Value-added and global export chains between Mexico, the United States, and Canada

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Abstract

This article sets out to disaggregate by origin and destination the value-added contained in the bilateral exports of the member countries of the United States-Mexico- Canada Agreement (USMCA) in the years 2005, 2010, and 2015. The objective is to identify the proportion of domestic value-added (DVA) that each country exports and the type of participation of each one in the region's value chains. A value-added input-output model was employed using interregional matrices from the Organization for Economic Cooperation and Development (OECD) for the years under analysis. The findings suggest that Mexican exports have the highest foreign value-added (FVA), meaning that Mexico and Canada have been superficially inserted into the region's value chains, while the US maintains complex chains with its trading partners.

Keywords: bilateral exports; global value chains (GVC); input-output; UMSCA region.

1. INTRODUCTION

Trade liberalization and openness, combined with globalization and technological advances, allowed the internationalization of the global production of goods and services, which in turn led to the international division of production and the formation of global value chains (GVCs). GVCs are the product of a highly organized system of sources and destinations for value-added in a global production network (Koopman *et al*., 2010). Each country currently participates in production chains via those processes in which it is generally more efficient than other countries (Inomata, 2017). Consequently, there has been a drastic global increase in the trade of intermediate goods that cross multiple international borders before becoming final goods and reaching the country of final consumption (Baldwin, 2013).

Studying GVCs is crucial when tracing the various global production routes taken by goods and services, determining the role that different countries play in GVCs, and identifying their characteristics. In light of this, gross trade statistics must be distinguished from trade in value-added statistics. The disadvantage of using the former is that they incur double counting, by considering twice the value of intermediate goods embodied in final products that cross national borders more than once (Koopman *et al*., 2010).

Understanding the real value of exports and the trade balance between countries requires disaggregating by origin the value-added contained in a country's exports into its three sources: domestic, foreign, and pure double counting. This is particularly pertinent when seeking to contrast the trade balance between two countries in terms of domestic value-added (DVA) and gross value-added (GVA).

Recently, Koopman *et al*. (2014) developed a decomposition method, which in addition to distinguishing between the sources of the value-added contained in exports, also identifies the destination of the DVA, that is, it recognizes how the recipient country makes use of exports and each countries' type of insertion into GVCs.

The accounting framework adopted for the proposed decomposition is formulated according to interregional input-output matrices, which describe the flow of goods and services between economic sectors in different countries, whether for intermediate or final consumption.

This reality imbues the consolidation of trade blocs and the signing of trade agreements with additional importance. The Mexican economy entered into the General Agreement on Tariffs and Trade (GATT) in 1986, and the North American Free Trade Agreement (NAFTA, now renamed USMCA) launched in 1994, resulting in Mexico's economy becoming more closely integrated into the world economy, especially that of North America. Since then, the trade relationships between Canada, the US, and Mexico have been strengthened, giving rise to one of the most dynamic regions in terms of the flow of goods, services, and factors of production. As a result of USMCA, Mexico's trade flows with North America increased significantly, especially with the US. In 2020, 83.9% of total Mexican exports were destined for the North American region, of which 81.2% went to the US and 2.7% to Canada (Secretaría de Economía [Ministry of Economy], 2021).

Although several studies assess USMCA's impact on trade, foreign direct investment, development, employment, and the generation of productive linkages (for example, Moreno-Brid *et al*., 2005; Boundi, 2017; Novelo, 2018; Torre *et al*., 2020), few studies analyze value-added trade in the region (Fujii-Gambero and Cervantes, 2013).

In a recent study focusing on Mexico and the US, Fuentes *et al*. (2020) found that in 2013 Mexico registered a trade deficit in DVA with the US, contrary to what conventional trade statistics show. According to the authors, this is explained by the high foreign value-added (FVA) content of Mexican exports. However, there are no studies that analyze bilateral trade among all USMCA members and, above all, that identify the source and use of the value-added content of exports.

This article sets out to disaggregate by origin and destination the value-added contained in the bilateral exports of the member countries of the United States-Mexico- Canada Agreement (USMCA) in the years 2005, 2010, and 2015, thereby identifying the share of DVA that each country exports and the nature of each country's insertion into the region's value chains. Analysis was conducted using the inter-regional input-output methodology proposed by Koopman *et al*. (2010 and 2014), applied to the 2005, 2010, and 2015 Inter-Country Input-Output (ICIO) matrices prepared by the OECD (2018).

The article is divided into four sections, in addition to this introduction and the conclusions. The first section defines some fundamental concepts, such as production fragmentation and GVCs. The second section then presents some data on trade between the USMCA countries for the study period. The third section goes on to discuss the methodology used to fulfill and apply this article's objectives. The fourth section presents findings and analyzes the results obtained from decomposition by origin and destination of the value-added contained in bilateral exports.

2. THE FRAGMENTATION OF PRODUCTION AND GLOBAL VALUE CHAINS

Economic and trade liberalization brought about major global transformations. One of the most important of these was the segmentation or fragmentation of production, which is directly related to the domestic location of industry and the supply of intermediate goods. According to Minian (2009), international segmentation seeks to reduce production costs and generate economies of scale.

Following on from the argument of production fragmentation, Krugman (1995) originally proposed the concept of GVCs, arguing that in international production networks, different countries generate added value through their participation in certain production stages of a good. GVCs divide the production process into stages, whereby different tasks are carried out in different countries.

Falling transport costs and advances in information and communication technologies enabled the formation of GVCs, which also reflect a system of sources and destinations of value-added in a global production network (Koopman *et al*., 2010). According to Gereffi and Fernandez (2016), GVCs link firms, workers, and consumers around the world; the authors describe the activities that go into making a product from conception to consumption, which can be concentrated in a single firm or across several firms. Currently, GVCs are dispersed around the world and different activities are carried out in different parts of the world.

For Baldwin (2013), meanwhile, the point of consumption has separated from the point of production, and goods now travel around the world in search of more profitable markets, accelerating the relocation of some production segments outside national borders where certain activities are performed more efficiently. How value is generated and transferred in global production chains is then a consequence of companies' efforts to optimize production networks (Inomata, 2017).

Taglioni and Winkler (2016), for their part, claim that an economy’s ability to insert itself into GVCs is a vital condition for the development and promotion of a country's competitiveness, one which depends both on the exporter's capacity and the capacity to import inputs from the rest of the world ((RoW). These authors argue that it is difficult for a country to become a major exporter in GVCs without first becoming a successful importer of intermediate goods.

It is also crucial to discern the stage of the production process in which each country participates. Baldwin *et al*. (2014) posit that developed economies engage in high value-added activities such as design, marketing, and post-sales services, while developing economies engage in lower value-added activities such as planning, production, and distribution, which is explained by the differentials in labor and raw material costs between developed and developing countries.

A recent study by Xiao *et al*. (2017) suggests that, although the international flow of production inputs has increased significantly, the geographical distance between GVCs still matters, and regional value chains are more dynamic than global ones.

3. EXPORTS BETWEEN THE USMCA COUNTRIES

For Mexico, the signing of NAFTA represented the consolidation of the process of liberalization and economic and trade openness (Puchet *et al*., 2011), which, in turn, consolidated the Mexican economy's insertion into global dynamics, especially at the regional level. In its most recent version, the Mexico-United States-Canada Agreement (USMCA), launched in July 2020, is the regulatory framework that governs trade between these countries and seeks to maintain the strong trade, production, and investment links that have been in place since its inception.

The Secretaría de Economía (2021) points out that the region's trade links are a key factor for the competitiveness of the productive sectors of the USMCA, in addition to being considered indispensable for efficient productive chains in the region.

North America is one of the world's most dynamic regions, with significant flows of goods, services, and factors of production, mainly generated by US economic activity. Data from the World Trade Organization ([WTO], (2021) indicate that North American countries' trade represents approximately 13.2% of world trade, meaning that three countries account for one-eighth of global trade.

Exports in the T-MEC bloc grew between 2005 and 2015 at an average annual rate of 2.9%, while those of Mexico, the US, and Canada grew at a rate of 3.5 and 0.8%, respectively (see table 1). Although Mexican exports grew at a higher rate than those of the other two countries, the US's and Canada's share of exports was higher; for example, in 2015, 43.5% of the region's exports came from the US, 29.2% from Canada, and 27.3% from Mexico.

The data reveal that Mexico's share increased by almost 5% during the study period, to the detriment of Canada's share. Moreover, 39.5% of US exports to the bloc went to Mexico, and the remaining 60.5% to Canada. In contrast, Mexico's and Canada's exports are concentrated in the US, representing 92.4% for the former and 97.4% for the latter.

Bilateral trade in the region takes place between the following pairs of countries: a) Mexico and the US, b) Mexico and Canada, and c) the US and Canada. In gross terms, bilateral trade in the years under analysis shows a clear trend; Mexico reports a surplus with the US and with Canada: with the former, it is growing, while with the latter it remains relatively constant (see table 1). On the other hand, the US has a trade deficit with Canada.

Table 1. Exports in the NAFTA region, 2005, 2010, and 2015

	2005	*2010*	*2015*	*Average annual growth*
Mexico	184 662.1	234 620.7	294 921.8	4.8
US	330 935.4	404 729.2	468 935.9	3.5
Canada	291 583.9	297 397.1	314 926.8	0.8
NAFTA	807 181.4	936 747.0	1 078 784.5	2.9
Share %				
Mexico	22.9	25.0	27.3	
US	41.0	43.3	43.5	
Canada	36.1	31.7	29.2	
Bilateral trade balance				
Mexico-US	43 390.0	59 806.0	79 014.1	
Mexico-Canada	6 696.7	12 103.6	12 201.7	
US-Canada	-83 078.4	-38 747.4	-32 087.9	

Source: Compiled by the authors based on data from OECD (2018).

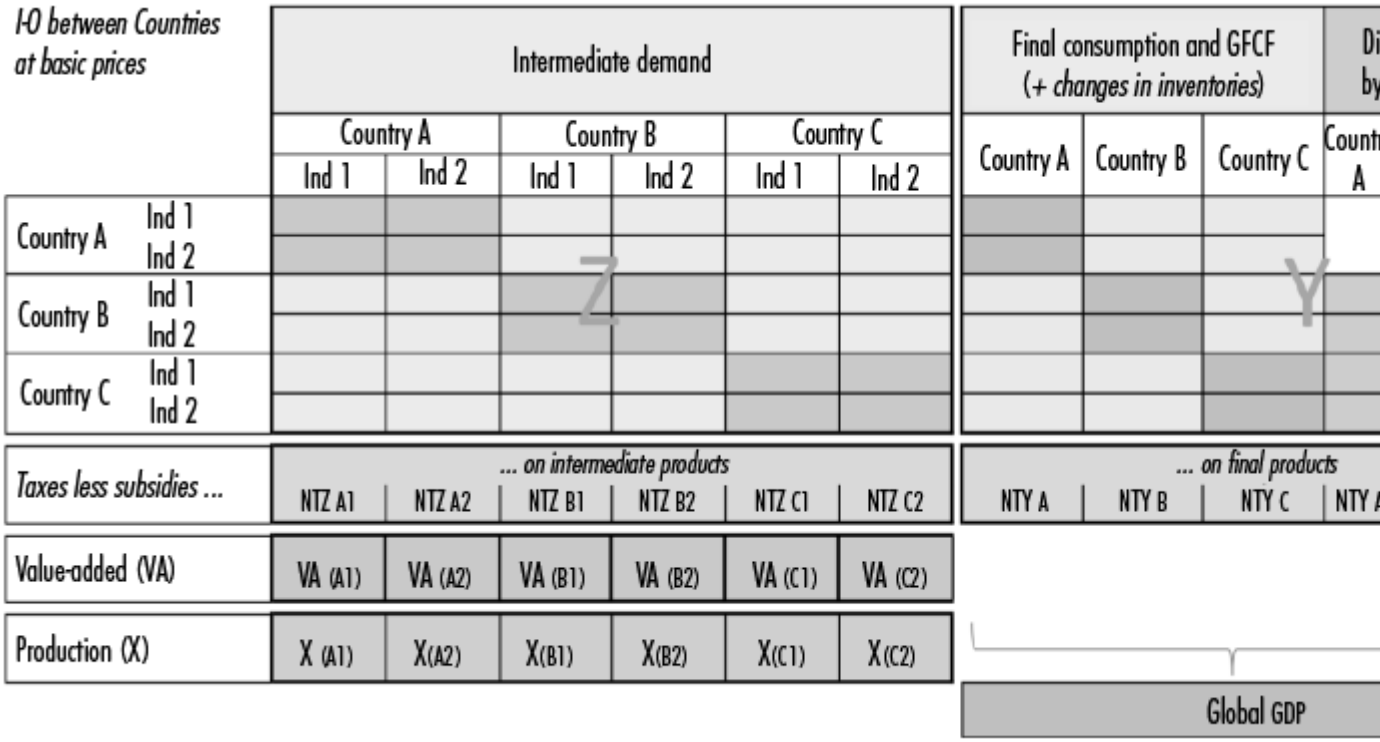
It is worth mentioning that the gross value of these transactions, when considering the value of intermediate goods incorporated in the exported products may overestimate the real value of bilateral exports between these countries. In this sense, a distinction needs to be made between gross trade statistics and trade in value-added.

4. METHODOLOGY

This article's analysis requires data on the productive and trade structure of Mexico, the US, and Canada, necessitating in turn an inter-regional accounting and methodological framework. Previously, the construction of interregional input-output matrices was a task that, besides being complicated and cumbersome, had to be carried out by the researcher on their own. In the last decade, however, renowned international institutions have made inter-regional input-output matrices available to the public, broadening the scope of research and facilitating the handling of information. Examples of such projects are a) the World Input-Output Database (WIOD), a project funded by the European Commission which provides a methodological and accounting framework for the countries of the European Union and 13 other countries, b) IDE-JETRO, a project funded by the Japan External Trade Organization, which, similar to the WIOD, presents interregional input-output matrices for Asian countries, and c) the OECD which provides a database of interregional input-output matrices (ICIO) for the period 2005-2015 with 64 countries worldwide (36 OECD members) from which the organization's trade in value-added (TiVA) indicators are derived.

This article uses the OECD (2018) ICIO matrices for the years 2005, 2010, and 2015, which disaggregate economic activity into 36 activity sectors. To facilitate the estimation of the value-added matrices, analysis omitted the 36th sector of private households with employed persons, as these cells are empty. These matrices record trade flows between sectors in different economies around the world, whereby a country's production, whether for domestic consumption or for export, is carried out using inputs from other countries. These matrices show world production and their structure is presented in figure 1.

Figure 1. Structure of an OECD ICIO Matrix



Source: OECD (2018)

One of the advantages of using this methodology is the availability of data on the value of goods flows between countries, which makes it possible to trace the value-added generation process of each product in each country (Inomata, 2017).

Following Koopman *et al*. (2010), and starting from the ICIO matrices, the interregional input-output model can be described by the equation of the general input-output model (equation 1), which in this case shows the sectoral output per country needed to satisfy final demand.

$$x = (I - A)^{-1} y = L\, y \qquad (1)$$

Where the matrix (*A*) of technical coefficients is of dimension $(rN \times rN)$ with *r* countries and N sectors, it is obtained from the matrix (*Z*) in Figure 1, (*L*) is the Leontief inverse of $(rN \times rN)$, and (*y*) is the final demand vector of magnitude $(rN \times 1)$.

With this structure and considering that the total exports of a country (*e*) comprise intermediate and final goods, the output required to satisfy total export demand is given by equation (2). It

should be noted that vector (*e*) represents the total exports of each country to the RoW. Later, this vector will be adapted to show bilateral trade between countries.

$$x^e = (I - A)^{-1}\, e = L\, e \tag{2}$$

Equation (2) represents the world production x^e needed to satisfy export demand, and has dimension $(rN \times 1)$, where (*e*) is the vector of total exports of magnitude $(rN \times 1)$. The value-added contained in total exports is obtained by pre-multiplying equation (2) by the vector of value-added coefficients *v*. However, to identify the origin and use of the value-added contained in each country's exports, the diagonalized vectors of exports $(\hat{e})$ and value-added $(\hat{v})$ of magnitude $(rN \times rN)$ (equation 3).

$$VAX = \hat{v}\, L\, \hat{e} \tag{3}$$

The value of gross exports is disaggregated according to the origin of the value-added contained in exports, which may be domestic or foreign, and according to the use, where the importing country may not be the destination country that consumes the final products, and rather the DVA is absorbed in other sections of the chain. To this end, a model is proposed that focuses on the bilateral trade relations of the three countries that make up the USMCA and the RoW, so that we work with four countries: the first country is Mexico, the second is the US, the third is Canada, and the fourth is the RoW Equation (3) and its components are matrix-represented in equation (4). To simplify the analysis, the matrix notation refers to vectors and matrices for each country; each v_r represents the diagonalized vector of country *r* value-added coefficients of dimension $(N \times N)$, the sub-matrices L_{rs} of the matrix *L* of coefficients of direct and indirect requirements per unit of final demand are of dimension $(N \times N)$, and each diagonalized vector of exports e_s is also of dimension $(N \times N)$. Therefore, the matrices $(\hat{v})$, *L*, $\hat{e}$, $\hat{v}L\hat{e}$ are of dimension $(rN \times rN)$.

$$VAX = \hat{v}L\hat{e} = \begin{pmatrix} v_1L_{11}e_1 & v_1L_{12}e_2 & v_1L_{13}e_3 & v_1L_{14}e_4 \\ v_2L_{21}e_1 & v_2L_{22}e_2 & v_2L_{23}e_3 & v_2L_{24}e_4 \\ v_3L_{31}e_1 & v_3L_{32}e_2 & v_3L_{33}e_3 & v_3L_{34}e_4 \\ v_4L_{41}e_1 & v_4L_{42}e_2 & v_4L_{43}e_3 & v_4L_{44}e_4 \end{pmatrix} \tag{4}$$

From the matrix of value-added contained in exports *VAX* (equation 4), the concepts of DVA and FVA contained in exports can be identified (Koopman *et al*., 2010):

1) Domestic Value-added (DVA): these are the terms of the main diagonal that account for the DVA contained in each country's exports: $DVA_r = v_r L_{rr} e_r$. For country 1, the DVA contained in its exports is $DVA_1 = v_1 L_{11} e_1$:

2) Foreign Value-added (FVA): is the sum of the terms outside the main diagonal and along a column, it measures the foreign value-added contained in a country's exports $FVA_r = \sum_{s \neq r} v_s L_{sr} e_r$. For country 1, the foreign value-added is: $FVA_1 = v_2 L_{21} e_1 + v_3 L_{31} e_1 + v_4 L_{41} e_1$.

The value of a country's exports must be equal to the gross value of exports, which requires examining the pure double counting (PDC). According to Miroudot and Ming (2019), PDC is defined as the value-added that crosses international borders more than once, and which according to Koopman *et al*. (2014) accounts for the fraction of the DVA that was initially exported but eventually returns to the original country. This means that the sum of the terms DVA, FVA, and PDC results in 100% of the value of gross exports, and the PDC term records the difference between the value of gross exports and the sum of DVA and FVA contained in exports (equation 5).

$$
\begin{aligned}
e_r &= DVA_r + FVA_r + PDC_r \\
e_r &= VAX_r + PDC_r \\
PDC_r &= e_r - VAX_r
\end{aligned}
\qquad (5)
$$

The PDC term is only observed when both countries export intermediate goods. If these were zero for one or both countries analyzed, then gross exports would be equal to the DVA and FVA contained in exports $(e_r = VAX_r)$ i.e., the PDC term would be zero. This is because the PDC term accounts for value-added shipped back and forth as part of intermediate trade between countries (Koopman *et al*., 2014). Similarly, when intermediate goods are exported between two countries and the PDC term is excluded, the accounting of gross exports will be incomplete, and will be less than 100%. Koopman *et al.* (2014) propose a further decomposition of the PDC term into its internal and external parts. However, since its application is beyond the scope of this article, only the total PDC term will be shown.

Likewise, the analysis of bilateral value-added exports allows us to disaggregate the exports of each economy by destination country (Stehrer, 2013), which means, for example, that the scalar

e1 that shows Mexico's total exports to the world can be disaggregated into Mexico's exports to the US (e_{12}), to Canada (e_{13}), and to the RoW (e_{14}): $e_1 = e_{12} + e_{13} + e_{14}$. Then, the diagonalized vector of exports by destination country can be rewritten as in equation 6.

$$\hat{e} = \begin{pmatrix} e_{12}+e_{13}+e_{14} & 0 & 0 & 0 \\ 0 & e_{21}+e_{23}+e_{24} & 0 & 0 \\ 0 & 0 & e_{31}+e_{32}+e_{34} & 0 \\ 0 & 0 & 0 & e_{41}+e_{42}+e_{43} \end{pmatrix} \quad (6)$$

The matrix of value-added contained in exports $VAX = \hat{v}L\hat{e}$ is:

$$VAX = \begin{pmatrix} v_1L_{11}(e_{12}+e_{13}+e_{14}) & v_1L_{12}(e_{21}+e_{23}+e_{24}) & v_1L_{13}(e_{31}+e_{32}+e_{34}) & v_1L_{14}(e_{41} \\ v_2L_{21}(e_{12}+e_{13}+e_{14}) & v_2L_{22}(e_{21}+e_{23}+e_{24}) & v_2L_{23}(e_{31}+e_{32}+e_{34}) & v_2L_{24}(e_{41} \\ v_3L_{31}(e_{12}+e_{13}+e_{14}) & v_3L_{32}(e_{21}+e_{23}+e_{24}) & v_3L_{33}(e_{31}+e_{32}+e_{34}) & v_3L_{34}(e_{41} \\ v_4L_{41}(e_{12}+e_{13}+e_{14}) & v_4L_{42}(e_{21}+e_{23}+e_{24}) & v_4L_{43}(e_{31}+e_{32}+e_{34}) & v_4L_{44}(e_{41} \end{pmatrix} \quad (7)$$

According to this logic, the bilateral trade relationship between the analyzed countries is even more evident, e_{st} represents the exports from country *s* to *t*, which at the same time are *t*'s imports from *s* (Stehrer, 2013). Bilateral trade in value-added between Mexico and the US is summarized by equation (8), where e_{12} is Mexican exports to the US and e_{21} is US exports to Mexico:

$$VAX = \begin{pmatrix} v_1 & 0 & 0 & 0 \\ 0 & v_2 & 0 & 0 \\ 0 & 0 & v_3 & 0 \\ 0 & 0 & 0 & v_4 \end{pmatrix} \begin{pmatrix} L_{11} & L_{12} & L_{13} & L_{14} \\ L_{21} & L_{22} & L_{23} & L_{24} \\ L_{31} & L_{32} & L_{33} & L_{34} \\ L_{41} & L_{42} & L_{43} & L_{44} \end{pmatrix} \begin{pmatrix} e_{12} & 0 & 0 & 0 \\ 0 & e_{21} & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix} \quad (8)$$

In this case, the equation shows for Mexico that $DVA_{12} = v_1L_{11}e_{12}$ represents the DVA contained in its exports to the U.S.; the sum $FVA_{12} = v_2L_{21}e_{12} + v_3L_{31}e_{12} + v_4L_{41}e_{12}$ represents the FVA (of countries 2, 3, and 4) contained in Mexican exports to the US. The same approach can be used to analyze bilateral exports between Mexico and Canada (e_{13}, e_{31}), between the US and Canada (e_{23}, e_{32}), and of each country with the RoW.

To determine the destination of the DVA contained in bilateral exports, a distinction is first made between exports of final goods (Y_{12}) and intermediate goods, $(A_{12}x_2)\ e_{12} = Y_{12} + A_{12}x_2$ and then intermediate goods are disaggregated according to the use the importing country gives them $(A_{12}x_2 = A_{12}x_{21} + A_{12}x_{22} + A_{12}x_{23} + A_{12}x_{24})$, which in the case of country 1 is (Koopman *et al*., 2010):

1) For processing and re-export back to the country of origin: $A_{12}\, x_{21}$.

2) For consumption in the importing country after processing: $A_{12}\, x_{22}$.

3) For processing and re-exporting to third countries $\sum_{t\neq 1,2} A_{12}x_{2t}$

From the above definition it follows that: $e_{12} = Y_{12} + A_{12}x_{21} + A_{12}x_{22} + \sum_{t\neq 1,2} A_{12}x_{2t}$, substituting in the expression of the DVA contained in exports $DVA_{12} = v_1 L_{11} e_{12}$ in equation 5, we obtain the total decomposition of the gross value of exports from country 1 to country 2 (equation 9).

$$
\begin{aligned}
e_{12} &= DVA_{12} + FVA_{12} + PDC_{12} \\
e_{12} &= v_1 L_{11} e_{12} + FVA_{12} + PDC_{12} \\
e_{12} &= v_1 L_{11} Y_{12} + v_1 L_{11} A_{12} x_{21} + v_1 L_{11} A_{12} x_{22} + v_1 L_{11} \textstyle\sum_{t\neq 1,2} A_{12} x_{2t} + FVA_{12} + PDC_{12}
\end{aligned}
\qquad (9)
$$

This decomposition is also presented in Figure 2. In order of appearance and for the case of country 1, the terms of equation (9) indicate (Koopman *et al*., 2014):

1) The DVA contained in exports of final goods that are directly absorbed in country 2 $(v_1 L_{11} Y_{12})$.

2) The DVA contained in intermediate exports used by country 2 to produce goods that are sent back to country 1 $(v_1 L_{11} A_{12} x_{21})$.

3) The DVA contained in intermediate exports used by country 2 to produce goods that are consumed in country 2 $(v_1 L_{11} A_{12} x_{22})$.

4) The DVA contained in the intermediate exports used by country 2 to produce goods that are re-exported to third countries. $(v_1 L_{11} \sum_{t\neq 1,2} A_{12} x_{2t})$

5) The FVA contained in FAE_{12} exports, which for our case with four countries is: $FVA_{12} = v_2 L_{21} e_{12} + v_3 L_{31} e_{12} + v_4 L_{41} e_{12}$.

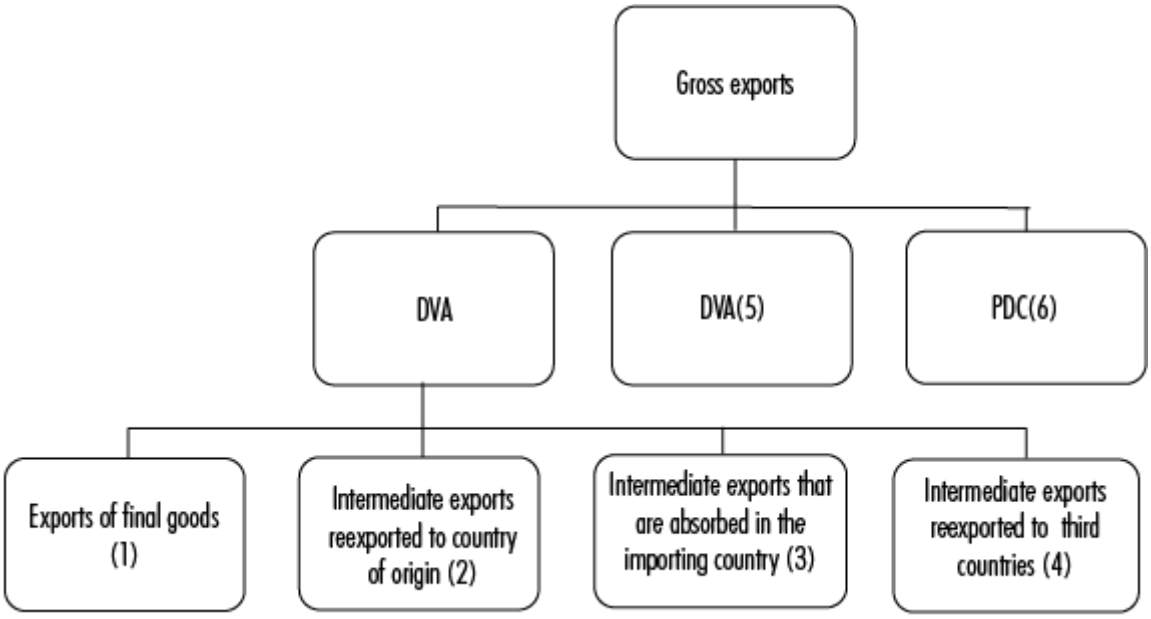
6) The pure double counting term PDC_{12}.

Recent literature on the subject indicates that one measure of a country's participation in GVCs is the type of chain it generates through its exports. And they can be simple or complex, depending on the number of times a product crosses the border. Wang *et al.* (2017) define the types of chains as follows: *a)* simple: observed when DVA or FVA crosses national borders for production only once. It is the value-added that once exported is not re-exported to third countries; *b)* complex: refers to the DVA or FVA contained in a country's exports used by the importing country to in turn produce exports of intermediate or final goods. A complex chain is observed when the value-added contained in exports crosses borders at least twice.

5. ORIGIN AND DESTINATION OF THE AGGREGATE VALUE CONTAINED IN BILATERAL EXPORTS FROM NORTH AMERICAN COUNTRIES

Value-added trade among the USMCA member countries is analyzed bilaterally. This means that the region's total trade is calculated using three models that factor in bilateral exports between pairs of countries as presented in equations (8) and (9). Based on these calculations, this section presents the decomposition of the value-added of total exports from one country to another (see Figure 2) by origin and destination. This is done to contrast the gross trade balance with the trade balance in DVA between Mexico and the US, Mexico and Canada, and the US and Canada, for the years 2005, 2010, and 2015. In terms of origin, value-added is divided into domestic, foreign, and double counting. In terms of destination, meanwhile, the value-added contained in exports can be absorbed directly in the recipient country via final goods, or in the case of intermediate goods, processed and then either consumed in the recipient country or re-exported back to the country of origin or to third countries. This decomposition provides valuable information on the insertion of each country in the regional value-added chain and the type of chain with which it participates. The findings reveal some crucial realities which are reviewed in detail in the following subsections.

Figure 2. Complete decomposition of the value-added contained in exports



Source: Compiled by the authors based on Koopman et al. (2014)

a) Mexico and the US

Table 2 shows the evolution of the origin of the value-added contained in exports between Mexico and the US. First, exports from Mexico to the US (Mexico-US) are shown, followed by US exports to Mexico (US-Mexico). The results indicate that the DVA contained in Mexican exports to the US is decreasing, falling from 74% in 2005 to 65% in 2015. The DVA of US exports to Mexico, meanwhile, is high and remained relatively constant, 86%, 84%, and 86% for 2005, 2010, and 2015, respectively.

On the one hand, the decomposition of value-added by origin reveals that the DVA of Mexican and US exports have very different structures. Mexico's exports to the US are highly dependent on U.S.-sourced inputs, as 11%, 10%, and 12% of FVA in 2005, 2010, and 2015 were of U.S. origin. In contrast, the share of Mexican value-added in US exports to Mexico in the same years was just 1%. This suggests that the US exports to Mexico intermediate products with high levels of US content that are transformed in Mexico to be re-exported to the US as final consumer products.

Moreover, in contrast to Mexico, the US managed to reduce the share of value-added coming from the RoW, an area in which China probably stands out. It is also evident that the share of the PDC term increased in Mexico.

On the other hand, the decomposition by destination indicates that Mexico exports to the US mainly final goods (34% in 2015), whose value-added is absorbed in the US, as well as intermediate goods that after being processed are also consumed in the US (27% in 2015); in other words, Mexico participates with a simple chain because its exports cross only one border (see Table 2). These data suggest that Mexico has a simple participation in regional chains, given that the value-added is destined for the US, either as a final product, or as a product that after being processed is consumed in the US, and does not reach other countries; only 4% is destined for a third country other than the US. Most of their exports experience only one border crossing.

Table 2. Origin and destination of value-added contained in exports between Mexico and the US, 2005, 2010, and 2015 (millions of dollars and percentage)

	2005	*2010*	*2015*
Mexico-US	**US$ 171 892.66**	**US$ 214 201.27**	**US$ 273 915.62**
Domestic	**74%**	**71%**	**65%**
Consumed in the U.S. in the form of final goods	34%	31%	34%
Processed in the U.S. for re-export to Mexico	0%	1%	1%
Processed in the U.S. for consumption in the US	37%	35%	27%
Processed in the U.S. for re-export to Canada	1%	1%	1%
Processed in the U.S. for re-export to the RoW	2%	3%	2%
Foreign	**24%**	**26%**	**31%**
US	11%	10%	12%
Canada	1%	1%	1%
RoW	12%	15%	18%
PDC	**2%**	**3%**	**4%**
US-Mexico	**US$ 128 502.66**	**US$ 154 395.31**	**US$ 194 901.54**
Domestic	**86%**	**84%**	**86%**
Consumption in Mexico in final goods	38%	37%	39%
Processed in Mexico for re-export to the U.S.	10%	10%	12%
Processed in Mexico for consumption in Mexico	35%	33%	31%
Processed in Mexico for re-export to Canada	1%	1%	1%
Processed in Mexico for re-export to the RoW	2%	3%	3%
Foreign	**13%**	**14%**	**12%**
Mexico	1%	1%	1%
Canada	2%	2%	2%
RoW	10%	11%	9%
PDC	**1%**	**2%**	**2%**
Trade balance	**US$ 43 390.00**	**US$ 59 805.96**	**US$ 79 014.08**
DVA balance	**US$ 17 899.53**	**US$ 23 094.90**	**US$ 9 762.29**

Source: Compiled by the authors using data from OECD (2018).

In contrast, US exports to Mexico appear to follow a more complex path. The findings show that US exports final goods (39% in 2015) and intermediate goods to Mexico, and that the value-added of the latter is absorbed in Mexico (31% in 2015), but is also re-exported back to the US (12% in 2015). This type of chain suggests a relationship in which Mexico directly provides the US with final goods, but indirectly provides services for the transformation of intermediate inputs that are returned to the US. In other words, the US participates in a complex chain.

Therefore, US exports to Mexico are mainly intermediate goods (43% = 31+12), which after being processed are either consumed in Mexico (31%) or re-exported to the US (12%). The US clearly provides the necessary inputs for the production or assembly of products in Mexico, while Mexico is mainly a supplier of final goods.

Although Mexico recorded a growing gross trade surplus in the years 2005, 2010, and 2015, if counted in terms of DVA, it is considerably smaller, and decreased significantly in 2015. The surplus in DVA went from US$17.89953 billion in 2005 to US$9.7623 billion in 2015. This suggests that Mexico's domestic earnings and export capacity declined significantly from 2005 to 2015. In 2015, the trade balance in DVA barely accounted for one-eighth of the gross trade balance, indicating that the U.S. actively participates as a supplier of intermediate inputs for the production of goods that Mexico exports rather than vice versa.

b) Mexico and Canada

Bilateral trade between Mexico and Canada is low, equivalent to less than 10% of bilateral trade between the other pairs of countries. Exports between Mexico and Canada have a relatively low DVA, with 33% of Mexico's exports to Canada being of external origin in 2015, while this figure was 27% for Canada for the same year (see Table 3). In each case, it is noteworthy that around 13% of this value comes from the US and only 1% comes from Canada for Mexico, as well as from Mexico in the case of Canada, meaning that the level of direct integration between Mexico and Canada is low and that these economies are integrated with each other via the US. This is explained by the destination of the DVA in each country's exports.

Table 3. Origin and destination of value-added contained in exports between Mexico and Canada, 2005, 2010, and 2015 (millions of dollars and percentage)

	2005	*2010*	*2015*
Mexico-Canada	**US$12 769.48**	**US$20 419.44**	**US$21 006.17**
Domestic	**67%**	**66%**	**63%**
Consumed in Canada in the form of final goods	31%	38%	35%
Processed in Canada for re-export to Mexico	0%	0%	0%
Processed in Canada for consumption in Canada	26%	19%	20%
Processed in Canada for re-export to the U.S.	8%	7%	6%
Processed in Canada for re-export to RoW	2%	2%	2%
Foreign	**30%**	**31%**	**33%**
Canada	1%	1%	1%
US	13%	12%	13%
RoW	16%	18%	19%
PDC	3%	3%	4%
Canada-Mexico	**US$6 072.74**	**US$8 315.86**	**US$8 804.46**
Domestic	**72%**	**72%**	**70%**
Consumed in Mexico in the form of final goods	32%	32%	27%
Processed in Mexico for re-export to Canada	1%	1%	1%
Processed in Mexico for consumption in Mexico	30%	28%	28%
Processed in Mexico for re-export to the U.S.	8%	9%	11%
Processed in Mexico for re-export to the RoW	1%	2%	3%
Foreign	**24%**	**25%**	**27%**
Mexico	1%	1%	1%
US	12%	12%	13%
RoW	11%	12%	13%
PDC	**4%**	**3%**	**3%**
Trade balance	**US$6 696.74**	**US$12 103.58**	**US$12 201.71**
DVA balance	**US$4 184.74**	**US$7 442.76**	**US$7 064.40**

Source: Compiled by the authors using data from OECD (2018).

Specifically, the results contained in Table 3 for 2015 show that, through Canada, Mexico has a minor participation in the regional production chain, given that 6% of Mexico's total exports to Canada are of Mexican value-added, and that, after being processed, in Canada they are destined for the US.

Similarly, in 2015 this indicator for Canada was 11%. This suggests that although trade between these two countries was low, they participated in the regional value chain with complex chains to reach their final destination in the US.

In both cases, the re-export ratio to the country of origin is low or nil; Mexican value-added exported to Canada does not return to Mexico, nor does Canadian value-added exported to Mexico return to Canada. Rather, they form a complex chain to reach the US. The chains can take the following route: MEX-CAN-EU or CAN-MEX-EU, although, of these two, the latter is the most significant (11% in 2015).

The bilateral trade relationship between Mexico and Canada results in a surplus for Mexico that almost doubled between 2005 and 2010, but did not grow in 2015. Although in terms of DVA Mexico still maintains the trade surplus with Canada, it represents approximately 58% of the total trade balance and is due to the fact that FVA content is higher in Mexico than in Canada.

c) US and Canada

Bilateral trade in value-added between the US and Canada has the following characteristics: on the one hand, US exports to Canada have a high DVA content that grew slightly between 2005 and 2015; in the final year it was 88%, with a share of Canada and Mexico of 2% and 1%, respectively; on the other hand, the DVA of Canadian exports was around 76%, a share of US value-added of 10% and of 1% for Mexico (see Table 4). For both economies, RoW contributes only 10% or less of the value-added contained in their exports.

Table 4. Origin and destination of value-added exports between the U.S. and Canada, 2005, 2010, and 2015 (millions of dollars and percentages)

	2005	*2010*	*2015*
US-Canada	**US$202 432.73**	**US$250 333.84**	**US$274 034.37**
Domestic	**86%**	**87%**	**88%**
Consumed in Canada in the form of final goods	45%	48%	45%
Processed in Canada for re-export to the U.S.	9%	8%	8%
Processed in Canada for consumption in Canada	29%	28%	32%
Processing in Canada for re-export to Mexico	0%	0%	0%
Processed in Canada for re-export to RoW	3%	3%	3%
Foreign	**13%**	**12%**	**11%**
Canada	2%	2%	2%
Mexico	1%	1%	1%
RoW	10%	9%	8%
PDC	1%	1%	1%
Canada-US	**US$285 511.15**	**US$289 081.26**	**US$306 122.29**
Domestic	**76%**	**77%**	**75%**
Consumed in the US in the form of final goods	23%	24%	24%
Processed in the U.S. for re-export to Canada	1%	1%	1%
Processed in the U.S. for consumption in the US	49%	47%	45%
Processed for reexport to Mexico in the US	1%	1%	1%
Processed in the U.S. for re-export to the RoW	2%	4%	4%
Foreign	**21%**	**21%**	**21%**
US	10%	10%	10%
Mexico	1%	1%	1%
RoW	10%	10%	10%
PDC	**3%**	**2%**	**4%**
Trade balance	**US$-83 078.42**	**US$-38 747.42**	**US$-32 087.92**
DVA balance	**US$-43 216.56**	**US$-3 762.14**	**US$12 358.60**

Source: Compiled by the authors using data from OECD (2018).

These findings indicate that the US exports to Canada final and intermediate goods that are mainly absorbed in Canada or re-exported back to the US, while Canada exports to the US mostly intermediate goods that are absorbed in the US.

The regional value chains generated between the US and Canada are similar to those observed between the US and Mexico: the US participates with a complex chain, while Canada participates with a simple chain. According to the data in Table 4, the US exports DVA to Canada in the form of final goods (45% in 2015), and intermediate goods exported with DVA are processed in Canada for consumption in Canada (32%) and for re-export back to the US (8%). The chain to Mexico and the RoW is very weak.

In contrast, Canadian value-added exports to the U.S. are mainly intermediate goods, which after processing in the U.S. are consumed in that country. Two-thirds of Canadian value-added exports to the U.S. are intermediate goods. Canadian exports do not return to their country of origin, nor do they reach third countries by this route.

The gross trade balance between the US and Canada was at a deficit for the US, but declined between 2005 and 2015. In terms of DVA, the deficit decreased at a faster pace to become a surplus for the US in 2015. In that year, the gross trade deficit was US$23.9438 billion, while in DVA the surplus amounted to US$12.3586 billion. This gives evidence of the high DVA content of US exports.

In summary, the findings reveal the following facts: a) unlike the US and Canada, and consistent with findings from Fuentes *et al*. (2020), Mexico has a high FVA content in its exports, which comes mostly from the US and RoW, where countries such as China and Korea may play a very important role; b) Mexico and Canada have a high US content in their exports, which suggests a certain dependence on US inputs; for Mexico, studies such as Ruiz-Nápoles (2004) warned of this trend, and more recently Murillo-Villanueva (2020) highlighted the loss of internal linkages as a consequence of import activity; c) Mexico and Canada trace simple chains with their exports to the US. Their DVA, given that they are absorbed as final or intermediate goods mostly in the US, only cross the border once; d) the U.S. builds complex chains with Mexico and Canada for processing and transforming intermediate inputs from the U.S., which then return to the US to be consumed; De la Cruz *et al*. (2011) arrive at similar findings, and e) although exports between

Mexico and Canada are relatively low, they succeed in tracing strong routes to serve the main market in the region, which is the US; a significant percentage of Mexican exports of intermediate goods to Canada are re-exported to the US after being processed, while the same applies for Canadian intermediate exports to Mexico that are then re-exported to the US.

6. CONCLUSIONS

The insertion and participation of Mexico, the US, and Canada into the value chains of the USMCA region differ among countries. The US stands out as the country with the highest proportion of DVA contained in its exports to the region and the value of its exports is around 86%. For Canada, this figure averages 74%, while for Mexico it represents only 68%. These findings point to the high FVA contained in Mexican exports.

Although Mexico maintained a gross and value-added trade surplus with the US and Canada during the study period, this situation is very close to being reversed, especially with the US — a country with which the value-added surplus balance was drastically reduced between 2005 and 2015. This trend is due to the wide difference in the share of DVA in each country's exports.

Meanwhile, Mexico's and Canada's exports to the region contain a high FVA from the US, amounting to 12% and 11% of the value of total exports, respectively, suggesting a certain dependence on imports of intermediate goods from the US.

Regarding the type of each economy’s insertion into the region's value chains, the US’ participation in the bloc is complex, while that of Mexico and Canada is simple. The first country supplies the other two with intermediate goods, which, after processing, are re-exported to the US. In this scenario, Mexico and Canada provide the necessary services for transforming or assembling products at low costs to return then them to their final consumption destination. This means that Mexico and Canada are mainly exporters of final goods, which do not reach third countries. Even though the main destination for Mexican and Canadian exports is the US, these two countries manage to build complex value chains with each other to reach the US with an additional border crossing. These trade links should be strengthened to allow both economies to increase their participation in the process of fragmentation of production in the region.

Mexico is undoubtedly connected very superficially to the region's value chain; of the three countries, it has the lowest DVA content, exports the least in total to the region, and participates

in a simple chain with its largest trading partner. All of the above suggests that the benefits of the USMCA will soon begin to dry up. To reverse this trend, it is essential to increase the DVA contained in exports, which requires strengthening productive linkages within the Mexican economy.

This study has yielded valuable data on Mexico's insertion into the NAFTA region. Future research on the subject could contrast the results of this work with those that would be obtained by using a different interregional database such as the WIOD, as well as analyze the value chains in the NAFTA region in the sectors, subsectors, or branches most relevant to the Mexican economy.

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