2022

Trade in Value Added in Gross Exports: A Better Metric for Understanding Texas-Mexico Trade Flows

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By:

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TECHNICAL REPORT

(English)

[1]We thank the SMU Mission Foods Texas-Mexico Center for their financial support of this project. Noé Arón Fuentes and Alejandro Brugués are professor-researchers at COLEF, Melissa Floca is a professor at the US-MEXICO CENTER at UCSD, and Gabriel González-König is a private consultant. The errors and omissions involuntarily made are the authors' responsibility.

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1.- Introduction

In 2018, the U.S.'s 60 billion dollar trade deficit with Mexico was a central part of President Donald Trump's initiative (2017-2021) regarding the cancellation or renegotiation of the North American Free Trade Agreement (NAFTA).

Nevertheless, the U.S. trade deficit with Mexico only reflects the value of the gross trade of final goods and does not precisely show the complexities in the trade flows of intermediate goods (imported supplies) between the two countries. Trade between both countries is based on binational supply chains of intermediate goods, which means that intermediate goods cross the border several times to produce a final good, and each time value can be added before they are exported again. Consequently, traditional measurements based on registering commercial exchanges without controlling middle or final destinations tend to duplicate the counting of intermediate goods, which results in a distorted number of trade flows when visualizing the productive input of each nation.

On the other hand, even if it seems obvious, it is important to emphasize that the U.S. and Mexico do not represent a homogeneous geographic space, but a space with differences. There are different dynamics and levels of interaction between the states in the U.S. and Mexico. Texas is Mexico's main trading partner, which is why we need to understand the complexity of trade flows of intermediate goods, the specialization in the co-production of a final good or service during certain stages and the different economic growth outcomes that stem from participating in these stages.

The main objective of this study is to analyze the particularities of the commercial and productive chains between Texas and Mexico in the year 2013, from the perspective of incorporated value-added trade in the gross value of exports. In order to do so, a biregional/bilateral product input table was created; this framework constitutes the methodological starting point of the study, which is why its characteristics will be carefully detailed later on.

On the other hand, among the alternatives to get value-added content for exports, we adopted the method developed by Wang, Wei and Zhu (2016), which analyzes value-added trade flows at the sectoral and bilateral level. For example, gross exports of a country's particular sector can be broken down by the sum of value-added contributions to its own sector, other sectors of the exporting country, sectors of the rest of the countries and the one that is double counted. This method allows the decomposition of value added contained in aggregate exports and identifies the economic sectors (and industries) that depend on the co-production chains between Texas and Mexico. It also details the complexities of the trade of intermediary goods and highlights the key industries that may be affected by a change in trade regulations between the U.S. and Mexico.

The study is organized as follows: section two explains the methodology for obtaining the biregional/bilateral product input table, reviews the decomposition framework for the value-added aggregated exports at the multilateral, bilateral and bilateral-sector levels, and describes the focus on productive specialization coefficients; section three discusses the cross-border productive specialization between Texas and Mexico; section four corresponds to the empirical analysis of the decomposition framework of value added for Texas and Mexico; section five shows the value chains of the main sectors; and section six includes the research conclusions.

2. Methodology

2.1. Biregional/bilateral product input table

The analysis of the commercial and productive chains between the economies of Texas and Mexico is based on the estimated statistics of the biregional/bilateral product input table. When developing the integrated Texas-Mexico table, it was considered appropriate that the sector aggregation level should be as detailed as possible. For Texas, we used the table in the IMPLAN (Minnesota Implan Group –MIG-, 2017) software for the year 2013, with a sector structure of 526 sectors. For Mexico, we used the national official table for 2013 (INEGI, 2014), disaggregated to the four digits of the North American Industry Classification System (NAICS), formed by 262 sectors.

The first step to generate the integrated Texas-Mexico model was to look for compatibility of sectoral classifications between individual models. Of the 526 sectors in the Texas table, a total of 488 corresponded to the four-digit level of NAICS in the Mexico table and the 38 remaining sectors combined activities of several individual sectors, which were assigned based on the average of their participation, using data from the economic census. 259 sectors resulted from this process. Then, the compatibility of activities between both tables required minor adjustments in the classifications, out of which 247 economic sectors were shown in the integrated Texas-Mexico table.

In the second step, producing the integrated biregional/bilateral table required estimating the trade flows between Texas and Mexico at the individual sector level, for which we have the specific aggregated international trade flows of both geographical areas. The distribution of the sector aggregates of imports and exports went through a similar process to that which was applied to the interregional product input tables (Canning & Wang, 2005).

The main reason for estimating the biregional/bilateral trade tables is an adaptation of the proposals included in (Miller & Blair, 2009; Szabó, 2015) and begins by considering that trade between both territories is part of the import and export aggregates contained in each of the tables; based on that, the international trade flows are subtracted from the total of both tables accordingly.

Using this process, we can incorporate the cross exchanges in the geographical areas making an initial distribution based on the structural composition of the import matrixes for each table. The consistency of the aggregates is reached by considering that the sum of the rows of international trade flows between both countries and the exports must coincide with exports by sector of the individual tables. Also, adding the columns of trade flows between Texas and Mexico and the imports from the rest of the countries must be added to the total number of imports of the individual matrixes by sector. Next, the adjustment of international trade values and imports and exports from the rest of the countries will be calculated by using the RAS[2] (Lahr & De Mesnard, June 2004) method, which adjusts the sum of the interior values with the total aggregates by rows and columns.

It is important to mention that the Texas-Mexico table shows a difference regarding the interregional multilateral model, which will later be explained. Since we did not include the rest of the U.S. and the rest of the world in the Texas-Mexico matrix, it is not possible to determine the Texan value added in extra regional intermediary input. Therefore, we have to assume that the rest of the U.S. exports act as if they are final goods. Therefore, the content of imported supplies incorporated into the exports of third countries (or their foreign content) is overestimated for Texas.

The general representation of the biregional/bilateral product input table is shown in Table 1. It is a combination of the sector interactions $(x_{i,j}^{s,r})$ and aggregate economics of final demand $(y_{i,j}^{s,r})$ for each region (s, r) and includes a registry of bilateral trade flows $(e_{i}^{s,r})$ and the rest of the world exports (e_{i}^{w}) for 247 sectors (i = 1,…,247).

The balance equations, in a matrix format, are shown in Table 1.

$$
\begin{aligned}
x^{s} &= x^{ss} + x^{sr} + y^{ss} + y^{sr} + e^{sw} \\
x^{r} &= x^{rs} + x^{rr} + y^{rs} + y^{rr} + e^{rw}
\end{aligned}
\qquad (1)
$$

where: x^{s} is the total gross production of region *s* which must be used as an intermediary good or final good, domestically or internationally; x^{ss} is the intermediary demand of intermediary goods or the region's own input in region *s*; y^{ss} is the final demand of final goods in country *s* of own final goods; x^{rs} is the intermediate demand of intermediate goods

[2] The RAS method is a translation of the matrix adjustment theory restricted to the estimation of input-product matrixes (total of rows and columns). This adaptation was first used as a technique to update the matrix of intermediary transactions (Mesnard, 1989).

or regional goods in region s; y^{rs} is the final demand of final goods from region s in region r; y, $x_i^{s,w}$ are the exports to the rest of the world from region s. The same analysis will be made for country r.

Table 1. Representation of the biregional/intercountry product input model

Millions of Dollars								
	Intermediate Demand 1_/		Final Demand					
	s	r	s		r		ROW	
	1…J…247	1…J…247	1…k 4	E	1…k. 4	E	Exp ROW	I=P
s	1 i $x_{IJ}^{s,s}$ 247	1 i $x_{IJ}^{s,r}$ 247	$y_{ik}^{s,s}$	e_i^s	$y_{ik}^{s,r}$	0	$e_i^{s,w}$	x^s
r	1 i $x_{IJ}^{r,s}$ 247	1 i $x_{IJ}^{r,r}$ 247	$y_{ik}^{r,s}$	0	$y_{ik}^{r,r}$	e_I^r	$e_i^{r,w}$	x^r
Imp ROW	1 i $m_{IJ}^{w,s}$ 247	1 i $m_{IJ}^{w,r}$ 247	y_{ik}^{wr}	0	$y_{ik}^{w,r}$	0	0	0
VA	1 P v_{PJ}^s 4	1 P v_{PJ}^r 4	0	0	0	0	0	GDP
I=P	x^s	x^r	$\sum y_k^s$	$\sum e^s$	$\sum y_k^r$	$\sum e^r$	$\sum e^w$	

1_/ abbreviations: s = country s; r = country r; ImpROW = Imports from Rest of the World; VA = Value Added; Exp ROW = exports rest of world I = Gross Input; P = Gross Product; y, GDP = Gross Domestic Product.
Source: the authors.

Based on Leontif's system about the linearity of the parameters of production function, i.e. $a_{ij} = {x_{ij}}/{x_j}$, structural equations are bilateraly defined,

$$a^{ss} = {x^{ss}}/{x^s} \quad (2)$$

$$a^{sr} = {x^{sr}}/{x^r} \quad (3)$$

$$a^{rs} = {x^{rs}}/{x^s} \quad (4)$$

$$a^{rr} = {x^{rr}}/{x^r} \quad (5)$$

Equations (2) and (4) represent the direct intraregional coefficients and equations (3) and (5) are the intraregional trade coefficients. By substituting these structural equations in the equation and adding them to the matrixes we get:

$$\begin{bmatrix} x^s \\ x^r \end{bmatrix} = \begin{bmatrix} a^{ss} & a^{sr} \\ a^{rs} & a^{rr} \end{bmatrix} \begin{bmatrix} x^s \\ x^r \end{bmatrix} + \begin{bmatrix} y^{ss} + y^{sr} \\ y^{rs} + y^{rr} \end{bmatrix} \quad (7)$$

By adding the previous terms, we have:

$$\begin{bmatrix} x^s \\ x^r \end{bmatrix} = \begin{bmatrix} I - a^{ss} & -a^{sr} \\ -a^{rs} & I - a^{rr} \end{bmatrix}^{-1} \begin{bmatrix} y^{sr} + y^{ss} \\ y^{rs} + y^{rr} \end{bmatrix} = \begin{bmatrix} b^{ss} & b^{sr} \\ b^{rs} & b^{rr} \end{bmatrix} \begin{bmatrix} y_s \\ y_r \end{bmatrix} \quad (8)$$

Where $b_{i,j}$ are the Leontif inverse coefficients or total coefficients, also $y^s = y^{sr} + y^{ss}$ and $y^r = y^{sr} + y^{rr}$. In other words, we have the solution to Leontif's equation system for the interregional case.

2.2. Koopman's decomposition and Stehrer's extension

Many authors have estimated the added value incorporated in exports using a product input table as framework. In particular, the work of Koopman, Wang and Wei (2012 and 2014) integrates the literature of vertical specialization and value added international trade based on a multilateral product input table, which breaks down the gross exports into their different value-added components. Stehrer (2013) and Wang, Wei and Zhu (2013) created methods to apply this work to a bilateral and sectoral/bilateral product input framework, respectively.

Koopman et al., used a multilateral product input matrix, which gives a unified framework from which several measurements for vertical integration in the productive processes between countries can be determined. Among them, the following are highlighted:

a. *Vertical integration (VS)*. Defined as the imported input content incorporated in exports – either directly or indirectly – or their foreign content. This measurement is based on the assumption that imports have been produced entirely abroad, without any input from the exporting country, a situation that is not met when a good is produced in several stages and trade between intermediate goods is produced both ways (Hummels, Ishii, & Yi, 2001).

b. *Exporter's vertical integration (VS1)*. Measures the exports of intermediary goods by other countries used for producing their exports. In other words, the exports of intermediary goods generated by the exports from their direct trade partners (Hummels, Ishii, & Yi, 2001).

c. *Returned domestic content (vS1*)*. Defined as the exported domestic value that is reimported by its country of origin, after being processed in the rest of the world (Daudin, Rifflart, & Schweisguth, 2011).

d. *Domestic value-added content in exports (VAX)*. Quantifies the value-added content in gross exports, such as the quotient between domestic value-added exports and gross exports (Johnson & Noguera, Accounting for intermediates: Production sharing and trade in value added, 2012).

A breakdown of the gross export flows in their added value, grouped according to origin, destination and double counting can be obtained through the framework. In other words, and according to these authors, the value-added content of gross exports can be broken down into three categories shown in Graph 1. Each category will be divided into three subcategories;

among which we highlight the one that reflects the amount of “double counting,” which is generated in customs due to having crossed the border several times.

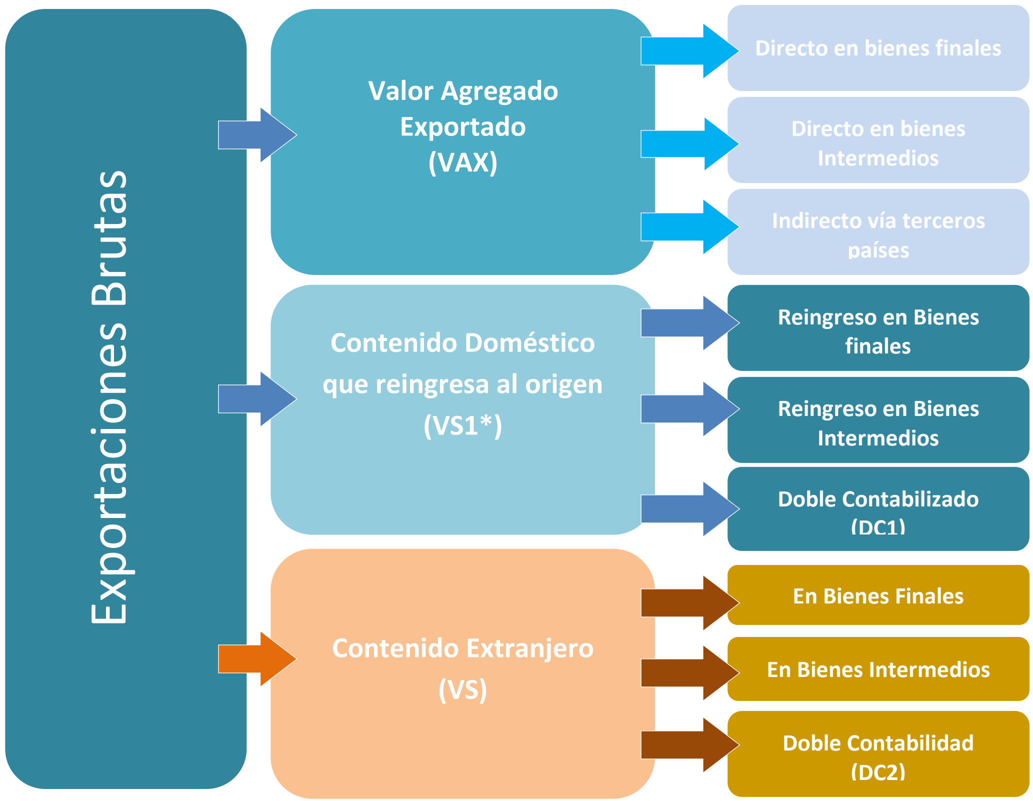
The value-added export (VAX) block that was previously defined can be divided into three areas:

a. *Final goods.* Defined as the amount of national added value in exports destined for final consumption in the importing country. This would be the case if there would be an absence of co-production between countries.
b. *Direct intermediary goods.* Defined as the amount of domestic value added in national exported goods made directly for the trade partner, so that it might continue the co-production process of final goods destined to their domestic market.
c. *Indirect intermediary goods.* Defined as the amount of domestic value added of incorporated exports which is reexported to a third country instead of being processed and consumed as a final good in the immediate destination country. Such a process implies a larger production chain than the bilateral one.

The block previously defined as exported domestic content and then reimported (VS1*) can be divided into three areas:

a. *Final goods*. Defined as the possibility of reentry for the national value added in exports as final goods produced abroad.
b. *Intermediary goods*. Defined as the possibility of value added returning in the form of new intermediary goods, which is exporting input with transformation abroad, then reimporting it as an industrial intermediary good subject to new transformation processes.
c. *Domestic double counting (DCI)*. Defined as the possibility that a fraction of value added returns to its country of origin in the form of intermediary goods. If these intermediary goods are processed and exported again, their domestic value added will have crossed the national borders on more than one occasion.

Graph 1. Framework for Koopman's decomposition of exports



Source: Authors' graph based on (Koopman, Wang, & Wei, 2014).

The block previously defined as foreign content of exports (VS) can be divided into three areas:

a. *Final goods*. Defined as the participation of imported final goods directly incorporated into exports.
b. *Intermediary goods*. Defined as the fraction of imported intermediary goods directly and indirectly reexported.
c. *Double domestic counting (DC2)*. Defined as the possibility that a fraction of the value added is reexported to the country of origin as intermediary goods; if the process continues crossing national borders several times, it can lead to double counting the foreign content.

It is important to mention that the methodology of (Koopman, Wang, & Wei, 2012) (Koopman, Wang, & Wei, 2014) was designed for the breakdown of value-added content in total aggregated exports on the multilateral level; and therefore, presents a disadvantage when applying it to the bilateral level. This is primarily because not all value-added trade has an exchange between them – there can also be transactions by third countries.

(Stehrer, 2013) proposes three modifications to the methodology of (Koopman, Wang, & Wei, 2014) if we want the total of the value-added components to be the exact sum of the total bilateral exports. The three modifications regarding to multilateral and aggregate cases are:

a. *Indirect value (IV)*. Defined as the amount of national added-value content included in the indirect exports to its partner. It is not part of the bilateral gross exports from the first to the second (there will be an implicit bilateral trade flow without a commercial counterpart in the customs' registries). This proportion of bilateral VAX is referred to as IV.
b. *Final re-export value (RE-X)*. Defined as the amount of national value added included in the final exports that a country sends to its partner, which is later re-exported to a third country, representing trade flows that do not have a VAX counterpart to its partner. On the one hand, the trade flow to the partner should be counted, and on the other, the added value (indirectly) towards the third country.
c. *Intermediary re-export value (RE-X1*). Measures the amount of national value added to exports that a country sends to its partner, which is then re-exported to a third country where they are not consumed but re-exported. That country will register the re-exported value added to the country of origin even if there are not any bilateral gross exports or VAX from the country of origin yet.

Consequently, the RE-X – or the proportion of value added transiting through the trade partner and then re-exported – may or may not have a bilateral trade flow counterpart. Only fractions of the bilateral VAX (IV) and RE-X will arrive to the trade partner through a bilateral export flow. Therefore, in order to guarantee that the total breakdown of value added is the exact sum of the gross bilateral exports, the transiting value added that the destination country receives indirectly must be subtracted. This approach has a disadvantage when applied to the bilateral sectoral level.

(Wang, Wei, & Zhu, 2013) propose a different methodology for dividing value added at the bilateral sector level. This modifies the disaggregated components of value added that can be grouped into the three previous categories. In section four, we present this concept in 16 terms for the bilateral sectoral level.

2.3. Wang, Wei, and Zhu Decomposition

The division of the sectoral-bilateral trade flows of the gross value-added exports proposed by (Wang, Wei, & Zhu, 2013) is complex and extensive. Due to space constraints, it is not possible to present the entire proposal. Nevertheless, we show the decomposition of the 16 terms of value added of the gross exports and a simple explanation of each component.

The decomposition of the exports from country s to country r (e^{rs}) according to their value components by origin, destination, and final and intermediary goods is as follows:

$$
\begin{aligned}
e^{rs} = {} & \overbrace{(v^s b^{ss})^T \# y^{sr}}^{T1} + \overbrace{(v^s l^{ss})^T \# a^{sr} b^{rr} y^{rr}}^{T2} + \overbrace{(v^s l^{ss})^T \# a^{sr} b^{rt} y^{tt}}^{T3} \\
& + \overbrace{(v^s l^{ss})^T \# a^{sr} b^{rr} y^{rt}}^{T4} + \overbrace{(v^s l^{ss})^T \# a^{rs} b^{rt} y^{tr}}^{T5} + \overbrace{(v^s l^{ss})^T \# a^{sr} b^{rr} y^{rs}}^{T6} \\
& + \overbrace{(v^s l^{ss})^T \# a^{sr} b^{rt} y^{ts}}^{T7} + \overbrace{(v^s l^{ss})^T \# a^{rs} b^{rs} y^{ss}}^{T8} + \overbrace{(v^s l^{ss})^T \# [a^{sr} b (y^{rs} + y^{st})]}^{T9} \quad (9) \\
& + \overbrace{[v^s (b^{ss} + l^{ss})]^T \# a^{sr} x^r}^{T10} + \overbrace{(v^r b^{rs})^T \# y^{sr}}^{T11} + \overbrace{(v^r l^{rs})^T \# a^{sr} l^{rr} y^{rr}}^{T12}) \\
& + \overbrace{(v^r b^{rs})^T \# a^{sr} l^{rr} e^{r*}}^{T13} + \overbrace{(v^t b^{ts})^T \# y^{sr}}^{T14} + \overbrace{(v^t b^{ts})^T \# a^{sr} l^{rr} y^{rr}}^{T15}) \\
& + \overbrace{(v^t b^{ts})^T \# a^{sr} l^{rr} e^{r*}}^{T16}
\end{aligned}
$$

The terms refer to:

- T1. Direct value added (DVA) of final goods exports.
- T2. DVA of intermediary exports of importing country r used in that country.
- T3. DVA of intermediary exports to importing country r, which are also intermediary exports to third countries t for the production of final goods to be used in third countries.
- T4. DVA of intermediary exports to importing country r for final exportation to third countries t.
- T5. DVA of intermediary exports to importing country r which are intermediary exports to third countries t.
- T6. DVA that returns as final goods from importing country r.
- T7. DVA that returns as final goods from third countries t.
- T8. DVA that returns as intermediary imports.
- T9. Double counting of DVA to produce final goods for exportation.
- T10. Double counting of DVA to produce intermediary goods for exportation.
- T11. Value added from direct importer r in final exports from country s.
- T12. Value added from direct importer r in the intermediary exports from country s.
- T13. Double counting of value added from direct importer r in exports from the country of origin s.
- T14. Value added from third countries t in final exports.
- T15. Value added from third countries t in intermediary exports.
- T16. Double counting of value added to third countries (*t*, *) in exports from the country of origin s.

Where v^i is the matrix of value added from country *i*, b^{ij} is the submatrix of the Leontif inverse matrix, l^{ij} is the Leontif inverse matrix from submatrix x^{ij}, *T* is transposed, y # refers to the multiplication of "element by element," similar to the product point of two vectors.

It can also be added as a domestic aggregate (DVA), foreign value added (FVA), return value added (RVA) and pure double counting (PDC).

- DVA is equal to the sum of terms T1 to T5. This is the sum of domestic value added that is used in other countries.
- RDV is equal to the sum of terms T6 to T8. It represents the exported value added that eventually returns to the country of origin.
- FVA is the sum of terms T11, T12, T14 and T15. It represents the part of exports whose value added comes from other countries (T11 and T12 for the direct importer; T14 and T15 for third countries).
- PDC is the sum of T9, T10, T13 and T16. It represents double counting.
- Total DVA is the sum of DVA and RDV. This is the sum of all domestic value added, regardless of where it ends up being consumed.

2.4. Biregional/bilateral productive specialization

Next, applying the information about productive relationships in the biregional/binational product input matrix, Texas' productive specialization will be determined, as well as to what degree it can be reinforced as a source that favors grouping industries into biregional/binational clusters.

The location quotients are calculated from the relationship between the sectoral employment proportions in the region and the country. If the result is over one, it indicates a region specialized in producing what we analyzed. If the result is less than one, it indicates a sub specialization. The mathematical expression for calculating it is $LQ_i = \frac{e_i^r / e^r}{e_i^n / e^n}$ and, for a correct analysis, it should be taken into account that this calculation is based on the following hypothesis:

- ✓ Equality in the sectoral productivity between the regions and the country
- ✓ Equality in the consumer patterns between the regions and the country
- ✓ Equality in the industry structure of the sectors in the regions and the country
- ✓ Similarity in technology between the regions and the country

The existence of binational clusters can stem from the existence of labor concentrations in a certain economic sector. These are productive relations between sectors, which are also important for the local economic system. The existence of clusters from the agglomeration of industries with similar specializations that require particular infrastructure, specialized services, amongst other things, will also be analyzed.

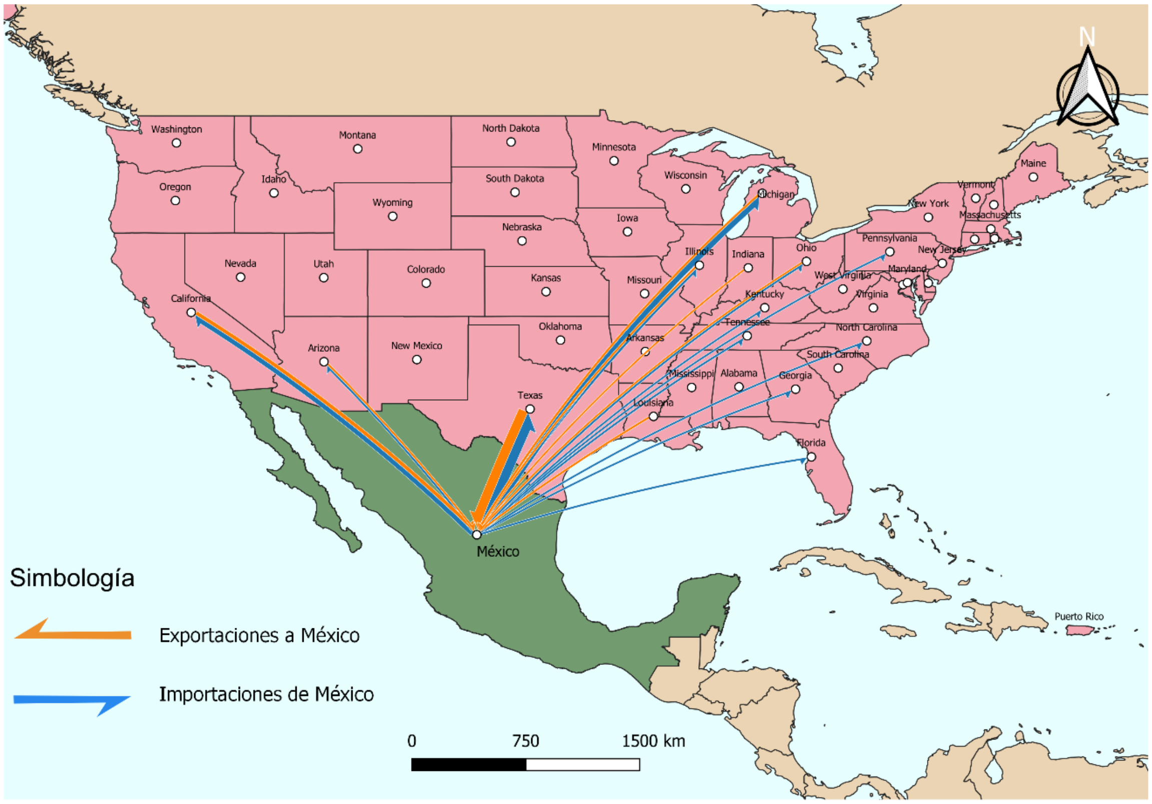
Finally, this reasoning can also be applied to the behavior of other economic variables, modifying them according to each case. This technique is useful for determining concentrations of economic variables in regions that allow for the discovery of a particular cause that triggers behaviors like the existence of natural resources, overall experience by the workers in the activities of a specific sector, etc.

3. Profile of the biregional/bilateral productive specialization

Texas is the top exporter in the United States. According to data from the U.S. Census Bureau (https://www.census.gov/foreign-trade/statistics/state/data/index.html), in 2014 the state exported 17.6% of total U.S. exports. That same year, its main trading partners were: Mexico, Canada, and China, to which it exported 35.1; 11.0 and 3.8%, respectively, and it has been that way for the last several years. Geographically, the border between Texas and Mexico is around half of the U.S.-Mexico border and this is very important, not only for Texas and Mexico trade, but also for trade between Mexico and other U.S. states that goes through the state en route to its final destination.

As shown in the map below, where the most relevant trade flows are represented at the state level with Mexico–more than 5 billion dollars – the most relevant trade flows identified were between Texas and Mexico, in both directions. After that, the next most important trade flow is between California and Mexico, also flowing both ways, and the exports from Mexico to Michigan in the auto industry. In the map, marked in blue, relevant trade export flows are shown. These flows have a tendency towards the eastern U.S. states, which indicates that they have to go through Texas to reach them, and that highlights the importance of bilateral trade.

Map 1. Trade flows towards and from Mexico through U.S. states



Source: Authors' graph using data from the Bureau of Transportation Statistics (BTS) Transborder Freight Data. Cartography based on Instituto Nacional de Estadística Geografía e Informática (INEGI) and ESRI Data & Maps.

In the case of Mexican states' trade with Texas, there is only available data about Texas export destinations. As we can see in Map 2, the state of Chihuahua is the main importer. In this case, trade flows larger than 5 billion dollars have been considered as relevant trade flows. After the state of Chihuahua, the destinations for Texan exports are as follows: Mexico City, the State of Mexico and the border states of Tamaulipas, Coahuila and Nuevo Leon.

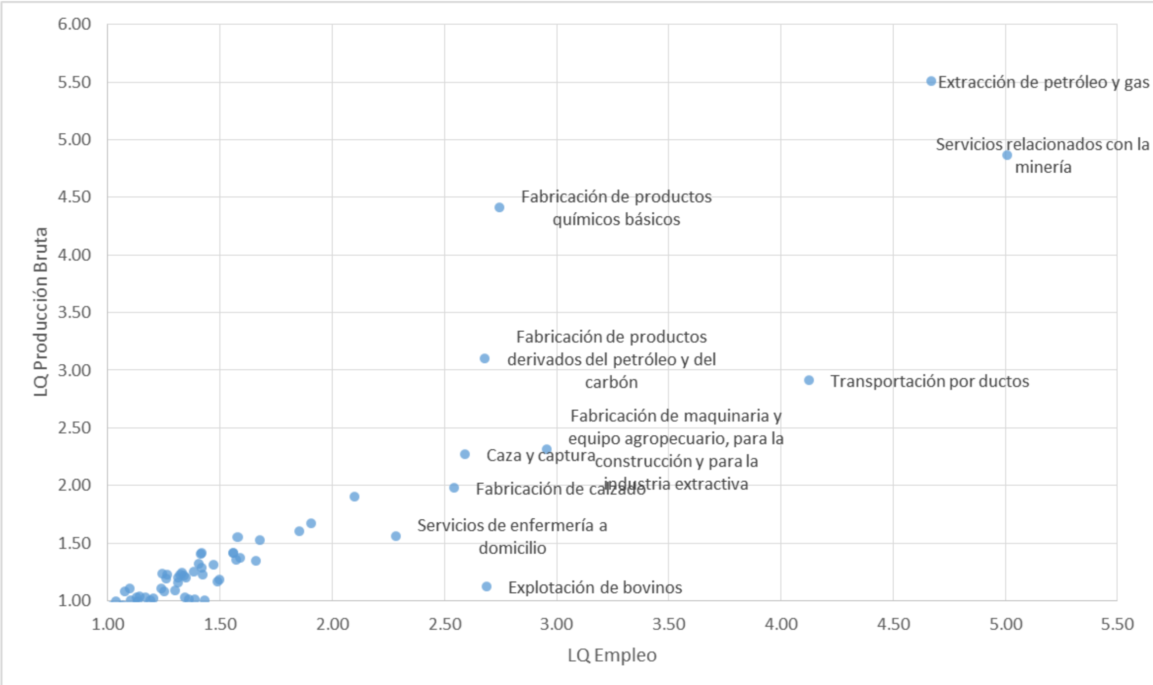
Map 2. Destination of Texan exports by Mexican state

Source: Authors' graph using data from the Bureau of Transportation Statistics (BTS) Transborder Freight Data. Cartography baed on Instituto Nacional de Estadística Geografía e Informática (INEGI) and ESRI Data & Maps.

The most important Texan products both for exports and imports are the following: mineral fuels, oils and waxes; computer equipment and parts; and electric machinery and parts, although not necessarily in that order.

The above information possibly indicates joint production processes along the border. Initially, we thought it would be relevant to explore the relationship between the sectoral specialization profiles in Texas and its exports to Mexico. In that regard, the following graph shows the relationship between the production specialization in Texas based on employment and gross production. The location of the data in the graph will show which sectors present significant employment or production concentrations that respond to a productive specialization.

Graph 2. Relationship between the location quotients (LQ) of employment and gross production

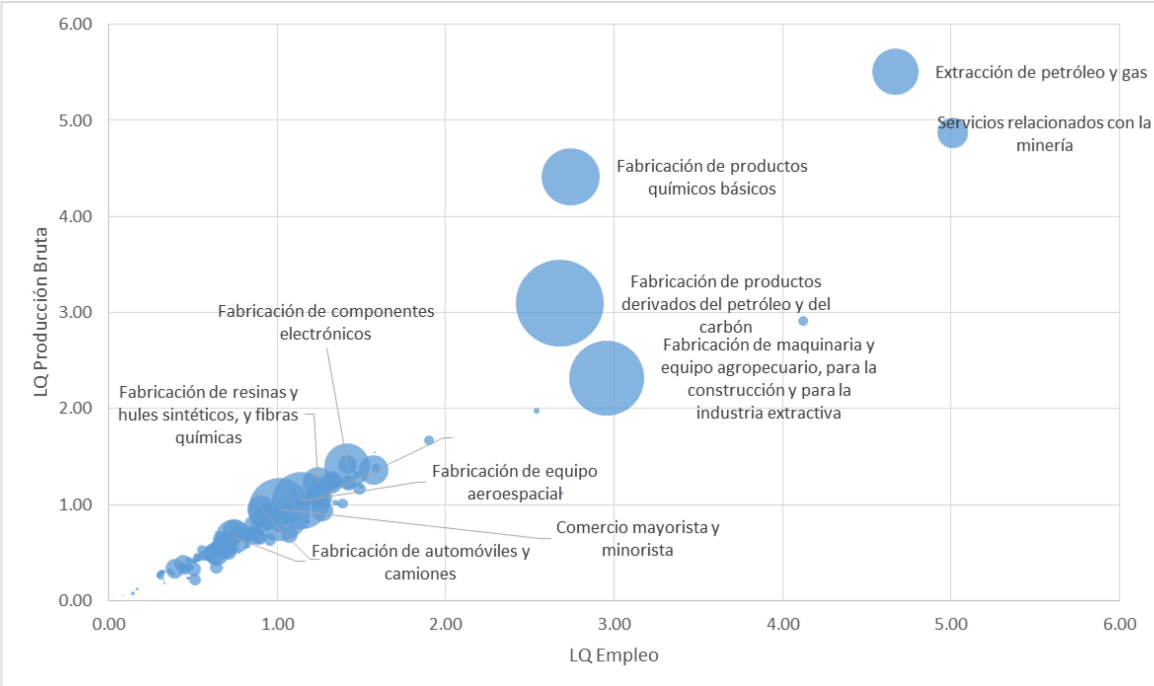


Source: Authors' graph using the Texas-Mexico Production Input Matrix.
Note: The results for all sectors are part of Appendix 1.

In Graph 2, we can see how there are high concentrations of economic activity in the oil and gas industry, along with its supporting activities and pipelines. There are also important concentrations of oil processing such as basic chemical industry and manufacturing of oil products. Other important activities are classified under machinery construction and hunting. Finally, there are two outstanding sectors more for their concentration of employment than production, which are the home healthcare market and activities related to cattle raising.

If we also incorporate this specialization export profile to the rest of the world, we can see how the largest volume of exports is associated with the sectors with the highest concentration of employment and production, which shows the productive advantages of Texas in the export market, as seen in Graph 3.

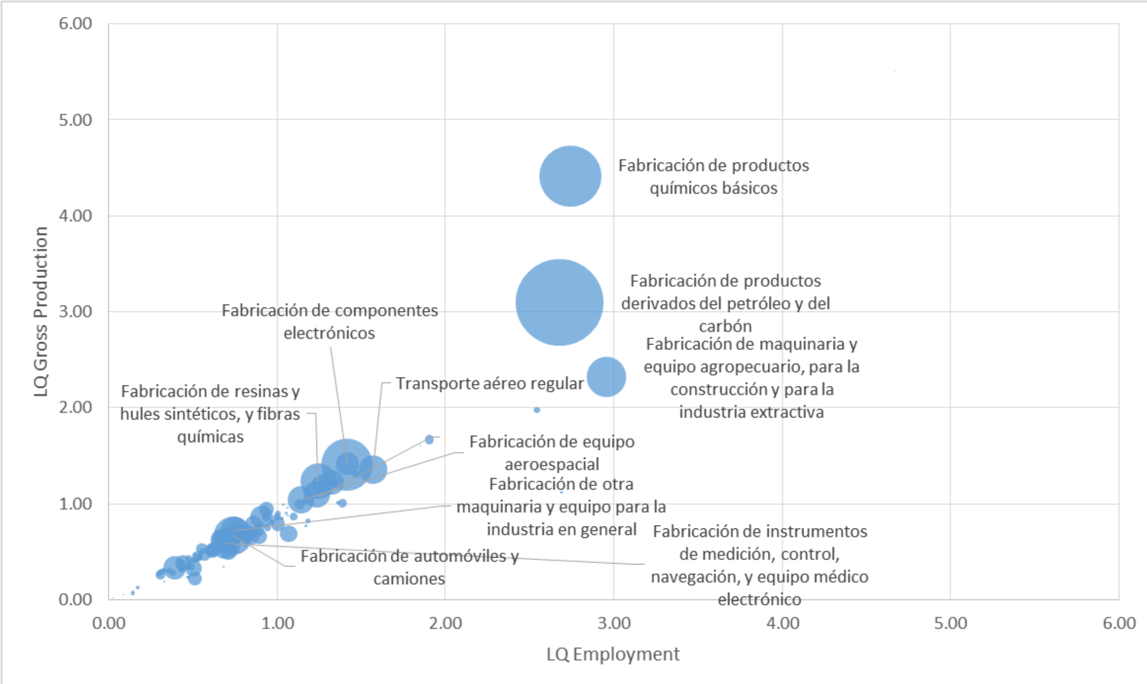
Graph 3. Relationship between the employment and gross production LQ and export value



Source: Authors' graph using the Texas-Mexico Production Input Matrix.
Note: The results for all sectors are part of Appendix 1.

When we restrict the export value to those where the destination is Mexico, as seen in Graph 4, we see how some sectors that are relevant to Texas are not always exported to Mexico, such as oil and gas products, given that they are also Mexican export products. In exports to Mexico, oil-based and chemical products stand out, and in a lesser amount, semiconductors and other electronic components. Comparing Texan exports to the rest of the world, the production of agricultural machinery stands out, as well as the mining industry, which is widely exported to the rest of the world, but very little of it to Mexico. This could also be due to the development of those sectors in the Mexican economy.

Graph 4. Relationship of the employment and gross production LQ and export value to Mexico



Source: Authors' graphic using the Texas-Mexico Production Input Matrix.
Note: The results for all sectors are part of Appendix 2.

The above information supports the position of Texas as Mexico's main trading partner and its reciprocal relationship is of utmost importance in the biregional/bilateral relationship, so much so that it shapes the particularities of the production chains and economies in the U.S. and Mexico.

There is no single criteria when evaluating the degree and importance of the underlying production chains between these neighboring economies. We can mention the existence of sectoral chains that are important at a strictly biregional/bileteral level, the degree in which they can be reinforced as a source of external economies that favor the agglomeration of industries at a biregional/binational level – the existence of biregional/binational clusters – and the importance of sectorial biregional/bilateral trade flows, amongst others. One possibility is to use the structure of sectoral chains on both sides of the border as criteria. The idea is that the more vertical the integration is between the activities of each economy, the more requirements for cross inputs. Nevertheless, this requires a detailed study of the trade flows between the regions, which will be discussed in the following section.

4. Decomposition of biregional/bilateral gross exports

In order to understand the roles of Texas and Mexico regarding gross commercial exchange and in terms of value added, we can establish the decomposition of trade flows at a biregional/bilateral level as criteria, namely from the differentiation of origin and destination of value added in biregional/bilateral exports. The geographical continuity and the North American trade agreement imply the existence of important binational input supply chains, which means that intermediary goods cross the border on several occasions to produce a final good and in each crossing of intermediary goods, value is added before exporting it again. This way, its importance is determined by local and foreign participation of value added in export goods – instead of imported components.

This is why we used the decomposition proposed by (Wang, Wei and Zhu 2013) for the biregional Texas and Mexico matrix presented in Table 2. As seen in the table, Texas' interaction with third regions (T4, T13, the total of T14 and T15, and T16) is considerably more than that of Mexico. This must be a result of the rest of the U.S. being considered as a third region in the model. Therefore, if there is trade between Texas and other American states, the model considers these movements as unrelated to biregional trade, while all the movements within Mexico are domestic in the Mexican case. Particularly, for Texas, the double counting from third regions exceeds that of Mexico by more than 9 billion.

Table 1. Breakdown of results of Texas-Mexico value-added trade, 2013.

Component	Texas (1)	Mexico (2)
Domestic value added in final exports (T1)	13,312.2	20,281.9
Domestic value added in intermediary exports absorbed by direct importers (T2)	25,541.6	42,443.1
Domestic value added in intermediary exports that were reexported to third regions (T4)	13,591.8	3,012.1
Domestic value added that returned as final goods (T6)	1,725.5	786.0
Domestic value added returning home as intermediary goods (T8)	1,532.1	3,018.1
Domestic origin double counting (T9+T10)	328.0	1,321.7
Foreign value added to exports of final products coming from a direct importer (T11)	786.0	1,725.5
Foreign value added to the export of intermediary goods from a direct importer (T12)	3,018.1	1,532.1
Double counting from the importing region (T13)	1,321.7	328.0
Trade with third regions (T14+T15)	25,212.0	24,504.6
Double counting from third regions (T16)	11,268.0	2,060.8

Total Gross Bilateral Trade	97,637.0	101,013.6

Source: Authors' table, based on the model by (*Wang et al.*, 2013).

In Table 3, we break down the added value of the regions more concisely. As Table 3 shows, there are two main differences between both regions. The first is that domestic value added is greater in Mexico by over 13 billion dollars. The second is that double counting is greater in Texas by over 9 billion dollars. In both cases, this means there is more domestic value-added content in Mexico's exports to Texas (close to 70%) than from Texas to Mexico (close to 57%).

Table 3. Breakdown of Value Added and Important Factors in Texas-Mexico Trade

Breakdown of Added Value	Texas to Mexico	Mexico to Texas
Domestic Value Added (DVA)	52,445.73	65,737.05
Returning Value Added (RDV)	3,257.58	3,804.02
Foreign Value Added (FVA)	29,016.04	27,762.15
Pure Double Counting (PDC)	12,917.64	3,710.40
Domestic Value Added (DVA+RDV)	55,703.31	69,541.07
Relative Index		
Export Value Added	0.5705	0.6884
National content of exports	0.5739	0.7015
Total Gross Bilateral Trade	97,636.99	101,013.62

Source: Authors' table, based on the model by (Wang *et al.*, 2013).

The results of the relative index in the table show how Texas's and Mexico's participation are only partially counted when considering trade in value added in foreign trade. It also shows how, when integrating returning value added, the countries' positions in terms of trade can change, as in the case of the Texas-Mexico trade relationship. Additionally, it is also important to recognize how imports from the rest of the U.S. and other countries partly explain trade in gross terms and how their integration allows us to better understand the contributions of those economies and third parties in bilateral trade relations.

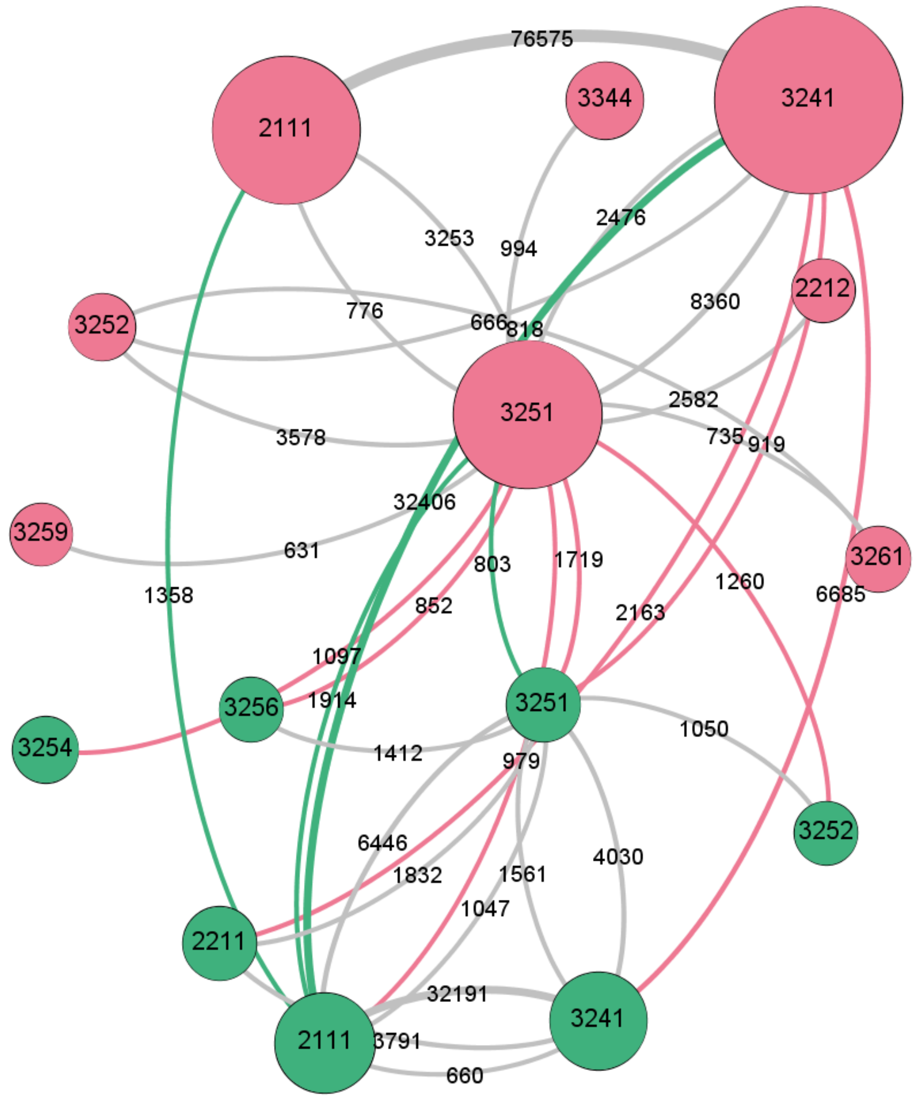
5. Relevant sector chains of the productive biregional/bilateral integration

In order to analyze the importance of relevant sectoral trade chains between Texas and Mexico, we can establish sectoral trade flows at a bilateral and biregional level as criteria. That would be the origin and size of the cross border productive sectoral chains. The geographical proximity of Texas to Mexico means that there are more cross inputs, so their importance is determined by bilateral foreign participation in the "extra-sectoral" input of each activity, which means comparisons that are not made within the same sector.

In this section, we will analyze the productive relationships between economic sectors resulting from the production of each one, based on the information in the Texas-Mexico input-product model. We will present the relevant production and trade relationships with graphs for each one in their own context, identifying origin, destination and value of exchanged goods, as well as the importance of each sector in gross production. This representation will be developed for the main sectors or sector groups identified as relevant to the bilateral relationship.

Below is the graph for sector 3251 (manufacturing of basic chemical products). In this graph and the following ones, the circles are the economic sectors of reference, whose sizes are proportional to their gross production and the numbers inside are each sector's code. The arches represent the value of the transactions between sectors and their size is proportional to the value of traded goods. The color pink refers to the sectors of the state of Texas or the export flows from Mexico to Texas. The color green refers to the Mexican sectors of the export flows from Mexico to Texas. The gray lines represent trade between sectors in the same region. The numbers above the arches are the exchanged amounts in millions of dollars and are located in the middle of the flow that represents them.

Graph 5. Graph for sector 3251 (manufacturing of basic chemical products)



Source: Authors' graph using data from the Texas-Mexico Input Matrix 2013.

Included sector codes

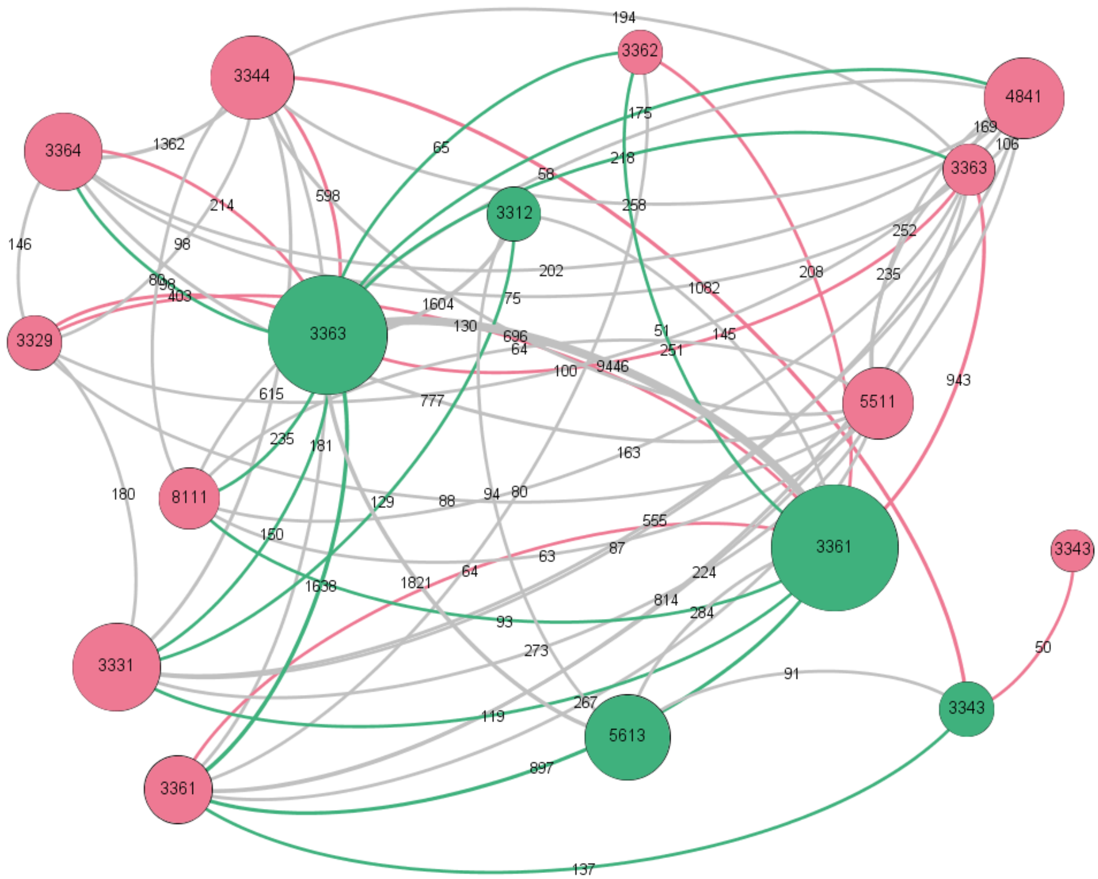
Texas	México
2111 Oil and gas extraction 2212 Natural gas distribution 3241 Petroleum and coal products manufacturing 3251 Basic chemical manufacturing 3252 Resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing 3259 Other chemical products and preparation manufacturing 3261 Plastics product manufacturing 3344 Semiconductor and other electronic components manufacturing	2111 Oil and gas extraction 2211 Electric power generation, transmission, and distribution 3241 Petroleum and coal products manufacturing 3251 Basic chemical manufacturing 3252 Resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing 3254 Pharmaceutical manufacturing 3256 Soap, cleaning compounds, and toilet preparation manufacturing

Graph 5 for sector 3251 (manufacturing of basic chemical products) shows how for Texas, in terms of production, this sector is comparable to sector 2111 (oil and gas extraction) and somewhat less than sector 3241 (petroleum and coal products manufacturing) and represents more than five times the size of its Mexican counterpart. Its main supplier in Texas is sector 3241 (petroleum and coal products manufacturing), to which it sold 3,253 and 2,682 billion dollars respectively – in this case, flows above 500 billion dollars are considered relevant. The main Mexican suppliers are sectors 2111 (oil and gas extraction) and sector 3251 (manufacturing of basic chemical products), which exported 1,914 and 803 billion dollars respectively in 2013.

In terms of binational relationships, aside from the sectors that export to Texas to supply this industry, there are five Mexican sectors considered relevant that import goods from this sector as part of their productive process. They are: 2111 (oil and gas extraction); 3251 (basic chemical manufacturing); 3252 (resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing); 3256 (soap, cleaning compounds, and toilet preparation manufacturing), which import a total of 5,900 billion dollars. Eventually, when the products for these sectors or part of them are exported, these amounts will be included in the export value and will be double counted when passing into the country's customs.

One of the most important sectors of the U.S.-Mexico trade relationship is the auto industry and auto parts, although it is especially important to Mexico. Based on this, the graph below combines sectors 3361 (motor vehicle manufacturing) and 3363 (motor vehicle parts manufacturing). The initial observation of the size of the sectors in the economy is shown, where they are sectors that contribute a lot to the gross product in Mexico, while they are significantly smaller for Texas. In this case, the threshold of the relevant transactions is 50 billion dollars.

Graph 6. Auto industry and auto parts



Source: Authors' graph using data from the Texas-Mexico Input Matrix 2013.

Included sector codes

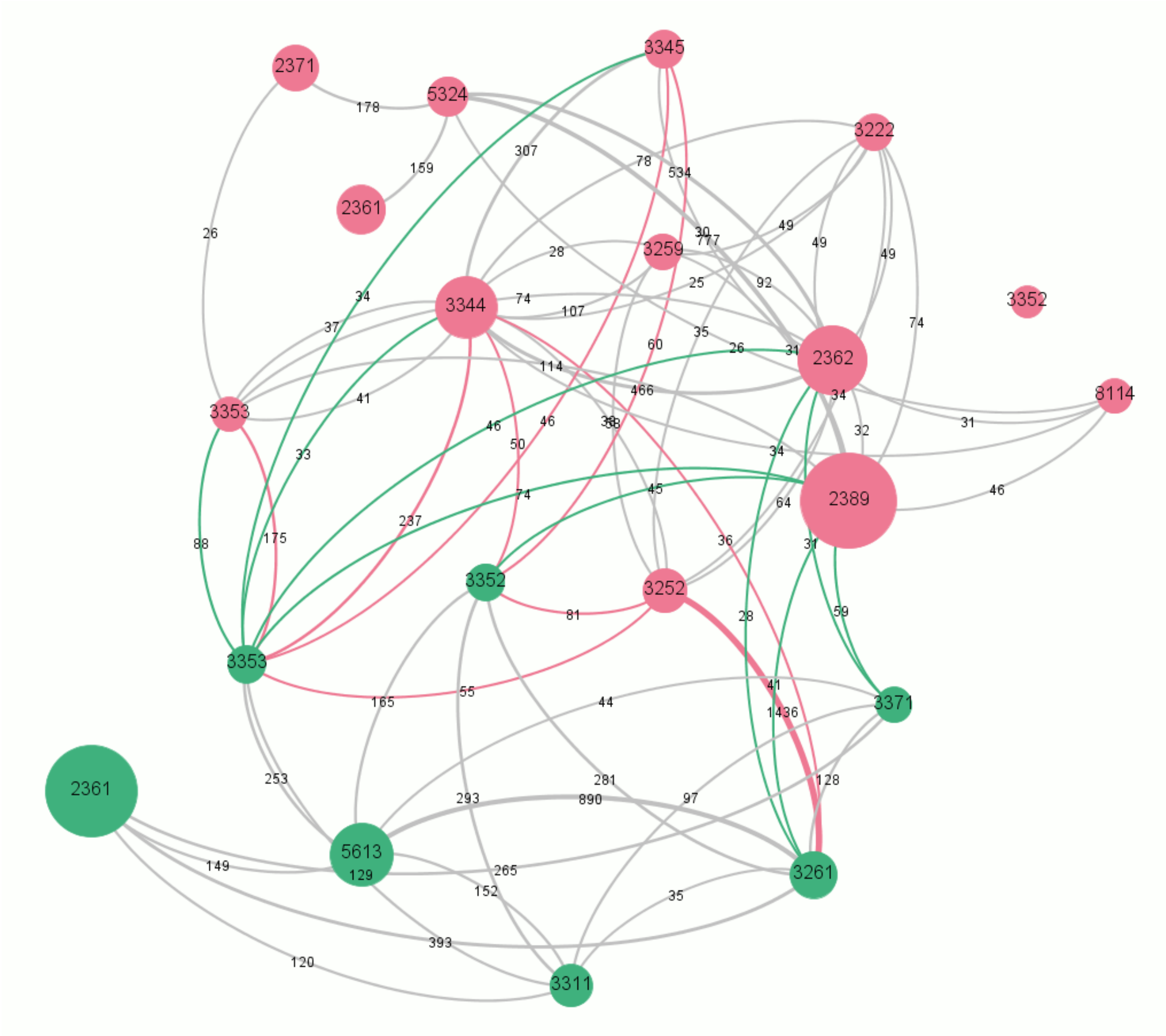
Texas	Mexico
3329 Other fabricated metal products manufacturing	3312 Steel product manufacturing from purchased steel
3331 Agriculture, construction, and mining machinery manufacturing	3343 Audio and video equipment manufacturing
3343 Audio and video equipment manufacturing	3361 Motor vehicle manufacturing
3344 Semiconductor and other electronic component manufacturing	3363 Motor vehicle parts manufacturing
3361 Motor vehicle manufacturing	5613 Employment services
3362 Motor vehicle body and trailer manufacturing	
3363 Motor vehicle parts manufacturing	
3364 Aerospace products and parts manufacturing	
4841 General freight trucking	
5511 Management of companies and enterprises	
8111 Automotive repair and maintenance	

The interrelations in the auto industry and auto parts graph show that the main trade relationship is Mexican auto parts into Mexican automobiles for over 9,400 billion dollars. This complementary relationship not only happens on this side of the border, but in Texas, these sectors also import and export their Mexican counterparts. The auto parts imports from Texas for 943 billion dollars and from their own sector for 1,821 are relevant to the production of automobiles. We also highlight the importance of sector 5613 (employment services) and the amount of the trade within the sector, which is over 1,800 billion dollars.

The significance of these sectors to Texas' economy is shown through the relevant relationships with various sectors. In the case of the automotive sector, its relationships with the following sectors are important: 3331 (agriculture, construction, and mining machinery manufacturing); 3361 (motor vehicle manufacturing); and 8111 (automotive repair and maintenance). The total sum is over 1,100 billion dollars – including 897 million dollars within the auto sector alone. In the auto parts sector, Mexican exports to Texas are much more relevant, since they jointly amounted to over 2.5 billion dollars in transactions in the following sectors: 3361 (motor vehicle manufacturing); 8111 (automotive repair and maintenance); 3363 (motor vehicle parts manufacturing); 4841 (general freight trucking); 3331 (agriculture, construction, and mining machinery manufacturing); and 3364 (aerospace products and parts manufacturing).

Finally, we have the graph for sector 3352 (household appliance manufacturing), which is relevant in exports from Mexico. In the graph, we can see how the sector does not generate gross production values compared to the rest of those included in the graph. In Mexico, this is a sector that is relatively integrated with other sectors of the national economy, with trade flows from national suppliers that exceed the amount of imports from Texas. The main national suppliers are sectors: 3261 (plastics product manufacturing); 3311 (iron and steel mills and ferroalloy manufacturing); and 5613 (employment services). In Texas, the main suppliers are sectors: 3252 (resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing); 3344 (semiconductor and other electronic component manufacturing; and 3345 navigational, measuring, electromedical, and control instruments manufacturing). In general, it adjusts to the profile of the maquila industry in Mexico with generic input – including labor – acquired in Mexico and specialized input acquired in the United States, in this case, in Texas.

Graph 7. Graph of sector 3352 (household appliance manufacturing)



Source: Authors' graph using data from the Texas-Mexico Input Matrix 2013.

Codes of included sectors:

Texas		México	
2361	Residential building construction	2361	Residential building construction
2362	Nonresidential building construction	3261	Plastic products manufacturing
2371	Utility system construction	3311	Iron and steel mills and ferroalloy manufacturing
2389	Other specialty trade contractors	3352	Household appliances manufacturing
3222	Converted paper products manufacturing	3353	Electrical equipment manufacturing
3252	Resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing	3371	Furniture manufacturing, excluding office and shelving
3259	Other chemical products and preparation manufacturing	5613	Employment services
3344	Semiconductor and other electronic components manufacturing		
3345	Navigational, measuring, electromedical and control instruments manufacturing		
3352	Household appliance manufacturing		
3353	Electrical equipment manufacturing		
5324	Commercial and industrial machinery and equipment rental and leasing		
8114	Personal and Household Goods Repair and Maintenance		

6. Conclusion

NAFTA is an agreement that has accelerated the commercial expansion between Texas and Mexico, at a higher level even than that between the U.S. and Mexico. This commercial process was strengthened by the productive sharing of co-production processes, intermediary goods and production stages between these economies at a biregional/bilateral level.

The biregional/bilateral trade chain presents some differences with respect to each economies' profile of global external insertion. While both countries' exports to the rest of the world are concentrated in oil and gas extraction products, the biregional/bilateral exchange is in the manufacturing of chemical products and semiconductors, the auto industry, computer equipment, and domestic appliances, among others.

Therefore, the economic integration process can be considered partially beneficial to both economies. On the one hand, it encouraged the expansion of internal markets, and it also fostered the creation of sectors that have high multiplying effects for product, income, employment, as well as innovation. On the other hand, these same sectors show difficulties in integrating globally into other global external markets. In other words, their commercial and productive chains are biregional/bilateral, without extending into global value chains.

When we analyze the incorporated flows of value added in the gross value of exports between Texas and Mexico, we notice that both are suppliers of intermediary goods and, consequently, the multiplying effect associated with biregional/bilateral exports is bigger than that for the U.S. and Mexico. In particular, the amount of domestic value added for Mexico's exports to Texas is close to 70%, while the corresponding one from Texas to Mexico is close to 57%. Another important difference worth highlighting is the high reciprocal dependency level on foreign input at the biregional/bilateral level.

Finally, we highlight three productive chains in which a larger biregional/bilateral integration can be seen: basic chemical products, automobiles and auto parts and manufacturing of household appliances. The first production group includes basic chemical products, rubber and plastics, which has a competitive and complementary reciprocal relationship between both the two economies and focuses on the interdependent trade of intermediary goods. The second industrial group includes the automobile and auto parts industry, which presents a biregional/bilateral productive complementary relationship in which Mexico specializes in the final phases and Texas in the intermediate ones. Finally, the household appliance group can be considered as a complementary process between specialized component producers in Texas and generic component producers on the Mexican side for the creation of a final product.

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