Composition of Gross Exports and Trade in Value-Added:

Toward a Deeper Analysis of Trade Between the United States and Mexico

Brancen Gregory

University of Tulsa

This paper will attempt to employ methodologies brought to the fore in the last 15 or so years, with a critical eye, to the situation of trade between the United States and Mexico. These two trading partners have recently gotten a boost of public attention, largely due to the renegotiation of NAFTA now underway between these two countries as well as their northerly neighbor, Canada. The current executive administration of the US understands the trade deficit with Mexico to be a ‘bad deal’ for the country, harmful to future economic prospects of competitiveness in the global market, and national welfare generally. The goals of this paper are to examine gross trade data between the two countries, decomposing it into components which better detail the structure of bilateral trade by extracting measures of domestic and foreign value-added in exports. This allows for a description of trade between Mexico and the United States at a more insightful level. This paper also opens the door for further research on value-added measures of trade imbalance, sector-level analysis of trade, value-added based measures of revealed comparative advantage, and other trade measures, for recent years.

The difference between gross and value-added trade has to do with intermediate goods. Intermediate goods are those used as inputs in the production of other goods. The importance of intermediates in global trade gives accounts of an increasing trend in the intermediates share of global trade, with one paper in particular estimating a share of up to two thirds of global trade (Johnson & Noguera, 2010). According to the United States Bureau of Economic Analysis (BEA), the value of intermediate inputs is calculated as the value of gross output less value added (US Department of Commerce, BEA, Bureau of Economic Analysis). The notion of value added becomes particularly important for analysis of international trade when the individual production processes of a significant portion of commodities become globally distributed. In such a case, foreign intermediate goods may enter into the production of a countries’ exports, meaning gross export statistics would represent an inflation of the value of domestic content that is exported. Using input-output tables the flow of value in exports can be traced among countries and accounted for. More will be said about such methods below.

Literature Review

The following review of pertinent literature will be be divided into sections of eponymous titles to the author(s) which they address. The first sections bring a historical context to the underlying methods of analysis involved in this analysis, whereas the final three sections contain information pertaining to the more recent development of the specific methodologies that are employed here. For more information on the early advancements in input-output analysis, see Carl Christ's indispensable analysis in his 1955 book *A Review of Input-Output Analysis*.

Quesnay

Input-Output (I-O) tables have their 'primordial' origins in the systems and methodologies of the French Physiocrats of the 18th century, the three most notable of whom being Richard Cantillon, François Quesnay, and Anne Robert Jacques Turgot. Since our interest here is the forerunning methodology of modern input-output analysis, it will suffice to address the work of Quesnay in the iterations of his *Tableau économique*, using the 1759 edition as a reference. It ought be noted, however, that Cantillon's analysis in prose can be expressed in a graphically similar way to that of Quesnay, as has been shown by Anthony Brewer (2005). Quesnay's various iterations of the *Tableau* all seek to trace the flow of funds among separate classes of citizens, each with their own role in the production process, with the mode of remuneration being rent (Kurz & Salvadori, 2000). The three classes are those of workers, landowners, and merchants, characterized respectively by Quesnay as the productive, proprietary, and sterile classes (1766). The *Tableau*, particularly in its 1759 form, appears as zig-zagging lines along which funds (in units of milliards) flow downward, through a course which represents one year of production (Quesnay, 1766). If Quesnay's framework of economic analysis seems elementary it is only due to hindsight and familiarity with the more developed methods which have built on his efforts. As we will see below, many of the economists employing I-O analysis or its precursors in their research have accredited inspiration to Quesnay, Karl Marx going so far as to call the *Tableau* “an extremely brilliant conception, incontestably the most brilliant for which political economy has up to then been responsible” (Kurz & Salvadori, 2000, p. 7).

Marx

Karl Marx, renowned political and cultural commentator, philosopher of history, and economist, employs a proto-IO framework in the second volume of Das Kapital, where he “[develops] his own *schemes of reproduction*” (Kurz & Salvadori, 2000, p. 13). Marx’s schemas more closely exemplify the inter-sectoral nature of the inquiry reflected in modern analysis, explicitly focusing on an input producing sector and a consumer goods producing sector. This can be contrasted to Quesnay’s sectoral classification which is made per the perceived contribution of a class to the net product. Marx’s framework also clarifies and emphasizes the circulatory nature of the transfer of funds, as opposed to a one-way, ‘downstream’ flow (Marx, 1885). However, circulation is implicit in Quesnay’s *Tableau*, as Quesnay himself acknowledged in the following quotation noted by Marx: “Cast a glance at the *Tableau Économique* and you will see that the productive class provides the money with which the other classes buy products from it, and that they return this money to it when they come back next year to make the same purchases...” (Marx, 1885, p. 213). It is beyond the scope of this paper to discuss the specific contributions of Marx to economic thought, made possible by his utilization of the framework of reproduction. Rather, we underscore the influence of Quesnay and his *Tableau* on Marx’s methodology, a certain continuity which is by no means unique to these two thinkers, but to a whole set of classical and more modern economists.

Leontief

The modern, matrix approach to I-O tables is most often attributed to Wassily Leontief. Leontief sought to examine the effects of changes in one sector, or industry, of the economy on others.

Such large-scale, detailed analysis was made accessible by the implementation of linear programming methods, among other advances which Leontief acknowledges, as reported in summaries of his two most consequential papers below.

In his seminal, 1936 paper, Leontief himself purports to be following in the footsteps of Francois Quesnay, constructing a "Tableau Economique of the United States for the year 1919" (Leontief, 1936, p. 105). The study considers 41 industrial accounts, alongside 3 additional accounts for household consumption, trade, taxes, etc. Leontief credits advances in national statistics (national balance of accounts), especially in the field of agriculture, with establishing a necessary datasource and toolkit (1936, p. 105). Leontief explains the structure of the matrix constructed in simple graphical terms. He discusses the significance of the sum of each row and column, emphasizing that the total of all these sums must be equal—i.e. total inputs equal to total outputs of the system. Leontief makes the distinction between gross and net accounting procedures. In doing so, the issue of double-counting is made explicit. Leontief argues that double-counting, while distortionary of welfare issues, is crucial in regards to inquiries into the structure of economic systems. Another issue that Leontief addresses is that of the homogeneity of industrial products and cost structures. Each accounting unit, however aggregated, is theoretically bound to the requirement for such homogeneity, but in practice is unachievable. Leontief discusses deeper reasoning extensively. In the final tables presented at the end of the study, one is shown in dollar terms, whereas the second, and final, is shown in percentages. The usage of proportionality accentuates the structural relevancies of the table produced, an insight which is taken advantage of in this analysis (1936).

By the time of his 1963 paper, Leontief's system had been expanded to cover multiple regions. An air of mathematical gravitas also accompanies the thirty years separating this from his pioneering work. The key theoretical addendum made possible within a multi regional framework is that of an indirect input-output relationship. Not only will country or region A obtain good i from region B, but they will also obtain some of this indirectly via its inclusion in a product from region C. The pattern is variously referred to as triangular or multilateral trade, and is congruent with the phenomena of global supply chains, or the disintegration of production across borders. In addition, another practical observance within the multi regional framework is that identical (or close enough) goods from different regions may be addressed. In such a case, as Leontief notes, neither consumer nor producer care as to the origin or destination of such products, only that they are bought or sold. All effects of regionalization enter into choice space via cost considerations (e.g. transportation costs, trade barriers, etc.). One important note is that within the restricted theorems of perfect rationality, it would make no sense for absolutely identical goods to be traded from country A to country B AND in the opposite direction. For this reason it is kept in mind that the goods are not perfectly identical, but similar enough to be substitutes. Leontief notes, however, that one reason we see cross-flows of the 'same' good is because data for such analysis is collected over a time-span, as opposed to instantaneously. Effects of seasonality can be understood to play a role in this matter, and as such cross-flows can be identified as a desirable property of the data, as they are more true to the facts on the ground. It does open up, though, questions into what other details and theoretical roadblocks are concealed or obstructed by such a drawn-out data collection process. For most analyses, it is necessary to close the multi regional system in terms of what trade pertains to regions outside of the area of inquiry. In national terms, this can be achiever by adding a Rest Of World ROW region within the model. Leontief shows his multi regional model to be a special type of Gravity Model, similar in functional form to that of Solow regarding production, among others (1963).

Hummels, Ishii, Yi

The first paper to be discussed, in the first section, is that of Hummels, Ishii, and Yi (1999), referred to henceforth as HIY. In this paper, the authors seek to measure what they refer to as 'vertical specialization' following Helleiner (1973), Balassa (1978), and Findlay (1978). Kalyan K. Sanyal

(1983) attributes the term ‘vertical specialization’ to Findlay specifically, though notes the essential definition was used by both Helleiner and Balassa as well. Hanson, Mataloni, and Slaughter (2002, p. 666) identify other names for the same phenomenon, “including de-localization, disintegration of production, fragmentation, global production sharing, foreign outsourcing, and slicing up the value chain”. Regardless of the name, the experience of those earlier economists in analyzing patterns of global production and trade has only become more poignant. HIY defines the phenomena, from a single agent’s vantage point, as the situation in which “imported inputs are used to produce a country’s export goods” (1999, p. 1). This is a more limited definition than simply trade in intermediate goods, as those intermediates could be otherwise used in the production of domestic final goods. Note also, that ‘goods’ here refers only to manufactures in the context of HIY, not services or capital goods. A separate measurement of vertical specialization for capital goods VS1 is also proposed in HIY, though it will not be addressed herein. The reason given for HIY’s narrowing of focus is twofold. First, their observation which contradicts the deepening of vertical specialization unless some differentiation is introduced; namely, a decrease in the overall portion of intermediates trade in gross trade statistics from “about 50% to 40% between 1970 and 1992, with even larger drops within the OECD” (1999, p. 4). Second, the back-and-forth motion which characterizes the phenomena in question is accounted for by HIY’s limitation of VS to imported inputs embedded in exports, since by definition the final product has multiple stages of its production traded. This allows for their “core idea that tariffs and transportation costs penalize vertically specialized goods each time they cross a border”, which becomes crucial when diagnosing causal determinants of the phenomenon in terms of theoretical models (1999, p. 5).

So, as follows from the explication above, the main objective of HIY in producing the measurement VS becomes decomposing gross trade statistics in such a way as to isolate “the value of imported inputs embodied in goods that are exported” (1999, p. 2). This is done via implementation of VS to input-output data which “[includes] sector-level data on inputs (distinguishing foreign and domestic sources), value-added, gross output, and exports" (1999, p. 6). The measurement is presented notationally as follows (1999, p. 7):

$$VS_k / X_k = \boldsymbol{u}\boldsymbol{A}^{\boldsymbol{M}}[\boldsymbol{I} - \boldsymbol{A}^{\boldsymbol{D}}]^{-\boldsymbol{1}}\,\boldsymbol{X} / X_k$$

The bold style in the equation represents vectorized components: u is a 1xn vector of 1's; A^m is the nxn input coefficients matrix for imported intermediates; [I-A^D]^-1 is the nxn matrix representation of a geometric sum, including the foreign content embedded in each stage of intermediate production that is then used to produce the final export; X is a nx1 vector of exports. As in our analysis, HIY is interested primarily in the time trends of vertical specialization and changes in the composition of trade, so the measurement VS has been normalized by, or represented as a share of, total exports X_k, where k indicates a country index (1999, p. 7).

The first result of HIY pertinent to this study is the general observation that the "[use] of imported inputs in domestic consumption has grown (everywhere but Japan), but their use in export sectors has grown faster. Hence, the increase in VS shares represents more than a general increase in reliance on imported inputs" (1999, p. 15) This serves as a retroactive, partial justification of HIY's limit of interest to vertical specialization as they define it, rather than all imported intermediates. The case of the United States accords with this global trend, with a 57.2% growth in the use of imported intermediates for domestic consumption being outpaced by 82% growth in their use for producing exports over the period 1972-1990 (1999, Table 8). In addition, HIY finds that, over the same period, the United States experienced an increase in the VS share of exports from 6% to 11% (1999, Table 2), while the total export share of gross output increased by 7%, with growth in the VS share accounting for 14.1% of that augmentation (1999, Table 4). It is noted by HIY, however, that due to the level of aggregation of the VS measurement, its share in exports is likely underestimated; in the case of the US, by as much as 44% (1999, p. 8). For the case of Mexico, HIY does not use I-O tables, but refers to gross statistics on the activities of the maquiladoras, which are firms that import intermediates with low to no tariffs or duties for assembly into a final export product. Nonetheless, the results of their inquiry are worth reporting. HIY estimates that over the period 1979-1997 VS share of exports rose from roughly 10% to 35% (1999, p. 11). Since these measurements limit their scope to the productive activity of maquiladoras, they are 'lower bounds' of the true figure (1999, p. 11). Over the same period, the export share of gross output increased 19%, with growth in VS accounting for 40% of that increment (1999, Table 4).

Johnson & Noguera

The second study in this section is that presented in a 2009 draft by Johnson and Noguera (JN). This draft was cross examined with a revised and abbreviated version of their 2012 paper, as published in Mattoo, Wang, & Wei (2013). Whereas HIY approaches the phenomena of the fragmentation of production by attempting to measure the value of imported intermediates embodied in exports, JN seeks to apply a direct measurement of the domestic value-added embodied in exports. This requires that they "[track] the value added produced in each country to the final destination at which that value added is consumed" (2009, p. 2) This leads to the significant effort of creating a world input-output table which provides the methodological basis from which to carry out the necessary computation. One benefit of this system over the more aggregate measure employed by HIY is that it better accounts for the "well known 'double-counting' problem" which arises in any trade statistics, but becomes significantly more problematic with an increase in the very situation being hypothesized in the relevant literature, namely, that of production sharing (2009, p. 2). This is precisely because of the 'back-and-forth' characteristic of production fragmentation described in HIY above, and the supplementary fact that "multi-country production networks imply that intermediate goods can travel to their final destination by an indirect route” (2009, p. 2). The JN framework for uncovering a fuller dynamic of production sharing thus “allow each country to both import and export intermediate goods” (2009, p. 2). This generalizing principle is in turn adopted by KWW and Wang, Wei, & Zhu (2013) (WWZ), which allows for a straight-forward proof of the equivalency of the VAX ratio to the corresponding measure in KWW for the 2-country 1-sector system, as will be shown below. For now, we will turn to the major benefits and results of JN.

The crucial observation by JN, which follows from their sufficient decomposition of gross exports, is that “to the extent that fundamental bilateral trade relations are distorted by intermediate goods trade…, so too are bilateral balances” (2009, p. 9). In addition, JN addresses three categories of empirical results: “(1) cross- sector variation in intermediate input intensity (equivalently, value added to output ratios); (2) cross-country variation in the composition of exports; and (3) cross-country variation in overall openness and bilateral trade patterns” (2009, p. 14). For now, we focus on those in the second and third categories. JN reports that, for the year 2001, 66% of United States’ exports to Mexico can be attributed to domestic value added, while 71% of the value of United States’ imports from Mexico is Mexican value-added (2009, p. 26). This results in a 15% decrease in the trade balance for the two countries, where the United States remains the net importer (2009, p.26). With adjustments for processing trade on the part of Mexico, which is expected to have a significantly different input composition, and therefore value-added share, for these activities, the results are more pronounced: the value-added trade balance is 32% less than the gross measure (2009, p.28).

Koopman, Wang, & Wei

Koopman, Wang, & Wei’s 2013 paper (KWW) encompasses the previous work in such a way that it represents the first exhaustive decomposition of gross trade into various value-added and double-counted components, in a highly generalized framework of accounting. In neglecting to “examine the causes and the consequences of global production chains” they allow themselves to better focus on the sufficiently arduous task of “[providing] a unified conceptual framework” for quantitative analysis of trade (2013, p. 1). To simplify comparison of JN and KWW’s equations corresponding to the VAX ratio, an appendix displaying the equivalency of the most disparate step in their respective derivations for a single term is included below. With this equivalency it is trivial to prove that the measures are indeed identical. One benefit of KWW having set upon this task, is that it provides significant insight, allowing them to critique the methodologies of the aforementioned research (HIY and JN) with a highly informed eye. KWW distinguishes the two according to their use of either national input-output tables, as in the case of HIY, or, as JN, the use of international input-output tables (2013, p. 2). One observation which bolsters the motivation for KWW’s research, and proves to be of high value to analysis of global trade, is the importance of taking into account double-counting, rather than excluding it from the analysis (2013, p. 2). KWW show that double-counted components can themselves be classified into distinct groups, which can distinguish countries with similar quantities of value-added exports, and give insight into a nations position in the global value chain (2013, p. 3). One more advantage of this research is the emphasis on use for further inquiry, such as into new measures of revealed comparative advantage based on value-added, as opposed to gross trade measures (2013, p. 3).

Moving to the empirical results of KWW’s decomposition of gross trade, we again focus on information pertaining to the two countries under consideration: the United States and Mexico. All results pertain to trade undertaken in 2004. For the United States, KWW reports a VAX ratio of 74.6% for value-added exports of 1.062 trillion to all destination countries (2013, p. 39). The VS share of exports is reported at 12.9% (2013, p. 39). In contrast, KWW reports a 51.6% VAX share for the sum of Mexico’s exports, including the processing sector, and a 48% VS share (2013, p.39). Dividing Mexico’s exports into ‘normal’ and processing exports helps to explain the low (high) portion of domestic (foreign) value-added in exports (2013). For processing exports KWW reports 36.3% VAX ratio and 63.4% VS share, whereas the ‘normal’ exports have figures more congruent with that of the average country among those examined: an 82.1% VAX share, and 17.3% VS (2013, p. 39). The significant takeaway here is that, though Mexico outperforms the United States in its value-added generated from normal exports, its high share of processing trade skews the overall metric of domestic value-added in exports to a much lesser overall value than the United States. gross measures will be misleading as, for instance, some portion of the value of a country's exports has been imported via intermediate goods.

Data Source

The data for this analysis comes from the World Input Output Database (WIOD), first released in 2013, and described in a paper published in 2012 by Marcel Timmer et.al. The project was established "to analyse the effects of globalization on trade patterns, environmental pressures and socio-economic development across a wide set of countries" (2012, p. 3). The updated WIOD, which was released in 2016 as the second release, covers 43 countries and 56 productive sectors (World Input-Output Database, 2017). The sectors adhere to the International Standard Industrial Classification revision 4 (ISIC Rev. 4), and the input-output tables it contains follow the standards of the System of National Accounts (SNA) 2008 release. The WIOD compiles data from various governmental national supply and use tables, as well as the input-output tables produced from them, to create a world input-output table in which the substantive property, "that total output by the domestic industry is equal to the use of output from the domestic industry such that all flows in the economic system are accounted for", is preserved (Timmer et.al., 2013, p. 4). This requires of the WIOD that a rest-of-world (ROW) adjustment be made to account for countries not directly included in the dataset. For more information on the construction of the WIOD, see Timmer et.al (2015) and Timmer et.al (2016). In addition, Guo, Lawson, & Planting (2002) examine various technology assumptions applied in the conversion of supply-use tables to input-output tables. The WIOD uses a mixed approach to the problem. A simplified, two country input-output table format is provided in Figure 1 below for visual aid.

Results

We first examine gross exports from Mexico and the United States, respectively, to all other countries in the data set, including the Rest of World estimate provided in the WIOD. Gross exports are divided into four 'buckets': 1) domestic value-added absorbed abroad (DVA), 2) domestic value added which returns to the home country in the form of intermediates or final products (RDV), 3) foreign value-added embedded in the home country's exports (FVA), and 4) purely double counted value which arises in trade accounting due to border-crossing (PDC). For the complete derivation of these terms see Wang, Wei, & Zhu (2013). The value of these four buckets over the fifteen year period are shown in Figure 2.1 for Mexico, and Figure 3.1 for the United States. Here it will suffice to address the disparate shares of each bucket across countries, visualized in Figures 2.2 and 3.2. For Mexico, the share of DVA in total gross exports remains fairly stable over the series at roughly 65%, whereas the United States share of DVA hovers around 80%. In Mexico's total gross trade, RDV makes up a trivial less than 1%, whereas in the United States its share is more significant, starting at roughly 10% in 2000 and decreasing to around 6% by 2009. The FVA share for Mexico remains around 30%, but slightly increase over the period in the United States, still making up less that 10% of total gross exports. Finally, the PDC share of total gross exports is approximately equal and constant for the two countries, at 2-3%. Already, marked differences have been shown, but we will turn to the decomposition of bilateral gross exports and its various components before offering any interpretive narrative.

Bilateral gross exports from Mexico to the United States share a fairly consistent structure with Mexico's total gross exports with only a slightly greater share of DVA and lesser share of FVA. The same comparison is more strikingly disparate in the case of the United States, where DVA is around 60% and RDV shares more significantly in gross exports to Mexico, beginning at roughly 25% in 2000 and ending around 20% in 2014. FVA and PDC both have greater shares in bilateral gross exports to Mexico from the United States, as well.

Concerning the different structures of total gross exports of the two countries in question, it is tempting to suppose that the United States plays a role in global trade that could be considered higher up the supply-chain than Mexico, particularly considering the role of RDV and FVA in each countries' bilateral gross exports with the other. RDV in bilateral exports is a signal of such a higher or relatively 'upstream' position because it represents the portion of gross exports which will undergo further productive activity before its return. However, a high share of RDV alone is not sufficient to identify a country's absolute position in the global supply chain. FVA is telling in this regard, as a high share more absolutely indicates a lower or relatively downstream position. These observations, combined with the large share of DVA in total gross exports from the United States, and relatively larger share of FVA in total gross exports from Mexico, bolster the claim. However, the benefit of KWW's methodology is that we can decompose each of the four buckets further into components which may help to expound on this matter. There is one more observation which must first be made, though. In so far as the United States bilateral gross exports contain a significant share of RDV, the trade balance released in gross terms may be misleading, since imports from Mexico may contain value-added by the United States. This, too, can be better addressed with the further decomposition below.

First, the domestic value-added share of bilateral exports absorbed abroad (DVA) can be decomposed into five components: 1) DVA in final goods exports absorbed in the direct importer (DVA_FIN), 2) DVA in exports of intermediates absorbed in the direct importer (DVA_INT), 3) DVA in exports of intermediates that are then reexported as intermediates to third countries for the production of final goods (DVA_INTrexI1), 4) DVA in exports of intermediates that are used in the production of final goods exports to third countries (DVA_INTrexF), and 5) DVA in exports of intermediates that are used in the production of intermediate exports to third countries that are used to produce further exports (DVA_INTrexI2). In both countries' cases the portion of DVA that is reexported by the direct importer to other countries, though increasing over the period, is relatively small, remaining less than 10% for Mexico and less than 13% for the United States. Also, both countries have seen a relative decline of the share of DVA embedded in final goods exports, with a roughly 12% decline for Mexico (mostly taking place over the period 2001 to 2004), and a more modest decline of less than 8% in the United States. Still, Mexico has a greater overall share of its DVA embedded in final goods exports at approximately 47%, compared to the United States' 32% share, in the final year, 2014. The decline in the share of DVA embedded in final goods exports is in part a result of the increase in reexported DVA, but also due to an increase in the share of DVA embedded in intermediate exports. This share grew by around 8% in Mexico's exports of DVA, and by 3% in that of the United States. Overall, the United States has a greater share of DVA embedded in intermediate goods at 55%, compared to Mexico's 43% in 2014.

The domestic value-added portion of bilateral exports that return home (RDV) can next be decomposed further into three components: 1) RDV in intermediate exports that return as final goods from the direct importer (RDV_FIN), 2) RDV in intermediate exports that return as final goods from a third country (RDV_FIN2), and 3) RDV in intermediate exports that return as intermediates from the direct importer (RDV_INT). RDV in intermediate exports that return via a third country accounts for less than 2% of total RDV in each country. The remaining two shares are in stark contrast to one another. In Mexico's exports of RDV, intermediates that return as intermediates dominate over those that return as final goods, whereas the inverse is true for the United States. The share of RDV returning as final goods to Mexico was 33% in 2014, with an 8% decline over the period; in the United States the same share was 59%, with a decline of around 12%. These declines are almost completely accounted for by an increase in the share of RDV returning as intermediates, in both cases. This total share comes to 65% and 35% for Mexico and the United States, respectively, in 2014.

Thirdly, the foreign value-added share of bilateral gross exports (FVA) can be decomposed into four components: 1) FVA in final goods exports which originates from the direct importer (MVA_FIN),

2) FVA in final goods exports which originates from other countries (OVA_FIN), 3) FVA in intermediate exports which originates from the direct importer (MVA_INT), and 4) FVA in intermediate exports which originates from other countries (OVA_INT). The four shares of FVA can be grouped either according to the source of the foreign value-added, or according to the type of export good. Following the first line of inquiry, the two shares of Mexico's FVA exports which originate in the United States decreased over the period 2000 to 2014 by 15%, ending at a combined 44% of FVA. The corresponding share of FVA in the United States' exports which originates from Mexico increased by around 2%, but made up less than 9% of FVA in 2014. Grouping FVA components by export type, the share embedded in final goods exports from Mexico to the United States decreased by 12%, to 62% in total FVA. The final goods share of FVA in bilateral exports from the United States also decreased, but by a lesser 7%, with a 34% share in total FVA. Both countries' intermediate share of FVA in exports increased by the same respective magnitudes. Mexico's FVA in intermediates represented 37% of FVA in 2014, whereas the United States' made up 65% in the same year.

Finally, the pure double-counted share of bilateral gross exports (PDC) can be decomposed into four components: 1) PDC due to the direct importer's production of exports (MDC), 2) PDC due to other countries' production of exports (ODC), 3) PDC due to domestic production of final goods exports (DDC_FIN), and 4) PDC due to domestic production of intermediate exports (DDC_INT). The share of PDC due to domestic exports makes up a relatively consistent share of total PDC in both countries. In Mexico's exports this share accounts for less than 12% of total PDC over the period, with the portions due to intermediates becoming more equal to that due to final goods over time. The share of PDC due to domestic production for the United States' exports makes up a greater share at less than 24% over the period, with the portion due to intermediates declining to a roughly equal share with that due to final goods exports. The two remaining components of PDC in gross exports are due to the direct importer and other countries' production for exports. Notably, though the share of PDC in

Mexico's gross exports due to other countries' production of exports increased by approximately 14%, to a 47% share in total PDC in the final year, the United States' comparable share dominates at 71% in 2014.

Discussion

Returning to the inferences to be made from this analysis, recall that although DVA in bilateral exports are similar in both Mexico and the United States, the remainder of value in the exports of the latter is dominated by RDV, whereas the former is dominated by FVA. This means that a bilateral trade balance in value-added terms would decrease both countries' trade level compared to the gross valuation, but decrease Mexico's value by a greater magnitude, rendering a better position for the United States. Further the fact that almost half of FVA in Mexico's exports originates from the United States gives significant credence to the notion that Mexico holds a more downstream position in the value-chain relative to the United States. While the role of competition in the trade structure of the two countries should not be undermined, neither should be the opportunity for cooperation between countries with different roles in global production, as evidenced by the highly differential structure of value in their exports. The role of PDC in gross exports, especially the high share of that in Mexico's exports due to production for exports in the United States, also deserves more inspection. Since the double-counting terms are caused by intermediates crossing borders multiple times, inspection of third parties who engage in trade with the United States and Mexico could be insightful.

Conclusion

The previous analysis is not sufficient to conclude anything regarding the absolute position of either country in the global supply-chain. An analysis involving all countries in the WIOD could better suit this purpose. Also, to define the exact roles of each country in the global economy, rather than a relative description, a sectoral-level analysis is needed. Such a study would also be beneficial in identifying linkages between particular foreign and domestic sectors which could be drivers of integration of productive activity. With the soon to be released supplement to the WIOD 2016 release, an analysis of welfare effects in terms of return to labor could be addressed.

While this study does not serve to answer some of the pressing questions named above, it nonetheless provides base statistics at high levels of aggregation which give insight into the structure of exports. The increasing role of intermediates as foreign sourced value embedded in exports has been highlighted, as well as the increased role of domestic value in the production of intermediate exports, particularly in the United States.

References

Balassa, B. (1978). Exports and Economic Growth: Further Evidence. *Journal of Development Economics*, 5(2), 181-189.

Brewer, A. (2005). Cantillon, Quesnay, and the Tableau Economique. Discussion Paper No. 05/577.

Christ, C. (1955). A Review of Input-Output Analysis. *Input-Output Analysis: An Appraisal*. 1. 137-182.

Findlay, R. (1978). Relative Backwardness, Direct Foreign Investment, and the Transfer of Technology: A Simple Dynamic Model. *The Quarterly Journal of Economics*, 92(1), 1-16.

Guo, J., Lawson, A., & Planting, M. (2002). From Make-Use to Symmetric I-O Tables: An Assessment of Alternative Technology Assumptions. *Proceedings of the 14th International Conference on Input-Output Techniques.*

Hanson, G., Mataloni, R., & Slaughter, M. (2004). Vertical Production Networks in Multinational Firms. *Review of Economics and Statistics*, 87(4), 664-678.

Helleiner, G. K. (1974). Manufactured Exports From Less Developed Countries and Multinational Firms, University of Toronto. Abstract from The Economic Journal, March, 1973, p. 21. The Int. Exec., 16: 25–27. doi:10.1002/tie.5060160116

Hummels, D., Ishii, J., Yi, K. (1999). The Nature and Growth of Vertical Specialization in World Trade. *Journal of International Economics*, 54, 75-96.

Johnson, R. & Noguera, G. (2012). Accounting for Intermediates: Production sharing and trade in value-added. *Journal of International Economics*, 86(2), 224-236.

Koopman, R., Wang, Z., Wei, S. (2014). Tracing Value Added and Double Counting in Gross Exports. *American Economic Review*, 104(2), 1-41.

Kurz, H. & Salvadori, N. (2000). ‘Classical’ Roots of Input-Ouput Analysis: A Short Account of its Long Prehistory. *Economic Systems Research*, 12(2), 153-179.

Leontief, W. (1936). Quantitative Input and Output Relations. *The Review of Economics and Statistics.* 18(3). 105-125.

Leontief, W., and A. Strout (1963). Multiregional Input–Output Analysis. In: Structural Interdependence and Economic Development (ed. T. Barna), pp. 119–150. New York: St-Martin's Press.

Marx, K. (1885). Capital: A Critique of Political Economy, Volume II.

Mattoo, A., Wang, Z., & Wei, S. (2013). Trade in Value Added: Developing New Measures of Cross-Border Trade. *The International Bank for Reconstruction and Development/The World Bank*.

Quast, B.A. and V. Kummritz (2015). decompr: Global Value Chain decomposition in R. CTEI Working Papers, 1.

Quesnay, F. (1766). Analyse de la formule arithmetique du TABLEAU ECONOMIQUE de la distribution des depenses annulles d'une Nation agricole. *Journal de l'agriculture, du commerce & des finances*, June, 11-41.

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Sanyal, K. (1983). Vertical Specialization in a Ricardian Model with a Continuum of Stages of Production. *Economica*, 50(197), 71-78.

Timmer, M., Erumban, A., Francois, J., et.al. (2012) The World Input-Output Database (WIOD): Contents, Sources and Methods.

Timmer, M., Dietzenbacher, E., et.al. (2015). An Illustrated User Guide to the World Input-Output Database: The Case of Global Automotive Production. *Review of International Economics, 23(3)*, 575-605.

Timmer, M., Los, B., Stehrer, R., de Vries, G. (2016). An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release. *GGDC research memorandum number 162, University of Groningen.*

US Department of Commerce, BEA, Bureau of Economic Analysis. (n.d.). Bureau of Economic Analysis. Retrieved October 30, 2017, from https://www.bea.gov/faq/index.cfm?faq_id=185

Wang, Z., Wei, S., Zhu, K. (2013). Quantifying International Production Sharing at the Bilateral and Sector Levels. *NBER Working Papers*, 19667, 1-127.

World Input-Output Database. (n.d.). Retrieved October 30, 2017, from http://www.wiod.org/release16

FIGURE 1

Sample I-O Table[1]

<table>
<tr><td rowspan="2"></td><td rowspan="2">Country</td><td colspan="4">Intermediate Use</td><td colspan="2">Final Demand</td><td rowspan="2">Total Gross Output</td></tr>
<tr><td colspan="2">MEX</td><td colspan="2">USA</td><td>Y^{MEX}</td><td>Y^{USA}</td></tr>
<tr><td>Country</td><td>Sector</td><td>MEX1</td><td>MEX2</td><td>USA1</td><td>USA2</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">MEX</td><td>MEX1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>MEX2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">USA</td><td>USA1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>USA2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Value-added</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total Input</td><td></td><td></td><td></td><td></td></tr>
</table>

1 Adapted from an example I-O table presented by Timmer, et.al. (2015, p. 577).

FIGURE 2

Figure 2.1

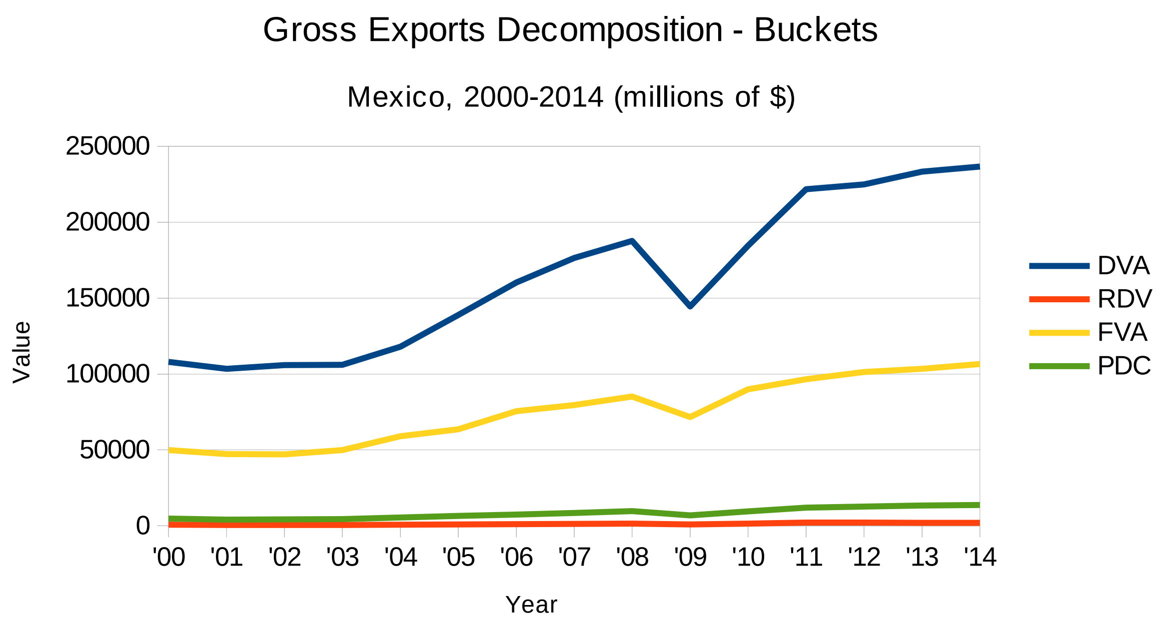


Figure 2.2

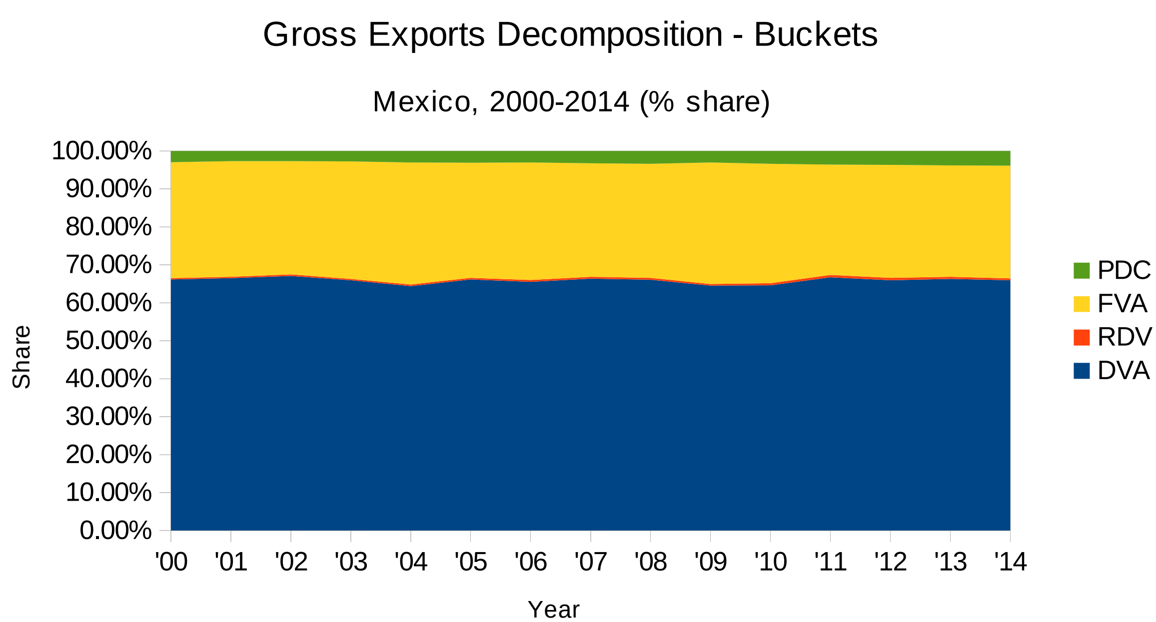


FIGURE 3

Figure 3.1

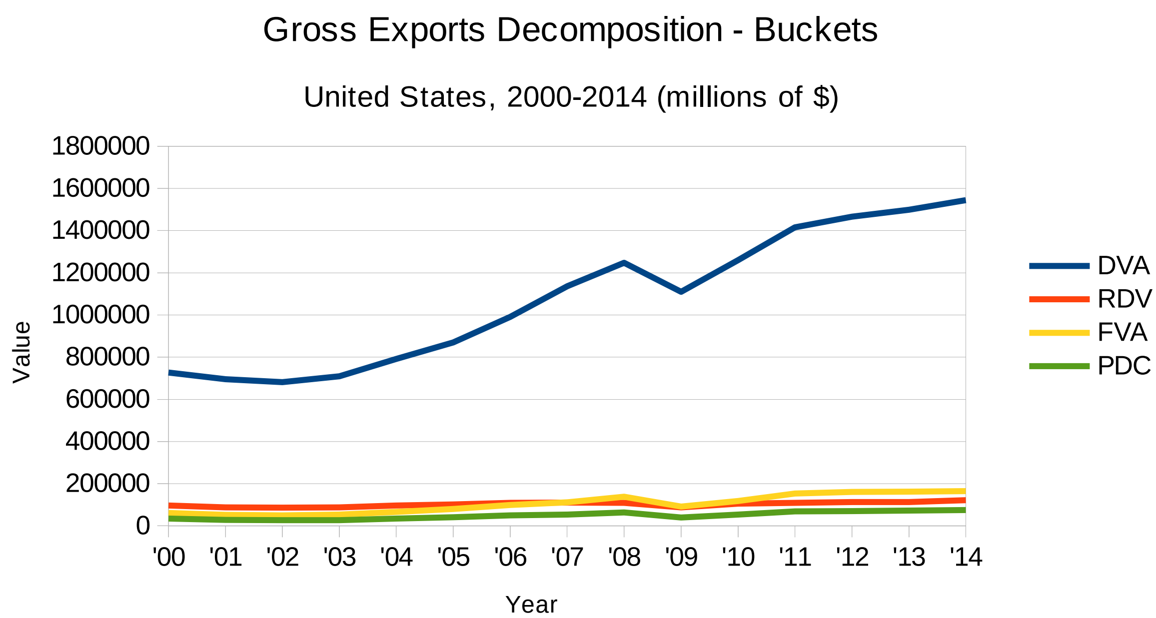


Figure 3.2

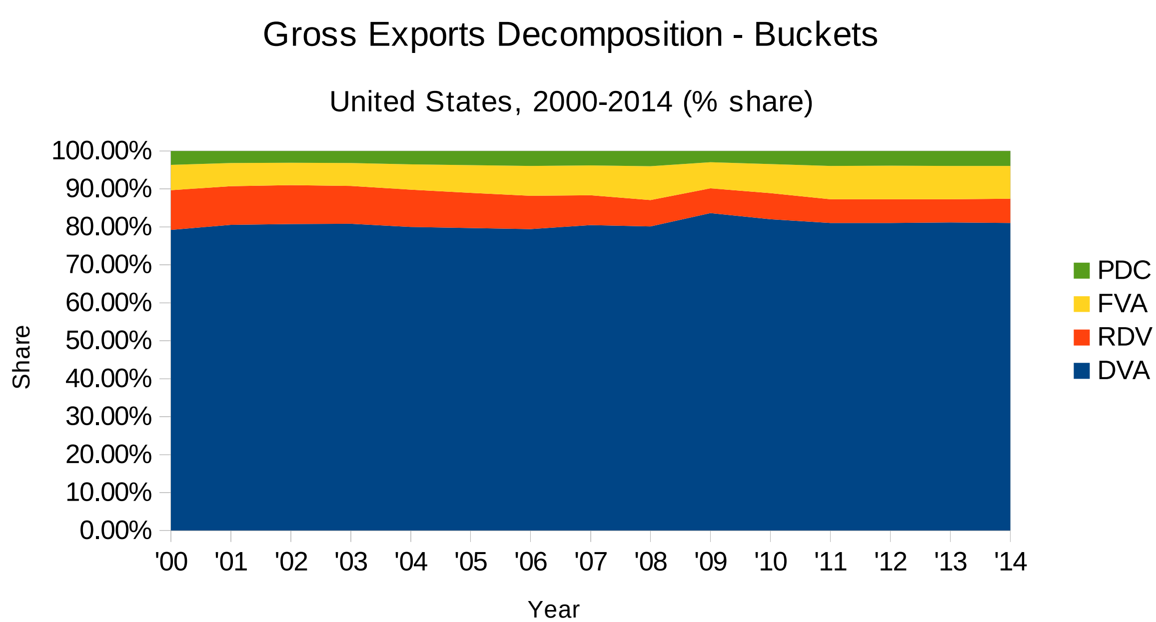


FIGURE 4

Figure 4.1

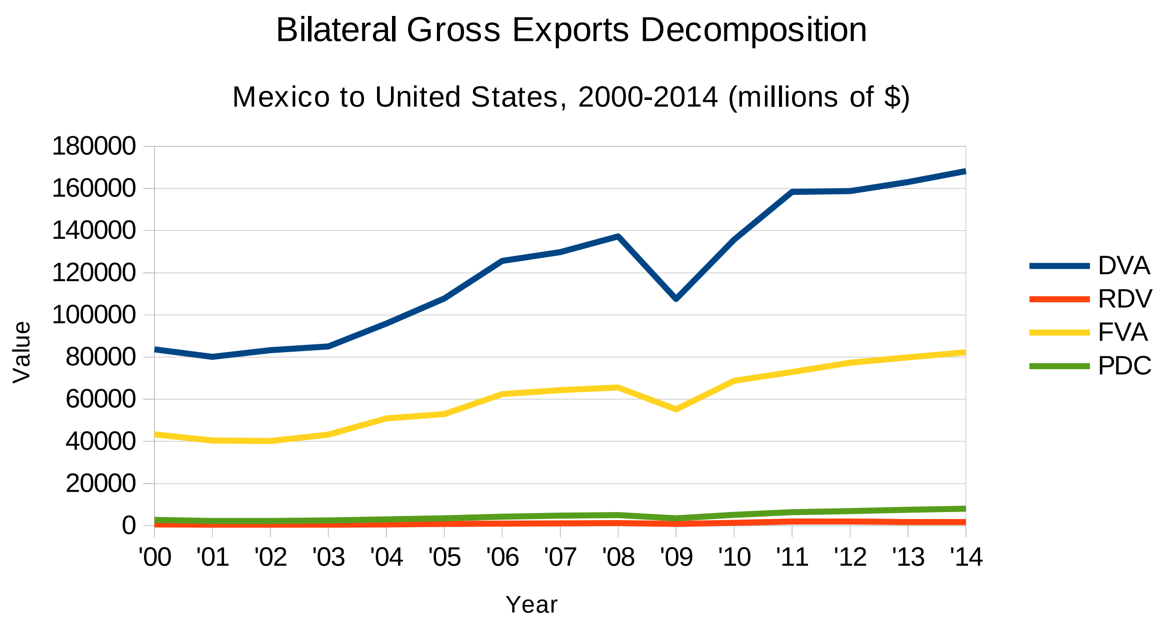


Figure 4.2

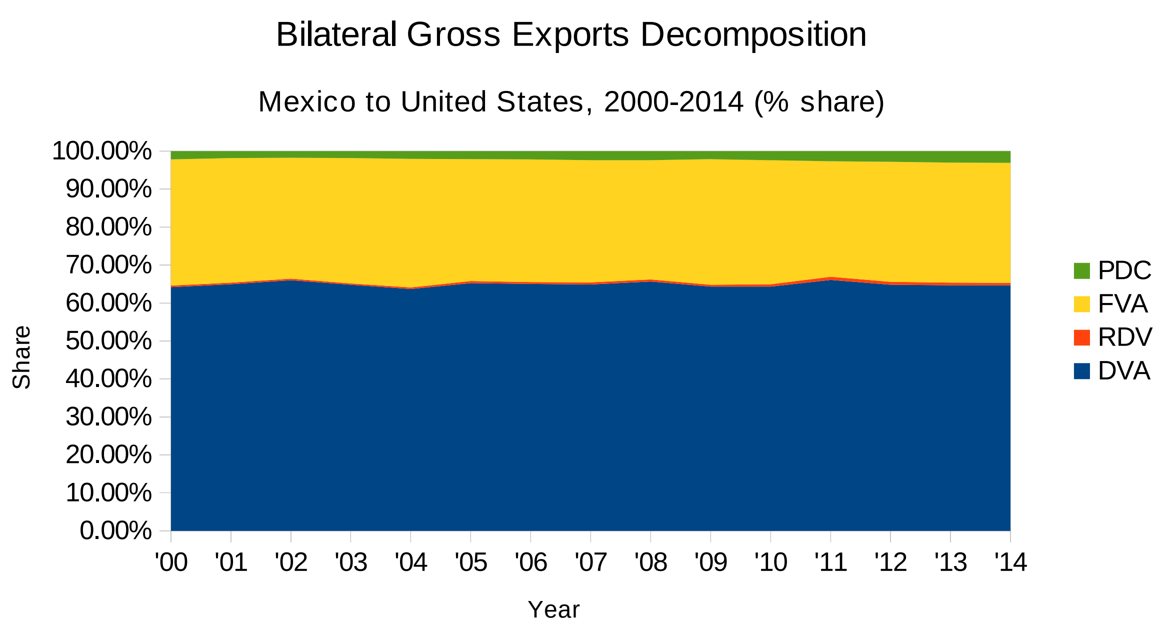


FIGURE 5

Figure 5.1

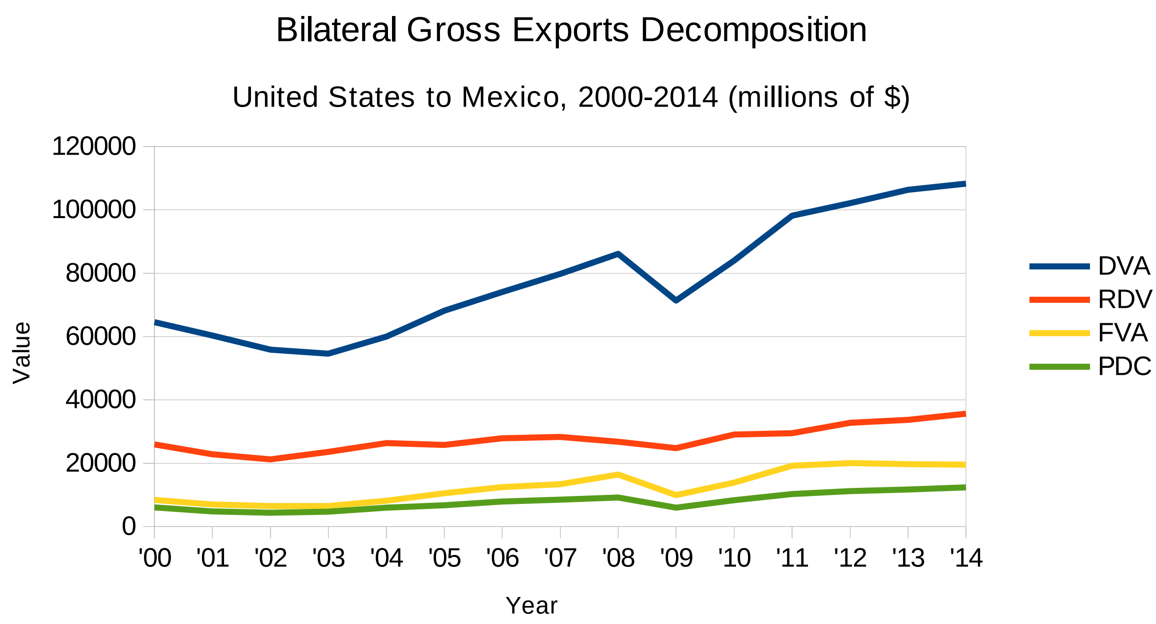


Figure 5.2

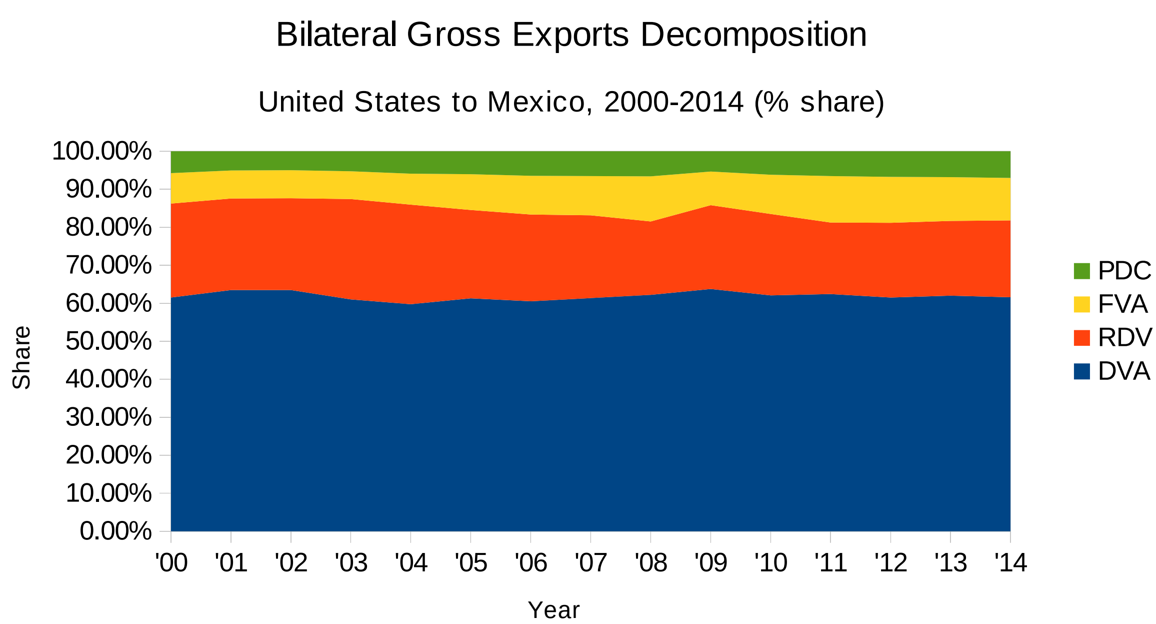


FIGURE 6

Figure 6.1

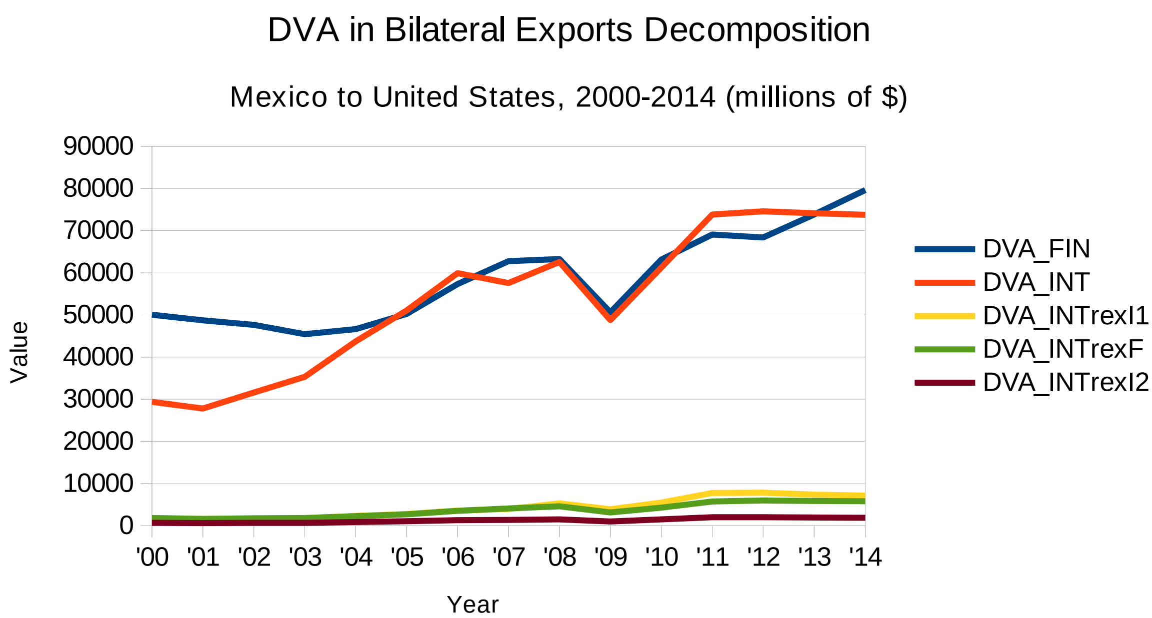


Figure 6.2

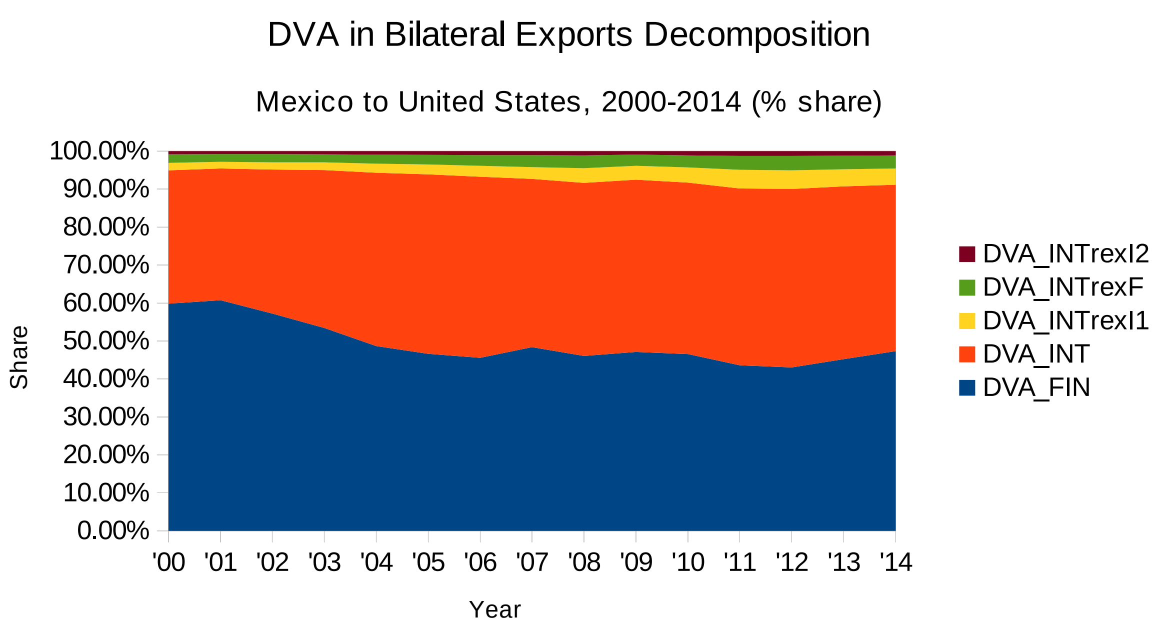


FIGURE 7

Figure 7.1

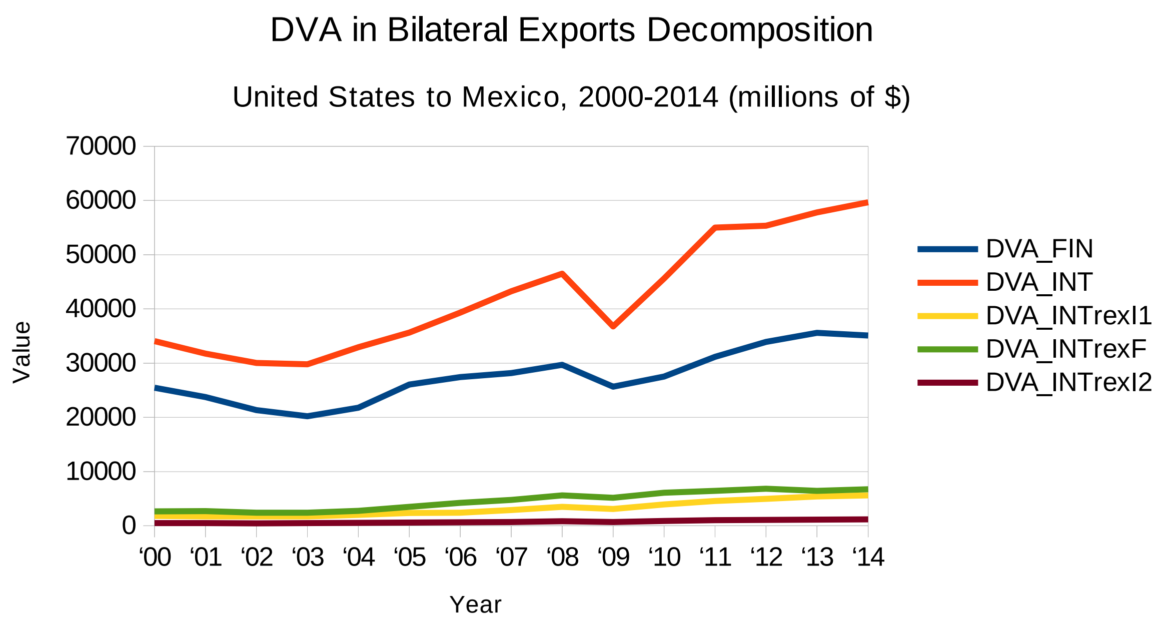


Figure 7.2

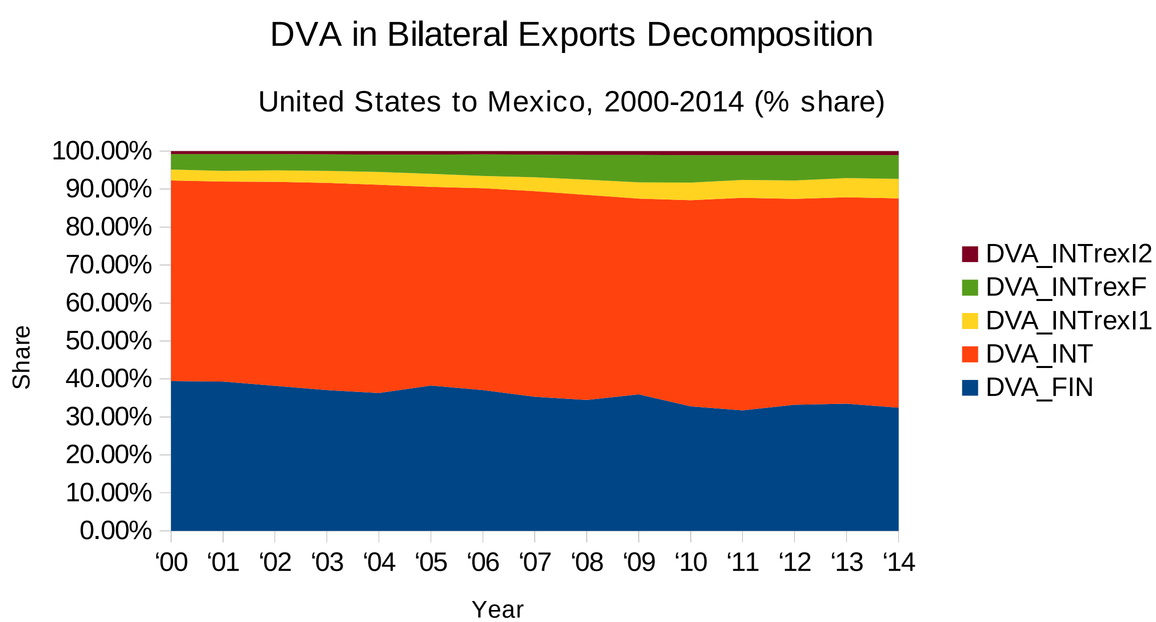


FIGURE 8

Figure 8.1

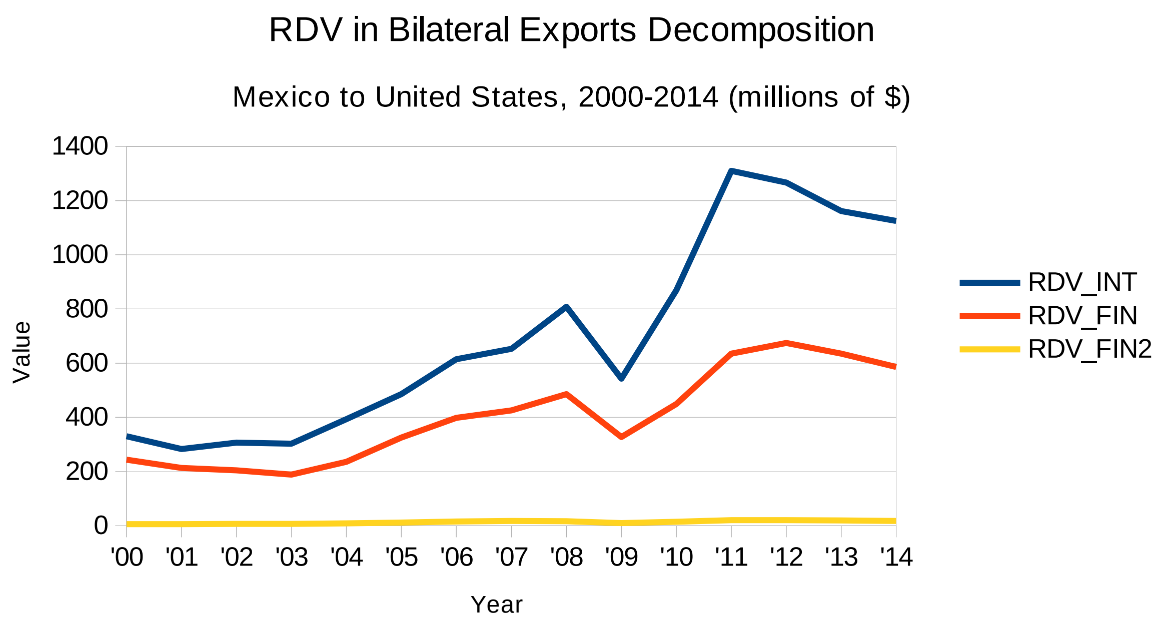


Figure 8.2

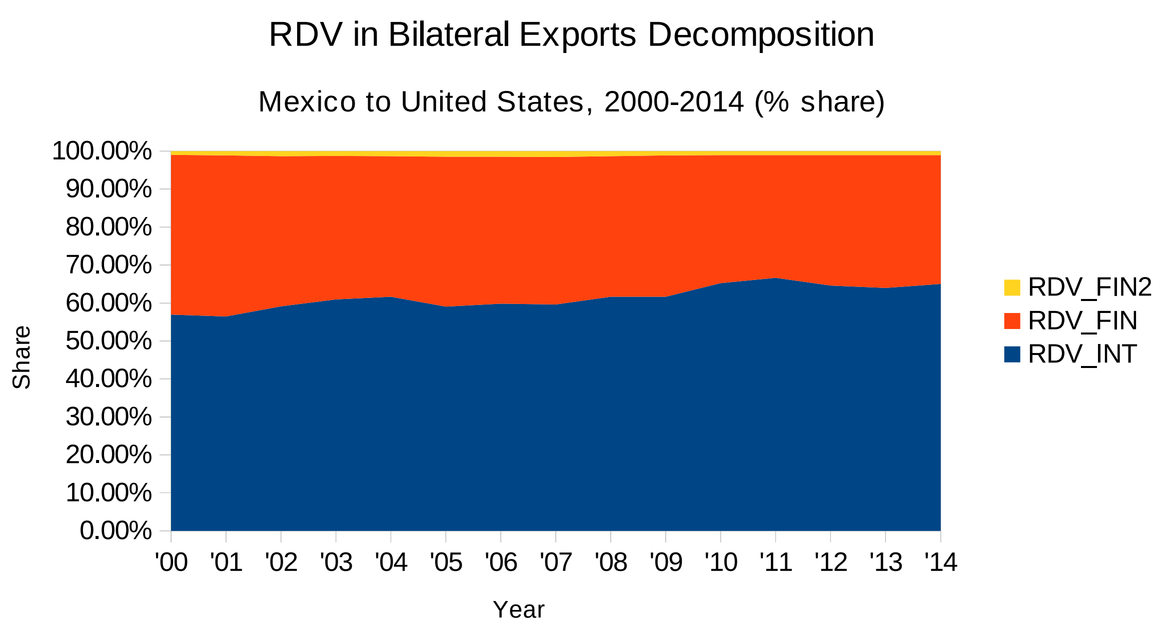


FIGURE 9

Figure 9.1

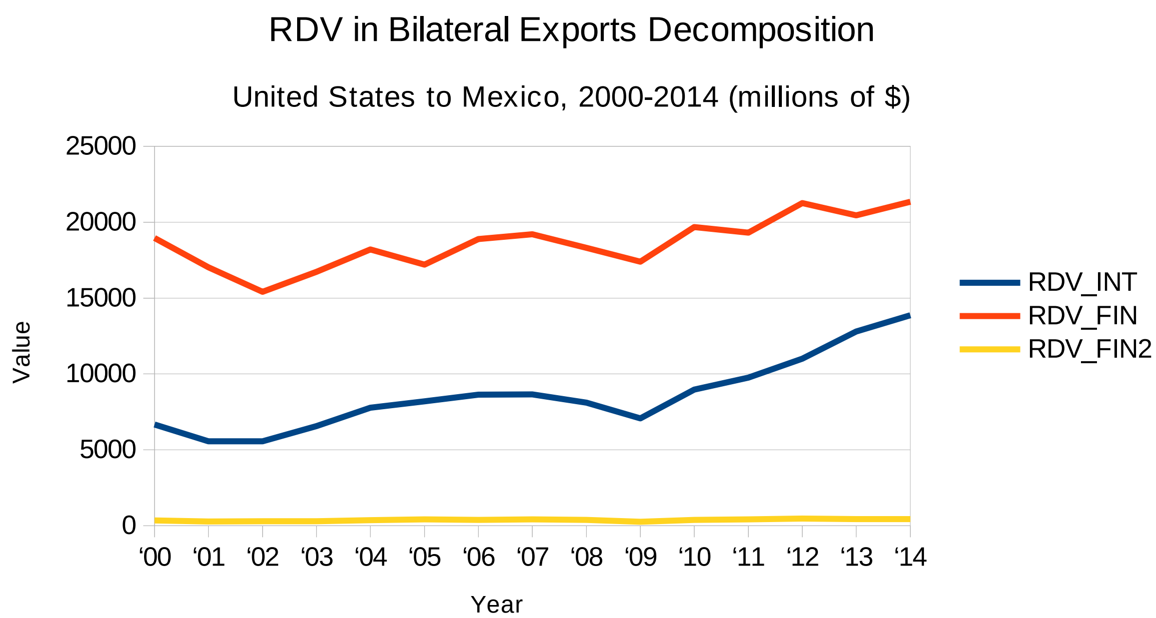


Figure 9.2

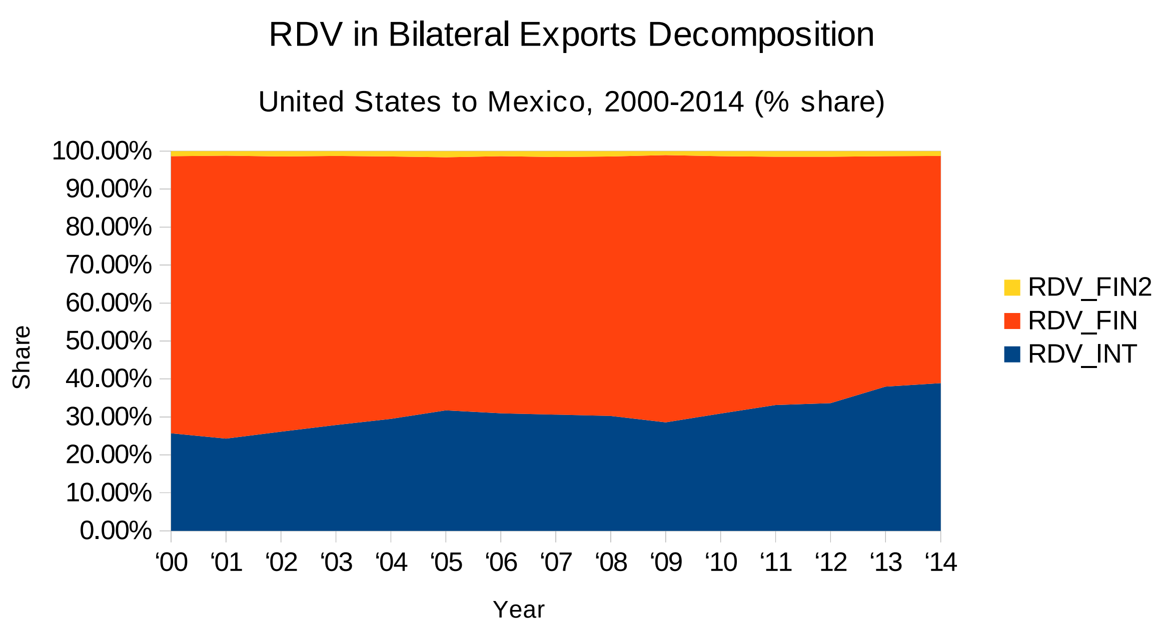


FIGURE 10

Figure 10.1

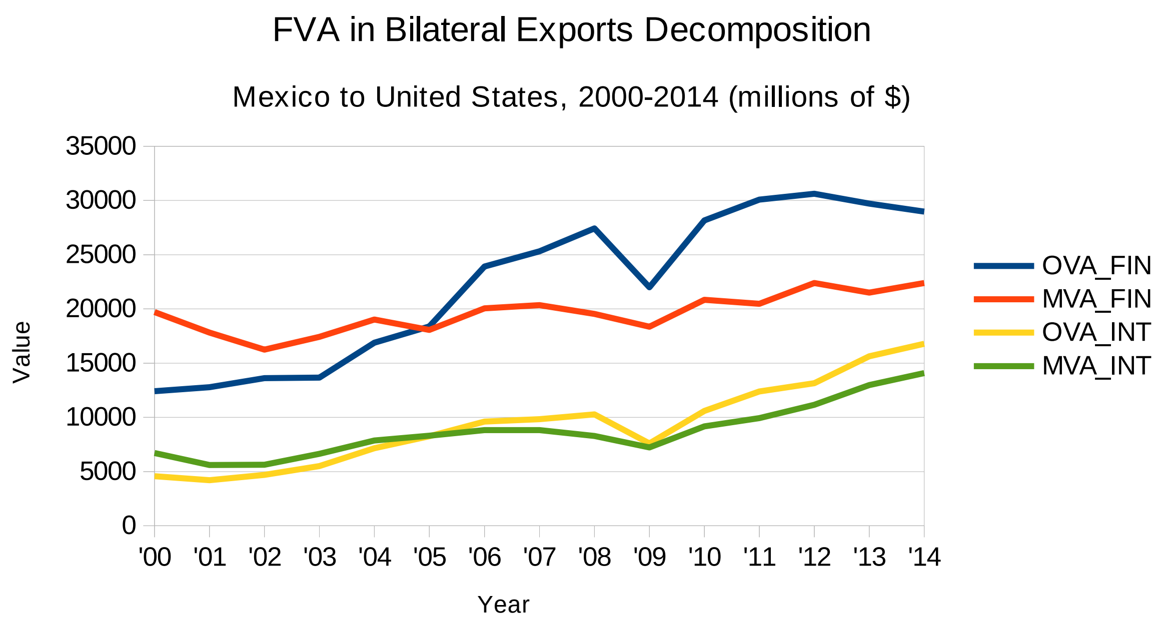


Figure 10.2

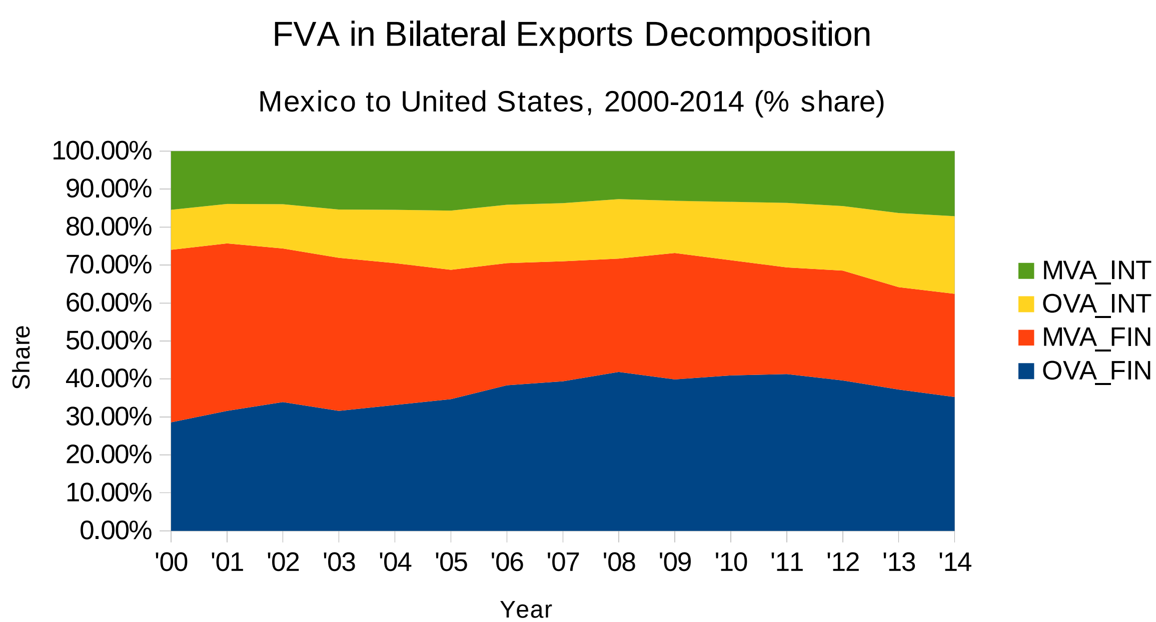


FIGURE 11

Figure 11.1

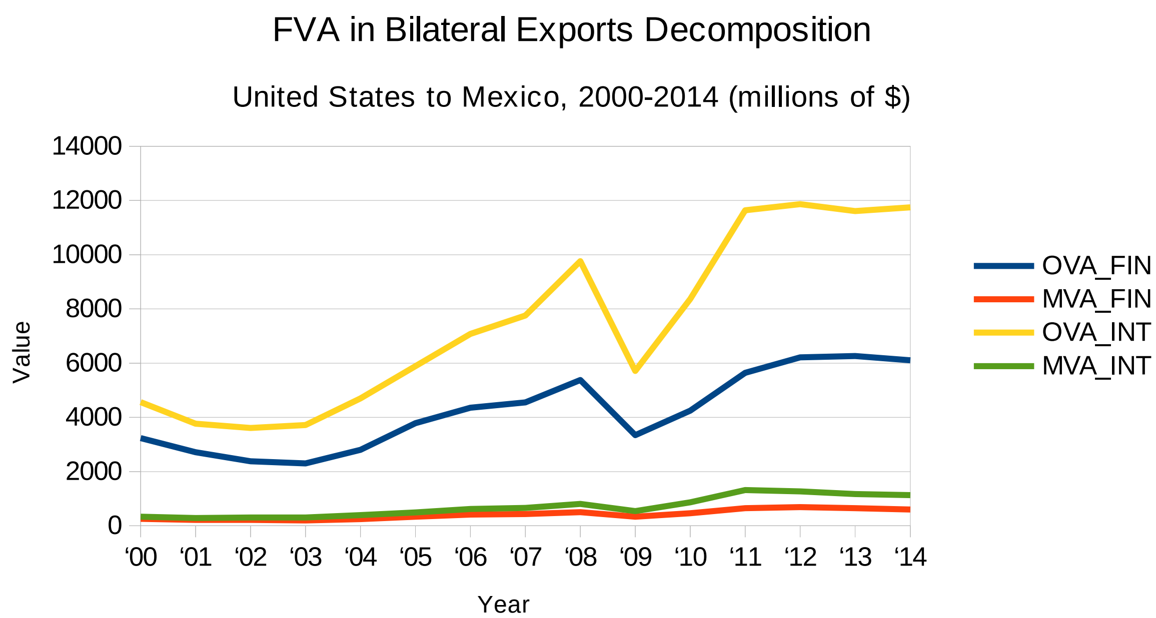


Figure 11.2

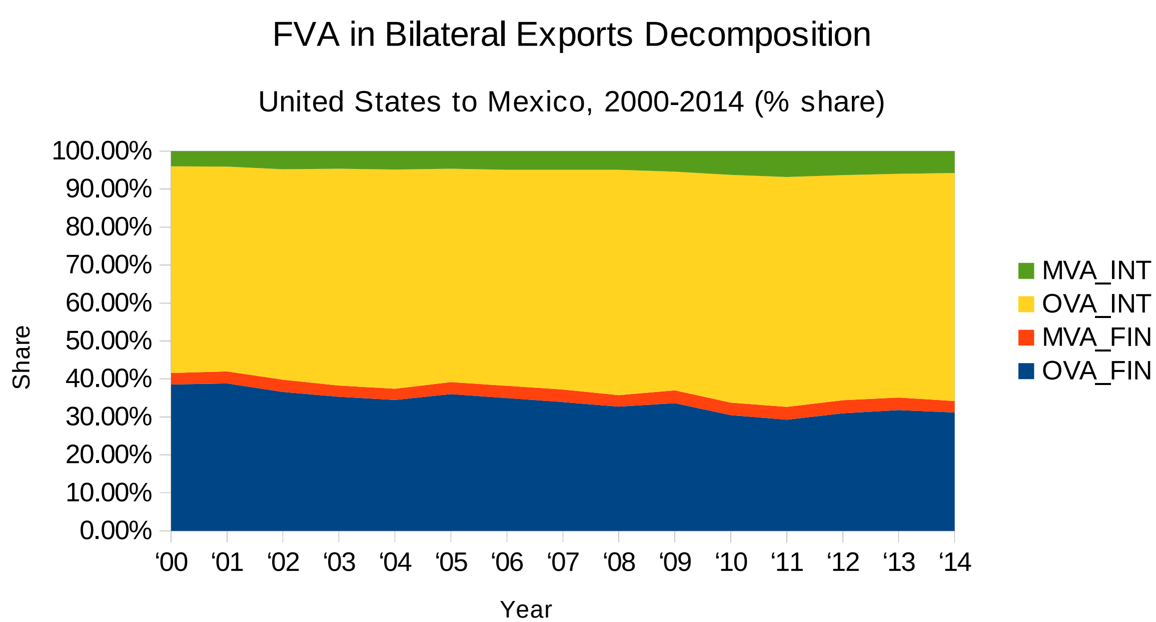


FIGURE 12

Figure 12.1

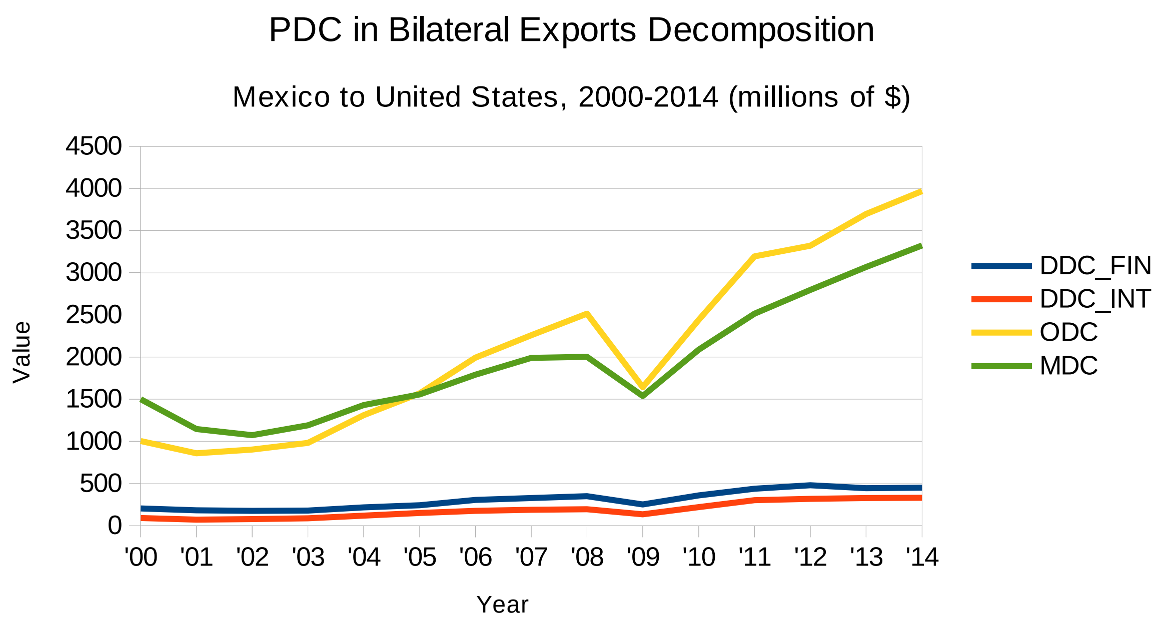


Figure 12.2

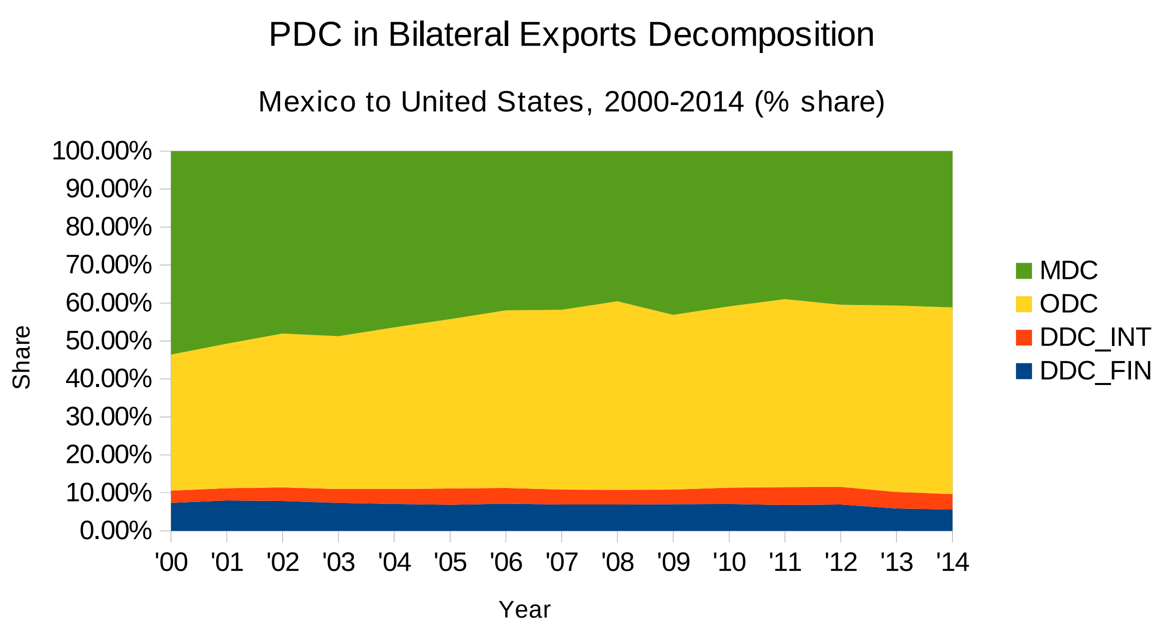


FIGURE 13

Figure 13.1

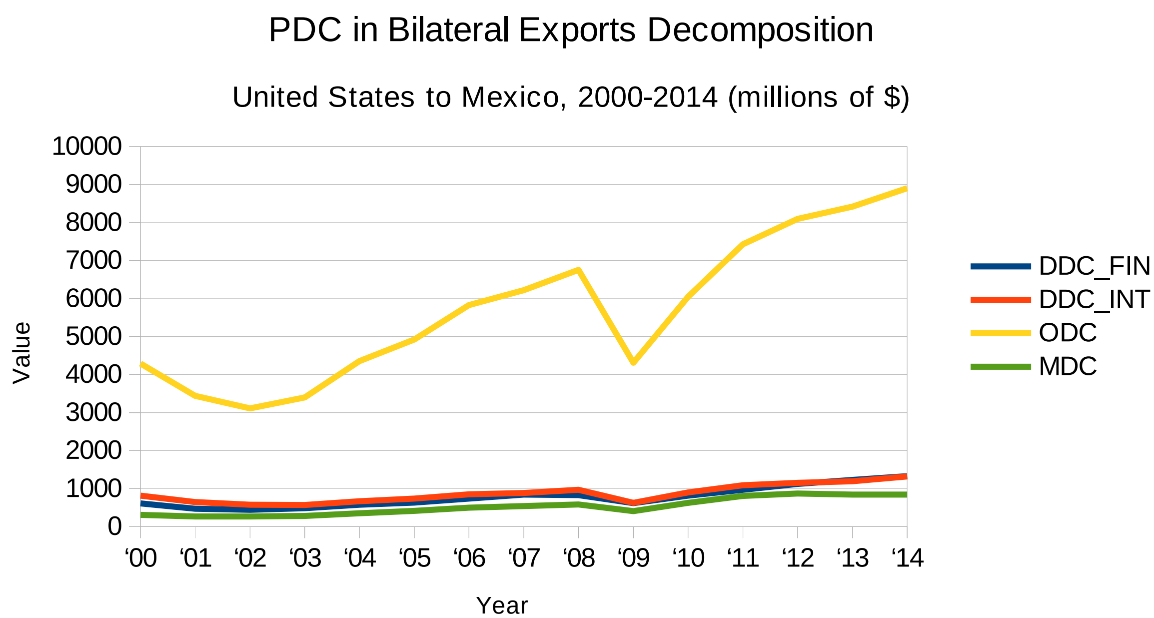
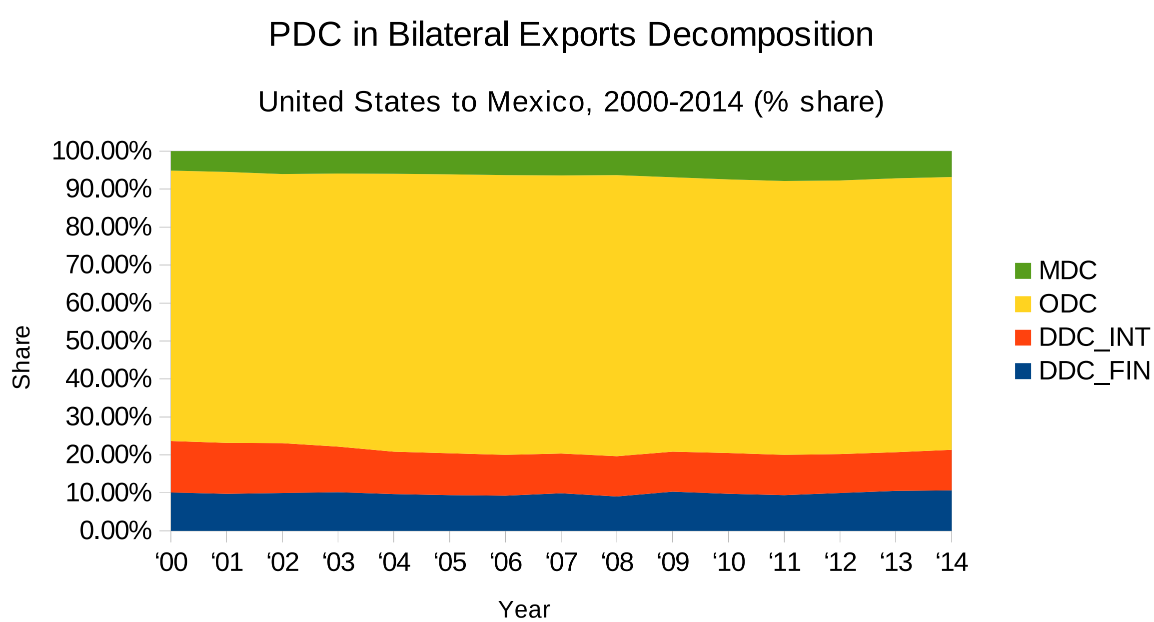


Figure 13.2



Appendix

$$x_{11}^{JN}=M_1\left(y_{11}+\frac{a_{12}}{1-a_{22}}y_{21}\right)$$

$$M_1=\left(1-a_{11}-\frac{a_{12}a_{21}}{1-a_{22}}\right)^{-1}$$

$$x_{11}^{JN}=\left(1-a_{11}-\frac{a_{12}a_{21}}{1-a_{22}}\right)^{-1}\left(y_{11}+\frac{a_{12}}{1-a_{22}}y_{21}\right)$$

$$x_{11}^{JN}=\frac{y_{11}+\frac{a_{12}y_{21}}{1-a_{22}}}{1-a_{11}-\frac{a_{12}y_{21}}{1-a_{22}}}$$

$$x_{11}^{JN}=\frac{\frac{y_{11}(1-a_{22})}{1-a_{22}}+\frac{a_{12}y_{21}}{1-a_{22}}}{\frac{1-a_{22}}{1-a_{22}}-\frac{a_{11}(1-a_{22})}{1-a_{22}}-\frac{a_{12}a_{21}}{1-a_{22}}}$$

$$x_{11}^{JN}=\frac{\frac{y_{11}-a_{22}y_{11}+a_{12}y_{21}}{1-a_{22}}}{\frac{1-a_{22}-a_{11}+a_{11}a_{22}-a_{12}a_{21}}{1-a_{22}}}$$

$$x_{11}^{JN}=\frac{y_{11}-a_{22}y_{11}+a_{12}y_{21}}{1-a_{22}-a_{11}+a_{11}a_{22}-a_{12}a_{21}}$$

$$x_{11}^{KWW}=b_{11}y_{11}+b_{12}y_{21}$$

$$b_{11}=\frac{1-a_{22}}{(1-a_{11})(1-a_{22})-a_{12}a_{21}}$$

$$b_{12}=\frac{a_{12}}{(1-a_{11})(1-a_{22})-a_{12}a_{21}}$$

$$x_{11}^{KWW}=\left(\frac{1-a_{22}}{(1-a_{11})(1-a_{22})-a_{12}a_{21}}\right)y_{11}+\left(\frac{a_{12}}{(1-a_{11})(1-a_{22})-a_{12}a_{21}}\right)y_{21}$$

$$x_{11}^{KWW}=\frac{y_{11}-a_{22}y_{11}+a_{12}y_{21}}{(1-a_{11})(1-a_{22})-a_{12}a_{21}}$$

$$x_{11}^{KWW}=\frac{y_{11}-a_{22}y_{11}+a_{12}y_{21}}{1-a_{22}-a_{11}+a_{11}a_{22}-a_{12}a_{21}}$$