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Articles

Foreign trade and employment in the northern border of Mexico

Comercio exterior y empleo en la frontera norte de México

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Abstract

The paper investigates the impact of the international trade on employment of the northern border states of Mexico and its integration with the economy of the United States during 2007-2020. In order to analyze the effect of commercial penetration on the evolution of employment in the region, a dynamic panel model is used to estimate the effect of exports and imports. The results indicate that at the level of total exports there is no clear correlation of the penetration of exports on employment in the region. In contrast, the penetration of manufacturing exports and imports showed a positive and statistically significant effect on manufacturing employment in the northern border region of Mexico. The coefficient of average manufacturing wages showed an inverse coefficient suggesting that the employment dynamics are limiting the growth of wage income.

Keywords: Northern border of Mexico, exports, imports, employment.

Resumen

El trabajo investiga los impactos del comercio exterior sobre el empleo en los estados de la frontera norte de México y su integración con la economía de los Estados Unidos durante 2007-2020. Con el objetivo de analizar el efecto de la penetración comercial en la evolución del empleo en la región se utiliza un modelo de panel dinámico. Los resultados indican que la penetración de las exportaciones totales no muestra una clara correlación con la dinámica del empleo en la región. Por su parte, la penetración de las exportaciones y de las importaciones manufactureras muestra un efecto positivo y estadísticamente significativo en el empleo manufacturero en la región de la frontera norte de México. El coeficiente de los salarios promedio manufactureros expresa un coeficiente inverso, lo que sugiere que la dinámica de empleo es una limitante del crecimiento de los ingresos salariales.

Palabras clave: frontera norte de México, exportaciones, importaciones, empleo.

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Introduction

The classical theory of international trade argues that international trade impacts employment. On the one hand, workers who are employed in industries that compete through imports experience losses with trade openness, on the other hand, employment increases in export industries. However, the effects of trade openness are more complex because they generate varied impacts depending on the type of economic activity and the level of development of countries or regions (Crozet & Orefice 2017).

The classic Heckscher-Ohlin model predicts that countries with a relative abundance of labor export goods that require intensive labor. From this perspective, a developing economy, such as Mexico, would be driven to produce labor-intensive goods for export, as is the case for the export maquiladora industry. Therefore, under this logic, the expansion of trade in this sector would generate greater demand for labor in the labor market, thus increasing total employment, in particular, in the states that concentrate this type of manufacturing activity.

In contrast, the new theory of international trade, which analyses the growing importance of intra-industrial trade, considers the possibility that labor-intensive economies increase their demand for capital, which increases the demand for imports and improves employment conditions (Feenstra & Hanson, 1997). In this way, the differentiation of output and economies of scale determine the expansion of intra-industry trade, which modifies the composition of employment through manufacturing industries (Jenkins & Sen 2006).

Several studies have conducted empirical tests of the relationship between exports and employment. Artuc et al. (2019) analysed the effect of changes in the trade exposure index on jobs, wages and labor informality in various South Asian countries for the 1999-2011 period. The econometric estimates of ordinary least squares indicated that there was no positive impact on total direct employment, but there was a reduction in informal employment and growth in formal employment. Kiyota (2016) used an input-output matrix and found that in the 1995-2009 period, exports, predominantly manufacturing, had an effect on employment in the economies of China, Indonesia, Japan and Korea. In particular, the effect on the manufacturing of machinery, electrical equipment and transportation was highlighted, translating into greater employment of workers in nonmanufacturing activities.

In the United States (USA), Feenstra et al. (2019) estimated the impact of industrial exports by sector for the 1991-2011 period using econometric forecasts and a Leontief matrix to study the impact of exports on employment. Their results indicate that manufacturing exports generated approximately 300 000 jobs that compensated for job losses resulting from imports from China. In relation to the analysis of the link between exports and the labor market in Mexico, Varela Llamas and Retamoza Yocupicio (2020) studied the 2005-2019 period using an autoregressive distributed lag model, finding that exports have a positive effect on the growth of industrial activity and formal employment.

It has been argued that the effects of the North American Free Trade Agreement (NAFTA) on the Mexican economy have been positive but moderate. The benefits have focused on the manufacturing sector in terms of the adaptation of technology imported from the USA, a higher employment rate, greater macroeconomic stability and the synchronization of the growth cycle of the economies of Mexico and the USA. However, disparities in income and occupation remain at the regional level (Villarreal & Fergusson, 2017). Likewise, since the establishment of NAFTA, there has been a notable increase in employment in the manufacturing sector in Mexico. In the first 10 years of the Agreement, approximately one million jobs were created; however, this figure did not have a significant impact on the total employment dynamics in the Mexican economy (Blecker, 2014). As a complement to the growth of manufacturing exports, manufacturing imports also exhibited very dynamic growth, which was concentrated in the import of inputs for export manufacturing production.

Trade openness and foreign investment intensified the existing regional advantages on the northern border; this openness and investment are driven by geographic proximity and local economic interactions, significantly boosting trade integration and manufacturing activity. Since 1997 to 2000, the exports of northern border states have increased their share in the national GDP, reflecting the impact of the economic integration of the United States and Mexico on bilateral trade (Mendoza, 2005).

The export manufacturing industry has become a fundamental sector of the economy of the northern border region, both for its weight in total exports and for its contribution to the generation of labor. However, the employment growth rate has not been as dynamic relative to the overall economic activity of the country (Tavares Luna & Varela Llamas, 2019). In this regard, it has been argued that the growth of the manufacturing sector in Mexico has not been a decisive factor in increasing formal employment because the relative importance of this sector in the total economic activity is lower than that of the service sector (Almonte et al., 2020). However, some studies have found, based on input-output matrices, that manufacturing exports have a positive impact on production and employment (Ruiz Napoles, 2017).

Manufacturing activities in which high levels of foreign direct investment (FDI) are concentrated show significant growth in employment for both skilled and unskilled workers (Saucedo et al., 2020). Regionally, the economies of the border states of Mexico and the USA, particularly those of border states such as California and Texas, have experienced an increase in trade integration. This has led to employment trends in the northern Mexican border region showing greater synchronization with employment trends in the United States (Mendoza, 2009). Thus, the growth of employment in the northern border region of Mexico has been concentrated in the service, manufacturing and trade sectors (Grijalva Monteverde, 2004). In particular, the states on the northern border of Mexico have had sustained growth in manufacturing jobs derived from their proximity to the United States and the boost from NAFTA. Employment concentrated in the transportation and electronics industries stand out (Angoa et al., 2009).

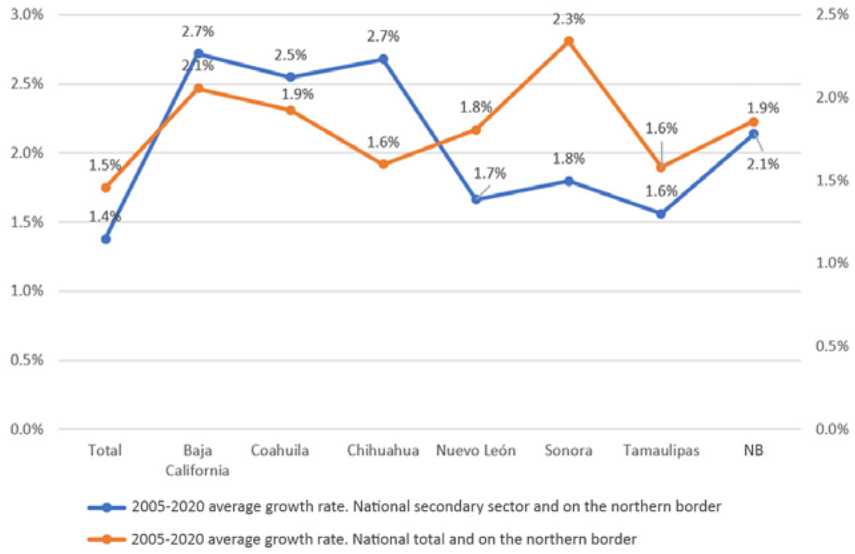
The northern Mexican border region is characterized by a greater share of manufacturing production and exports compared to the national average in Mexico and by growth and a significant proportion of manufacturing employment among total employment in the region. For this reason, it is important to estimate the extent to which foreign trade is a determining factor in employment in this border region of Mexico. To address this objective, this paper is structured as follows. The next section describes and analyses the evolution of employment and foreign trade in the northern border region. Then, the theoretical perspective and methodological strategy to estimate the relationship between foreign trade and employment are presented, the results of the estimates are discussed, and finally, the conclusions of the study are presented.

Evolution of trade and employment on the northern border of Mexico

The economic integration of the states on the northern Mexican border with the United States economy accelerated as a result of the boost of NAFTA on foreign direct investment and international trade (Mendoza, 2005). Likewise, a new agreement between the United States, Mexico and Canada (T-MEC) has established guidelines that can continue to promote the growth of jobs associated, particularly, with manufacturing economic activity. The expansion of total employment in the region of the northern border states of Mexico has been greater than the growth seen by the country as a whole. Thus, between 2005 and 2020, the average annual growth rate of the employed population of the border region was 1.9%, while for the entire country, this rate was lower, reaching only 1.4% (Figure 1).

In addition, for the manufacturing sector, the difference between growth rates is even greater in the border region. The average annual growth rate in the same period for the secondary sector nationally was 1.5%, and the growth rate for the northern border states was 2.1% (Figure 1). Employment patterns along the northern border suggest the existence of factors that have had a greater impact in that region than in the rest of the country. Furthermore, when analysing the growth rates of the total employed population and the secondary sector at the national level and in the border region, each of the border states saw a total growth rate and manufacturing sector growth rate that were higher than the national level for the reference period. In particular, the cases of the states of Baja California, Chihuahua and Sonora stand out.

Figure 1. Growth rates of total employment and of the national manufacturing sector and in the northern border states, 2005-2020



Source: own elaboration with data on employment, unemployment and underemployment rates, the monthly results of the National Survey of Occupation and Employment, for the Population Aged 15 Years and Older (Economic Information Bank of the National Institute of Statistics and Geography, 2021)

In addition, the creation of manufacturing jobs has varied within the region. Some states have consolidated their capacity to create new jobs, while others have decreased it, indicating the relative importance of job creation in the region. For example, Chihuahua, which for several years has been established as the main manufacturing job centre along the northern border of Mexico, has increased its contribution to the creation of manufacturing jobs in the region, with an average quarterly variation of 2.4% during the 2013-2020 period (Table 1). Similarly, Baja California has shown a rapid employment growth rate of 2.5%. Additionally, Coahuila and Sonora, although they have experienced sustained growth in the number of manufacturing jobs, both seem to face difficulties in recovering growth dynamics as of 2018, when the region faced a reduction in the rate of growth of this type of employment.

Table 1. Share and average growth of manufacturing jobs in the northern border states of Mexico, 2013-2020 (thousands of employees)

	Baja California		Coahuila		Chihuahua		Nuevo León		Sonora		Tamaulipas		Northern border
Year	Em-ploy-ment	%	Em-ploy-ment	%	Em-ploy-ment	%	Em-ploy-ment	%	Em-ploy-ment	%	Em-ploy-ment	%	
2013/01	242.9	17.5	230.1	16.6	304.4	21.9	306.9	22.1	111.5	8	194.1	14	1 389.9
2013/02	251.4	17.7	235.2	16.6	307.7	21.7	308.8	21.8	115.7	8.2	198.8	14	1 417.7
2013/03	252.9	17.8	238.4	16.7	308.2	21.6	310.6	21.8	115.7	8.1	198.1	13.9	1 423.9
2013/04	250.1	17.7	235.6	16.6	307.3	21.7	309.6	21.9	114.9	8.1	197.8	14	1 415.2
2014/01	252.5	17.5	243.1	16.9	310.7	21.6	312.7	21.7	117.9	8.2	203.9	14.2	1 440.6
2014/02	260.7	17.7	248.7	16.9	317.6	21.6	318.1	21.6	118.7	8.1	207.4	14.1	1 471.3
2014/03	268.4	18	253.7	17	323.9	21.7	320.9	21.5	117.5	7.9	208.6	14	1 493.1
2014/04	272.7	18	261.1	17.2	329.6	21.7	323.2	21.3	117.9	7.8	211.4	13.9	1 515.9
2015/01	269.8	17.8	261.3	17.2	334.9	22.1	320.6	21.1	114.8	7.6	215.0	14.2	1 516.4
2015/02	281.0	18.1	266.4	17.2	345.9	22.3	325.2	21	115.5	7.5	216.7	14	1 550.7
2015/03	282.7	18	267.8	17	358.8	22.8	327.5	20.8	116.3	7.4	219.0	13.9	1 572.2
2015/04	286.9	18.1	268.9	16.9	365.2	23	328.6	20.7	117.9	7.4	220.7	13.9	1 588.2
2016/01	286.5	18	269.8	17	363.4	22.9	328.3	20.6	117.7	7.4	224.1	14.1	1 589.9
2016/02	295.9	18.3	270.8	16.7	371.2	22.9	335.8	20.7	117.8	7.3	229.3	14.1	1 620.7
2016/03	304.7	18.5	277.9	16.8	374.6	22.7	343.2	20.8	117.6	7.1	231.8	14	1 649.8
2016/04	307.8	18.6	279.9	16.9	368.7	22.2	345.7	20.8	121.4	7.3	234.9	14.2	1 658.4
2017/01	300.8	17.8	284.0	16.8	392.2	23.2	346.6	20.5	123.4	7.3	240.1	14.2	1 687.1
2017/02	310.1	18	286.1	16.6	400.2	23.3	350.9	20.4	126.4	7.4	245.7	14.3	1 719.4
2017/03	320.5	18.3	290.9	16.6	402.0	23	356.7	20.4	127.8	7.3	251.9	14.4	1 749.9
2017/04	317.2	18.1	292.1	16.7	402.6	23	357.9	20.4	128.8	7.3	254.9	14.5	1 753.5
2018/01	314.4	17.8	298.5	16.9	403.0	22.9	361.1	20.5	126.7	7.2	259.8	14.7	1 763.4
2018/02	323.3	18.1	303.9	17	407.9	22.8	365.9	20.4	126.8	7.1	262.7	14.7	1 790.6
2018/03	326.6	18	305.9	16.9	410.2	22.7	368.4	20.3	129.1	7.1	270.0	14.9	1 810.2
2018/04	328.9	18	309.7	17	414.4	22.7	367.6	20.2	129.3	7.1	272.9	15	1 822.8
2019/01	324.4	17.8	310.3	17	414.9	22.8	368.7	20.2	128.7	7.1	274.1	15.1	1 821.3
2019/02	328.2	18	304.3	16.7	417.4	22.9	370.3	20.3	129.5	7.1	270.9	14.9	1 820.6
2019/03	331.8	18.2	304.3	16.7	414.7	22.8	368.7	20.3	129.1	7.1	270.3	14.9	1 818.9
2019/04	328.2	18.3	299.3	16.7	414.6	23.1	361.6	20.2	128.0	7.1	262.4	14.6	1 794.1
2020/01	324.9	18.3	293.9	16.5	410.9	23.1	361.2	20.3	125.7	7.1	261.6	14.7	1 778.3
2020/02	320.7	18.6	280.2	16.2	398.7	23.1	352.2	20.4	123.1	7.1	250.4	14.5	1 725.3
2020/03	343.5	19.2	281.0	15.7	419.1	23.5	356.2	19.9	127.6	7.1	258.2	14.5	1 785.8
2020/04	352.7	19.3	287.6	15.8	430.2	23.6	363.7	19.9	128.1	7	261.7	14.3	1 824.0
WAQGR (%)	2.50		0.77		2.43		0.73		1.13		1.05		1.29

Source: own elaboration with information from Inegi (Economic Information Bank, Monthly Survey of the Manufacturing Industry, 2021)
Note: the weighted average quarterly growth rate (WAQGR) was calculated as the sum of the weighted percentage change in quarterly employment

Regarding the evolution of exports, the northern border region generates a large percentage of total exports from Mexico. The proportion of the total has remained relatively constant from 2007 to 2020, representing 64.6% in 2007, with a slight reduction in its share in 2020 to 60.7% (Table 2). The growth of manufacturing exports both nationally and in the northern border region of Mexico has increased rapidly, reaching an average annual rate of 5.3% for the national manufacturing sector and 4.6% for the northern border in the 2007-2019 period. Therefore, although in recent years the importance of exports from the border region has decreased slightly, it is still considered a determining factor for all exports from Mexico and has a great impact on economic activities along the northern border.

Table 2. Total exports of Mexico and the northern border states, 2007-2020 (thousands of dollars)

Period	Total manufacturing exports, 1	Manufacturing exports northern border, 2	2/1
2007	197 384 916	127 461 129	64.6%
2008	213 130 121	135 536 647	63.6%
2009	170 386 441	106 091 332	62.3%
2010	219 121 794	136 238 485	62.2%
2011	244 505 223	149 688 546	61.2%
2012	266 487 058	160 667 488	60.3%
2013	281 604 751	168 879 877	60.0%
2014	306 164 993	182 679 528	59.7%
2015	313 284 745	185 324 994	59.2%
2016	303 395 403	182 855 705	60.3%
2017	324 988 164	191 141 383	58.8%
2018	352 625 592	205 528 823	58.3%
2019	372 781 602	220 602 761	59.2%
2020	336 011 403	203 906 100	60.7%
AAGR 2007-2019	5.3%	4.6%	

Source: own elaboration with data from Inegi (Economic Information Bank, series of annual merchandise exports by federal entity, 2021. https://www.inegi.org.mx/sistemas/bie/default.aspx)
AAGR: average annual growth rate

Export dynamics for the northern border region states of Mexico have exhibited differentiated behaviour. Within the northern border region, Chihuahua, Coahuila, Nuevo León and Baja California account for the highest proportion of the region's manufacturing exports (Table 3). Likewise, these states exhibited the highest growth rates in the period and greatly exceeded the growth rate for the border region as a whole. The high share of manufacturing exports linked to the predominance of manufacturing jobs in the region suggests the possibility that manufacturing trade has driven total employment in the border region.

Table 3. Evolution of northern border exports by state, 2007-2020 (thousands of dollars)

Period	Northern border	Baja California	Coahuila	Chihuahua	Nuevo León	Sonora	Tamaulipas
2007	127 461 129	29 145 320	17 445 918	27 830 369	19 787 004	11 430 382	21 822 136
2008	135 536 647	29 997 652	21 719 553	27 584 359	21 749 192	11 569 282	22 916 609
2009	106 091 332	23 920 274	13 868 570	24 367 428	17 314 297	8 959 351	17 661 412
2010	136 238 485	25 615 342	21 907 674	33 834 247	21 332 522	12 915 605	20 633 095
2011	149 688 546	26 636 867	27 147 559	36 999 547	24 577 396	13 109 976	21 217 201
2012	160 667 488	28 093 925	31 516 739	40 176 407	25 796 114	13 488 265	21 596 038
2013	168 879 877	28 459 589	32 955 390	42 501 385	25 865 201	16 966 302	22 132 010
2014	182 679 528	30 460 616	34 754 656	44 548 775	31 477 802	14 694 771	26 742 908
2015	185 324 994	33 570 658	36 127 823	39 407 530	34 493 669	15 767 077	25 958 237
2016	182 855 705	30 476 077	37 539 888	42 408 468	32 138 642	15 650 521	24 642 109
2017	191 141 383	30 651 026	38 788 142	45 496 896	35 954 342	14 992 697	25 258 280
2018	205 528 823	32 623 783	40 336 173	50 990 367	39 439 691	15 351 032	26 787 777
2019	220 602 761	34 554 015	47 108 297	55 579 835	39 671 108	15 121 687	28 567 819
2020	203 906 100	32 835 419	44 368 779	53 119 817	34 278 838	13 104 761	26 198 486
AAGR 2007-2019	4.6%	1.4%	8.3%	5.8%	5.8%	2.3%	2.2%

Source: own elaboration with data from Inegi (Economic Information Bank, series of quarterly exports of goods by federal entity, 2022)
AAGR: average annual growth rate

With regard to imports of the states along the northern border of Mexico, as in the country as a whole, the manufacturing sector plays a predominant role in total imports. Notably, manufacturing imports from the U.S., through means of transportation, reached an average annual growth of 4.1% in Mexico, while in the northern border region, the average annual growth rate was 4.7% (Table 4). To a large extent, the greatest dynamism of import growth is related to intra-industrial trade, carried out by the maquiladora and export manufacturing industries, within the framework of the growing development of global supply chains.

In particular, the largest volumes of imports are located in Chihuahua, Nuevo León and Baja California. In addition, the first two states presented average annual growth rates higher than the national average and the northern border region average. Thus, Chihuahua had an average growth rate in the period of 6.3%, with that for Nuevo León being 6.2%; for the northern border region, it was 4.1%, and nationally, it was 5.3%. The greater relative growth of imports and exports in the northern border states occurred, in part, from the growing trade within the automotive and electronic sectors, which have a significant number of production and export plants located in the northern border region (Mendoza-Cota, 2021). This trend has allowed greater relative trade in the region with the United States, which has impacted economic activity and employment in the region.

Table 4. Evolution of imports of the Mexican border states, 2007-2020 (thousands of dollars)

	2007	2013	2019	2020	AAGR (2007-2019)
Total imports (A)	136 541 262	226 079 069	256 374 085	212 671 751	5.3%
Manufacturing imports (B)	113 451 616	167 058 566	186 462 018	152 336 240	4.1%
% B/A	83.1%	73.9%	72.7%	71.6%	
Northern border (C)	58 648 898	93 363 694	103 366 083	100 734 197	4.7%
% C/B	51.7%	55.9%	55.4%	66.1%	
Baja California	11 747 287	14 290 639	18 445 881	15 911 638	3.8%
Chihuahua	16 514 627	30 333	35 113	32 359	6.3%
Coahuila	8 106 698	12 481 131	10 723 996	7 567 360	2.3%
Nuevo León	8 170 949	14 021 591	17 126 835	14 896 875	6.2%
Sonora	5 157 416	5 253 888	6 247 564	5 412 339	1.6%
Tamaulipas	8 353 469	10 880 077	12 684 069	10 186 724	3.5%

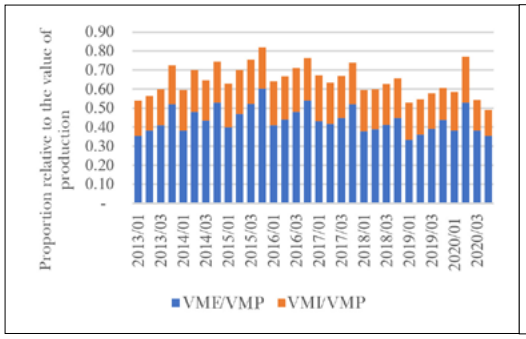
Source: own elaboration with data from the US Census Bureau: Economic Indicators Division. USA Trade Online
AAGR: average annual growth rate

The analysis of the proportion of the value of manufacturing exports and imports with respect to the value produced in this same sector in the states of the northern border region suggests that those with a greater penetration of their manufacturing trade into the United States economy would have also experienced a greater sustained increase in the number of manufacturing jobs and were even able to hold onto their relative importance among the region's total manufacturing employment. In particular, the state of Chihuahua, whose economy produces the highest number of manufacturing jobs among the six border states, saw a gradual increase in the penetration of its manufacturing exports and imports that reached, on average, 72% and 52%, respectively, during the period analysed (Figure 2).

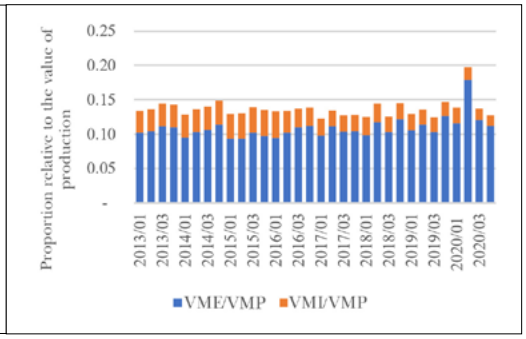
Baja California, meanwhile, experienced a process of manufacturing trade integration with the US economy that gradually intensified until 2017 and seemed to decrease slightly during 2018 and 2019, in accordance with the trends for state manufacturing jobs (Figure 3). The penetration of manufacturing trade, in this case, reached an average of 44% for exports with respect to the value of production and 21% for imports. The process of trade integration for Tamaulipas' manufacturing activity, on the other hand, contrasts markedly with that experienced by the set of border states due to the rapid increase in the penetration of their manufacturing exports and imports.

Figure 2. Evolution of the proportion of manufacturing exports and imports with respect to the value of manufacturing production in the states of the northern border of Mexico, 2013-2020

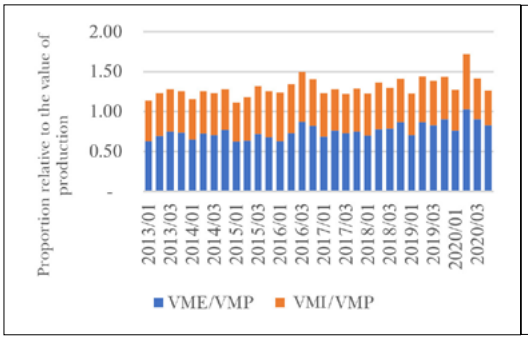
A) Baja California



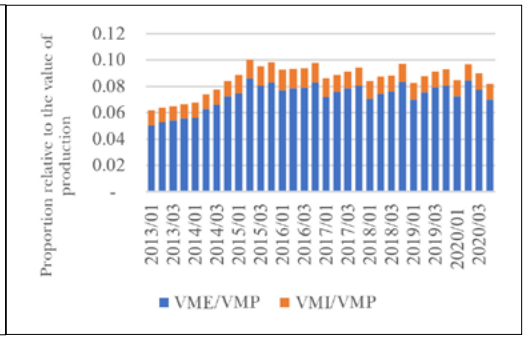
B) Coahuila



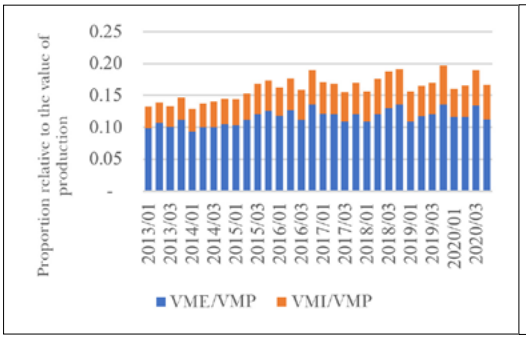
C) Chihuahua



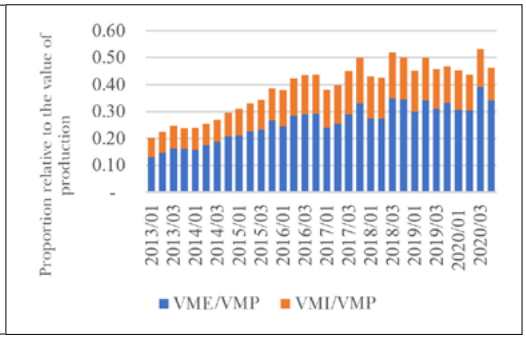
D) Nuevo León



E) Sonora



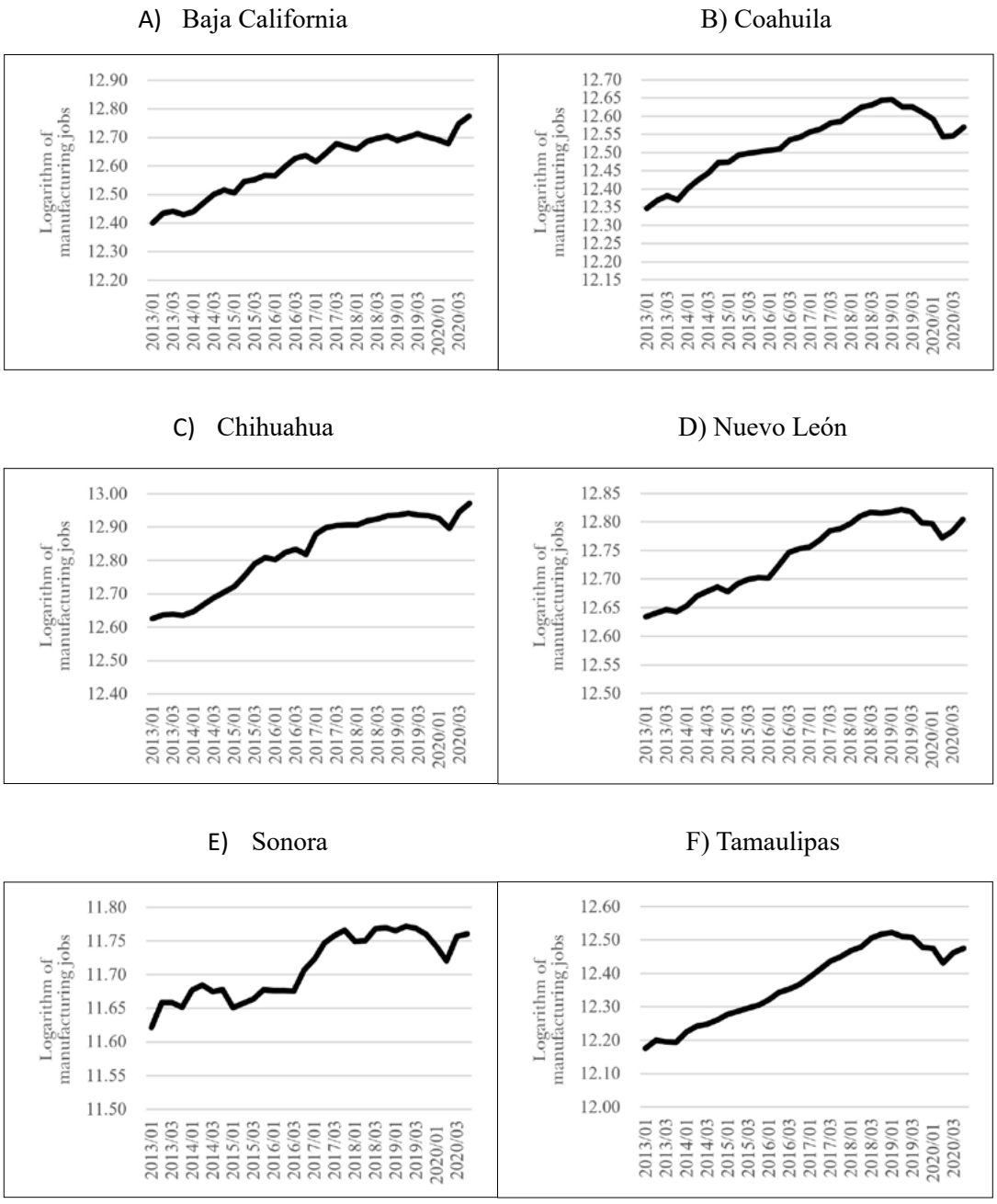
F) Tamaulipas



Source: own elaboration with data on state GDP from national accounts and exports obtained from the series of the external sector of the Economic Information Bank of the National Institute of Statistics and Geography

Note: VME: value of manufacturing exports; VMI: value of manufacturing imports; VMP value of manufacturing production

Figure 3. Evolution of the number of manufacturing jobs in the northern border states of Mexico, 2013-2020

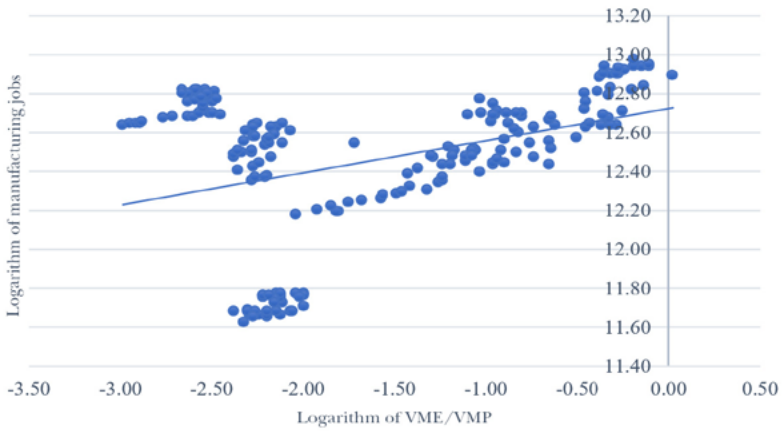


Source: own elaboration with data on employment, unemployment and underemployment rates and monthly results of the National Survey of Occupation and Employment, for the Population Aged 15 Years and Older (Economic Information Bank of the National Institute of Statistics and Geography)

In this regard, as seen in Figure 2, the proportion of the value of manufacturing exports with respect to the value of production increased from 13% to 34%, while that for imports increased from 7% to 12%, which corresponds with the increasing trend in manufacturing jobs. The states of Coahuila, Nuevo León and Sonora have processes of trade integration in their manufacturing activities with the US economy that has remained stable over the past 17 years, with a slight increase in the penetration achieved by manufacturing exports and imports in the latter state (Figure 2), which could explain the difficulty that these states found in resuming the growth rate of manufacturing jobs reached in 2018.

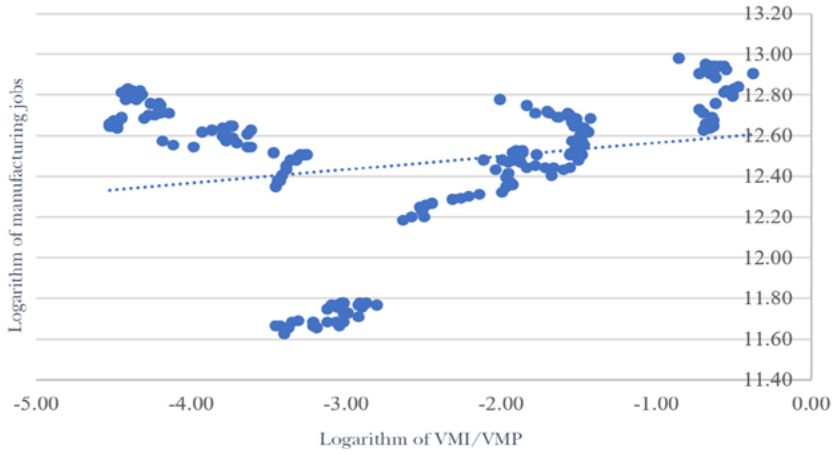
Figures 4 and 5, which describe, respectively, the relationship between the penetration of manufacturing exports and imports with respect to employment in this sector clearly indicate, in both cases, that more trade integration favours the creation of manufacturing jobs. This aspect would explain, therefore, why some states such as Chihuahua and Baja California continue to strengthen their trade ties with the US economy as a channel to consolidate their labor markets, particularly those tied to manufacturing activities, and why states such as Tamaulipas are making significant progress in integrating their state economy into the US economy through manufacturing trade. This aspect, however, would imply that the states of Coahuila and Sonora would have to push the creation of location advantages and productive capacities that allow them to compete effectively in the attraction and creation of manufacturing companies while developing the conditions to increase the penetration of their manufacturing trade. With respect to the state of Nuevo León, greater integration of manufacturing activity with the US economy would create additional jobs to those created by the economic activities most integrated into the national economy.

Figure 4. Scatterplot of export penetration and employment in the manufacturing industry of the states of the northern border of Mexico, 2013-2020



Source: own elaboration with data on state GDP from national accounts and exports obtained from the series of the external sector of the Economic Information Bank of the National Institute of Statistics and Geography
Note: VME: value of manufacturing exports; VMP: value of manufacturing production

Figure 5. Scatterplot of import penetration and employment in the manufacturing industry of the northern border states of Mexico, 2013-2020



Source: own elaboration with state GDP data from national accounts and exports obtained from the series of the external sector of the Economic Information Bank of the National Institute of Statistics and Geography and imports from the US Census Bureau: Economic Indicators Division. USA Trade Online
Note: VMI: value of manufacturing imports; VMP: value of manufacturing production

The review of the evolution of exports and imports and employment in the manufacturing sector of the region of the northern border states of Mexico suggests that the region's trade with the United States plays a predominant role in the employment dynamics of the region. In this sense, it is relevant to establish an econometric model to carry out estimates to measure the extent to which this activity has impacted the labor market of the northern border region of Mexico.

Theoretical and methodological aspects to evaluate the effect of trade on employment

In general, the theoretical perspective for analysing the impact of international trade on employment in the manufacturing sector is based on the proposition that exports and imports affect the labor input required for production. There are different theoretical approaches that highlight the potential factors that can determine the way in which the growth of international trade impacts employment growth. From Keynesian theory, export growth, as a component of aggregate demand, can stimulate production and, therefore, employment (Villanueva, 2017). However, international trade can also influence employment due to its impact on labor productivity because it can modify the sectoral composition of the economy and guide it towards capital-intensive activities (Gibson, 2011).

The approaches of the classic models of international trade indicate that countries with an abundance of labor will experience an increase in labor-intensive exports. In

the case of the Mexican economy, there is an increase in labor-intensive maquiladora exports. According to the Stolper-Samuelson theorem, changes in employment occur through changes in relative prices in international trade, which determine shifts in the demand for employment between industries and generate changes in business productivity. However, it has been stated that the positive impact of trade on employment may be greater in developing countries because many imports are noncompetitive (Wood, 1995).

In addition, intra-industry trade is related to the adjustment of the costs of production factors. Lovely and Nelson (2000, 2002) used a two-sector model to analyse the effects of intra-industry trade. Their results indicate that intra-industry trade generates adjustments at the intersectoral level, which implies long-term changes in the relative prices of the factors. Likewise, the empirical analysis has shown that in some countries, the marginal intra-industrial trade indicator has been associated with adjustments in the labor market, particularly in the short term (Brülhart, 2000). Additionally, Cabral and Silva (2006) estimated a panel model to analyse the relationship between intra-industry trade and labor mobility and suggest that this occurs both between sectors and between occupations.

Intra-industry trade also has implications for the production processes of some manufacturing activities at the international level. For example, the U.S. automotive industry has experienced significant structural changes that have fragmented the production processes of that industry across different countries. This trend has boosted vertical intra-industry trade in the U.S. automotive and auto parts subsectors with its main trading partners (Türkcan & Ates, 2011). In this way, the context of the growing intra-industrial trade in the total world trade and, in particular, of vertical intra-industrial trade (Greenaway et al., 1995), which characterizes a large part of the trade of the states bordering Mexico, allows us to assume that international trade has the potential to increase the demand for labor.

In this way, when assuming an economy without full employment, the impact of foreign trade on jobs can be analysed through an aggregate demand model, where employment E is a function of output Y and the employed workers per output unit L: $E = LY$ (1). When obtaining the growth rates of expression 1, growth in employment $\dot{E} = \dot{L} + \dot{Y}$ (2) is a function of the increase in the coefficient of employment per unit of output and the growth of the output (Gibson, 2011). From the above, it can be deduced that as long as foreign trade generates output growth, employment increases. Thus, to determine the impact of trade on employment, it is necessary to analyse the effect of trade on economic growth and, subsequently, its effect on changes in employment.

International trade and its effect on employment dynamics

In this study, the estimate of the effect of trade on employment along the northern border of Mexico is founded on the theoretical approach of labor demand based on a Cobb–Douglas function developed by Greenaway et al. (1999): $Y_{ijt} = A^{\varphi} K_{ijt} L^{\beta}_{ijt}$ (3),

where i is the industry, j is the state, t is time, Y is real output, K is the capital stock, L is units of labor utilized, α and β are factor share coefficients of production and labor, and $\emptyset$ represents the change in the efficiency of these factors. When using the function to maximize profits, where the marginal productivities of the factors are equal the wage w and the capital cost c, the equation is solved and, by taking logarithms, the following expression is obtained:

$$\ln L_{ijt} = \theta_0 + \theta_1 \ln (w_{ijt\,\tau/c}) + \theta_2 lnY_{ijt} \qquad (4)$$

where $\theta_0 = -(\varphi lnA + \alpha ln\alpha - \alpha ln\beta)/(\alpha+\beta)$, $\theta_1 = -\frac{\alpha}{\alpha+\beta}$, and $\theta_2 = \frac{1}{\alpha+\beta}$

This expression indicates that the demand for employment is a function of the productive efficiency, which is given by technological change A and the costs of wages s and capital c. To integrate the effect of international trade, it is considered that changes in productive efficiency are linked to foreign trade. It is assumed that the effect of trade over time is positive; therefore, $A_{ijt} = e^{\varphi_{0\,i}\,t} I^{\varphi_1} X^{\varphi_2}$, where t is time, I imports and E exports, and it is assumed that the parameters φ are positive. This, employment is determined using the following equation:

$$\ln L_{ijt} = \theta_0 + \delta_0 T + \delta_1 lnI_{ijt} + \delta_2 lnX_{ijt} + ln\,\theta_1 (s_{ij\tau/c}) + {}_2 lnY_{ijt} \qquad (5)$$

where: $\theta_0 = -(\alpha ln\alpha + \alpha ln\beta) / (\alpha + \beta)$, $\delta_0 = \delta\theta_0$, $\delta_1 = \delta\theta_{01}$, $\delta_2 = \delta\theta_2$, $\delta = \frac{\theta}{\alpha+\beta}$

Equation 5 indicates that the behaviour of employment is determined by economic activity, wages and the impacts of foreign trade, which reflect technological change in that equation. The empirical specification used to calculate the relationship between exports and employment assumes a short-term relationship whose estimation is based on a dynamic model that measures the impact of the adjustment process of the dependent variable on the explanatory variables, and it is assumed that these will have a positive dynamic effect on employment in the region of the northern border states.

Methodological aspects

There are different methodologies that have been used to analyse the effect of foreign trade on employment. One approach is based on factor content models, which seek to verify the theory of international trade in relation to the effects of foreign trade on the structure of work skills and, therefore, on employment in the manufacturing sector (Feenstra & Hanson, 1996). The growth accounting perspective considers the impact of foreign trade on employment when analysing changes in domestic demand, exports and productivity. Thus, the contribution of exports to employment growth depends on the proportion of exports in the total output, the growth rate of exports and the composition of labor-intensive exports (Wood, 1995).

Additionally, input-output matrices have been used, such as those developed by Feenstra and Sasahara (2018), Kien (2015), Ruiz Napoles (2017) and Sasahara (2019), among others. This methodology allows capturing both the direct employment generated by the exporters and the employment generated indirectly through the input-output intersectoral linkage. Some limitations of the method are related to the assumption that the distribution of imported inputs among all inputs is equal across all sectors. Other studies have used different econometric methods to estimate the relationship between exports and employment. In their study on the impact of exports on employment in Peruvian companies for the 2003-2010 period, Martincus et al. (2017) used an ordinary least squares model with instrumental variables. Feenstra et al. (2019) also used ordinary least squares with instrumental variables to analyse the effect of Chinese imports and U.S. exports on industrial jobs for the 1991-2007 period.

In this work, an approximation of the empirical model is carried out based on the following aspects: the difference in wage costs in the aggregate of workers in the industries, the presence of innovation shocks generated by foreign trade and the formation of expectations about wages. To obtain the variables of the model of foreign trade and employment at the national level, the following sources of information were consulted: the state gross domestic product was obtained from national accounts data published in the Economic Information Bank (BIE) of the National Institute of Statistics and Geography (Inegi), total state exports were obtained from the external sector data published by the BIE, total state imports from the US were obtained from the Bureau of Transportation Statistics, and for wage information, the daily wages paid in the formal sector of the economy published by the Mexican Social Security Institute (IMSS, by its acronym in spanish) were taken. Regarding the model that relates employment with manufacturing exports for the northern border states, the value of production and wages were obtained from the Monthly Survey of the Manufacturing Industry (EMIM, by its acronym in spanish) published in the BIE, state manufacturing exports were acquired from external sector data published by the BIE, and the total state imports of the US were obtained from the Bureau of Transportation Statistics.

Two models were estimated: the first relates total employment with total trade, total economic activity and total wages of the states of the border region, and the second estimates the same variables for the manufacturing sector. The series used in the models to analyse the effects of foreign trade on employment along the northern border of Mexico are performed for two periods due to data availability. The first period is from 2013 to 2020 for total jobs in the region, and the second covers the 2007-2017 period for the analysis of manufacturing jobs. Due to the number of observations in the first series, the unit root and panel cointegration tests were estimated to determine whether the relationships between the variables could be considered long term. The results of the Breitung, Levin, Lin and Chu and Im, Pesaran and Chin tests suggest, in general terms, that the variables included in the model are stationary (Table 5).

Table 5. Unit root panel test

Variable	Breitung	Levin, Lin and Chu	Hadri	Im, Pesaran and Chin
Y	-2.19	-6.63	-2.08	-5.93
	0.01*	0.0*	0.98	0.0*
X/Y	-1.28	2.24	1.86	-3.39
	0.00*	0.09	0.31	0.00*
I/Y	-3.16	-3.58	0.41	-2.48
	0.00*	0.00*	0.36	0.01*
S	-3.94	-3.92	0.41	-1.64
	0.00*	0.00*	0.34	0.05**
Y = gross domestic product, X/Y = exports as a proportion of GDP, I/Y = imports as a proportion of GDP, S = average wages				
* indicates rejection of the Levin, Lin and Chu (LLC), Im, Pesaran and Chin and Breitung null hypothesis of nonstationarity, with a statistical significance of 1%, and of the Hadri hypothesis of stationarity				

Source: own elaboration

With respect to the panel cointegration tests, the Pedroni and Hadri cointegration tests led to the rejection of the hypothesis of no cointegration in the period analysed (Table 6). That is, the results show that for GDP and total state export series, there is a possible long-term equilibrium, which does not necessarily imply the existence of common factors or trends.

Table 6. Panel cointegration tests

Pedroni cointegration test	Statistic	*P* value
Phillips-Perron t modified	0.72	0.24
Phillips-Perron t	-7.81	0
Dickey-Fuller t augmented	-7.25	0
Kao cointegration test		
Dickey-Fuller t modified	-2.99	0.0001
Dickey-Fuller t modified unadjusted	-7.82	0
Dickey-Fuller t unadjusted	-6.67	0
Westerlund cointegration test		
Variance ratio	-1.64	0.05

Source: own elaboration
Pedroni, Kao and Westerlund: null hypothesis: No cointegration. Alt: cointegration

To perform a comparative analysis of the total GDP and manufacturing sector series, the same dynamic panel methodology was used with lags in the employment variable for estimating the two series and instrumental variables to control the possibility of endogeneity. The advantage of dynamic panel models with respect to static panel models is the inclusion of more information, which allows estimating the short-term and long-term effects of the explanatory variables on the dependent variable. If the dynamic panel includes the lag levels of the dependent variable as regressors, which violates strict exogeneity due to the association of the lagged dependent variable with the error, the Arellano-Bond model is used; this model takes the first differences of the regression to eliminate the individual effects, and the lags of the dependent variable are taken. Furthermore, the model uses the generalized method of instrumental moments and variables. The empirical equation that is established to estimate the impact of foreign trade on the employment of the border states of Mexico is defined as follows:

$$L_{ij,t} = \alpha_i + \delta_1 X_{ij,t} + \delta_2 L_{ij,t} + \delta_3 s_{ij,t} + \theta_1 Y_{ij,t-1} + \sigma_{ij} + \varepsilon_{ij,t} \qquad (6)$$

where L_{ijt} = total employment of the economic sectors i for each of the northern border states j at time t, s_{ijt} = average real wage of industry i in state j at time t, Y_{ijt} = the real output, α_i = industry-specific effects, $Y_{ij,\,t-1}$ is the lagged dependent variable that is included as an explanatory variable and the error term that is divided by the idiosyncratic error $\varepsilon_{ij,t}$ and the error that does not vary with time σ_{ij}. Endogeneity is generated by including the dynamic term represented by the lagged dependent variable.

A generalized model of moments was established using lags in the dependent variable and an instrumental variable to avoid serial correlation. To avoid inconsistency in the estimator of the dynamic panel model, due to the elimination of the individual effects of the error that generates a correlation between the lagged endogenous variable and the error term, a first differentiation was applied to the variables of the series (Nickell, 1981), and instrumental variables were used to eliminate the correlation between the idiosyncratic error and the lagged variable. Therefore, the model assumes that the lagged error term $\varepsilon_{ij} - \varepsilon_{ij} - 1$ follows an MA(1) process and that the explanatory variables of the equation are strictly exogenous with respect to the error term.

Results of the estimations

To analyse the effect of foreign trade on employment in the northern Mexican border region, two dynamic panel models were established; the first includes the lags of the total employment variable as regressors, and the second includes the lags of manufacturing jobs in Mexico as regressors. Initially, the Arellano-Bond estimator test was performed for both models to determine if the dynamic panel model presented a serial correlation with the differentiated residuals.

Regarding the first model for total employment in the northern border region, the results do not reject the existence of a correlation in the first difference of the AR(1)

errors; therefore, the model is considered adequate and does not show a serial correlation (Table 7). Additionally, to corroborate whether there are restrictions on the exogenous instruments of the dynamic panel estimation, the Sargan test was estimated. The *p values* of the Sargan statistic were 0.98 for one lag; therefore, the dynamic model shows instrumental variables that are exogenously valid. Regarding the second model, the Arellano-Bond and Sargan tests indicate that there is no correlation with or restrictions of the instrumental variables (Table 8).

Table 7. National employment: Arellano-Bond autocorrelation test and Sargan heteroscedasticity test

Lags	Autocorrelation test of the first difference in errors			Sargan test for overidentifying restrictions	
	Order	Z	Prob > z	Chi	Prob > chi²
One lag	1	-0.87	0.038	0.01	0.98
Null hypothesis of the Arellano-Bond test: there is no correlation among the first-order differentiated errors. Null hypothesis of the Sargan test: the overidentifying restrictions are valid.					

Table 8. Manufacturing jobs: Arellano-Bond autocorrelation test and Sargan heteroscedasticity test

Lags	Autocorrelation test of the first difference in errors			Sargan test for overidentifying restrictions	
	Order	Z	Prob > z	Chi	Prob > chi2
One lag	1	-2.42	0.04	22.95	0.92
Null hypothesis of the Arellano-Bond test: there is no correlation among first-order differentiated errors. Null hypothesis of the Sargan test: the overidentifying restrictions are valid.					

The dynamic panel model for the set of economic activities along the northern border was estimated based on a lag. The results show that the coefficients of GDP and import penetration were positive and statistically significant. The coefficient of the inputs of the formal sector was negative and statistically significant (Table 9). These results indicate that the shift in employment rate at the northern border is related to the economic activity dynamics and inversely related to wages, which corresponds to the theoretical approach of the model. However, the coefficient of export penetration was negative, a result that does not conform to the approach of trade openness as a driver of employment growth. The penetration of imports in the northern border region of Mexico has a positive and statistically significant impact on employment in the region. This result suggests that global value chains and intra-industry trade play driving roles in employment dynamics.

Table 9. Dynamic panel estimates. Dependent variable: total employment in border states, 2013-2020

66 observations, 6 groups	
Variables	Lag 1 in instrumental variable[1]
C	-153.74
	70.11
LNY	5.32*
	2.16
LN(X/Y)	-13.08*
	5.51
LN(I/Y)	8.6
	3.61*
LNSF	-2.91**
	1.3
Number of instrumentals	57
Wald chi2(5) =	118.59
Prob > chi2	0

[1] Instrumental variable T/Y (% of international trade in GDP)
All variables were logarithmically transformed.
* and ** indicate statistical significance at the 1% and 5% confidence levels, respectively.
LNY = gross domestic product; LN(X/Y) = export penetration; LN(I/Y) = import penetration; LNSF = total wages

In the model for the manufacturing sector in the states of the northern border of Mexico, the coefficients of value of production and of penetration of exports and imports were positive and statistically significant (Table 10). The results suggest that foreign trade with the US plays an important role in the promotion of manufacturing jobs in the states along the northern Mexican border. In addition, the estimates highlight the importance of this sector in the economic dynamics of the northern border states. Finally, the coefficient of wages was negative and statistically significant; therefore, low wages, particularly those paid to workers in the maquiladora plants along the northern border, have been an incentive for job growth. This could imply a complicated scenario for achieving growth in manufacturing jobs coupled with a substantial increase in the income of workers in the manufacturing sector along the northern border of Mexico.

Table 10. Dynamic panel estimates. Dependent variable: total manufacturing jobs in border states, 2007-2017

66 observations, 6 groups	
Variables	Lag 1 in instrumental variable[1]
C	0.24
	70.11
LNVP	0.05 *
	0.008
LNX	0.03*
	0.008
LNI	0.03*
	0.007
LNIF	-0.01*
	180
Number of instrumentals	180
Wald chi2(175) =	7 533.51
Prob > chi2	0

[1] Instrumental variable T/GDP (% of international trade of GDP)
All variables were logarithmically transformed.
* Statistically significant at the 1% confidence level
LNVP = manufacturing production value; LNX = manufacturing export penetration; LNI = manufacturing import penetration; LNIF = manufacturing wages

Conclusions

The establishment of the NAFTA and later the T-MEC and the geographic proximity to the US have significantly increased foreign investment and trade in Mexico. In particular, there is a greater trade integration of the states in the northern border region of Mexico. This has increased manufacturing activities and employment in the region. The states of Chihuahua and Baja California stand out and have been characterized as having faster employment growth in the region. Likewise, there is a notable share in both the penetration of exports and the penetration of imports in several states along the northern border. The models that relate employment to exports and imports suggest that greater trade integration with the United States would promote employment in the border region.

The analysis of the impact of foreign trade on employment has generally been approached from the perspective of classical theory and the new theory of international trade. From the traditional model of trade theory, the effect on employment will depend on the negative impact of imports that compete with domestic production, the growth of employment in the export sector, and the capital-labor ratio that

characterizes this sector. The new theory of international trade suggests that the internationalization of production processes has generated a growing intra-industrial trade that allows imports and exports to have a positive effect on employment tied to international trade.

From the perspective of the aggregate demand approach, employment growth is a function of an increase in the employment coefficient per unit of output and the effect of foreign trade on output growth. Using an empirical dynamic panel model based on this approach, estimates were made in which the dependent variable is employment and is a function of trade penetration, state GDP, the value generated in the manufacturing industry and the average wages of workers in the northern border states. The results indicate that export penetration does not have an impact on total employment in the region. However, the output level and imports showed positive and significant coefficients. Likewise, wages in the region were negative, which conforms to the assumptions of the model. The results of the estimates for total employment in the region suggest that the effect of export penetration has not had a multiplier effect to boost the economic growth of border states as a whole. This result is probably related to the limited impact of export income on demand in the northern border region, which may be restricting the multiplier effect from exports.

However, the model that was estimated for the manufacturing sector in the northern border region indicated positive and significant coefficients for both export and import penetration. The above results suggest that the growth in manufacturing jobs is significantly linked to foreign trade in this sector in this border region. The importance of foreign trade in the dynamics of manufacturing jobs can be explained by the development of global supply chains and the fragmentation of production processes, which led to a significant increase in maquiladora and export manufacturing establishments in the northern border region of Mexico. In addition, the results of the estimations indicate that the coefficient of manufacturing wages was negative, suggesting that the low wages paid to workers in the maquiladora and export manufacturing industry could be a limitation for the manufacturing trade in generating multiplier effects in total economic activity and, therefore, for employment in other economic activities in the northern border region of Mexico.

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