-1994:12}}} \right) = -0.01 + 3.98 \Delta \log (Er_c \ 1990:02-1994:12)_{t-1} -$$

$$0.86 \Delta \log \left(\frac{Q_{man \ mx \ 1990:02-1994:12}}{Q_{man \ us \ 1990:02-1994:12}} \right)_{t-2} - 1.19(\varepsilon_{11})_{t-1} .$$

(-0.30) (2.10)^{**} (-5.63)^{***} (-7.53)^{***}

$R_{aj}^2 = 0.59$ $D.W. = 1.76$ $C.Akaike = -0.92$ $n = 1990:02 - 1994:12$

Long-term

$$\log \left(\frac{\frac{W_{mx} 1995:01-2006:12}{h_{mx} 1995:01-2006:12}}{\frac{Eo 1995:01-2006:12}{W_{us} 1995:01-2006:12}} \right) = 5.09 + 2.08 \log (Er_c 1995:01-2006:12)_{t-1} - 0.40 \log \left(\frac{Q_{man mx} 1995:01-2006:12}{Q_{man us} 1995:01-2006:12} \right)_{t-2} .$$

$$\begin{array}{ccccccc} (10.06)^{***} & & (14.01)^{***} & & & & (-4.22)^{***} \\ R_{aj}^2 = 0.66 & D.W. = 1.88 & C.Akaike = -0.75 & n = 1995:01 - 2006:12 & & & \end{array}$$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 1995:02-2006:12}{h_{mx} 1995:02-2006:12}}{\frac{Eo 1995:02-2006:12}{W_{us} 1995:02-2006:12}} \right) = 5.12 + 2.09 \Delta \log (Er_c 1995:02-2006:12)_{t-1} -$$

$$0.41 \Delta \log \left(\frac{Q_{man mx} 1995:02-2006:12}{Q_{man us} 1995:02-2006:12} \right)_{t-2} + 0.05(\varepsilon 12)_{t-1} .$$

$$\begin{array}{ccccccc} (9.95) & & (13.81)^{***} & & & & (-4.22)^{***} \\ R_{aj}^2 = 0.65 & D.W. = 1.99 & C.Akaike = -0.73 & n = 1995:02 - 2006:12 & & & (0.56) \end{array}$$

Note: When the error term is no significant, it means that it is no significantly different from zero. Thus, the long-term relationship established in the cointegration equation is in equilibrium, Kennedy (1992).

Long-term

$$\log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}{w_{us\ 2007:01-2013:02}}} \right) = 1.35 + 1.12 \log (Er_c\ 2007:01-2013:02)_{t-1} - 0.33 \log \left(\frac{Q_{man\ mx\ 2007:01-2013:02}}{Q_{man\ us\ 2007:01-2013:02}} \right) .$$

$$\begin{array}{ccc} (2.90)^{***} & (8.03)^{***} & (-5.82)^{***} \\ R_{aj}^2 = 0.56 & D.W. = 1.78 & C.Akaike = -2.24 \quad n = 2007:01 - 2012:12 \end{array}$$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}{w_{us\ 2007:01-2013:02}}} \right) = 0.001 + 1.27 \Delta \log (Er_c\ 2007:01-2013:02)_{t-1} - 0.65 \Delta \log \left(\frac{Q_{man\ mx\ 2007:01-2013:02}}{Q_{man\ us\ 2007:01-2013:02}} \right)$$

$$\begin{array}{ccc} (0.17) & (4.14)^{***} & (-7.17)^{***} \\ -1.00(\varepsilon_{13})_{t-1} & & \\ (-7.72)^{***} & & \end{array}$$

$$R_{aj}^2 = 0.61 \quad D.W. = 2.01 \quad C.Akaike = -2.37 \quad n = 2007:02 - 2012:12$$

Appendix 2.1.2

Statistics of Table 3. Manufacturing Output. Growth Rates. Selected Periods

$$\left(\frac{\frac{Q_{man\ mx\ 1987:01-1994:12} - Q_{man\ mx,t-12,1987:01-1994:12}}{Q_{man\ mx,t-12,1987:01-1994:12}}}{\frac{Q_{man\ us\ 1987:01-1994:12} - Q_{man\ us,t-12,1987:01-1994:12}}{Q_{man\ us,t-12,1987:01-1994:12}}} \right) = 1.32.$$

(1.83)**

$$R_{aj}^2 = 0.01 \quad C. Akaike = 6.76 \quad n = 1987:01 - 1994:12$$

$$\left(\frac{\frac{Q_{man\ mx\ 2007:01-2013:02} - Q_{man\ mx,t-12,2007:01-2013:02}}{Q_{man\ mx,t-12,2007:01-2013:02}}}{\frac{Q_{man\ us\ 2007:01-2013:02} - Q_{man\ us,t-12,2007:01-2013:02}}{Q_{man\ us,t-12,2007:01-2013:02}}} \right) = 1.25.$$

(23.15)***

$$R_{aj}^2 = 0.01 \quad C. Akaike = 5.28 \quad n = 2007:01 - 2013:02$$

Appendix 2.2

Statistics of Table 4. Production workers. Elasticity of Mexican hourly wage with respect of United States hourly wages, and Mexican real exchange rate. Monthly frequency. Selected periods

Long-term

$$\log \left(\frac{\frac{W_{mx \ 1987:01-1994:12}}{h_{mx \ 1987:01-1994:12}}}{\frac{Eo \ 1987:01-1994:12}{pfg_{us \ 1987:01-1994:12}}} \right) = 6.18 + 2.44 \log \left(\frac{w_{us \ 1987:01-1994:12}}{pfg_{us \ 1987:01-1994:12}} \right) + 1.38 \log (Er_c \ 1987:01-1994:12)_{t-1}.$$

$$R_{aj}^2 = 0.83 \quad (5.00)^{***} \quad (4.07)^{***} \quad (14.67)^{***}$$

D.W. = 2.02 *C.Akaike* = -1.34 *n* = 1987:01 – 1994:12

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx} 1987:01-1994:12}}{\frac{h_{mx} 1987:01-1994:12}}{\frac{Eo 1987:01-1994:12}}}{pfg_{us} 1987:01-1994:12} \right)$$

$$= -0.01 + 7.32 \Delta \log \left(\frac{W_{us} 1987:01-1994:12}{pfg_{us} 1987:01-1994:12} \right) + 3.82 \Delta \log (Er_c 1987:01-1994:12)_{t-1} - 1.09 (\varepsilon 4)_{t-1}.$$

(-1.19) (5.14)^{***} (4.49)^{***} (-10.09)^{***}
 $R_{aj}^2 = 0.63$ $D.W. = 1.93$ $C.Akaike = -1.53$ $n = 1987:02 - 1994:12$

Long-term

$$\log \left(\frac{\frac{W_{mx} 1995:01-2006:12}}{\frac{h_{mx} 1995:01-2006:12}}{\frac{Eo 1995:01-2006:12}}}{pfg_{us} 1995:01-2006:12} \right) = 2.55 + 0.88 \log \left(\frac{W_{us} 1995:01-2006:12}{pfg_{us} 1995:01-2006:12} \right) + 1.42 \log (Er_c 1995:01-2006:12).$$

(5.09)^{***} (3.18)^{***} (12.32)^{***}
 $R_{aj}^2 = 0.69$ $D.W. = 1.63$ $C.Akaike = -1.07$ $n = 1995:01 - 2006:12$

Short-term

$$\Delta \log \left(\frac{\frac{W_{mx \ 1995:01-2006:12}}{h_{mx \ 1995:01-2006:12}}}{\frac{Eo \ 1995:01-2006:12}{pfg_{us \ 1995:01-2006:12}}} \right)$$

$$= -0.001 + 3.63 \Delta \log \left(\frac{W_{us \ 1995:01-2006:12}}{pfg_{us \ 1995:01-2006:12}} \right) + 1.66 \Delta \log (Er_c \ 1995:01-2006:12) - 0.77 (\varepsilon 5)_{t-1}.$$

(-0.14) (3.36)^{***} (4.05)^{***} (-8.52)^{***}
 $R_{aj}^2 = 0.48$ $D.W. = 1.96$ $C.Akaike = -1.13$ $n = 1995:01 - 2006:12$

Long-term

$$\log \left(\frac{\frac{W_{mx \ 2007:01-2013:02}}{h_{mx \ 2007:01-2013:02}}}{\frac{Eo \ 2007:01-2013:02}{pfg_{us \ 2007:01-2013:02}}} \right) = 2.86 + 1.34 \log \left(\frac{W_{us \ 2007:01-2013:02}}{pfg_{us \ 2007:01-2013:02}} \right) + 1.29 \log (Er_c \ 2007:01-2013:02).$$

(2.30)^{***} (4.77)^{***} (6.04)^{***}
 $R_{aj}^2 = 0.35$ $D.W. = 1.93$ $C.Akaike = -1.92$ $n = 2007:01 - 2013:02$

Short-term

$$\Delta \log \begin{pmatrix} \frac{W_{mx} 2007:01-2013:02}{h_{mx} 2007:01-2013:02} \\ \frac{Eo 2007:01-2013:02}{pfg_{us} 2007:01-2013:02} \end{pmatrix}$$

$$= 0.002 + 2.63 \Delta \log \left(\frac{w_{us} 2007:01-2013:02}{pfg_{us} 2007:01-2013:02} \right) + 1.54 \Delta \log (Er_c 2007:01-2013:02) - 1.01 (\varepsilon_6)_{t-1}.$$

(0.19) (3.80)*** (3.90)*** (-7.98)***

$R_{aj}^2 = 0.55$ $D.W. = 1.91$ $C.Akaike = -1.93$ $n = 2007:01 - 2013:02$

Appendix 2.3

Statistics of Table 5. Production workers. Elasticity of United States production and nonsupervisory employees, with respect to United States and Mexican hourly wages. Monthly frequency. Selected periods.

Long-term

$$\begin{aligned} \log (L_{us\ 2007:01-2013:02}) = & 9.61 - 0.88 \log \left(\frac{Q_{man\ mx\ 2007:01-2013:02}}{Q_{man\ us\ 2007:01-2013:02}} \right) - 0.59 \log \left(\frac{W_{us\ 2007:01-2013:02}}{pfg_{us\ 2007:01-2013:02}} \right) \\ & (19.51)^{***} \qquad \qquad \qquad (-6.72)^{***} \qquad \qquad \qquad (-6.07)^{***} \\ + 0.37 \log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}}{pfg_{us\ 2007:01-2013:02}}} \right) & + 0.03 \log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}}{pfg_{us\ 2007:01-2013:02}}} \right) * D. \\ & (3.25)^{***} \qquad \qquad \qquad (-6.72)^{***} \\ R_{aj}^2 = 0.78 \quad D.W. = 1.06 \quad C.Akaike = -3.48 \quad n = 2007:01 - 2013:02 \end{aligned}$$

Note: D stands for a December dummy variable.

Short-term

$$\Delta \log (L_{us\ 2007:01-2013:02}) = -0.001 - 0.05 \Delta \log \left(\frac{Q_{man\ mx\ 2007:01-2013:02}}{Q_{man\ us\ 2007:01-2013:02}} \right) - 0.14 \Delta \log \left(\frac{w_{us\ 2007:01-2013:02}}{pfg_{us\ 2007:01-2013:02}} \right)$$

(-1.69)**
(-2.45)***
(-2.80)***

$$+ 0.04 \Delta \log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}{pfg_{us\ 2007:01-2013:02}}} \right) - 0.04 \Delta \log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}{pfg_{us\ 2007:01-2013:02}}} \right) * D - 0.07 (\varepsilon 7)_{t-1}$$

(4.38)*** (-3.41)*** (-3.08)***

$R_{aj}^2 = 0.45$ $D.W. = 0.93$ $C.Akaike = -7.22$ $n = 2007:01 - 2013:02$

Appendix 2.4

Statistics of Table 6. Production workers. Elasticity of United States wage bill with respect to hourly wages and manufacturing production index of United States and Mexican hourly wages. Monthly frequency. Selected periods

Long-term

$$\log \left(\frac{W_{us \ 1987:01-1994:12}}{pfg_{us \ 1987:01-1994:12}} \right) = 10.89 + 0.58 \log \left(\frac{w_{us \ 1987:01-1994:12}}{pfg_{us \ 1987:01-1994:12}} \right) + 0.24 \log (Q_{man \ us \ 1987:01-1994:12})_{t-1}$$

(20.97)^{***} (2.53)^{***} (1.78)^{**}

$$- 0.07 \log \left(\frac{\frac{W_{mx \ 1987:01-1994:12}}{h_{mx \ 1987:01-1994:12}}}{\frac{Eo \ 1987:01-1994:12}}{pfg_{us \ 1987:01-1994:12}}} \right)$$

(-2.99)^{***}

$$R_{aj}^2 = 0.12 \quad D.W. = 0.98 \quad C.Akaike = -4.37 \quad n = 1987:01 - 1994:12$$

Short-term

$$\Delta \log \left(\frac{W_{us\ 2007:01-2013:02}}{pfg_{us\ 2007:01-2013:02}} \right) = -0.002 + 0.97 \Delta \log \left(\frac{W_{us\ 2007:01-2013:02}}{pfg_{us\ 2007:01-2013:02}} \right) + 0.47 \Delta \log (Q_{man\ us\ 2007:01-2012:10})$$

(-2.09)**
(9.47)***
(10.16)***

$$+ 0.05 \Delta \log \left(\frac{\frac{W_{mx\ 2007:01-2013:02}}{h_{mx\ 2007:01-2013:02}}}{\frac{Eo\ 2007:01-2013:02}{pfg_{us\ 2007:01-2013:02}}} \right) - 0.10(\varepsilon_9)_{t-1}$$

(7.23)***

(-2.82)***

$$R_{aj}^2 = 0.78 \quad D.W. = 1.14 \quad C.Akaike = -6.71 \quad n = 2007:01 - 2013:02$$

APPENDIX 3.

Equation (2): Unit Root Test

Variable	Test	Lags	Critical values*	Significance	t-Statistic	Include in test***
$\left(\frac{Q_{man\ mx\ 1987:01-1994:12} - Q_{man\ mx,t-12,1987:01-1994:12}}{Q_{man\ mx,t-12,1987:01-1994:12}} \right)$ $\left(\frac{Q_{man\ us\ 1987:01-1994:12} - Q_{man\ us,t-12,1987:01-1994:12}}{Q_{man\ us,t-12,1987:01-1994:12}} \right)$	ADF**	0	-3.524233	1% level	-10.51325	A
			-2.902358	5% level	-10.43851	B
			-2.588587	10% level	-8.961166	C
$\left(\frac{Q_{man\ mx\ 2007:01-2013:02} - Q_{man\ mx,t-12,2007:01-2013:02}}{Q_{man\ mx,t-12,2007:01-2013:02}} \right)$ $\left(\frac{Q_{man\ us\ 2007:01-2013:02} - Q_{man\ us,t-12,2007:01-2013:02}}{Q_{man\ us,t-12,2007:01-2013:02}} \right)$	ADF**	0	-3.544063	1% level	-9.797599	A
			-2.910860	5% level	-7.172170	B
			-2.593090	10% level	-7.236434	C

* MacKinnon (1996) one-sided p-values, for rejecting the Null Hypothesis of having a unit root;

** ADF Augmented Dickey-Fuller test. Critical values for 1% level, 5% level, 10% level of confidence interval;

*** Include in the Augmented Dickey-Fuller test equation: A intercept, B trend and intercept, C none;

Source: independent variables of Appendix 2.1.2 equations.

APPENDIX 4.

Equation (2): Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test

Equation (2) 1987:01-1994:12

F-statistic	2.150285	Prob. F(2,69)	0.1242
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Equation (2) 2007:01-2013:02

F-statistic	2.366582	Prob. F(2,57)	0.1030
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Source: independent variables of Appendix 2.1.2 equations.

APPENDIX 5.

Residuals of cointegrating equations. Unit Root Test

Variable	Test	Lags*	Critical values**	Significance	t-Statistic	Include in test***
ε_1	ADF	11	-3.510259	1% level	-1.846681	A
			-2.896346	5% level	-3.199410	B
			-2.585396	10% level	-1.739780	C
ε_2	ADF	10	-3.54610	1% level	-8.473341	A
			-2.91173	5% level	-8.399889	B
			-2.593551	10% level	-8.556128	C
ε_3	PP	4	-3.476472	1% level	-4.150813	A
			-2.881685	5% level	-5.918563	B
			-2.577591	10% level	-4.232146	C
ε_4	PP	3	-3.525618	1% level	-8.243288	A
			-2.902953	5% level	-8.210842	B
			-2.588902	10% level	-8.320128	C
ε_5	ADF	10	-3.54610	1% level	-7.514899	A
			-2.91173	5% level	-7.515014	B
			-2.593551	10% level	-7.581756	C
ε_6	PP	7	-3.476472	1% level	-9.994172	A
			-2.881685	5% level	-10.38461	B
			-2.577591	10% level	-10.02005	C

APPENDIX 5. (continues)

Variable	Residuals of cointegrating equations. Unit Root Test			Significance	t-Statistic	Include in test***
	Test	Lags*	Critical values**			
ε_7	ADF	11	-3.525618	1% level	-6.595172	A
			-2.902953	5% level	-7.282937	B
			-2.588902	10% level	-6.653905	C
ε_8	ADF	10	-3.54610	1% level	-6.814311	A
			-2.91173	5% level	-6.745694	B
			-2.593551	10% level	-6.89121	C
ε_9	PP	7	-3.476472	1% level	-9.871799	A
			-2.881685	5% level	-10.18885	B
			-2.577591	10% level	-9.898504	C
ε_{10}	PP	13	-3.525618	1% level	-8.516532	A
			-2.902953	5% level	-8.45279	B
			-2.588902	10% level	-8.634194	C
ε_{11}	ADF	10	-3.54610	1% level	-7.454336	A
			-2.91173	5% level	-7.471276	B
			-2.593551	10% level	-7.540834	C
ε_{12}	PP	5	-3.476472	1% level	-11.43275	A
			-2.881685	5% level	-12.14142	B
			-2.577591	10% level	-11.46746	C

APPENDIX 5. (continues)

Variable	Residuals of cointegrating equations. Unit Root Test					
	Test	Lags*	Critical values**	Significance	t-Statistic	Include in test***
ε_{13}	ADF	11	-3.525618	1% level	-7.381388	A
			-2.902953	5% level	0.664294	B
			-2.588902	10% level	-7.446109	C
ε_{14}	PP	5	-3.500669	1% level	-9.830433	A
			-2.892200	5% level	-9.756124	B
			-2.583192	10% level	-9.898763	C
ε_{15}	PP	6	-3.476472	1% level	-10.38376	A
			-2.881685	5% level	-10.92626	B
			-2.577591	10% level	-10.41507	C
ε_{16}	ADF	11	-3.525618	1% level	-8.093557	A
			-2.902953	5% level	-8.272264	B
			-2.588902	10% level	-8.160548	C
ε_{17}	ADF	0	-3.527045	1% level	-5.132278	A
			-2.903566	5% level	-5.206263	B
			-2.589227	10% level	-5.167852	C
ε_{18}	ADF	0	-3.540198	1% level	-4.430112	A
			-2.909206	5% level	-5.155882	B
			-2.592215	10% level	-4.466561	C

APPENDIX 5. (continues)

Variable	Residuals of cointegrating equations. Unit Root Test			Significance	t-Statistic	Include in test***
	Test	Lags*	Critical values**			
ε_{19}	ADF	10	-3.524233	1% level	-2.736048	A
			-2.902358	5% level	-3.489230	B
			-2.588587	10% level	-2.763503	C

* MacKinnon (1996) one-sided p-values, for rejecting the Null Hypothesis of having a unit root;

** Critical values for 1% level, 5% level, 10% level of confidence interval;

*** Include in the Augmented Dickey-Fuller test equation: A intercept; B trend and intercept and C none;

ADF stands for Augmented Dickey-Fuller test;

PP stands for Phillips-Perron test.

Note: all the residuals from 1 to 19 are integrated of order zero $I(0)$.

Source: residuals from the long-term estimated equations reported in Appendix 2.1; 2.2; 2.3 and 2.4.

APPENDIX 6.

129 primary industrial activities. Correspondence throughout time

The primary industrial activities for Mexican manufacturing are available for four overlapped periods, *i.e.* first period 1987-1995; a second period: 1994-2008; a third period 2005-2010 and fourth period 2007-up to date. The four periods have a monthly frequency. These four periods are based on various industrial classifications and different number of primary industrial activities.

The first period, *i.e.* 1987-1995 is based on the *Catálogo Mexicano de Actividades Económicas* (CMAE) or Mexican Catalog of Economic Activities, with four digits as a system of classification for the original 129 primary industrial activities. The second period 1994-2008 used the *Clasificación Mexicana de Actividades y Productos* (CMAP 1994) or Mexican Classification of Activities and Products, with six digits as a system of classification for 205 primary industrial activities. The third period 2005-2010 used the North American Industry Classification System (NAICS 2002), with at least six digits for its classification system for 230 primary industrial activities. The fourth period 2007-up to date uses the North American Industry

Classification System (NAICS 2007), at least six digits are used in this system for the classification of 240 primary industrial activities.

In order to obtain continuous periods of time, *i.e.* not overlapped, it was necessary to obtain consistency in the number of primary business activities throughout time.

This is achieved by performing a match of the original 129 primary industrial activities which compose in its entirety the first period (1987-1994), with the following periods: 1994-2008 and 2009-up to date. In order to match the original 129 primary business activities with the following industrial activities throughout time (four digits), the next correspondence tables were used: CMAE-CMAP 1994 (from the first period to the second, that is to say, from the original four digits to six); CMAP 1994-SCIAN 2002 (from the second period to the third, that is to say, from 6 digits to 6 digits) and SCIAN 2002-SCIAN 2007 (from the third period to the fourth, from 6 digits to 6 digits).

Systematically, the source for linking the original 129 primary industrial activities with the subsequent periods has been the *Instituto Nacional de Estadística y Geografía* (INEGI) or National Institute of Statistics and Geography, *Encuesta*

Industrial Mensual or Monthly Industrial Survey. The first correspondence table used is available upon request. The rest of correspondence tables are available on line.⁵⁶

The above matching exercise is not required for United States case. This is due to several reasons. First, the United States Census Bureau reviews every five years the NAICS in order to keep pace with changes in the economy. Second, the United States census maintains and assigns only one NAICS code for each establishment based on its primary industry activity.⁵⁷ Third, the manufacturing information provided by the United States Census Bureau is continuous through time. Fourth, the available data is not overlapped. These four reasons made unnecessary applying to United States manufacturing survey data a process like the one above mentioned for the Mexican case.

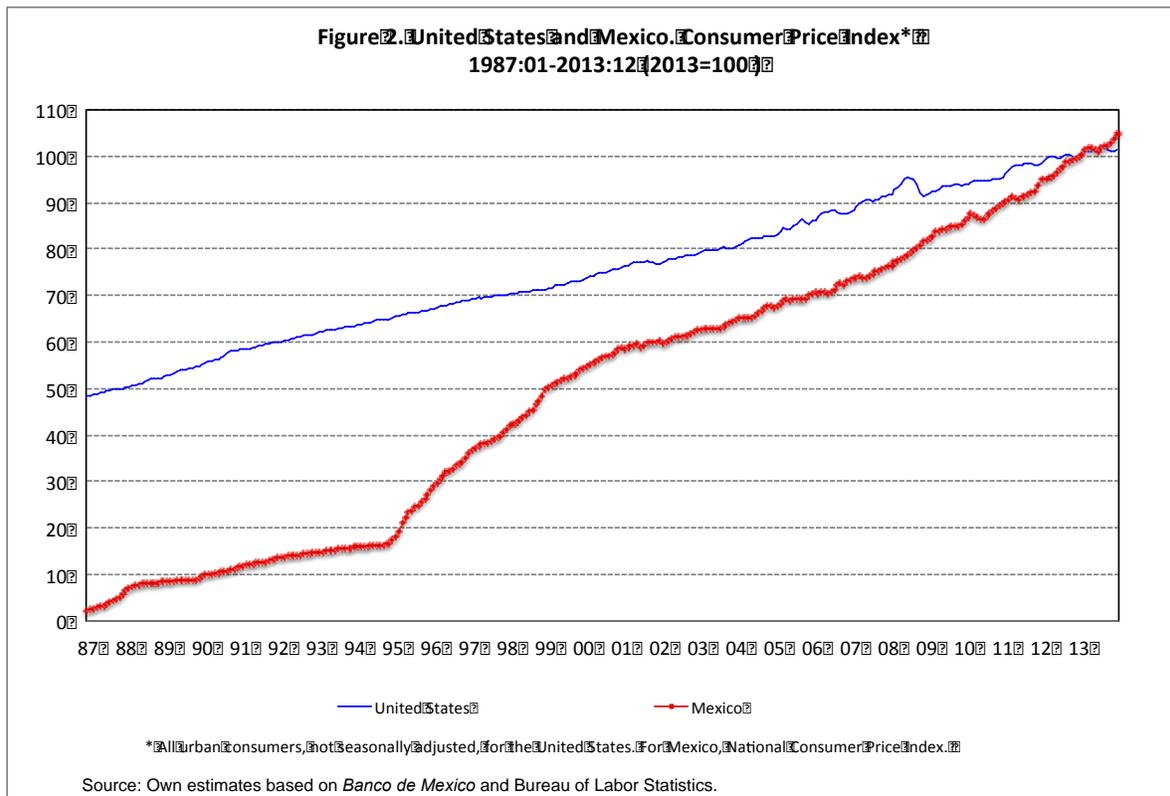
⁵⁶ Information available in the INEGI web page. The specific links are listed in the references.

⁵⁷ Information available in United States Census Bureau web page.

APPENDIX 7.

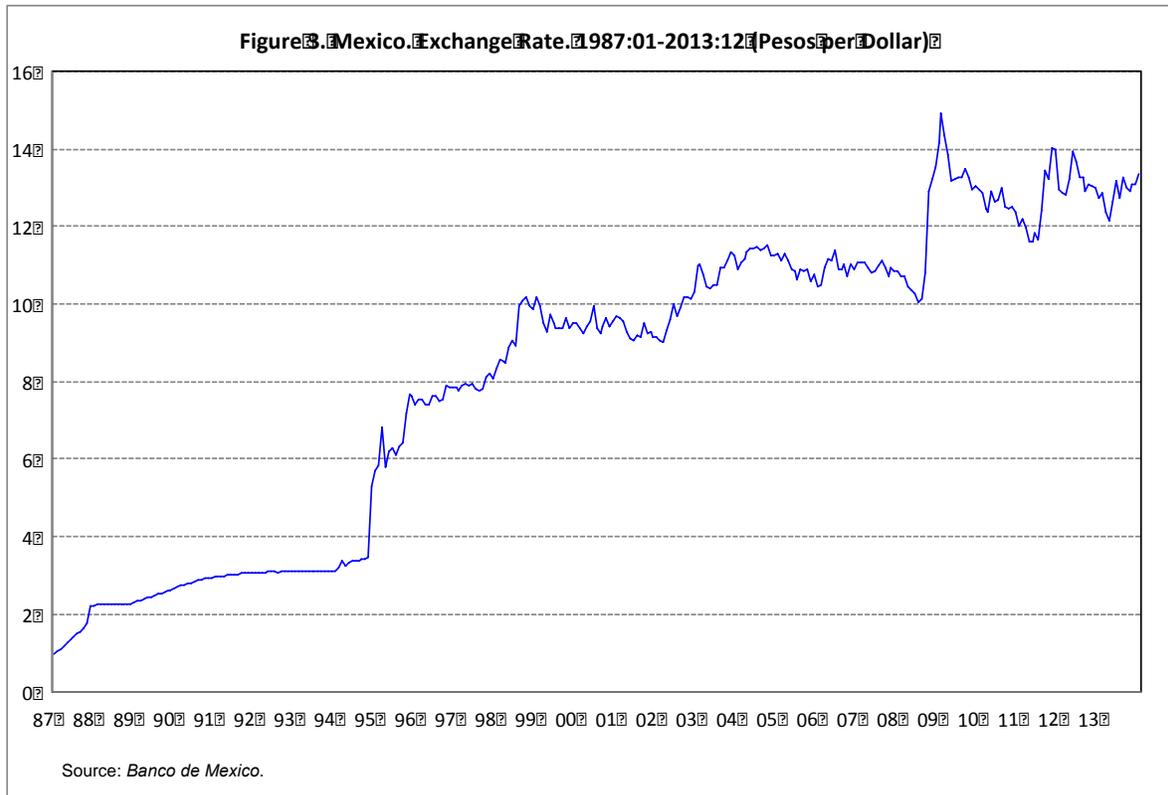
Mexico and United States Inflation and Peso Exchange Rate

It should be noted that Mexico exposes a long-term price instability. For the period of 1987-2013 and considering for both countries 2013 as a basis, the United States exposed an average of 48.3 in 1987, doubling within this period. Meanwhile, Mexico climbed from an average of 2.3 in the same year, up to more than 26 times.⁵⁸



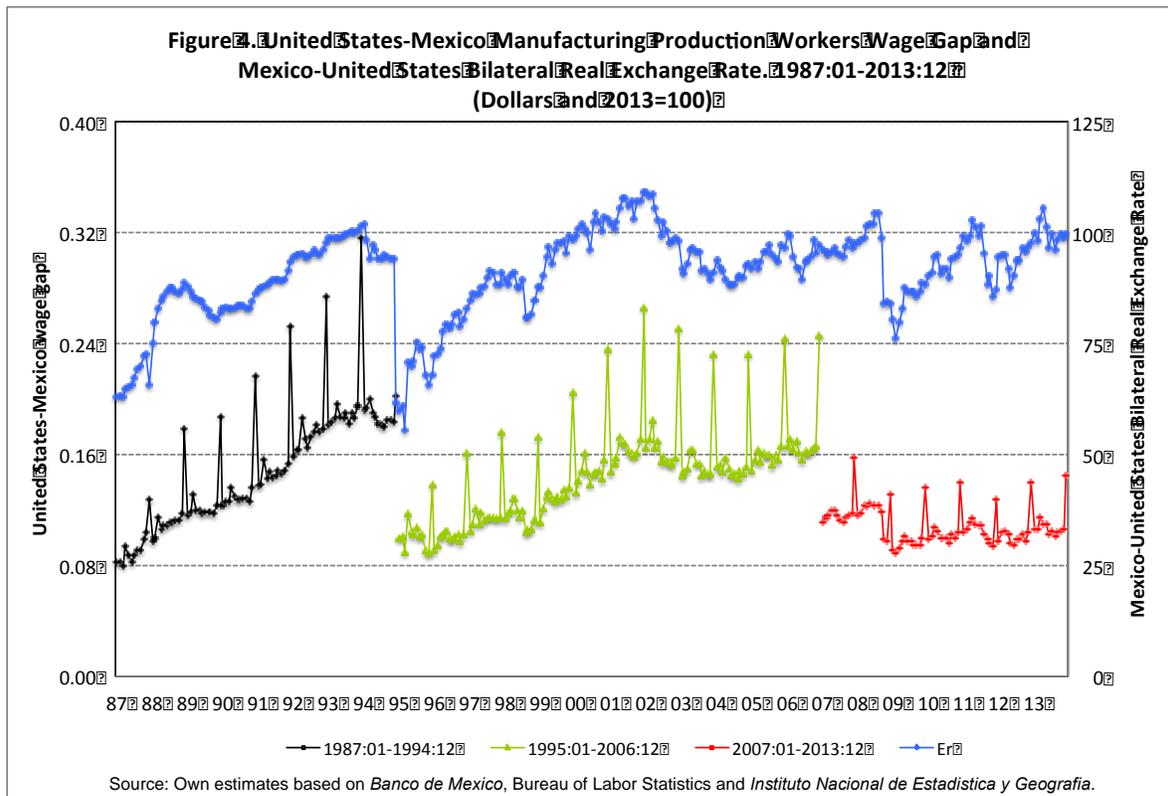
⁵⁸ It should be conceded that after 1996, inflation has receded.

The loss of purchasing power for the Mexican peso during the period referred previously has had its counterpart through the devaluation of the Mexican currency during the same period. In January, 1987, for instance, exchange rate was at 978 pesos per dollar. In January 1993, the unit of account was modified, whereby three zeros were removed from the currency *i.e.*, old pesos. The “new” peso was equivalent to a thousand of the old peso. Considering the current unit of account, the exchange rate at the beginning of 1987 was at 0.978 pesos per dollar. By the end of 2013, it had reached over 13 pesos per dollar, as shown in Figure 3. That is to say, the peso has devalued during the period under analysis, by over 1,300 percent, in turn, reflecting the local inflation prevalent in Mexico.



During these periods there are two main devaluation episodes. Following Mexico entrance to NAFTA, a considerable devaluation took effect, as the peso devalued 100% from 3.5 to the dollar by the end of 1994. This had to do with the heavy indebtedness of the Mexican economy after several years of enduring considerable current account deficits including public indebtedness. Although Mexico was the first country to show the entailed feebleness, this event affected various Latin American countries, basically for the same reason, better known as the Tequila

Effect. The second episode is connected with the last world recession, by the end of 2008, when the currency rose from 10 to 12 pesos per dollar.



The real exchange rate⁵⁹ and the wage gap move alongside. At first sight, the movements of both variables seem to be parallel. In addition to this, during the periods under which the Mexican peso has been undervalued, *i.e.* 1995 and 2009,

⁵⁹ “The real exchange rate between two countries may be defined as the relative price of one country’s consumption basket in terms of the consumption basket of the other country.” Mussa (1986).

the wage gap increases. As an illustration of this increase, the end of 1994 this gap register a value close to 0.17, while at the beginning of 1995 just after the Tequila crisis took place and the peso loss value, it registered a value around 0.09. This same pattern is also followed during the 2009 world crisis.

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