Origin and Destination Sectors of Indirect Domestic Value Added Embodied in Mexico's Manufacturing Exports

Fujii-Gambero, Gerardo and Cervantes-Martínez, Rosario

School of Economics, National Autonomous University of Mexico (UNAM)

2015

ORIGIN AND DESTINATION SECTORS OF INDIRECT DOMESTIC VALUE ADDED EMBODIED IN MEXICO'S MANUFACTURING EXPORTS[1]

Gerardo Fujii-Gambero. School of Economics, National Autonomous University of Mexico (UNAM), fujii@unam.mx
Facultad de Economía, edificio B, cubículos 111 y 112
Ciudad Universitaria
Universidad Nacional Autónoma de México
04510 México, D.F.
Tel. (52 55) 56 22 21 72

Rosario Cervantes-Martínez. University Center for Economic and Administrative Sciences, University of Guadalajara, Mexico, mariac@cucea.udg.mx

[1] A preliminary version of this paper was published in Levy Economics Institute Working Papers Collection, No. 760, 2013.

ORIGIN AND DESTINATION SECTORS OF INDIRECT DOMESTIC VALUE ADDED EMBODIED IN MEXICO'S MANUFACTURING EXPORTS

Gerardo Fujii-Gambero
Rosario Cervantes-Martínez

Abstract

As domestic exports usually require imported inputs, the value of exports differs from the domestic value added contained in exports. The higher the domestic value added contained in exports, the higher domestic national income created by exports will be. In this case, exports will expand the domestic market. Therefore, exports will stimulate economic growth in two ways: through their direct effect on aggregate demand and through their effect on the domestic market. For these reasons, the estimate of the magnitude of the domestic value added contained in exports helps explain the capacity of exports to lead economic growth.

Domestic exports may be classified in direct and indirect exports. Direct exports are the goods sold to other countries, and indirect exports are the domestically produced inputs incorporated in direct exports. The distinction between direct and indirect exports leads to the distinction between direct and indirect domestic value added contained in exports. Direct value added consists of incomes paid to the production factors directly involved in exports, while indirect value added equals the income contained in domestically produced inputs incorporated into exports. Therefore, the magnitude of indirect value added depends on the density of the domestic inter-sectoral linkages.

The purpose of this paper is to present an estimation of domestic indirect value added contained in Mexico's manufacturing exports in two ways. The first one derives from the fact that a direct exporting sector may be the vehicle through which other sectors may export in an indirect way. This leads us to estimate the indirect value added contained in exports by sector of *origin.* The second way refers to the sectors of *destination* of this indirect value added, that is, the direct exporting sectors in which the value added contained in indirect exports of each sectors appears. Calculations are based on a 2003 input-output matrix for Mexico (INEGI, 2008). Results for the maquiladora-industry exports are shown separately from the rest of manufacturing. In order to distinguish the indirect value added in exports by sector of origin and destination of intermediate inputs, we work with square matrixes of indirect domestic value added multipliers.

Key words: Domestic value added in exports, Indirect value added, Indirect value added by sector of origin, Indirect value added by sector of destination.

JEL classification: C67, E01

1. Introduction

A formula often found in the opening of any macroeconomics text asserts that income is equal to the sum of internal demand and net exports. Although the value of the flow of exports determines the amount of imports that it can finance and thus influences the level of income, the fact that exported goods incorporate imported intermediate goods means that the value of exports will be different to the domestic value added contained in exports. The higher the domestic value added in exports, the higher the export sector's share of national income, meaning that exports can lead to a greater expansion of the domestic market, and that exports can encourage growth both as a direct expansion of aggregate demand, as well as through their effect on domestic demand. Therefore, if we know how much domestic value added is contained in exports, we can better explain the ability of the export sector to boost growth of the economy as a whole.

In the past few decades, the international fragmentation of production processes in some sectors, most noticeably in the electronics and automotive industries, has increased dramatically. Fragmentation has widened the gap between the value of exports and domestic value added in exports, insofar as production in the electronics and automotive sectors uses a very high level of imports.

This has encouraged a growing number of investigations, both in developed countries as well as in some recently industrialized countries, whose purpose is to calculate the domestic value added contained in exports. Some of this research has been conducted by Breda, Cappariello, and Zizza (2007); Breda and Cappariello (2008); Daudin, Rifflart and Schweisguth (2009); and Johnson and Noguera (2011).

In recent studies on this topic, domestic value added in exports has been split into direct and indirect components (Chen, Cheng, Fung and Lau (2005); Chen, Cheng, Fung, Lau, Sung, Yang, Zhuy and Tang, (2008); Koopman, Wang and Wei (2008); He and Zhang (2010); y De la Cruz, Koopman and Wang (2011)). This division arises because domestic exports can be classified into these same categories. If direct exports are represented by goods sold abroad, then indirect exports are the domestically-produced inputs that are included in products directly exported by the country. The more intense both backward and forward linkages are, the greater indirect exports will be. The division of domestic exports into direct and indirect components implies that the domestic value added contained in

exports may also be split into direct and indirect elements. The former is equal to the income paid to owners of factors of production directly involved in export activity; the latter represents income contained in domestic inputs that are included in exports. Therefore, the magnitude of domestic indirect value added in exports in an economy depends on the intensity of the intra and inter-sectoral linkages within the country. If two economies have the same level of exports, but one of them has denser internal linkages than the other, the exports from the former will generate a higher share of national income than the latter. In other words, the increase in domestic value added in exports establishes a means of overcoming the traditional conception that views domestic-demand-led and export-led growth as alternative paths. Several authors have highlighted other relevant aspects of the same concern; Timmer, Los, Stehrer and Vries (2013) proposed rethinking the concept of competitiveness in terms of domestic value added incorporated in exports.

The objective of this paper is to propose a new way of looking at indirect domestic value added incorporated into Mexico's manufacturing exports. Intermediate goods incorporated into exports are indirect exports, considered herein from two perspectives: when we refer to indirect value added by sector of origin, our point of departure is the sector that is directly exporting and demanding intermediate goods to produce the goods ultimately bound for export. These intermediate goods have their origin in different sectors and, from this perspective, we track the sectors in which these intermediate goods have been produced. In other words, this procedure allows us to identify the distribution of value added (VA) contained in the intermediate inputs of domestic origin that are incorporated in exports according to the sector that produced them. When we use the expression indirect value added in exports according to the destination sector, our point of departure is the intermediate goods-producing sector that is the indirectly exporting sector. In this case we are interested in identifying, for each sector producing intermediate goods, the directly exporting manufacturing sectors that purchase these intermediate goods, and which, therefore, serve as conduits through which indirect value added produced by other sectors is being exported. Analysis of this data from this perspective allows us to identify the distribution of the indirect value added exported by each sector among the direct exporting sectors.

The systematization of information in these two ways is important for all economies, since it allows us to identify the intensity of domestic relationships between the direct exporting sectors and the sectors that supply them with intermediate goods, which operate as indirect exporters from these two perspectives: on the one hand, from the perspective of sectors that produce indirect value added that is incorporated in exports and, on the other hand, from the perspective of direct exporting sectors that serve as a vehicle for the export of indirect value added. This is a particularly relevant for economies whose export sector is strongly integrated into global value chains, such as Mexico's, given that its value chain helps determine the export sector's contribution to the generation of domestic product.

Calculations are based on data from Mexico's input-output matrix for 2003 (INEGI, 2008) that allow us to partition the economy into two sectors: the maquiladora export industry (MEI), and the domestic economy (e.g., that part of the economy that excludes the first). The 2008 matrix no longer includes this division and for this reason it is not possible to investigate separately the indirect value added in exports from the maquiladora industry, which, undoubtedly, is the most relevant.

This paper is structured as follows: section 2 provides a brief description of the growth of Mexico's exports and the transformations they have undergone; section 3 lays out briefly the results of two previous investigations on VA incorporated in Mexico's manufacturing exports and endeavors to explain the differences between the conclusions of these papers and the data contained in the OECD's data base, *Trade in Value Added*; section 4 explains the methodology for breaking down indirect domestic value added in manufacturing exports by origin and destination sectors, and section 5 outlines the distribution of indirect value added by origin and destination sectors for 2003. The paper ends by discussing the conclusions.

2. Growth and Changes in Exports

Between 1992 and 2012 Mexico's total exports grew considerably, from a point just shy of 50 billion dollars to some 375 billion dollars over a sixteen-year period. This led to a marked increase in the country's export coefficient, from 13% to more than 30% over the same period (Banco de México, 2013).

Mexico's export growth occurred simultaneously with a change in the make-up of exported goods. Table 1 shows data regarding the country's export profile. The main conclusions are:

- Manufacturing exports represent 84% of the country's total exports (2013).
- Medium-to-high-technology manufacturing exports comprise 78% of industrial exports (2012).
- Exports of transportation equipment and electronics contributed the greatest share of manufacturing exports: 29% and 28%, respectively (2003).
- The greatest share of manufacturing exports comes from the maquiladora industry (62% in 2003). Its weight in exports of electronic equipment was overwhelming (88%).

For the purposes of this paper, it is important to consider the weight of the maquiladora industry and the rest of the economy in exports, since the former sector can be characterized as being import intensive in parts and components, which are then assembled within Mexico to produce final export goods. Further, by thus considering these sectors, we can evaluate export data by level of technology, obtained from the classification of products by technological level, from another perspective; it is entirely possible that a country can specialize in a technologically simple phase of a product that is itself of high technology. This is especially important to consider in countries in which an important portion of manufacturing exports are generated within the context of global value chains where Mexico participates intensely. Its role within the framework of these chains is located in the unskilled but labor-intensive process, meaning that, although the product itself is of high technology, the productive process carried out within Mexico is technologically unsophisticated.

[Table 1]

Yet, notwithstanding the growth and transformations within the export sector, economic growth has been relatively modest at 2.6% (1994-2012). We can partially explain this significant contrast between exports and growth by highlighting that the domestic value added content in manufacturing exports is not particularly high.

3. Domestic Value Added in Exports

Based on the 2003 matrix prepared by INEGI and discussed in Fujii and Cervantes (2013), we present in what follows the calculations of domestic value added contained in manufacturing exports, both for all exports as well as for the domestic economy, for the maquiladora export industry, and for sectors with the greatest weight in manufacturing exports. What follows is based largely on the main conclusions of the paper just cited (see Table 2):

- For all manufacturing exports, domestic value added represents 42% of exports; in domestic economy exports, this coefficient is significantly higher than maquiladora industry exports (75% vs. 22%).
- This coefficient is significantly lower in electronic equipment exports (21%) as compared to transportation equipment (50%). Given the weight of the maquiladora sector in exports of the electronic industry, the former figure is very much influenced by the extremely low domestic value added contained in exports of electronic products originating in this export sector (14%). Looking at transportation equipment exports, more than half comes from the domestic economy in which domestic value added is equal to 68% of export value.
- For total manufacturing exports, direct value added is 23% of all exports, while indirect value added is 20%. Obviously these coefficients are significantly lower in electronic industry exports (13% and 8%, respectively), and even lower in the exports of the maquiladora industry's electronic products: direct value added is equal to 8% of exports, and indirect value added is 6% of exports.
- In transportation equipment exports, to which the domestic economy contributed more than half of exports, direct value added is equal to 27% of exports and indirect value added to 22% of exports; these figures are significantly higher in exports of the domestic economy than in those of the maquiladora industry (35% and 33%, and 17% and 8%, respectively).

[Table 2]

In papers by De la Cruz, Koopman and Wang (2011) and in the OECD database, *Trade in Value Added*, export value is also divided into direct and indirect domestic, and foreign, value added. According to OECD data, domestic value added contained in Mexico's manufacturing exports represents 62.1% of exports; direct domestic value added, 31%; and indirect domestic value added, 31.1% (2009). Papers by De la Cruz, Koopman and Wang show two blocks of data (lower and upper bound), to three and four digits of the North American Industry Classification System for three years (2000, 2003, and 2006) for all manufacturing exports and for maquiladora-industry exports. Estimates of the lower bound are very similar to those in Fujii and Cervantes, but not those of the upper bound, in which domestic value added in exports turns out to be substantially lower. Reasons for these differences are the following: in OECD data, indirect domestic value added is equal to domestic value added incorporated only in intermediate goods that are directly necessary to produce export goods. In other words, this concept of indirect domestic value added in exports does not include domestic value added that is created in phases that are upstream in the direct production of intermediate goods incorporated in exports. In estimations carried out by De la Cruz, Koopman and Wang (2001), and by Fujii and Cervantes (2013), indirect domestic value added includes both that which is generated in direct production of intermediate goods of domestic production that are directly incorporated to exports, as well as VA that is created at all stages that within the country produce inputs for the production of intermediate goods of domestic origin that are incorporated in exports. Secondly, the two aforementioned papers contain disaggregated data for the domestic economy and for the maquiladora-export industry, which does not occur with the OECD data. By not considering the specificity regarding the generation of VA in the sector that contributes more than 60% of the country's manufacturing exports, the result should be an overestimation of the content of domestic value added in exports that greatly exceed the underestimation derived from a rigid meaning of the concept of indirect domestic value added as defined by the OECD.

With regards to the first point, INEGI (2008b) explains two fundamental differences between the maquiladora-export industries (MEI) and those of the domestic economy that are relevant for the topic taken up herein: First, MEI companies use a greater share of imported inputs; second, MEI companies do not supply intermediate inputs to companies of

the domestic economy, since all of their production is exported (INEGI, 2008b:35). Thus the estimation presented herein is based on INEGI's information and allows us to distinguish between two types of exported products: those from the domestic economy that use relatively less imported inputs and can simultaneously be sold as goods in process or as final consumer goods; and other products, from the maquiladora industry, that incorporate a larger share of intermediate inputs and are only sold in foreign markets. In contrast, in preparing the import matrices that the OECD-WTO use for their estimations, an assumption of proportionality is made, "…which assumes that the share of imports of any product consumed directly as intermediate consumption or final demand (except exports) is the same for all users." (OECD-WTO, 2012:15). By not distinguishing between users of imports (the destination sectors), an overestimation of domestic value added content is made, since, in the Mexican economy, import coefficients vary significantly by sectors and, also, by whether the imported product is for intermediate consumption (work-in-progress) or for final consumption (finished product). Another possible source of discrepancy between INEGI estimations and those of the OECD-WTO has to do with the fact that the classification by economic sectors that each entity uses does not coincide exactly (we have noted previously that INEGI uses the North American Industry Classification System).

Lastly, the differences in the upper-bound estimations done by De la Cruz, Koopman, and Wang, on the one hand, and by Fujii and Cervantes, on the other, are due to the fact that in the first paper maquiladora industry exports include exports incorporated in the Mexican government's High-Volume Exporting Companies Program, which means that 90% of manufacturing exports become processing exports. In our paper, the maquiladora industry refers solely to the industry that, according to INEGI, is classified as such; secondly, our knowledge of the Mexican economy makes it difficult to accept that almost all of the country's manufacturing exports are processing exports.

4. Methodology

Following the work of Koopman, Wang and Wei (2008) and that of He and Zhang (2010), in Fujii and Cervantes (2013) we explained the methodology used to calculate the total domestic value added contained in Mexico's manufacturing exports. With data from INEGI's 2003 input-output tables, the matrices of VA multipliers for the domestic economy

(DE) and the maquiladora export industry (MEI) are expressed by equations (1) and (2), respectively.

$$M^{DE} = A_V^{DE}(I - A^{DE})^{-1} \quad (1)$$

$$M^{MEI} = \left((A_V^{DE}(I - A^{DE})^{-1})\, A^{MEI}\right) + A_V^{MEI} \quad (2)$$

where M^{EI} is a nxn dimension matrix, whose elements $m_{i,j}^{DE}$ represent the share of domestic value added attributed to sector i by unit of export in sector j, produced by non-maquiladora companies; n is the number of branches or subsectors of the economy; $(I - A^{DE})^{-1}$ is the known Leontief inverse matrix; and A_V^{DE} is the diagonal matrix of value-added coefficients, whose elements in the main diagonal are obtained by dividing the VA by sector i by the gross value of production in that same sector. Therefore, when $i = j$, the direct and indirect intra-industrial effects are obtained, all elements not found in the main diagonal represent solely indirect effects.

With regards to the effect that the maquiladora export industry exports have on the generation of domestic value added, in equation (2) the term $(A_V^{DE}(I - A^{DE})^{-1})\, A^{MEI}$ corresponds to the indirect effects that maquiladora-industry exports have on the companies of the domestic economy. Where A^{MEI} is a matrix of nxn dimensions and its elements represent the share of inputs consumed by the export sector j that come from companies within the domestic economy; A^{MEI} is a matrix of coefficients of domestic inputs consumed by the MEI and provided by the DE. Note that $A_V^{DE}(I - A^{DE})^{-1}$ is the value-added multiplier matrix from DE. Finally, A_V^{MEI} is a diagonal matrix of value-added coefficients from the MEI and represents the direct effects of maquiladora exports on domestic value added.

When estimating the effects that manufacturing exports have on domestic value added, in equations (1) and (2), the assumption is that the model's equilibrium depends mainly on conditions of demand, in accordance with a production function of fixed proportions. This means that if, in the expression $(I - A^{DE})^{-1}$, the inverse of Leontief, there are an infinite number of rounds of intermediate demand to satisfy a unit of final demand of each of the sectors, then in each round the shares of intermediate inputs and the value-added coefficients remain constant. Likewise, with this method, it is not possible to ascertain how and to what extent domestic value added generated by exports, either direct

or indirect, affects the other vectors that make up final demand (consumption or investment)[2].

Thus the model we use in this paper can be interpreted as an *ex post* equilibrium model in the sense that, for the period in question (2003), we take as given the following variables and coefficients: 1) final demand vector; 2) export vector; 3) technical coefficients matrix; and 4) value-added coefficients vector. Therefore this is a domestic value added (GDP) distribution model, based on the value of manufacturing exports among direct exporting sectors and indirect exporting sectors.[3] Consequently, the limitations in the methodology adopted come mainly from the inability to explain how an export vector, based on VA generated directly and indirectly, affects the level of household consumption derived from wages paid to people employed, or even, based on that same value added, how investment can be induced based on the profit margin generated through exports.

To estimate just the indirect effects of manufacturing exports on the generation of domestic value added, in equations (3) and (4), we find the "indirect value added multipliers" matrices.

$$MI^{DE} = A_V^{DE}[(I - A^{DE})^{-1} - I] \quad (3)$$

$$MI^{MEI} = (A_V^{DE}(I - A^{DE})^{-1})\, A^{MEI} \quad (4)$$

Where MI^{DE} is a matrix of nxn dimensions, its elements $mi_{i,j}^{DE}$ represent indirect value added generated by sector i by unit of export of sector j. Thus, for example, if the value of multiplier $mi_{i,j}^{DE}$ is equal to zero, this means that sector i does not produce inputs for sector j; in other words, the position variables represent the origin and destination sectors of the inputs, respectively.

It can be shown, based on equation (3), that subtracting the identity matrix (*I*) from the inverse of Leontief does not eliminate the initial effect in the generation of domestic value added given by the direct effect per unit of exported product. As stated previously,

[2] With respect to the limitations of the input-output model based on the inverse of Leontief, and on the calculation of the VA generated, see the discussion in Guerra and Sancho (2010), and Maresa and Sancho (2012).

[3] See Los, Timmer and Vries (2012), and Timmer, Los, Stehrer, and Vries (2013) regarding the illustrative and explanatory value of the input-output model using the inverse of Leontief in the generation of value through inter-industrial relationships.

since this is an *ex post* model, and given the distributive property of matrix multiplication, we derive from equation (3):

$$MI^{DE} = (A_V^{DE}(I - A^{DE})^{-1}) - (A_V^{DE} I) \quad (5)$$

And by the properties of the identity matrix:

$$MI^{DE} = [(A_V^{DE}(I - A^{DE})^{-1}) - (A_V^{DE})] \quad (6)$$

Multiplying equation (6) by a diagonalized matrix with ones in the main diagonal and zeroes in the rest, of dimension nxn, $\hat{f}$, and assuming a unit of exported product in each sector:

$$MI^{DE} = [(A_V^{DE}(I - A^{DE})^{-1}) - (A_V^{DE})]\,\hat{f} \quad (7)$$

Then, by the distributive property,

$$MI^{DE} = (A_V^{DE}(I - A^{DE})^{-1})\hat{f} - (A_V^{DE})\hat{f} \quad (8)$$

We obtain that equation (3) and equation (8) are equivalent and represent the indirect effects that final demand has in the generation of VA in supplier sectors of intermediate inputs: the subtraction of direct value added, expressed by $(A_V^{DE})\hat{f}$, is done after exports $\hat{f}$ generated the indirect effect by means of the expression $(A_V^{DE}(I - A^{DE})^{-1})\hat{f}$.

Thus equation (3) is considered to be a matrix of multipliers because, for each unit of exported product in sector *j*, in any element $mi_{i,j}^{DE}$ we know how much VA in sector *i* was generated, in addition to the direct value added in export sector *j*. Further, the coefficient $mi_{i,j}^{DE}$ is the ratio of change of VA in sector *i* as a result of increases in exports of sector *j*.

A reading by columns, both in equation (3) and equation (4), yields the concept of backward linkages derived by a fixed-proportion production function, which excludes the possibility of substituting intermediate inputs, so that the coefficients can be added to obtain the total indirect effects of export sector *j*. Yet if we read by rows, we get a dichotomous or binary interpretation, in the sense that if we begin with a fixed-proportion production function, sector *i* does provide a certain amount of inputs to export sectors *j*, or it does not provide inputs because these are not required in the production processes. In other words, if we read by rows, in principle we are interested in determining how many elements have a value equal to zero and how many have a positive number.

If the industrial classification corresponds to products that, under the conditions of a fixed-proportion production function, can be incorporated in other productive process in which value is added to them, a reading by rows of a matrix of indirect effects would indicate a potential level of diversification of production in sector *i* as an intermediate input. This means, indirectly, to the extent that within each industrial sector *i* there are more null entries, this sector will be more dependent on its own final demand and, at the same time, will benefit less from the positive changes in final demand in the remaining industrial sectors.

Thus for the purposes of this paper, the idea of "forward linkages" is not associated with the supply conditions by industrial sector, in the sense that companies can market their production in fixed proportions among different destination sectors, as assumed in the Ghosh matrix (Ghosh, 1958). Notwithstanding that Guerra and Sancho (2010) have shown that the supply model represented by the inverse of Ghosh can be simplified to the demand model represented by the inverse of Leontief by means of a fixed-proportion production function, the purpose of introducing an estimation of indirect value added in matrix form is to demonstrate how industries participate as indirect exporters, in other words, as suppliers of intermediate inputs, for a given vector of manufacturing exports.

Calculating the indirect effects on domestic value added associated with maquiladora industry exports means estimating total inputs demanded by sectors *j* of the MEI, of sectors i of the DE, as if these inputs were exported by companies in the domestic economy. Thus, in equation (4), we see how, by means of the inverse of Leontief, if sector *j* of the MEI consumes one unit of input (product) that originates in sector i of the DE, the production of this input, in turn, demands a certain quantity of inputs from companies in the domestic economy. So, each multiplier is the result of the product between each one of the value-added multipliers of the DE by the share of domestic inputs incorporated into the production of goods in each one of the MEI sectors. In equations (9) and (10), an example shows how an indirect value-added multiplier is calculated:

$$mi_{11}^{DE} = va_1^{DE} r_{11}^{DE} - va_1^{DE} \tag{9}$$

$$mi_{11}^{MEI} = (va_1^{DE} r_{11}^{DE}) ci_{11}^{MEI} + (va_1^{DE} r_{12}^{DE}) ci_{21}^{MEI} + (va_1^{DE} r_{13}^{DE}) ci_{31}^{MEI} + \cdots + \\ \ldots + (va_1^{DE} r_{1n}^{DE}) ci_{n1}^{MEI} \tag{10}$$

where terms $r_{i,j}^{DE}$ are elements from the inverse of Leontief inverse and represent the coefficients of input or total product requirements in sector i needed to satisfy a unit of final demand in sector j; va_i^{DE} is the coefficient of VA in sector i of the domestic economy; and ci_{ij}^{MEI} is the coefficient of domestic inputs that sector j of the maquiladora industry demands from sector i of the DE.

Thus, the value of multiplier mi_{11}^{DE} in equation (9) represents the quantity of VA generated by the purchase of inputs from sector 1 (origin) to produce one unit of exportable product in this same sector (destination); therefore, in the equation, only direct value added is subtracted.

On the other hand, in equation (10), coefficient ci_{11}^{MEI} shows us the share of domestic inputs that one unit of product in sector 1 (destination) of the MEI buys from sector 1 (origin) of the DE, while coefficient ci_{21}^{MEI} indicates the share of domestic inputs that sector 1 of the MEI purchases from sector 2 of the DE in order to produce one unit of product, and so successively until coefficient ci_{n1}^{MEI}, which indicates what the share is of domestic inputs of sector n of the DE that is demanded to produce a good in sector 1 of the MEI.

Hence, in expression $(va_1^{DE} r_{11}^{DE}) ci_{11}^{MEI}$, what is measured is total VA generated in sector 1 of the DE (originating sector of total inputs) by unit of exports in sector 1 of the MEI. Expression $(va_1^{DE} r_{12}^{DE}) ci_{21}^{MEI}$ measures VA in sector 1 of the DE that is generated because this sector is providing inputs to sector 2 of the DE, and the latter, in turn, sells inputs to sector 1 of the MEI, which, in the end, exports all its production. In other words, the sum of all terms in equation (9) represents total VA generated in sector 1 of the DE because it provides, directly and indirectly, inputs to sector 1 of the MEI.

The following section discusses results of an estimation of indirect domestic value added by origin and destination sectors of domestic inputs generated by Mexican manufacturing exports that, based on equations (3) and (4), are obtained by multiplying the diagonalized Mexican manufacturing export matrices by the indirect value added matrices in 2003:

$$IVA^{DE} = (A_V^{DE}[(I - A^{DE})^{-1} - I])E^{DE} \quad (11)$$

$$IVA^{MEI} = \left((A_V^{DE}(I - A^{DE})^{-1})\, A^{MEI}\right)E^{MEI} \quad (12)$$

where E^{DE} y E^{MEI} are diagonalized matrixes of manufacturing exports of companies in the domestic economy (DE) and the maquiladora export industry (MEI), respectively, and where every matrix has only the value of the manufacturing sectors' exports in the main diagonal and zero in the rest.

5. Indirect domestic value added in manufacturing exports by sectors of origin and destination

In part II of this paper we indicated that indirect domestic value added is 20% of manufacturing exports; 37% in exports of the domestic economy; and 9% of the maquiladora industry's exports. This means that although maquiladora exports make up 62% of manufacturing exports, these have only 28% of the indirect domestic value added contained in them.

In the following section we will analyze data on sectors in which this indirect value added is created and also examine data from export sectors that receive this indirect value added and incorporate it in their exports.

5. 1. Indirect value added in manufacturing exports by sector of origin

Figure 1 shows, by sectors of origin, the percentages of indirect value added contained in total manufacturing exports, and in exports of the three sectors that contribute most to exports, figure 1A; in exports of the domestic economy, figure 1B, and in exports of the maquiladora export industry, figure 1C (the data behind this figure can be found in online appendix). Almost 80% of indirect value added in manufacturing exports originates in non-manufacturing sectors. This share is similar in the three sectors that contribute the largest part of manufacturing exports; slightly lower in exports of the domestic economy, and slightly higher in exports of the maquiladora export industry. For total manufacturing exports, only VA originating in the rest of manufacturing (i.e., not the transportation equipment nor the electronic and electrical sectors), is of particular prominence, but significantly less than indirect value added of non-manufacturing origin. Intra-sectoral indirect domestic value added only bears some weight in transportation equipment and electronics exports provided by the domestic economy. However, this latter share should be evaluated in light of the fact that indirect value added contained in exports of this sector are

only 5% of total indirect value added in manufacturing exports. Care must also be taken when evaluating the percentage by sectors of origin of indirect value added incorporated in maquiladora-industry exports. Although this percentage is similar to that of total manufacturing exports and to that of domestic-economy exports, we should bear in mind that indirect domestic value added in maquiladora-industry exports is only 28% of the total indirect value added in manufacturing exports.

[Figure 1]

5. 2. Indirect value added in manufacturing exports by sector of destination

Figure 2 reveals the distribution by final-export sectors of VA generated by indirect exports. Block A shows this distribution for total manufacturing exports; Block B for domestic-economy exports; and Block C for maquiladora-industry exports. In these graphs we have excluded information related to electronic-and-electrical-equipment industry exports as well as maquiladora-industry and transportation equipment-industry exports, since the absolute value of indirect value added incorporated in the exports of these sectors is of little significance. The graph show that both for the total of manufacturing exports and for domestic-economy exports, the largest part of indirect value added contained in exports is incorporated in exports of transportation equipment and from other manufactures. This is usual for total exports as well as for manufacturing and non-manufacturing value added incorporated in exports. Nonetheless, the transportation-equipment sector stands out from the rest due to the fact that almost all indirect value added incorporated in its exports is incorporated in the exports of that same sector. In this regard, maquiladora-industry exports have a distinctive feature because there are four sectors that are a vehicle for exporting indirect value added. Yet the relevance of this information should be considered in light of the fact that, as previously mentioned, maquiladora-industry exports contain only a bit more than a forth of total indirect value added incorporated in Mexico's manufacturing exports.

[Figure 2]

5. 3. Indirect value added and characteristics of the export sector

The characteristics described in the distribution of indirect domestic value added in manufacturing exports by sectors of origin of said VA, and according to the sectors to

whose exports it is incorporated, demonstrate, on the one hand, certain traits that underpin relationships among the directly exporting activities and the rest of the economy, and, on the other hand, the characteristics of Mexico's manufacturing exports. With regards to the first point, the low indirect domestic value added incorporated in manufacturing exports, and particularly in those of the maquiladora industry, shows the weakness of the domestic linkages among export sectors and the rest of the economy. Second, it also shows that these linkages are particularly weak among the manufacturing sectors themselves.

These traits have their origin in the fact that most of Mexico's manufacturing exports are located in global value chains in which Mexico has specialized in assembling products whose parts and components are imported. This means that the domestic indirect value added of manufacturing origin incorporated in manufacturing exports is small, also explaining that there are so few directly exporting sectors that act as a vehicle through which other sectors can indirectly export value added. Exports of the electronics industry, which are a substantial part of exports and come almost exclusively from the maquiladora industry, are the most outstanding example of this situation. The VA generated in other sectors that is incorporated in the exports of the maquiladora electronics industry is almost 20 billion pesos, of which only 18 percent has its origin in manufacturing. This attests to the fact that the parts and components used by the electronics industry located in Mexico are essentially imported. On the other hand, the domestic value added contained in the exports of other sectors but which originate in the domestic electronics industry is only 1 billion pesos, indicating that this sector basically produces and exports finished goods.

Mexico's particular export specialization can be observed in the breakdown of export data into parts and components on the one hand, and finished goods on the other, as per the UN's COMTRADE Revision 2, Section 7—Machinery and Transportation Equipment. Table 3 shows this sector's exports, which accounted for 74% of the country's manufacturing exports in 2010, as classified into these two types of goods. The same table details the information for products in Section 7 at the four digit level. The most relevant conclusions from this information are the following: first, considering the entire section, 73% of exports are finished goods; and second, breaking exports down at the two digit level and regrouping them in the six divisions that contribute 97% of the section's exports, we see that 74% of these are finished goods, rising to 96% in the case of Division 75—Office

Machines. At the three digit level, 71% of the groups that contribute 72% of exports are finished goods, and at the four digit level, six subgroups contribute 55% of Section 7 exports, 72% of which are finished goods.

[Table 3]

6. Conclusions

In this paper we have focused on the indirect value added incorporated in Mexico's manufacturing exports from two perspectives: first, from that of the sectors of origin of indirect domestic value added in exports and, second, from that of the directly exporting manufacturing sectors in which indirect domestic value added is incorporated.

Our analysis has shown that most of the indirect value added incorporated in manufacturing exports does not have it origin in manufacturing itself and that most of indirect value added contained in manufacturing exports is incorporated in exports of just one sector. These indicators, plus the low share of indirect value added incorporated in manufacturing exports points to the weakness of inter- and intra-sectoral linkages among manufacturing exports and the rest of manufacturing. This is particularly evident in maquiladora-industry exports, which make up most of manufacturing's exports.

The domestic value added incorporated in exports that are integrated in value chains depends directly on two factors: the imported component of exports and the role that countries have in the production chain. Up to now, discussion regarding ways of increasing domestic value added in exports has focused mostly on the former, leading to the proposal that, to increase same, the chains should be internally reintegrated, in other words, imported parts and components that are incorporated in exports should be produced within the country. In our opinion, the feasibility of such a policy is doubtful. As the productive processes are increasingly fragmented and as the costs of communications and transportation drop, it will become more profitable for companies to expand international production networks according to the specific advantages provided by each country in producing parts and components. Therefore it may be necessary to refocus the substance of the discussion regarding this problem to the topic of the role that countries have within these chains. We ought to differentiate two rankings in the chain, high and low, according to the magnitude of the VA that is incorporated in them, the phase of product assembly

representing the lower ranking in the chain, while the higher ranking includes the production of high-value components, the product's technological development, design, logistics, marketing, and post-sale servicing (Gereffi, 2014). Indirect value added incorporated in exports within the framework of value chains is incorporated in the value of parts and components that are integrated in exported products. For countries that occupy a low ranking in the chain, foreign value added incorporated in exports is equal to the value of imports. But in countries that import products assembled abroad and have participated in the higher phases of the chain, the imported product contains domestic value added that was previously exported by those countries. In other words, in countries that participate in the higher phases of the chain, the value of imports to produce exports is different than the foreign value added incorporated in imports. For example, the percent of domestic manufacturing value added, re-imported as a percentage of manufacturing exports, is 5.2% in the United States; 7.3% in Germany; 10.5% in South Korea; these figures contrast with those from China (3.7%), and Mexico (2.5%) (OECD, *Trade in Value Added 2009*).

From this discussion we see that one of the relevant research topics is finding the distribution of export value in countries that participate in integrated production in specific value chains, as well as identifying the factors that explain why companies decide to locate production in certain countries.

Further, considering the fact that indirect domestic value added in exports integrated into value chains and in exports that are not integrated into these chains is very different, in countries in which an important part of exports is concentrated in the integrated production within chains, it is worthwhile to show data of VA in production and in exports separately for these two types of exports. This requires us to separate the input-output matrix into two segments, one for exports within the processing trade, and the other for the remaining export sector.

Finally, we would like to highlight the main limitations of this investigation. Some arise due to the availability of data, from the level of aggregation of the data, as well as from the fact that, for example, in the case of domestic economy industries, we did not have a method that would allow us to reliably identify the share of imported inputs contained in exported products and in those destined for the domestic market by domestic-economy companies, which can be different, in addition to the fact that inputs can also be different

according to different types of products. Another limitation stems from the fact that, when we consider an input-output model based on the inverse of Leontief as an *ex post* distribution model, it is not possible to identify what role is played by supply conditions in any particular economy, (in our case the Mexican economy), in the generation of indirect value added (for example, changes in labor productivity, in unit labor costs, or even in market conditions for determining prices). This means that results of this study should be interpreted solely as the VA that was indirectly generated based on the demand for intermediate inputs needed to produce a certain quantity and variety of export products, assuming that the value-added coefficients remain constant and that the production function is one of fixed proportions. Based on the inverse of Leontief, the fact that domestic inputs incorporated directly in the production of exported goods require, in turn, more domestic inputs, means that in each round of demand of intermediate inputs both the demand of domestic intermediate inputs and the value-added coefficients remain constant. This means that the effects that generation of VA have, in turn, on final demand are not being considered.

ACKNOWLEDGMENTS

We are grateful to Bart Los and an anonymous referee for their valuable comments. This work was supported by National Council of Sciences and Technology of Mexico (CONACyT), grant 10017, project 152740.

REFERENCES

Banco de México (2013). *Informe anual 2012*, México.

Breda, E. and R. Cappariello (2008). "A Tale of Two *Bazaar* Economies: An Input-Output Analysis of Germany and Italy." Rome, Italy: Bank of Italy, Economics and Financial Statistics Department.

Breda, E., R. Cappariello, and R. Zizza (2007). "Measures of the External Trade Impulse to Economic Growth: How Relevant Is the Internationalization of Production?" Rome, Italy: Bank of Italy, Economic Research Department.

Chen, X., L. K. Cheng, K. C. Fung, and L. J. Lau (2005). "The Estimation of Domestic Value Added and Employment Induced by Exports: An Application to Chinese Exports to the United States." Paper presented at the 2005 American Economic Association Meeting, Philadelphia, PA, January 7–9.

Chen, X., L. K. Cheng, K. C. Fung, L. J. Lau, Y. Sung, C. Yang, K. Zhuy, and Z. Tang (2008). "Domestic Value Added and Employment Generated by Chinese Exports: A

Quantitative Estimation," MPRA paper No. 15663. Munich Personal RePEc Archive.

Daudin, G., C. Rifflart, and D. Schweisguth (2009). "Who Produces for Whom in the World Economy." Working Paper No. 2009-18. Paris, France: Observatoire francais des conjonctures économiques.

De la Cruz, J. R. Koopman, and Z. Wang (2011). "Estimating Foreign Value-Added in Mexico's Manufacturing Exports." Working Paper No. 2011-04A.Washington, DC: US International Trade Commission, Office of Economics.

Fujii, G. and R. Cervantes (2013). "Valor añadido en las exportaciones manufactureras de México." *Revista de CEPAL* 109 (English versión in *CEPAL Review* 109).

Gereffi, G. (2014). "New Trends in Value Chain Upgrading: Lessons from Small and Large Countries". *Seminario UNAM/INEGI Cadenas de valor en las exportaciones mexicanas*. April 10th. http://www.inegi.org.mx/eventos/2014/exportaciones/doc/P-Gary Gereffi.pdf.

Ghosh, A, (1958.) "Input-output Approach in an Allocation System", Economica, 25:58-64.

Guerra, A.I. and F. Sancho (2010). "A comparison of input-output models: Ghosh reduces to Leontief (But 'closing' Ghosh makes it more plausible)". Universitat Autònoma de Barcelona. First version, April 2010.

He, D. and W. Zhang (2010). "How Dependent Is the Chinese Economy on Exports and in What Sense Has Its Growth Been Export-led?" *Journal of Asian Economics* 21: 87–104.

INEGI (2008). *Matriz de insumo-producto de México 2003*. http://www.inegi.org.mx/est/contenidos/proyectos/scn/c_anuales/matrizinsumo/default.aspx

INEGI (2008b). *Matriz de insumo-producto de México 2003*. MIP 2003, Metodología http://www.inegi.org.mx/est/contenidos/proyectos/scn/c_anuales/matrizinsumo/default.aspx

Johnson, R. and G. Noguera (2011). "The Value-Added Content of Trade." *VOX,* June 7. http://www.voxeu.org/article/value-added-content-trade-new-insights-us-chinaimbalance

Koopman, R., Z. Wang, and S.-J. Wei (2008). "How Much of Chinese Exports Is Really Made in China? Assessing Domestic Value-AddedWhen Processing Trade Is Pervasive." Working Paper 14109. Cambridge, MA: National Bureau of Economic Research.

Los, B., M. Timmer and G. J. de Vries (2012). "China and the World Economy: A Global Value Chain Perspective on Exports, Incomes and Jobs." Groningen Growth and Development Centre, Faculty of Economics and Business, Unversity of Groningen. October, 2012.

Maresa, A. and F. Sancho (2012). "Leontief versus Ghosh: two faces of the same coin", Document de Treball, XREAP 2012-18, Xarxa de Referència en Economia Aplicada.

OECD-WTO (2012). Trade in Value Added: Concepts, Methodologies and Challenges, Joint OECD-WTO Note, http://www.oecd.org/sti/ind/49894138.pdf

Timmer, M.P., B. Los, R. Stehrer, and G. J. Vries (2013). “Fragmentation, incomes and Jobs: an analysis of European competitiveness”, *Economic Policy*, Vol. 28, Issue 76, October 2013, pp.613-661.

Table 1
Export composition (percentages)

Type of product (2013)[1]		Industrial exports by technological content (2012)[2]			Manufacturing exports by products and sector (2003)[3]			
					Products		Sector	
							Domestic economy	Maquiladora exports
Manufactures	84	Natural-resource-based products		10	Electronic equipment	29	12	88
Crude oil	12	Technological level	Low	11	Transport equipment	28	58	42
Agriculture	3		Medium	49	Electric equipment	9	19	81
Minerals	1		High	29	Other	34	49	51
Total	100		Total	100	Total	100	38	62

[1] INEGI
[2] COMTRADE
[3] Fujii & Cervantes (2013)

Table 2
Domestic value added in manufacturing exports (2003; percentages of exports)

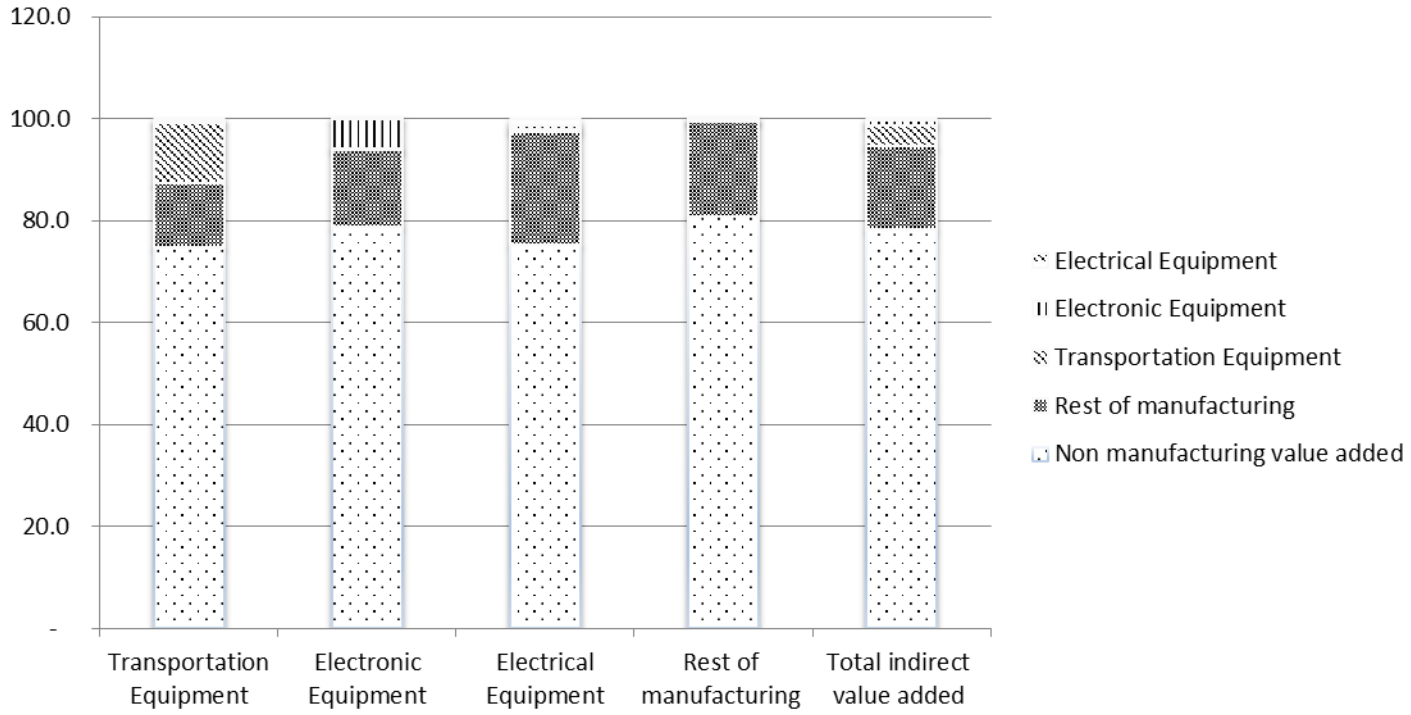
	Total manufacturing			Domestic economy			Maquiladora exports		
	Value added	Direct VA	Indirect VA	Value added	Direct VA	Indirect VA	Value added	Direct VA	Indirect VA
Electronic equipment	21	13	8	71	44	27	14	8	6
Transport equipment	49	27	22	68	35	33	25	17	8
Electrical equipment	34	19	15	76	41	35	24	14	10
Other	56	28	28	82	38	44	33	19	14
Total	42	22	20	75	37	37	22	13	9

Fuente: Fujii & Cervantes (2013)

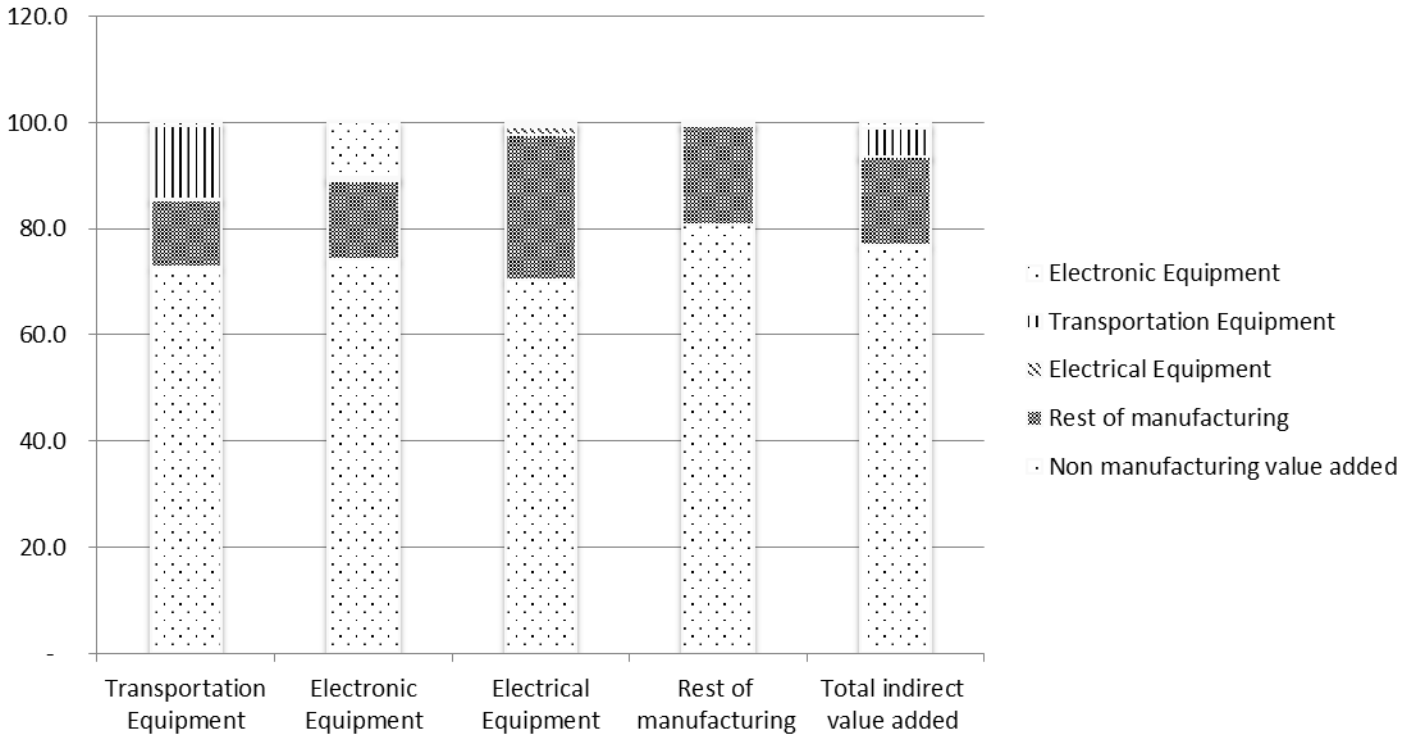
Table 3
Exports composition: Final Goods and Parts and Components (percentages)

	% of section's 7 exports	Final goods (%)	Parts and components (%)
Section			
7. Machinery and transport equipment			
Total	100	73	27
Divisions			
71. Power generating machinery and equipment	7	57	43
74. General industrial machinery and equipment, nes, and parts of, nes	7	91	9
75. Office machines and automatic data processing equipment	10	96	4
76. Telecommunications, sound recording and reproducing equipment	22	64	36
77. Electric machinery, apparatus and appliances, nes, and parts, nes	18	76	24
78. Road vehicles	33	73	27
Sum	97	74	26
Groups			
752. Automatic data processing machines and units thereof	9	100	0
761. Television receivers	13	100	0
764. Telecommunication equipment, nes; parts and accessories, nes	8	0	100
772. Electrical apparatus for making and breaking electrical circuits	4	0	100
773. Equipment for distribution of electricity	4	100	0
778. Electrical machinery and apparatus, nes	4	96	4
781. Passenger motor vehicles (excluding buses)	15	100	0
782. Lorries and special purposes motor vehicles	7	100	0
784. Motor vehicle parts and accessories, nes	9	0	100
Sum	72	71	29
Subgroups			
7523. Complete digital central processing units; digital processors	5	100	0
7611. Television receivers, colour	13	100	0
7643. Television, radio broadcasting; transmitters, etc	6	0	100
7810. Passenger motor vehicles (excluding buses)	15	100	0
7821. Motor vehicles for transport of goods or materials	7	100	0
7849. Other parts and accessories, for vehicles of headings 722, 781-783	9	0	100
Sum	55	72	28

Figure 1. Indirect value added in manufacturing exports by origin sector, percentages, 2003.
A. Total manufacturing



B. Domestic economy



C. Maquiladora exports

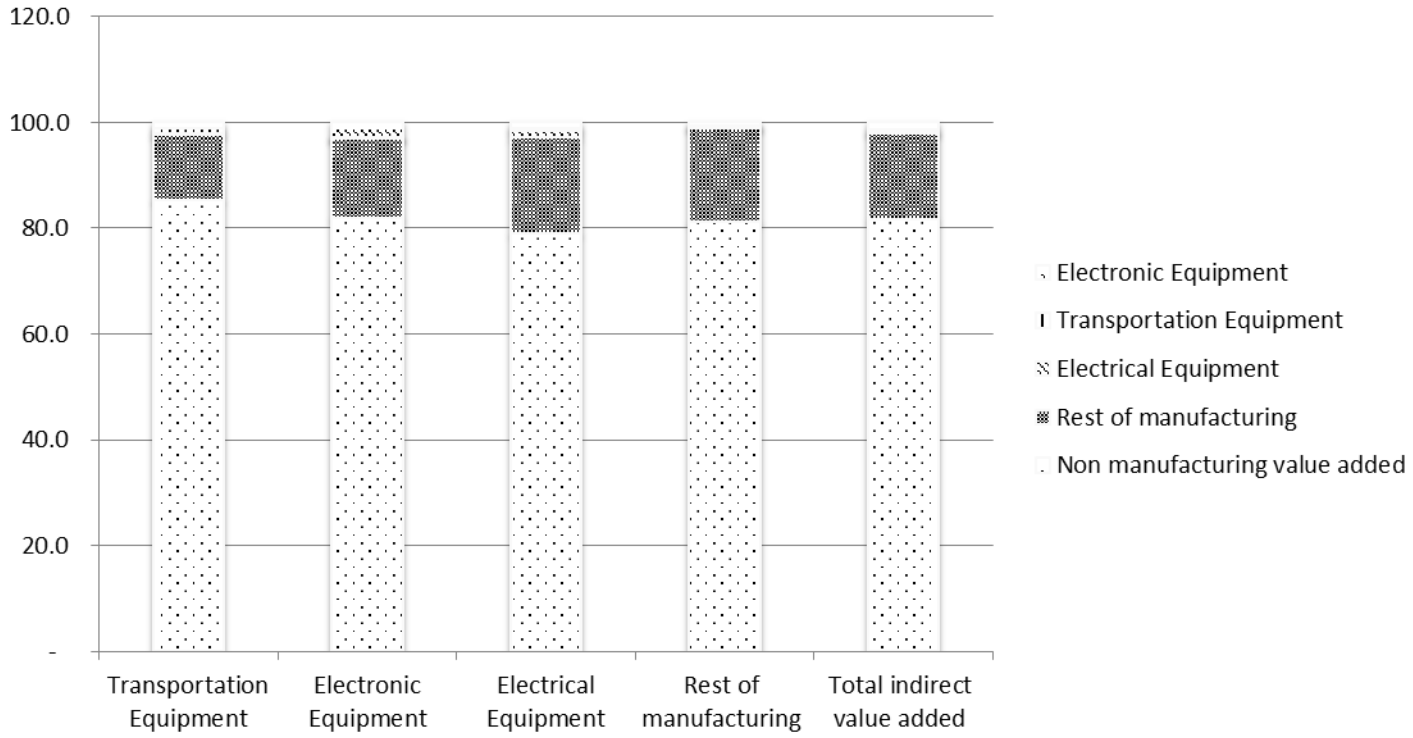
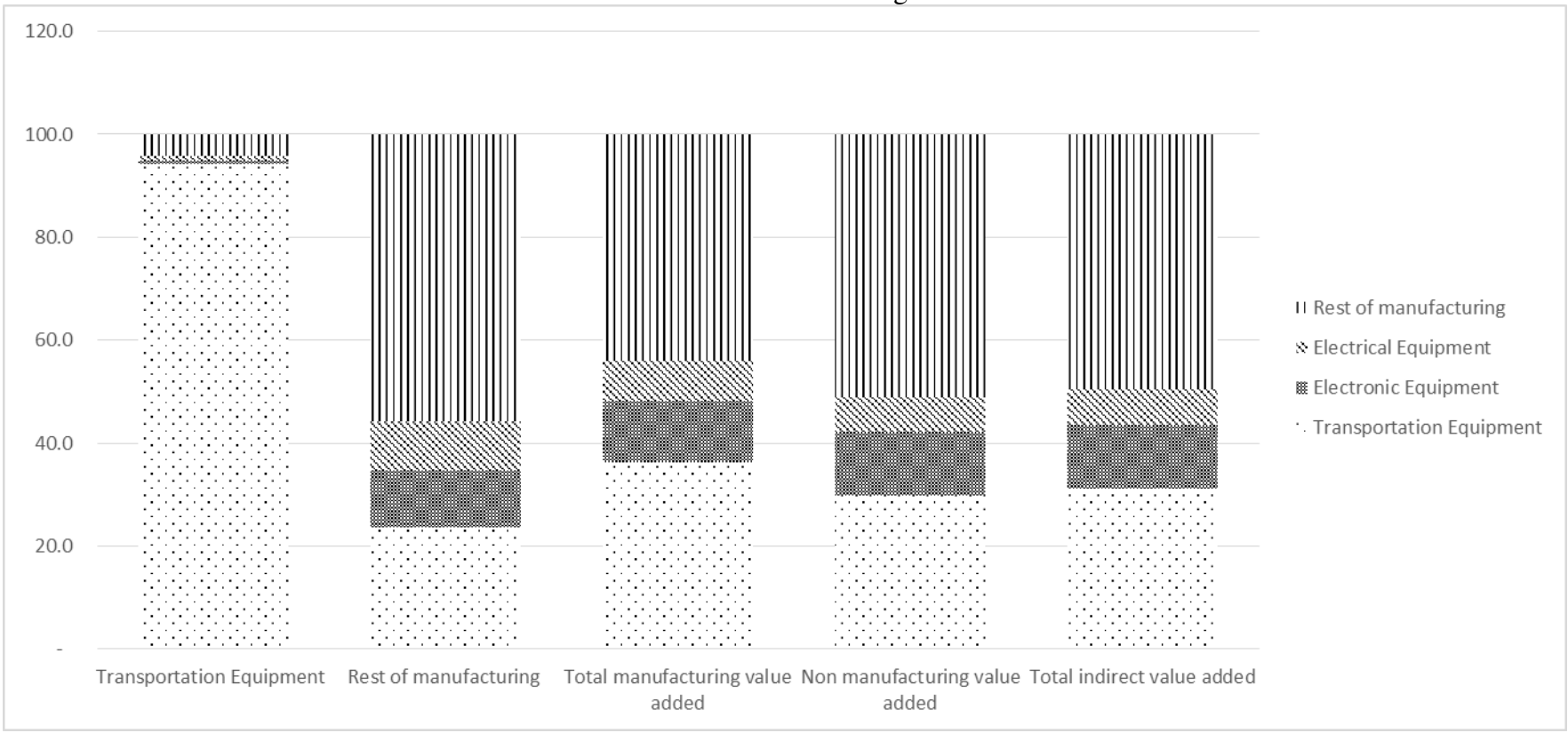
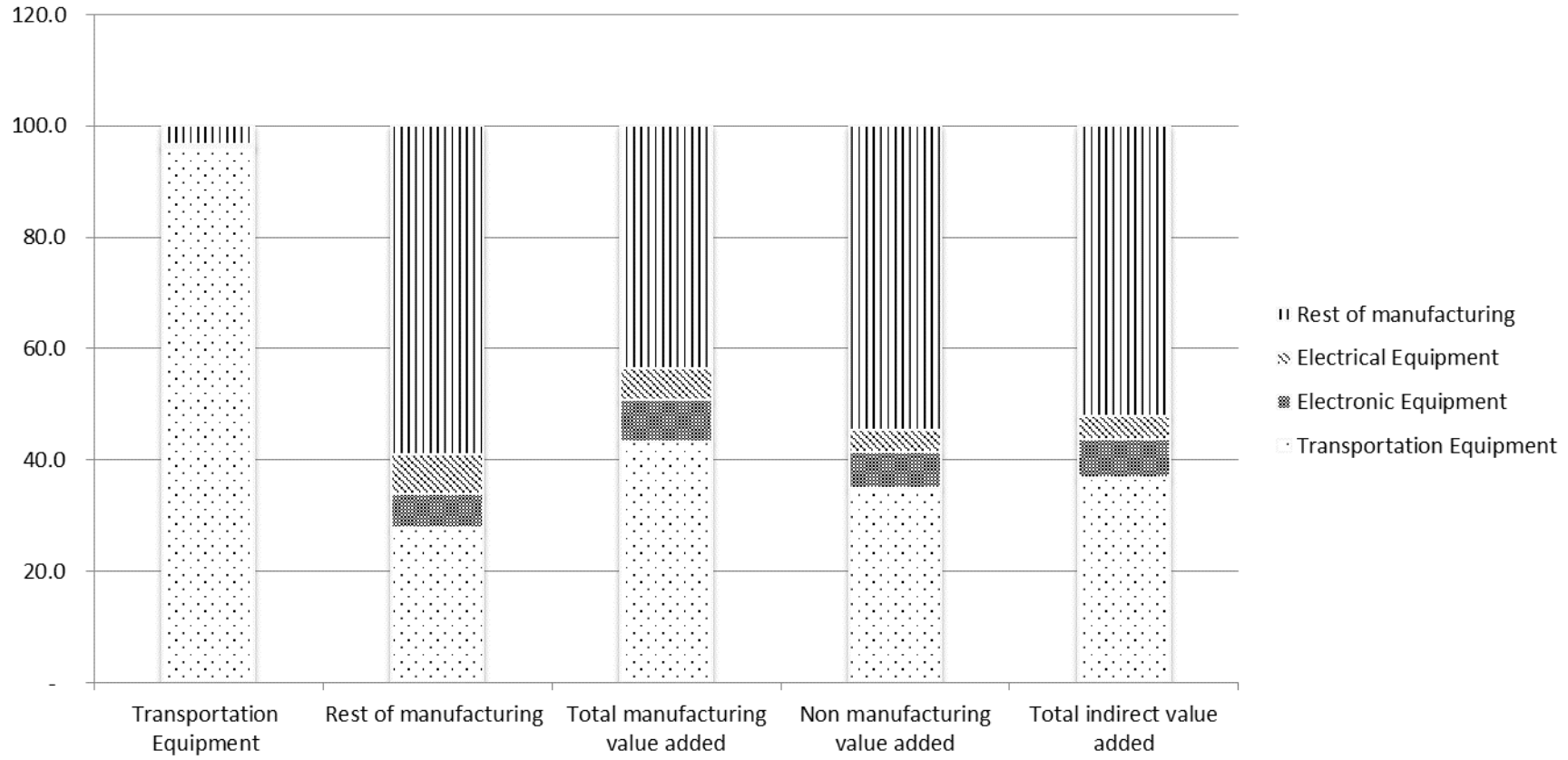


Figure 2. Indirect value added in manufacturing exports by destination sector, percentages, 2003
A. Total manufacturing



B. Domestic economy



C. Maquiladora exports