Industry-specific measures of exposure to international trade*

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Abstract

We propose e framework to construct industry-specific measures of exposure to international trade through different channels for the manufacturing sector using Input-Output tables, industrial surveys and trade balance data. The measures we propose may capture the share of total imports and imports by origin in apparent consumption, the direct and indirect share of imports in production costs, the share of total exports and GVC-related exports in total sales, and the share of international trade in production. We estimate them at the most narrow industry classification in Mexico and document an increasing importance of international trade in domestic production and consumption. To further illustrate their usefulness for different purposes, we approximate and illustrate the importance of international trade in the goods included in the Consumption Price Index and the Producer Price Index baskets in Mexico. We find that the importance of imports is heterogeneous across different types of goods, and that it has increased in the past two decades. We also find that prices of goods that are more traded have increased at a lower rate than those that are less traded. This work underscores the usefulness of measuring the participation of international trade at the industry level to enhance policy analysis.

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1 Introduction

Trade integration may have several implications for macroeconomic outcomes, including output, consumption and inflation. This is because the import and export of goods affects the supply of goods and services in an economy and exposes the domestic economy to external shocks.

In this paper, we set forth a conceptual framework to think about the different mechanisms through which international trade may affect economic activity and propose measures that approximate the importance of each of these channels for manufacturing industries. Our measures capture the heterogeneity across manufacturing industries in terms of the relevance of international trade and allow us to track its changing importance across time. Their construction combines information from manufacturing surveys, Input-Output Tables (I-O tables), and customs data.

The first set of measures focuses on imports, which may consist of final goods that are directly consumed by households, or inputs used for domestic production. The first measure is the share of imports in apparent consumption.[1] This measure gauges the extent to which conditions of foreign supply affect domestic consumption, supply, and prices. It is also a measure of exposure of consumption and living costs to external supply shocks. We also approximate the importance of different specific countries as suppliers of goods imported and consumed in the domestic country in order to identify if the exposure to a specific economy is particularly salient.

A second measure regarding imports estimates the share of imported inputs in domestic production costs. We also approximate the participation of inputs sourced from specific countries in total costs. An additional measure focuses on the indirect share of imports in costs, since companies may use domestic inputs whose production required imported materials. These measures are relevant because they capture the extent to which domestic production is exposed to foreign shocks and the degree to which import prices may affect production costs, and therefore domestic output and inflation.

The third set of measures considers instead exports, and specifically estimates the share of exports in total industry sales, considering separately total exports and exports by destination. The fact that part of an industry's production is exported may influence output and also inflation, since greater participation in foreign markets may imply that international price references are relevant for domestic producers.[2] Moreover, the share of exports in total sales may indicate each industry's comparative advantage, so local productivity gains could be greater in industries that have seen a larger increase in export participation over the medium term.

In addition, to the extent that firms' participation in international trade is associated with the integration into global value chains (GVCs), the implications of trade for output, productivity, and prices may be more complex.[3] In particular, the output of firms that are part of a value chain should be understood as part of the production process of a global enterprise, meaning that some global factors may be more relevant than domestic ones in determining production costs and output levels. Moreover, the pricing decisions may

[1] Apparent consumption refers to the total sales of each product in the domestic market: sales by domestic producers in the domestic market plus imports.

[2] If exporting firms are unwilling to set different prices in domestic and foreign markets, international price movements could be passed through to the domestic market.

[3] Participation in GVCs involves sophisticated integration processes and long-term contractual relationships between firms that encourage client-specific investments, customization of inputs, and the transfer of technology or credit flows between firms (Antràs, 2020).

respond to strategic motivations that have little to do with the traditional determinants of prices in a domestic economy. We therefore also approximate the share of exports associated with GVCs in total industry sales by identifying the share of imported inputs and intermediate goods in industry's exports.

Finally, we propose a global measure of international trade participation in industry production that incorporates the two main ways in which domestic firms are exposed to international trade: the imports of inputs and the exports of finished goods. By capturing both dimensions as a share of total production, this measure provides a comprehensive assessment of the relevance of international trade for manufacturing industries.

Using the framework proposed, we then estimate each of these measures for the manufacturing sector in Mexico over the period 2003-2023 at the most disaggregated level (6-digit code) of the North American Industrial Classification System (NAICS). A descriptive analysis illustrates the growing importance of international trade in Mexico and the heterogeneity across manufacturing industries.

Finally, in order to illustrate how these measures may be used to enhance economic analysis, we present a particular use case. Concretely, we analyze the exposure of price index baskets in Mexico to international trade. Measuring the importance of international trade for the goods included in price baskets is relevant because the degree to which products are traded internationally is indicative of the extent to which their prices may be exposed to exogenous shocks, exchange rate fluctuations, or even fully determined in the international market (as opposed to being directly driven by domestic market conditions). This exposure may influence the strength of the response of inflation to its domestic determinants.

To perform said analysis, we link each item in the basket of manufactured goods from the Mexican consumer price index (CPI) and producer price index (PPI) to the industry that produces it. This allows to obtain trade exposure measures at the item level. A graphical analysis illustrates the growing importance of imports and exports in the representative consumption and production baskets used to measure inflation in Mexico. REVISAR CON RESULTADOS DE CARLOS The analysis also confirms that Mexico's trade liberalization has led to greater consumption of imported goods (as measured by the representative basket of consumption of the CPI), increased exports of manufactured products, and a diversification in the origin of inputs used by manufacturing firms in production (as measured by the representative production basket of the PPI). Notably, we do not find evidence that the share of imported content in total national manufacturing output has increased, although it has risen in certain industries. This may be due to the fact that trade integration has been accompanied by strong development of domestic supply chains.

Finally, we divide the items in the price index baskets into quartiles according to their level of exposure to international trade as estimated by the measures proposed. We use these quartiles to illustrate the differential evolution of these baskets' price indices between 2010 and 2022. REVISAR CON RESULTADOS DE CARLOS We find evidence that the goods produced by industries in which international trade plays a more significant role tend to be those that, on average, displayed the smallest accumulated increase in prices between 2010 and 2022.

This paper makes three main contributions to the economics literature. First, it proposes a framework that may be used to construct similar measures for different economies other than Mexico. In particular, we propose how the importance of GVC-related trade can be approximated using data from national input-output matrices, trade balances, and industrial surveys. This measure can therefore be constructed at the highest level of industry disaggregation for which such data exist in different countries.

Second, we estimate several measures of exposure to international trade for the Mexican manufacturing industries. To our knowledge, no such measures exist for the country at this level of disaggregation.[4] We believe these are valuable tools that could be used in various studies to deepen the analysis of the impacts of international trade in Mexico. Their value lies in capturing different dimensions of international trade, the heterogeneity among different industries, and the evolution across time. Moreover, as they are defined at the highest level of industrial disaggregation, users can conduct the analysis at the desired level by aggregating the measures. By making these measures publicly available, we hope to enhance economic analysis in the country.

The third contribution is the link to price index data, that allows to illustrate the changing composition of price baskets in Mexico over time according to the importance of international trade across its various dimensions. This is valuable as it shows how imports have become more important in household consumption, and both imports and exports have grown in importance for national production. In this way, we document the process of trade integration from the perspective of goods consumed by households or produced in the country, as well as the heterogeneity that exists between industries. This is relevant in practice because, although all goods are inherently tradable, there is significant variation in the extent to which they are actually traded. This also allows one to compare the evolution of prices of products more or less exposed to international trade. Thus, the descriptive exercise shown in this paper illustrates an example of how these measures may provide useful analysis. As a byproduct of this process, we also constructed a correspondence between the items in the National Consumer Price Index (INPC) basket and the industrial classes that produce them. While this was necessary to approximate international trade participation at the product level, it could also be used for other applications where it is desirable to link goods in Mexican price baskets with their producing industries.

The remainder of the document is structured as follows. Section 2 summarizes related literature. Section 3 describes the conceptual framework and the proposed definition of the measures of international trade participation. Section 4 presents some descriptive statistics of the estimated measures for the case of Mexico at the industry level. Section 5 links the items that form price index baskets to the industries that produce them and shows descriptive analysis to illustrate the importance of trade in these baskets. Section 6 concludes.

2 Literature

This work is related to three strands of literature. The first is a strand that has constructed similar measures in order to study the implications of trade on prices or productivity in economies. For example, using a measure of import participation in production costs, it has been argued that the degree of exchange rate pass-through may vary depending on the importance of imports in production costs. However, to our knowledge, equivalent measures have only been constructed for a group of industrialized economies (Goldberg y Campa, 2010), for Colombia (Casas, 2020), and for Turkey (Ertuğ et al., 2020), and only for industries at a broader level of aggregation than those proposed in this paper.[5] In addition, other studies have calculated measures of import participation in total inputs or export participation in sales, even at the firm level. These studies argue that

[4] While INEGI publishes a measure of the Exported Value Added of Global Manufacturing, which approximates the links of industries into global value chains, that measure is only available at the industry group level (4-digit codes).

[5] In Casas (2020) and Ertuğ et al. (2020), the relationship between pass-through and trade exposure is studied in two steps. First, pass-through is calculated by industry, and then it is correlated with the importance of imports in production costs.

firm heterogeneity is important for measuring the gains from international trade (Ramanarayanan, 2020; Tintelnot et al., 2018), or for studying the effects of trade openness on aggregate prices (Blaum et al., 2018).

A second strand emphasizes the role of trade openness in decreasing global inflation levels and increasing inflation synchronization (R. A. Auer et al. 2019; De Soyres y Franco 2019; Andrews et al. 2018; Banco Mundial 2019). This literature argues that economic globalization strengthens trade ties, promotes the transmission of knowledge and the mobility of the factors of production, provides access to cheaper or higher-quality production inputs, and encourages the fragmentation of production (see, for example, Kugler y Verhoogen 2009). These factors positively affect global productivity and reduce price pressures. Within this strand, the literature has also focused on studying the implications of trade participation specifically linked to Global Value Chains (GVCs). It has been found that these contribute to greater synchronization of global inflation, as production linkages amplify the transmission of inflationary shocks originating in different countries (R. Auer et al., 2017). The position within the chains also appears to be relevant. Specifically, synchronization may be stronger in industries higher up the production chain (or further from final consumers), as they face inventory adjustments from all downstream industries (Ferrari, 2019). Moreover, while backward participation (the imported content of exports) seems to increase the bilateral correlation of inflation between two countries, forward participation (the share of exports that are re-exported from the destination country) implies greater correlation with global inflation (De Soyres y Franco, 2019).

The third related strand of literature seeks to measure the tradability of products in price index baskets, specifically by separating products into two groups: the basket of tradable goods and the basket of non-tradables (see Knight y Johnson (1997) for the case of Australia, Dixon et al. (2004) for New Zealand, and Johnson (2017) for the United States). In this paper, unlike those mentioned, we do not seek to define whether a good is tradable or not. We begin with the assumption that, in principle, all manufactured goods are tradable, as they could potentially be imported or exported. Thus, the focus of this work is to identify which of the manufactured goods (or their components) are actually exported or imported. This is important because we would expect that the prices of those that are traded are more responsive to foreign factors.

3 A conceptual framework to construct measures of the participation of international trade in manufacturing industries

This section proposes different measures to capture the importance of international trade, distinguishing between the different ways in which trade can be relevant for economic activity. The conceptual framework will be best suited for thinking about these measures for the manufacturing sector, although it may be adapted to other tradable sectors.[6] In this case, it is possible that some measures, such as the share of exports associated to GVC, may become less relevant.

The most direct way in which trade affects the domestic activity is through the imports of products that are consumed in the country. We approximate the share of imported products in the total national consumption of each industry using the value of domestic market sales of products manufactured in each country by industry i at time t ($DS_{i,t}$), and the total value of imports of goods produced by industry i at

[6] In particular, we use data sources that, for the case of Mexico, are available for the manufacturing sector.

time t ($M_{i,t}$).[7] Thus, the **import share in apparent consumption** of the industry, that captures the relative importance of imported goods in the total supply available to domestic agents within each industry, is defined as follows:

$$\mu_{i,t}^{tot} = 100 \cdot \frac{M_{i,t}}{M_{i,t} + DS_{i,t}} \tag{1}$$

Considering that economic dynamics may be affected by the origin of imported products, it may also be important to consider measures of the **import share by origin in the industry's apparent consumption**. The particular origin that is relevant will be country-specific, and will be determined by each country's main trading partners (more specifically, its main suppliers). Let $M_{i,t}^{o}$ denote the value in pesos of imports from origin o for industry i in year t.[8] This measure is defined as follows:

$$\mu_{i,t}^{o} = 100 \cdot \frac{M_{i,t}^{o}}{M_{i,t} + DS_{i,t}} \tag{2}$$

The output and prices of manufactured products can also be affected by international trade through production costs, as firms use imported inputs. Therefore, we also define the **direct share of imports in production costs** ($\Upsilon_{i,t}^{D}$) as the value of imported inputs relative to total business costs. The measure requires data on the value of total imported inputs, total domestic inputs, and total wage bill for each industry i in year t ($MI_{i,t}^{tot}$, $DI_{i,t}^{tot}$, and $W_{i,t}$ respectively).[9] With this information, the measure is defined as follows:

$$\Upsilon_{i,t}^{D} = 100 \cdot \frac{MI_{i,t}^{tot}}{MI_{i,t}^{tot} + DI_{i,t}^{tot} + W_{i,t}} \tag{3}$$

Considering once again that the origin of imports is relevant (since that determines the origin of the external shocks that may affect economic activity), we identify the countries from which the inputs used by each industry are imported and approximate the **direct share of imports by origin in production costs**. Let $r_{k,t}^{o}$ denote the share of origin o in the imports of products from industry k in year t,[10] and let m_{ki} represent the value of imports of goods produced by industry k and used as inputs by industry i.[11] An underlying assumption of this measure is that the composition of input k by origin is the same across all

[7] The sources of these two indicators need not be the same. For example, for the case of Mexico domestic sales are available from manufacturing surveys, while total imports are drawn from trade balance data. While this measure could also be calculated using data from the same source through the I-O table, we choose not to use that source since it is only available with a lag, and only with a periodicity of 5 years. In contrast, industrial surveys and trade balance data is available yearly.

[8] The source of this information for the case of Mexico is data on the trade balance. The viability of constructing this measure will depend on the availability of this information for each country.

[9] For the case of Mexico, data for these variables are obtained from the manufacturing industry surveys. The input category considers the value of goods and services consumed by economic units in their production activities, including. It includes raw materials, packaging, fuels and lubricants, spare parts, electricity consumption, freight for sold products, and payments for repairs, staffing services, rent, royalties, and training. These are the categories considered in the Mexican manufacturing survey, but the definition could be adapted according to data availability in each economy.

[10] For the case of Mexico this is obtained from trade balance data.

[11] For the case of Mexico this is obtained from the I-O table.

industries that use k to produce, and equal to the national average.[12] Thus, the measure is defined as follows:

$$\Upsilon^{O}_{i,t} = 100 \cdot \frac{MI^{tot}_{i,t} \cdot \frac{\sum_k r^{o}_{k,t} \cdot m_{ki}}{\sum_k m_{ki}}}{MI^{tot}_{i,t} + DI^{tot}_{i,t} + W_{i,t}} \tag{4}$$

For the following measure, we consider that production is also indirectly exposed to imports, since the domestic inputs used could contain foreign components.[13] Under the assumption of perfect competition at all stages of production, changes in the marginal costs of importing firms—caused by movements in the prices of foreign currency–priced inputs or exchange rate fluctuations—will be fully transmitted along the production chain. To capture this dimension, we use information from the I-O table on the share of inputs coming from industry k (domestically produced) in the production costs of industry i (s_{ki}). More explicitly, $s_{ki} = \frac{q_{ki}}{C_i}$, where q_{ki} is the value of domestically produced products by industry k and used as inputs by industry i, and C_i is the total value of domestic and foreign-origin inputs used by industry i plus the wages paid by this industry, according to the I-O table. Using this information, we construct the measure of the **indirect share of imports in production costs for each industry i in year t ($\Upsilon^{I}_{i,t}$)** in two steps. In the first, we define the total share of imports in production costs ($\Upsilon^{T}_{i,t}$) as follows:[14]

$$\Upsilon^{T}_{i,t} = \Upsilon^{D}_{i,t} + \sum_k s_{ki} \cdot \Upsilon^{T}_{k,t} \tag{5}$$

To calculate $\Upsilon^{T}_{i,t}$, we define the matrix $\boldsymbol{S}$ as a matrix with elements s_{ki}.[15] Defining $\boldsymbol{\Upsilon^{T}_{t}}$ and $\boldsymbol{\Upsilon^{D}_{t}}$ as two vectors stacking the elements $\Upsilon^{T}_{i,t}$ and$\Upsilon^{D}_{i,t}$ respectively, and $\boldsymbol{I_n}$ as the identity matrix of dimension n, where n is the number of industries in Mexico, equation 5 can be expressed in matrix form as:

[12] An additional underlying assumption for the case of Mexico is that the industry composition of imported inputs from other industries does not vary over time, since we use the share of imported inputs by industry as reported in the 2018 input-output matrix. Since I-O tables are generally updated unfrequently, this is plausibly an assumption that will apply for many use cases.

[13] Tintelnot et al. (2018) show that the relevant characteristic for determining the transmission of external demand shocks to sales is total exposure to foreign markets, not whether the firm exports directly or indirectly.

[14] This expression is a simplification of substituting $\Upsilon^{T}_{i,t}$ into the following recursive formula:

$$\Upsilon^{T}_{i,t} = \Upsilon^{D}_{i,t} + \sum_k s_{ki} \cdot \left[\Upsilon^{D}_{k,t} + \sum_j s_{jk} (\Upsilon^{D}_{j,t} + ...) \right] \implies \Upsilon^{T}_{i,t} = \Upsilon^{D}_{i,t} + \sum_k s_{ki} \cdot \Upsilon^{T}_{k,t}$$

Since $\Upsilon^{D}_{i,t}$ is constructed using data from the manufacturing sector only, the construction of the total import share is conservative, as it assumes that non-manufacturing industries have zero direct import participation.

[15] To clarify, the matrix $\boldsymbol{S}$ is related to the transposed technical coefficients matrix, with two additional distinctions. While the technical coefficients matrix represents the ratio between intermediate inputs from each industry and total output, the matrix $\boldsymbol{S}$ represents the ratio between the value of intermediate inputs and total costs derived from the value of inputs and wages (i.e., excluding capital costs). Thus, the latter excludes net value added from wages and product taxes. The second distinction is that only domestic inputs are used in the numerator.

$$\boldsymbol{\Upsilon_t^T} = \boldsymbol{\Upsilon_t^D} + \boldsymbol{S}\boldsymbol{\Upsilon_t^T} \implies \boldsymbol{\Upsilon_t^T} = (\boldsymbol{I_n} - \boldsymbol{S})^{-1}\boldsymbol{\Upsilon_t^D}$$

$$\text{Where } \boldsymbol{S} = \begin{pmatrix} s_{11} & s_{21} & \dots & s_{n1} \\ s_{12} & s_{22} & \dots & s_{n2} \\ \vdots & & \ddots & \vdots \\ s_{1n} & s_{2n} & \dots & s_{nn} \end{pmatrix}; \qquad s_{ji} = \frac{q_{ji}}{C_i}$$

By definition, $\Upsilon^T_{i,t} \geq \Upsilon^D_{i,t}$, so $\Upsilon^I_{i,t}$ is calculated in the second stage as a difference:[16]

$$\Upsilon^I_{i,t} = \Upsilon^T_{i,t} - \Upsilon^D_{i,t} \tag{6}$$

In order to have a measure that captures the importance of exports in the industry's sales, we use data on the value of sales in the domestic and foreign markets ($DS_{i,t}$ and $XS_{i,t}$ respectively). The **export share in total sales** of industry i in year t is defined as:

$$\kappa_{i,t} = 100 \cdot \frac{XS_{i,t}}{XS_{i,t} + DS_{i,t}} \tag{7}$$

Analogous to the measures of import shares by origin, we construct a measure of the **share of exports by destination in total sales** of industry i in year t, calculating the share of destination d in the industry's exports. Denoting the value of exports of industry i to destination d in domestic currency as $XS^d_{i,t}$, the measure of exports by destination is approximated as:

$$\kappa^d_{i,t} = 100 \cdot \frac{XS^d_{i,t}}{XS_{i,t} + DS_{i,t}} \tag{8}$$

We also seek to capture the dimension of trade flows associated with GVCs as these production arrangements have gained importance in international trade and could have complex implications for activity and prices. We propose to approximate the importance of GVCs with a measure of the share of GVC-associated exports in the total sales of the industry.[17] This measure is constructed in two steps. First, the fraction of

[16] In this way, $\Upsilon^D_{i,t}$ can be used if the goal is to analyze the direct impact of imports on production costs, $\Upsilon^I_{i,t}$ if the aim is to understand producers' indirect exposure to imports through inputs purchased in the domestic market, or $\Upsilon^T_{i,t}$ if one wants to illustrate total exposure to imports through both channels.

[17] Given the difficulty of measuring this phenomenon, the literature has used different measures to approximate it: the share of international trade in intermediate goods in production; the backward participation, which refers to the fraction of the value added in a country's exports that was produced in another country (approximated using the share of imported inputs in exports); and the forward participation, which captures the extent to which a country's exports are not fully absorbed in the importing country, but rather incorporated as production inputs in that country's exports to other countries (approximated as the share of domestically produced inputs in the exports of the rest of the world). The advantage of measuring the importance of GVCs by the share of intermediate goods in international trade is that it can be constructed relatively directly using trade flow data and product classification by type of good. Its disadvantage is that it is not sufficiently precise, since it could take a very high value for an industry whose production inputs are imported but only serves domestic demand. In contrast, forward and

exports associated with GVCs is identified (see Borin y Mancini (2019)), and second, the importance of these exports in the industry's total sales is quantified.

The objective of the first step is to capture the two important dimensions of GVCs: imported inputs used by the industry in the production of its exports (backward participation) and the industry's exports used as production inputs in other countries (broad forward participation, see De Soyres y Franco (2019)). Therefore, we propose to isolate these two specific components of exports as follows. Forward participation will correspond to exports of intermediate goods (the assumption is that if intermediate goods are exported, production is fragmented across at least two countries: the domestic one and the export destination. This is because the exported goods require at least one additional production stage to become a finished product). Backward participation will correspond to the foreign content (share of imported inputs in production costs) of exports of the remaining products. We define $X_{i,t}^{int}$ as the value in pesos of intermediate goods exports produced by industry i in year t, which corresponds to the export value of the subset of products in $X_{i,t}$ that correspond to intermediate goods (see section 4 for the details).[18] The fraction of exports associated with GVCs ($X\_GVC_{i,t}$) is defined as:

$$X_{GVC_{i,t}} = \underbrace{\frac{X_{i,t}^{int}}{X_{i,t}}}_{\substack{\text{Share of intermediate goods in exports} \\ \approx \textbf{Forward participation in GVC} \\ \text{(broad definition)}}} + \underbrace{\underbrace{\frac{MI_{i,t}^{tot}}{Y_{i,t}}}_{\text{Foreign content share}} \cdot \underbrace{\left(1 - \frac{X_{i,t}^{int}}{X_{i,t}}\right)}_{\text{Share of finished goods in exports}}}_{\approx \textbf{Backward participation in GVC}} \tag{9}$$

An important assumption behind this measure is that the fraction of imported inputs in the total industry's production value is the same for exports as for sales in the domestic market, so the value of $\frac{MI_{i,t}^{tot}}{Y_{i,t}}$ obtained from manufacturing surveys may be used.[19] The second step calculates the importance of exports associated with GVCs in the total sales of the industry, so that the **share of exports associated with GVCs in the industry's sales** ($GVC_{i,t}$) is defined as:

$$GVC_{i,t} = 100 \cdot X\_GVC_{i,t} \cdot \frac{XS_{i,t}}{XS_{i,t} + DS_{i,t}} \tag{10}$$

This measure conceptually approximates the "broad" measure of participation in GVCs proposed

backward participation measures are more precise to capture GVC involvement but require the use of international input-output tables and are therefore defined at very aggregated industry levels. For the case of Mexico, the statistics institute (INEGI) provides a measure of the value of global manufacturing production that approximates Mexico's production involved in global value chains by identifying firms whose production is linked to other countries. According to INEGI, "global manufacturing comprises economic activities that, according to production arrangements, highlight the sequences of interconnected production processes distributed across more than one country, dedicated to manufacturing activities. Consequently, in this process, imported raw materials are transformed into a higher-value product that serves as input in another process and another country." INEGI identifies global manufacturing firms as those belonging to one of the following three groups: 1) Exporting firms whose inputs mainly come from abroad (at least two-thirds of inputs as a share of exports are imported); 2) Exporting firms with majority foreign capital participation; 3) Exporters of intermediate inputs. However, this measure is only available at the industrial branch level (4-digit NAICS), which is still too aggregated for the purposes of this work, so it was discarded for analysis.

[18] Following De Soyres y Franco (2019), this category includes only intermediate goods, excluding final goods and capital goods.

[19] The literature has highlighted that exporting firms are also the main importers (see Amiti et al. (2014)), which would imply that our measure could be biased downwards.

by De Soyres y Franco (2019), which consists of the fraction of exports of intermediate goods or goods with foreign content, thus excluding the domestic content that is exported as final goods (and presumably consumed directly by consumers in the export destination) from export flows.[20] The advantage of our measure of exports associated with GVCs in industry sales is that it has greater disaggregation compared to other existing measures. However, it still has the disadvantage that conceptually it is defined at the industry level, while GVC participation occurs at the firm level. Therefore, it implicitly ignores the "narrow or relational" conception of GVCs proposed by Antràs (2020), which highlights very particular characteristics such as the persistence of relationships between firms and transactions within the same firm. The measure is also subject to the criticism raised by de Gortari (2019) since it assumes that all products of an industry use the same input composition by origin, hiding the high heterogeneity that actually exists.

Finally, we construct a measure that captures both dimensions of international trade relevant to domestic production, that is, the import of inputs and the export of manufactured products. Denoting the production value in domestic currency as $Y_{i,t}$, the **share of international trade in production** is defined as follows:[21]

$$\Upsilon_{i,t}^{CT} = 100 \cdot \frac{MI_{i,t}^{tot} + XS_{i,t}}{Y_{i,t}} \tag{11}$$

4 International trade participation in the Mexican industries

In this section we specify the sources of information and the details regarding the specific choices we made to construct the measures for the case of Mexico.[22]

4.1 Data

All measures were constructed at the 6-digit NAICS (2023 version).[23] Data on the value of total, domestic and imported inputs used by each industry; wages; domestic and foreign market sales; and production; are obtained from the Annual Manufacturing Industry Survey (EAIM) conducted by INEGI. The EAIM is available annually for the manufacturing sector, and the information is classified according to NAICS. We used the following data series: the 2009 Industrial Annual Survey (EIA), which covers the period 2003–2009 and is classified under NAICS 2002; the 2008 Annual Manufacturing Industry Survey (EAIM

[20] In traditional measures of GVC participation, the forward participation is defined as the domestic content that is re-exported from another country, thus isolating re-exported productive inputs (either directly or in manufactured goods in the destination country that are re-exported to other countries) from those used in the production of the direct partner and consumed in that same country. The data used in this paper does not allow identification of re-export flows from the destination country, so the forward participation component in GVCs includes the domestic content of all intermediate goods, which encompasses the forward participation defined as re-export flows, plus the domestic content used as productive input in goods consumed in the export destination. This implies that exports are considered part of a GVC as long as the exported goods are used in some additional stage of production, regardless of the country in which this occurs, and necessarily means that production takes place in at least two different countries.

[21] This measure can conceptually exceed 100 since exports include imported content.

[22] The sources of information may be specific to those that provide the most accurate data on each of the elements used in each measure in each particular economy.

[23] In the NAICS classification system, the manufacturing industry as a whole refers to a specific sector(2-digit code). The 3-digit code refers to the subsector, the 4-digit code to the industry group, the 5-digit code is referred to as the NAICS Industry, and the 6-digit code the national industry.

2008), covering 2009–2017 and classified under NAICS 2007; the 2013 Annual Manufacturing Industry Survey (EAIM 2013), which provides data from 2013 to 2021 and is classified under NAICS 2013; and the 2023 Annual Manufacturing Industry (EAIM 2023) that is classified under the 2018 version of NAICS and provides data from 2018 onwards. Since these data sources use different versions of NAICS, and the results need to align with the 2023 version of the system, it was necessary to harmonize the classifications and convert all survey data to the 2023 version. To do this, we used the official concordances between NAICS versions provided by INEGI. Because some 6-digit NAICS codes have changed over time, some of these in certain versions have no correspondence with other versions. This harmonization process led to the loss of certain 6-digit NAICS codes.[24] In the end, the chained series consist on XXX codes- VER CON CARLOS SI ESTO ES LO QUE SE HACE, O CÓMO ESTÁN LOS ARCHIVOS AL FINAL. Y AJUSTAR LA REDACCIÓN. TAMBIÉN ESPECIFICAR CUÁNTAS CLASES TENEMOS EN CADA CENSO Y CUÁNTAS EN LAS ENCADENADAS.

We also use information from the administrative data on the trade balance (customs data), provided by the Bank of Mexico.[25] The data from this source are classified according to the Tariff Schedule of the General Import and Export Tax Law (TIGIE), which, at the six-digit level, corresponds to the Harmonized Commodity Description and Coding System (HS code).

To identify imports and exports for each 6-digit NAICS code, we used the publicly available concordance between TIGIE and NAICS, which are published by INEGI. Finally, we used the 2018 I-O table at the 6-digit NAICS code available from INEGI (which uses the 2018 version of NAICS), as well as the "Broad Economic Categories" (BEC) classification from the United Nations Statistics Division. The BEC classifies products—based on the Harmonized System—into categories of intermediate goods, capital goods, and final goods.

To be more specific, sales in the domestic and export markets, the value of imported inputs, domestic inputs, total wages, and output value for each industry i in year t ($DS_{i,t}$, $XS_{i,t}$, $MI^{tot}_{i,t}$, $DI^{tot}_{i,t}$, $W_{i,t}$, and $Y_{i,t}$ as defined in section 3), are obtained from EAIM.[26] All variables are given in Mexican pesos.

Data on imports of goods produced by industry i at time t- both total and by origin o ($M_{i,t}$ and $M^o_{i,t}$)- are obtained from trade balance data. For the case of Mexico, we distinguish four origins that are relevant: the United States, China, nine Asian economies (South Korea, Malaysia, Taiwan, Thailand, Vietnam, India, the Philippines, Singapore, and Indonesia), and the rest of the world. Data on exports by destination is also obtained from the trade balance. In particular, because EAIM does not contain information about the destination of foreign sales, in order to estimate $\kappa^d_{i,t}$ we approximate $XS^d_{i,t}$ using data from the trade balance on total exports and those to destination d ($X_{i,t}$ and $X^d_{i,t}$, respectively). In particular, we approximate $XS^d_{i,t}$ as follows:[27]

[24] The transformation of data from older NAICS versions to the 2023 version at the 6-digit NAICS code level was carried out as follows: INEGI provides concordance tables that indicate, for each 6-digit NAICS code in the older version, the corresponding 6-digit codes in the subsequent NAICS version. Each of these is assigned the value of the relevant survey variable. This procedure is repeated for each version of the NAICS classification until reaching the 2023 version. The value of each variable assigned to the 2023 6-digit code corresponds to the sum of all matching observations, omitting duplicates, that ultimately correspond to that industry.

[25] The microdata for the trade balance are available through Banco de México's EconLab. The EconLab collected and processed the data as part of its effort to promote evidence-based research and foster ties between Banco de Mexico's research staff and the academic community. Inquiries regarding the terms under which the data can be accessed should be directed to econlab@banxico.org.mx.

[26] In the EAIM, the input category refers to the value of goods and services consumed by economic units in their production activities. It includes raw materials, packaging, fuels and lubricants, spare parts, electricity consumption, freight for sold products, and payments for repairs, staffing services, rent, royalties, and training.

[27] In practice, this multiplies sales to the foreign market according to EAIM by the share of exports to destination d within an

$$XS^{d}_{i,t} = XS_{i,t} \cdot \frac{X^{d}_{i,t}}{X_{i,t}} \tag{12}$$

Due to the importance of US as an export destination of Mexico, for the share of exports by destination, we focus exclusively on the US. Data on imports and exports are also given in Mexican pesos.

Information on the value of goods produced by industry k and used as inputs by industry i, imported and domestically produced (m_{ki} and q_{ki}, respectively) as well as the total value of domestic and foreign-origin inputs used by industry i plus wages paid by this industry (C_i) is obtained from the 2018 I-O table.[28] In particular, for the calculation of q_{ki} we use the product-by-product I-O table at the 6-digit NAICS code level; q_{ki} corresponds to the row for industry k in the column for industry i in the domestic origin table. Meanwhile, C_i corresponds to the sum of all rows (excluding taxes and value added) in the column for industry i in the total product-by-product I-O table (including domestic and imported inputs).

CARLOS, CREO QUE NOSOTROS HICIMOS ALGO DISTINTO ¿CIERTO? CREO QUE IGNORAMOS LOS QUE NO TENÍAN DIRECTA? Y SOLO TRABAJAMOSOCN LA M ATRIZ RESTRINGIDA? ¿REPONDERAMOS O QUÉ HACEMOS? There were other instances where we have to make further assumptions. For the calculation of $\Upsilon^{T}_{i,t}$, we make an additional assumption for the industries in the I-O table that do not have data for $\Upsilon^{D}_{i,t}$: we assign the average value of the branch to which they belong. In addition, for the calculation of the share of exports associated with GVC, the subset of products considered intermediate goods correspond to those classified as such according to the Broad Economic Categories (BEC) classification of the United Nations Statistics Division.

The estimated measures of exposure to international trade defined in section 3 between 2003-2023 by 6-digit NAICS code defined for each series of the manufacturing industry survey can be accessed here.

4.2 Descriptive statistics on the importance of international trade in industries in Mexico

We present some descriptive statistics of the measures aggregated at the industrial subsector level (3-digit NAICS) for the year 2023. Tables 1 and 2 show the simple average of the 6-digit NAICS codes within each subsector for some measures. Column (1) in table 1 indicates the number of 6-digit NAICS codes within each subsector used in the estimations (all codes included in EAIM). The table reveals heterogeneity in the importance of international trade across different subsectors. For example, the share of imports in apparent consumption ranges from 1.0% in the food industry to 94.9% in the computer equipment and other electronic devices manufacturing industry, while the share of exports associated with global value chains varies between 3.5% in the beverage and tobacco industry and 43.6% in the transportation equipment

industry according to the trade balance. We calculate this indirectly (through the ratio of export data from the trade balance), rather than by defining $XS^{d}_{i,t} = X^{d}_{i,t}$, to avoid the discrepancies that could arise due to the different data sources (for example, calculating shares of exports to destination d above one).

[28] For the measure of the direct share of imports by origin in production costs, some discrepancies emerge by linking information of the I-O table and trade balance data. For these cases (i.e., where the I-O table shows that an industry uses imported inputs from another industry, but trade balance data show no imports of products from that second industry in a given year), the measure assigns the share of inputs from that industry (according to the I-O table) to a residual category, separate from the United States, China, the nine Asian economies, and the rest of the world. This means that in some cases, the sum of the input shares by origin may not add up to 1.

manufacturing industry. It is notable that the total share of imports in production costs is similar to the direct share, indicating a relatively low estimated indirect participation. Additional descriptive statistics for the aggregated manufacturing sector are included in Appendix A.

Table 2 presents the estimated average of the share of imports in apparent consumption and production costs by origin, as well as the share of exports to the United States for 2023. The table highlights the importance of the United States as Mexico's trading partner, as this destination accounts for 22.3% of total sales in Mexico's manufacturing sector, as well as 22.4% of total consumption in the country of goods produced by this sector. The importance of China also stands out, since according to the estimates, 12.0% of total consumption in Mexico of products manufactured by the sector comes from this country, notably the computing and electronic equipment subsector, where products from China represent 38.3% of total consumption in the country.

To better illustrate the heterogeneity across industries, figure 1 shows the distribution of the measures constructed for all 6-digit codes for 2023. This illustrates the large variation across industries, especially noticeable for the measure of the participation of imports in apparent consumption.

Table 1: Participation in International Trade by Subsector, 2023.
Per cent

	Number of 6-digit codes	Import share in apparent consumption	Import share in production costs			Export share in total sales	Share of exports associated w/GVCs in industry's dales	Share of international trade in production
			Direct	Indirect	Total			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Food Manufacturing	27	50.9	10.3	7.1	17.3	36.3	33.0	40.1
Beverage and Tobacco Product Manufacturing	5	92.5	23.9	8.2	32.0	56.7	31.4	55.3
Textile Mills	7	69.7	12.4	15.4	27.8	26.3	4.9	30.2
Textile Product Mills	5	63.0	27.7	13.5	41.1	33.6	21.1	44.7
Apparel Manufacturing	8	39.5	31.4	16.1	47.5	13.5	10.4	31.4
Leather and Allied Product Manufacturing	5	1.0	16.6	14.0	30.6	37.7	1.8	42.4
Wood Product Manufacturing	5	55.0	20.1	9.6	29.7	25.8	21.7	31.5
Paper Manufacturing	5	95.5	22.7	5.1	27.8	71.4	24.0	37.7
Printing and Related Support Activities	2	27.2	13.3	6.8	20.1	20.0	16.2	23.0
Petroleum and Coal Products Manufacturing	3	51.1	27.0	0	27.0	8.4	3.7	19.20
Chemical Manufacturing	18	70.2	39.8	10.2	50.0	57.0	44.2	66.2
Plastics and Rubber Products Manufacturing	11	78.7	20.0	7.2	27.2	47.9	30.9	47.5
Nonmetallic Mineral Product Manufacturing	13	29.0	13.0	16.3	29.2	10.6	3.9	17.1
Primary Metal Manufacturing	11	40.0	2.6	13.3	15.9	7.3	0.2	7.8
Fabricated Metal Product Manufacturing	14	61.3	26.6	11.0	37.6	27.2	24.2	39.4
Machinery manufacturing	13	59.2	9.9	12.0	21.9	18.0	12.8	20.0
Computer and Electronic Product Manufacturing	8	62.0	34.7	15.5	50.2	31.9	29.8	46.8
Electrical equipment, appliance, and component manufacturing	9	26.1	11.2	11.5	22.7	16.7	2.6	21.6
Transportation Equipment Manufacturing	16	45.9	15.8	14.3	30.1	17.0	12.2	22.2
Furniture and Related Product Manufacturing	4	55.1	5.8	11.9	17.7	18.8	19.1	21.9
Miscellaneous Manufacturing	9	64.2	14.8	8.5	23.3	23.2	10.3	20.3
Total manufacturing	198	54.1	19.0	10.8	29.8	28.8	17.1	32.7

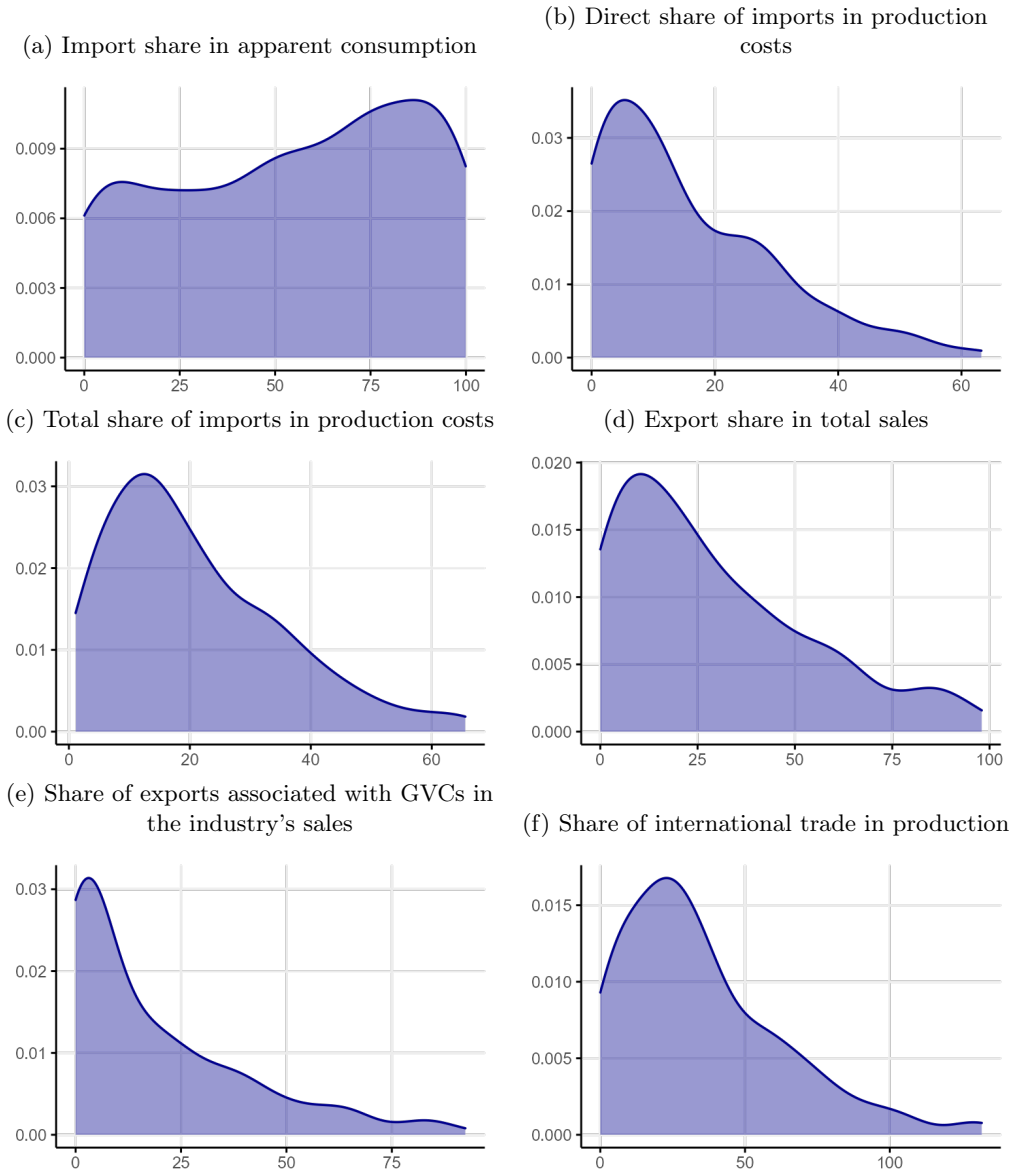
The simple average of each measure is reported for the 6-digit codes in each subsector according to the 2018 version of the NAICS.

Table 2: Share of Imports by Country of Origin by Subsector, 2023
Per cent

	Number of 6-digit codes	Import share in apparent consumption				Import share in production costs				Share of exports to the USA in total sales
		USA	China	9 Asian[a]	ROW	USA	China	9 Asian [a]	ROW	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Food Manufacturing	27	21.3	5.6	4.6	19.4	4.3	1.4	0.9	3.5	27.3
Beverage and Tobacco Product Manufacturing	5	34.5	18.9	8.3	30.8	9.2	5.2	3.2	6.2	50.3
Textile Mills	7	6.2	32.7	9.1	21.6	3.8	3.6	1.3	3.6	23.7
Textile Product Mills	5	32.8	12.1	5.1	13.0	16.6	2.60	2.6	5.5	28.5
Apparel Manufacturing	8	26.5	3.9	1.9	7.3	17.8	4.2	2.1	7.0	9.9
Leather and Allied Product Manufacturing	5	0.5	0.0	0.0	0.5	9.3	0.9	0.9	5.3	25.5
Wood Product Manufacturing	5	23.5	11.6	5.3	14.6	8.0	4.1	2.8	5.0	22.3
Paper Manufacturing	5	21.5	32.4	25.4	16.2	6.8	6.2	5.7	3.9	61.8
Printing and Related Support Activities	2	8.1	7.3	2.1	9.9	7.0	1.3	0.9	3.5	18.7
Petroleum and Coal Products Manufacturing	3	45.3	0.9	2.0	2.9	21.2	0.9	1.5	2.5	8.1
Chemical Manufacturing	18	30.6	13.3	8.6	17.8	17.0	7.8	5.0	9.7	49.5
Plastics and Rubber Products Manufacturing	11	24.1	28.2	8.4	18.0	7.4	4.9	3.2	4.4	43.2
Nonmetallic Mineral Product Manufacturing	13	15.6	3.7	0.8	8.9	6.6	1.5	1.1	3.7	8.1
Primary Metal Manufacturing	11	15.9	15.5	2.4	6.1	0.9	0.8	0.3	0.6	7.0
Fabricated Metal Product Manufacturing	14	32.4	6.7	4.1	18.1	15.9	2.8	2.0	5.3	14.1
Machinery manufacturing	13	7.0	22.3	9.0	21.0	4.4	1.2	0.5	3.7	9.1
Computer and Electronic Product Manufacturing	8	24.4	22.8	4.3	10.5	19.4	7.8	3.0	4.4	22.2
Electrical equipment, appliance, and component manufacturing	9	14.8	1.3	0.8	9.4	6.2	0.5	0.4	3.6	11.0
Transportation Equipment Manufacturing	16	13.6	22.0	3.4	6.9	7.3	3.2	1.8	2.7	15.6
Furniture and Related Product Manufacturing	4	22.4	6.8	1.5	24.4	3.3	0.9	0.4	2.2	20.7
Miscellaneous Manufacturing	9	22.5	18.4	7.5	15.8	7.2	2.6	1.6	3.3	20.7
Total manufacturing	198	21.1	13.6	5.5	14.0	9.5	3.1	2.0	4.3	23.7

The simple average of each measure is reported for the 6-digit codes in each subsector according to the 2018 version of the NAICS.
[a] Includes South Korea, Malaysia, Taiwan, Thailand, Vietnam, India, the Philippines, Singapore, and Indonesia.

Figure 1: **Distribution of the importance of international trade across manufacturing industries, 2023**



The distribution function of the 6-digit codes according to the measure of participation in international trade is shown in each panel. The sample includes all manufacturing codes included in the 2023 EAIM.

One useful feature of the measures constructed is that they allow to illustrate the evolution of the importance of international trade in the manufacturing industry in Mexico over time. Figures 2, 3, and 4 show the evolution of some measures between 2003 and 2023 for the total manufacturing industry, the food manufacturing, and the Transportation Equipment Manufacturing subsectors, respectively. We show the evolution of each EAIM series in different colors. As the fitures show, even that each one of the subsequent series overlap for at least one year, they differ in the levels. There are two reasons why this may be the case. First, the industry classification is updated for each series, so the sample of 6-digit codes, and of firms surveyed, may differ between them. Second, there may be methodological changes in the survey that may

affect the leverls of the variables constructed. In order to analyze the evolution throughout the period, we also construct a chained series (depicted in the dotted pink line in figures 2 to 4).[29] For the remainder of the paper, all the analysis that requires using the time series that covers the whole period will be limited to the sample of 6-digit codes that can be tracked throughout 2003-2023.

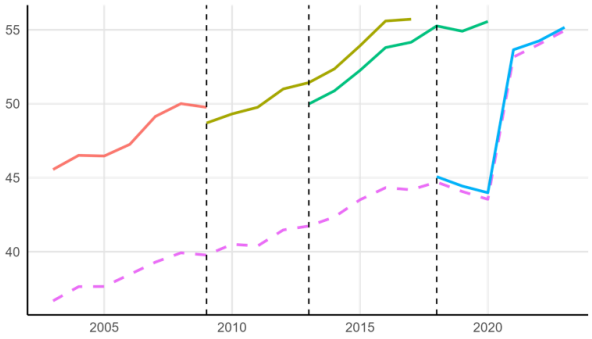
Figure 2 shows the exercise for the manufacturing sector as a whole in Mexico.A clear increase is observed throughout the period in the participation of imports in apparent consumption, exports in sales, and share of exports associated with GVCs in total sales (panels (a), (d), and (e)).[30] Additionally, there is a slight decline in the direct share of imports in production costs, as well as in their total share (panels (b) and (c)). The decline in the total participation of imports in costs seems to be driven by the former. This behavior may reflect the development of clusters of domestic suppliers for exporting firms, which could be meeting the demand for inputs amid the expansion of the export sector. The increasing trend in the participation of exports seems to dominate in aggregate, as the participation of international trade in production has shown a growing trend during the period (panel (f)).

[29] To construct the full-period series for each 6-digit code, we begin with the levels of each measure from the most recent survey and chain them backward using the annual variations of that code in the previous survey (this can be done because there is at least a one-year overlap between each series). Since the industrial classification version differs across each manufacturing survey, some 6-digit codes are lost in the chaining process. The transformation of data from older NAICS versions to the 2023 version at the 6-digit NAICS code level was carried out as follows: INEGI provides concordance tables that indicate, for each 6-digit NAICS code in the older version, the corresponding 6-digit codes in the subsequent NAICS version. Each of these is assigned the value of the relevant survey variable. This procedure is repeated for each version of the NAICS classification until reaching the 2023 version. The value of each variable assigned to the 2023 6-digit code corresponds to the sum of all matching observations, omitting duplicates, that ultimately correspond to that industry. This means that the chained series does not coincide with the level of the 2023 EAIM series in the figures, even though it will coincide for the average of the subset of 6-digit codes included in the chained series for the years 2020-2023. This also means that each time a new version of the EAIM (or each time the NAICS classification is updated) the chained series are modified.

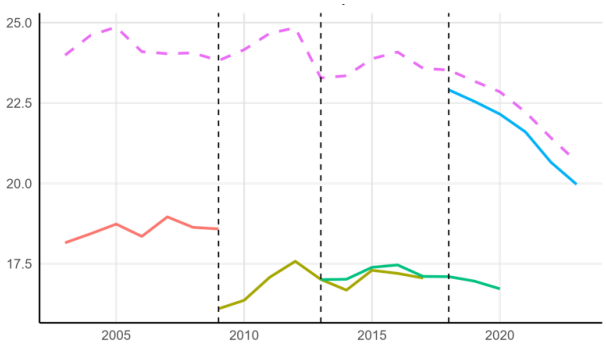
[30] For the case of import share in apparent consumption, there is a noticeable increase between 2020 and 2021 in the measure constructed for EAIM23 series (blue line). This sharp increase coincides with the sharp increase in the value of merchandise imports of Mexico between these years

Figure 2: **Evolution of the importance of international trade**
Total manufacturing sector
Participation (%)

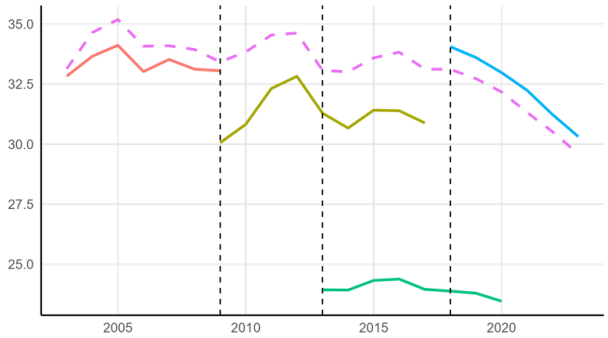
(a) Import share in apparent consumption



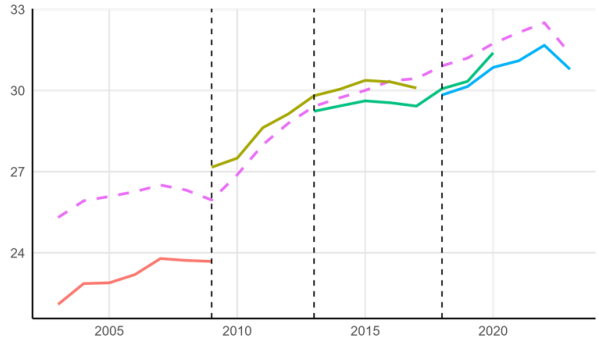
(b) Direct share of imports in production costs



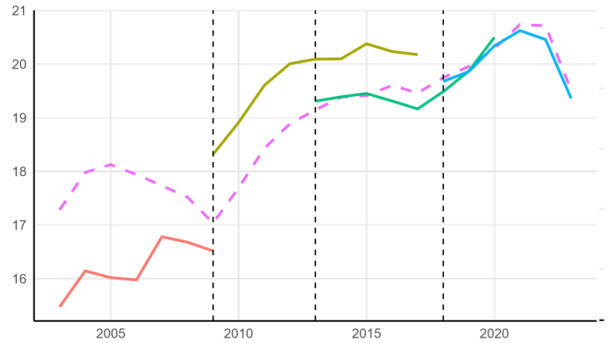
(c) Total share of imports in production costs



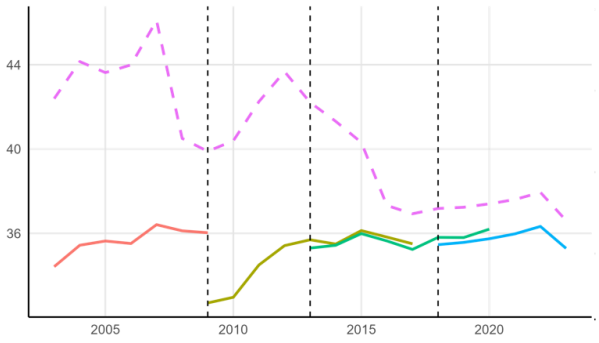
(d) Export share in total sales



(e) Share of exports associated with GVCs in the industry's sales



(f) Share of international trade in production

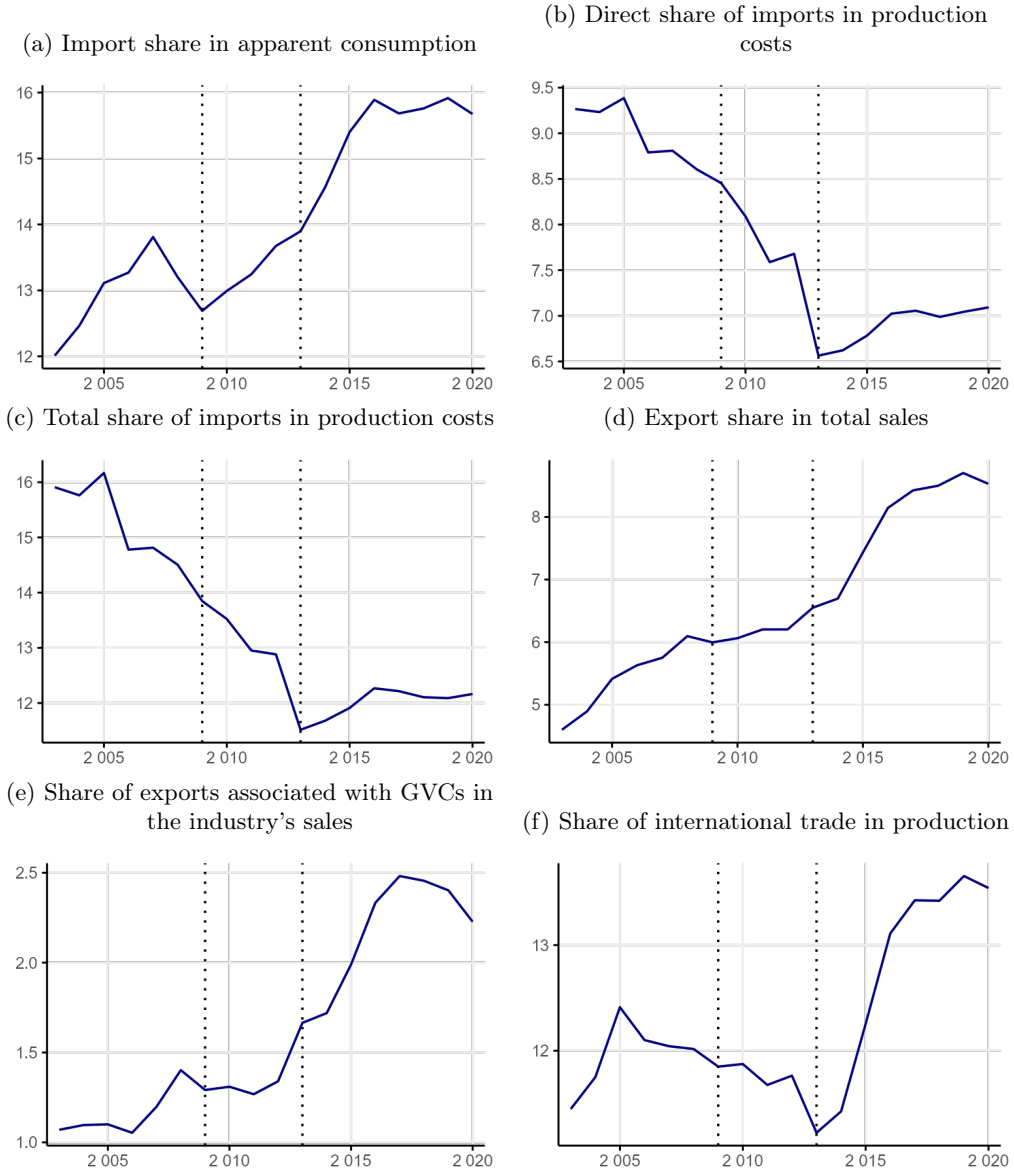


Note: The simple average for each measure is plotted for the subsample of 6-digit codes that may be linked throughout the entire period. The dotted vertical lines illustrate the chaining periods used for constructing the series.

Figure 3 shows the exercise for the food manufacturing subsector, which is the second most important manufacturing subsector in Mexico in terms of gross production value, and the most important in terms of number of establishments. Although international trade plays a relatively minor role in this industry (reflected in lower levels of the constructed measures as compared to the manufacturing sector average), broadly similar trends are observed: an increase in the participation of imports in apparent consumption and exports in sales, and decreases in the direct and total participation of imports in production costs. Notably, these last two measures stopped decreasing in this sector starting in 2013. Another difference between the

food sector and the aggregate manufacturing sector is that the increase in the participation of international trade in production seems to have occurred starting in 2013.[31] The third notable difference is that the participation of exports associated with global value chains (GVCs) appears to be negligible in this subsector (it is estimated that GVC-associated exports represent less than 2.5% of the industry's total sales), despite the measure showing an increasing trend throughout the period.

Figure 3: **Evolution of the importance of international trade**
Food manufacturing
Participation (%)



Note: The simple average for each measure is graphed for the subsample of 6-digit codes that correspond to the food manufacturing subsector and that may be linked throughout the entire period. The dotted vertical lines illustrate the chaining periods used for constructing the series.

[31] The changes in the trends observed since 2013 should be interpreted with caution, as that year coincides with a change in the survey, which means that some methodological change could be part of the explanation of the changes.

In Figure 4 we show the evolution of the measures for the transportation equipment subsector, which, given the importance of the automotive sector in Mexico, corresponds to the most important manufacturing subsector in terms of gross production (representing around one-third of total manufacturing production). Unlike the food industry,it has a clear export-oriented profile and association with global value chains (GVCs). Indeed, international trade appears to play a significant role, greater than the average for the manufacturing sector as a whole. For example, exports associated with GVCs have gained importance and currently represent more than half of sales in this subsector. It is also notable that the participation of international trade in production (exports plus imported inputs) even exceeds the total value of production.

Figure 4: **Evolution of the importance of international trade**
Transportation equipment subsector
Participation (%)

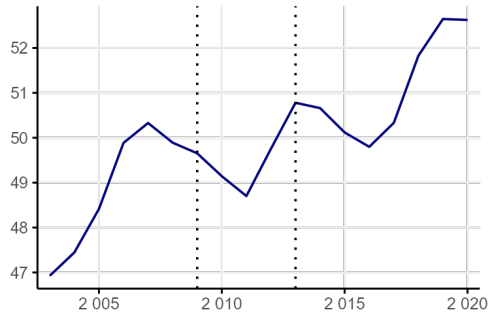
(a) Import share in apparent consumption

(b) Direct share of imports in production costs

(c) Total share of imports in production costs

(d) Export share in total sales

(e) Share of exports associated with GVCs in the industry's sales



(f) Share of international trade in production

Note: The simple average for each measure is graphed for the subsample of 6-digit codes that correspond to the transportation equipment subsector and that may be linked throughout the entire period. The dotted vertical lines illustrate the chaining periods used for constructing the series.

5 Relevance of international trade for price index baskets in Mexico

In this section, we use the proposed measures to conduct a descriptive analysis of the importance of international trade for manufactured goods included in the consumer price index (CPI) and producer price index (PPI) baskets in Mexico. The analysis is carried out at the generic level. The international trade

measure assigned to each generic item corresponds to that of the industrial class that produces it. Several items can be classified within the same 6-digit industry, so all of them are assigned the same measure. In the case of the items in the PPI, this correspondence is direct, as INEGI identifies each generic within the industrial class that produces it. In the case of the CPI, INEGI only indicates the branch (4-digit industry) to which each generic corresponds, so the correspondence from generic to class was done manually, using the 2013 SCIAN catalog available from INEGI as a reference. This catalog provides industrial descriptions for SCIAN, including a list of products manufactured by each class.[32] Some CPI items are associated with more than one class, so the measures assigned to these items correspond to the average of the associated classes, weighted according to the apparent consumption of each class.[33] The correspondence we constructed between the CPI items and the SCIAN 2013 industrial class can be found at the following link: Data.

[34]

Due to the nature of the constructed measures, only the items produced by an industry within the manufacturing sector are included in this analysis. Therefore, the analysis in this section is limited to the basket of manufactured goods from the PPI and CPI. In the case of the CPI, this basket is a subset of the merchandise basket of the core component.[35] We obtain the consumer and producer price data from INEGI. For the latter, we use data on total production prices for the domestic market.

5.1 Composition of price index baskets based on the degree of international trade participation

We begin by analyzing the evolution of the composition of the price baskets for manufactured goods according to the different ways in which international trade can be relevant. For these exercises, the sample of items is limited to those linked to industries for which a consistent time series of trade participation measures can be constructed over the entire period. This means that items corresponding to industrial classes lost during the process of chaining series across different versions of the manufacturing survey are excluded from the analysis. In all cases, each bar in the graphs represents the weighted sum of the corresponding measure for each generic in the indicated subsector. The weight used corresponds to the weight of each generic in the relevant price index (CPI or PPI), reweighted so that the balanced basket of manufactured goods sums to one over the entire period.

Starting with the composition of the CPI, Figure 5 illustrates the composition of the manufactured goods index based on imports of consumer goods, as well as the domestic and imported content in national production. The analysis is shown for the manufacturing sector as a whole (panel (a)) and for a selected sample of subsectors chosen arbitrarily.[36] It can be observed that the consumption of imported products has gained importance at the aggregate level (orange bars in panel (a)). This increase is particularly pronounced

[32]; The correspondence can be found at this link: https://www.inegi.org.mx/app/scian/

[33]; Apparent consumption is used as the weighting factor because the CPI aims to represent the average household consumption patterns in Mexico.

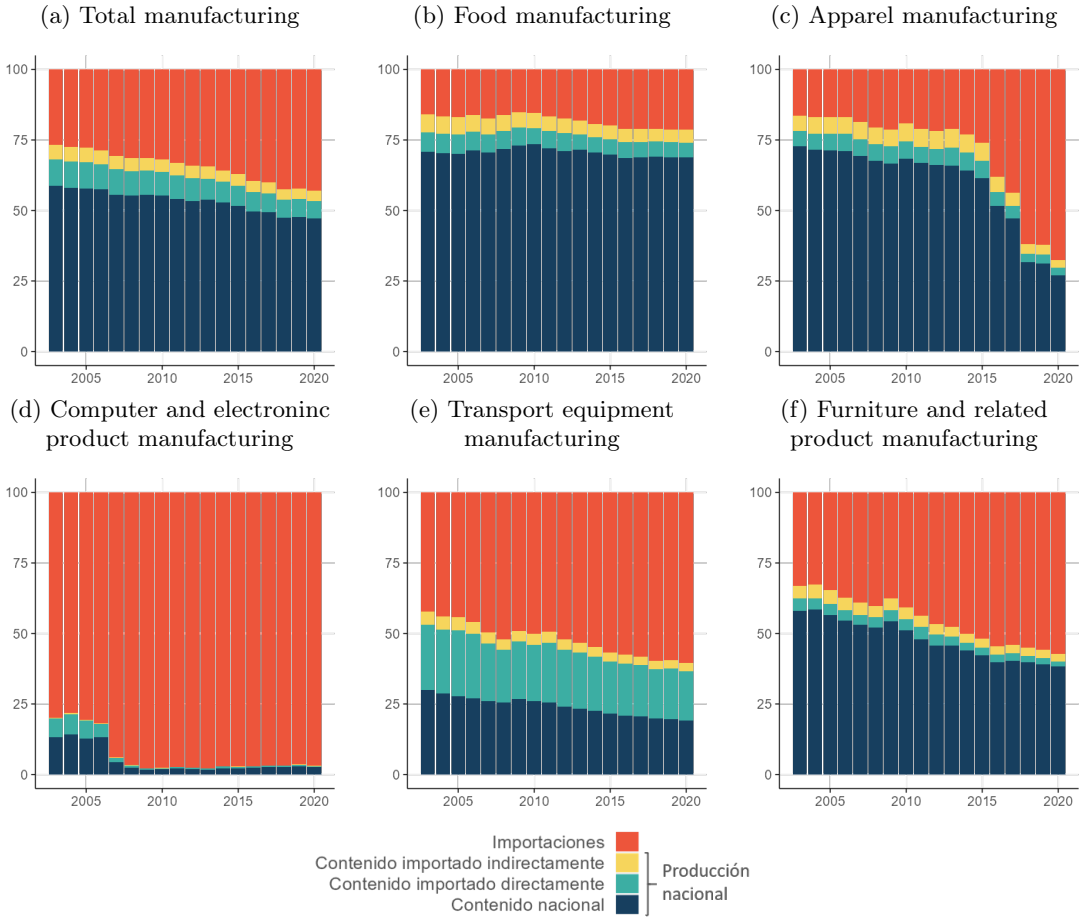
[34] INEGI provides information on the 6-digit NAICS industry associated with each item in the Producer Price Index (PPI) basket, but only the industry group (4-digit code) for those in the Consumer Price Index (CPI) basket. The mapping of these items to their corresponding 6-digit code was carried out manually as part of this paper.

[35]; The following goods are excluded because, according to the correspondence, they are produced by non-manufacturing industries: newspapers, magazines, textbooks, other books, pizzas, rotisserie chicken, barbacoa or birria, carnitas, other cooked foods, footwear services and items, other dried legumes, corn.

[36]; Results are shown only for a sample due to space constraints, but results for all subsectors are available upon request from the authors.

in recent years for clothing (panel (c)), although a clear upward trend is also visible for automobiles and auto parts (panel (e)), as well as for furniture (panel (f)). The estimates in this study suggest that the vast majority of computers and other electronics purchased in Mexico are imported (panel (d)). On the other hand, the share of imported content in domestic production (green bars) does not appear to be as significant, except for the transportation equipment subsector, and it has even declined in the aggregate index—consistent with the results from the previous section.

Figure 5: **Composition of the manufactured goods in the CPI basket by domestic content and imports in apparent consumption**
Percentage share

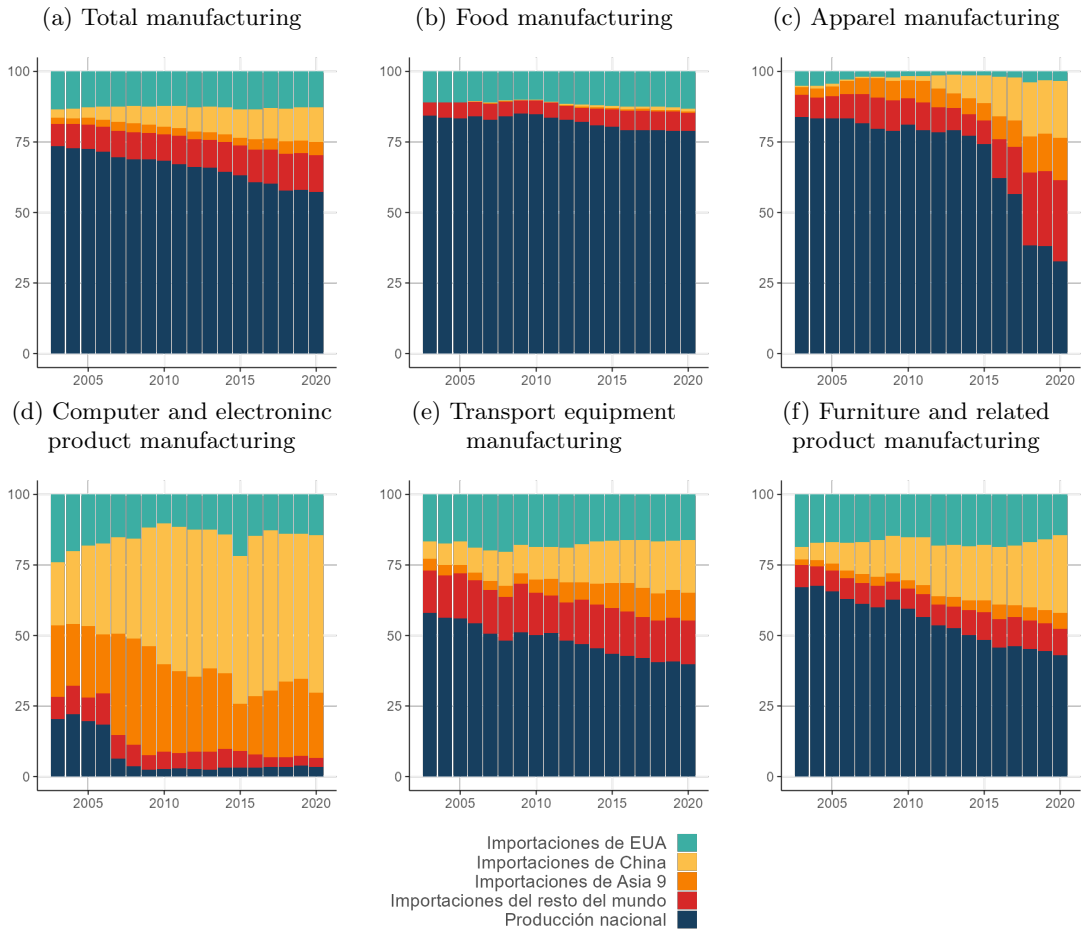


For each subsector, the weighted average of each measure within the CPI basket is graphed, using the weights of each generic item within this basket, normalized so that they sum to 1 across the total manufactured goods in the sample. The sample is limited to items associated with industrial classes whose series can be chained over the entire period.

In Figure 6, we separate imports according to the origin of the products in the CPI basket. It is noteworthy that, during the study period, the share of the United States in apparent consumption remained relatively constant (green bars). In contrast, the growth in China's share (yellow bars) is evident both in the aggregate and across all the subsectors shown, except for the food industry. Similarly, the increase in the share of the nine selected Asian economies (orange bars) is notable in the clothing sector, the computer and electronics equipment sector, and the transportation equipment manufacturing sector. The share of partners

from other parts of the world (red bars) has also grown in the apparent consumption of clothing, products manufactured by the transportation equipment subsector, and manufactured goods as a whole.

Figure 6: **Composition of the apparent consumption of manufactured goods in the CPI basket by origin**
Percentage share



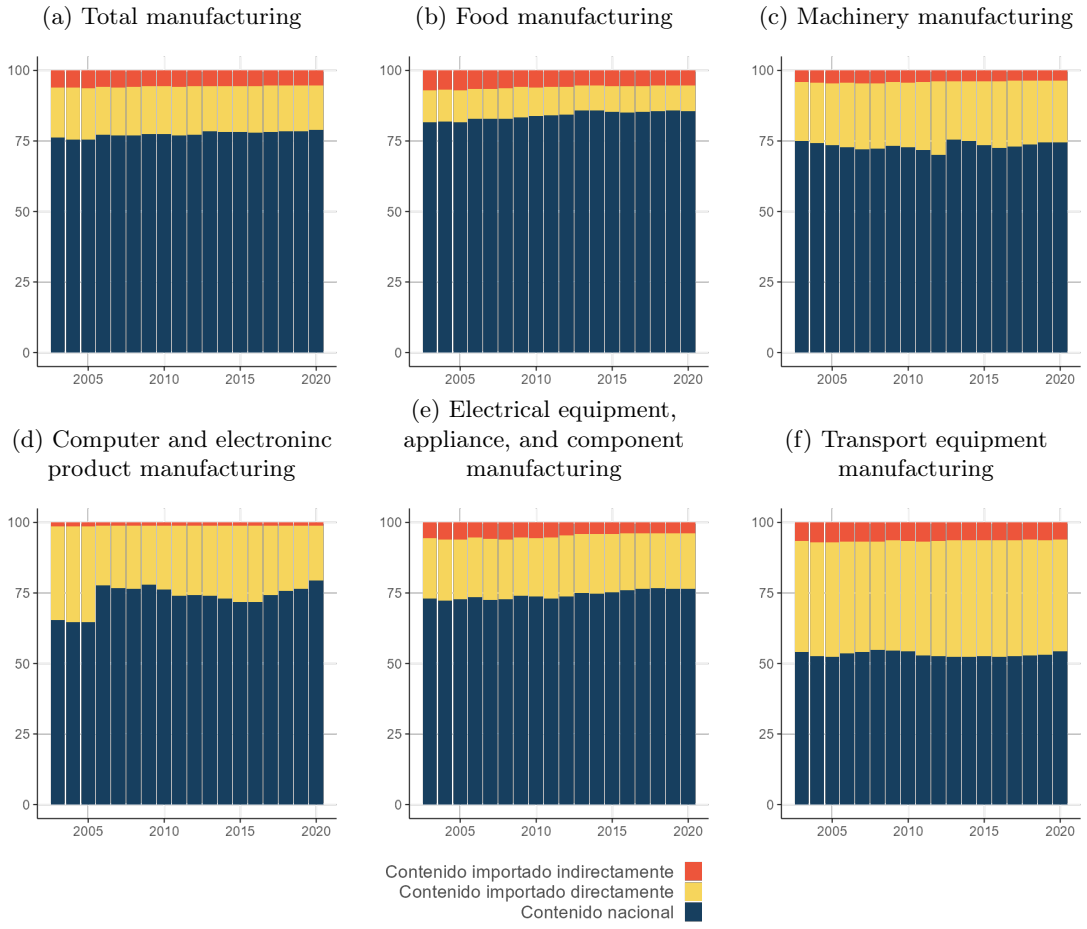
Note: For each subsector, the weighted average of each measure within the INPC basket is graphed, using the weights of each generic item within this basket, normalized so that they sum to 1 for the total of manufactured goods in the sample. The sample is limited to items associated with industrial classes whose series can be chained throughout the entire period.

The following graphs present an analogous analysis for the case of manufactured goods in the INPP. This exercise provides an additional perspective because, unlike the INPC basket—which reflects the representative consumption of households in Mexico—this basket better reflects the country's productive profile. Therefore, the following figures illustrate the composition of the basket of goods included in the INPP according to the trade-related measures relevant to this price index. We omit measures of apparent consumption since final imported products are not priced in the INPP. On the other hand, we include measures of import participation in production costs by origin, as well as export participation measures, which are priced in the INPP but not in the INPC.

In Figure 7, we illustrate the composition of production costs according to the importance of imported

inputs for the items in the INPP basket. National content (blue bars) refers to inputs sourced from the domestic market plus remunerations. Recall that direct imported content refers to inputs purchased from foreign markets, while indirect imported content refers to the foreign content fraction of goods due to the fact that domestic inputs may themselves be manufactured using imported inputs. These graphs highlight that the share of content imported either directly or indirectly in costs appears to have remained fairly constant over time for the manufacturing sector as a whole. There is a slight increase visible in the fraction of national content in the food industry and in the electrical apparatus and equipment industry. Notably, for the transportation equipment subsector, it is estimated that almost half of the content of the goods in the basket is imported, which could reflect this industry's tendency to globally fragment its production.

Figure 7: **Composition of the manufactured goods in the PPI basket by the share of imported content in production costs during 2019**
Percentage share

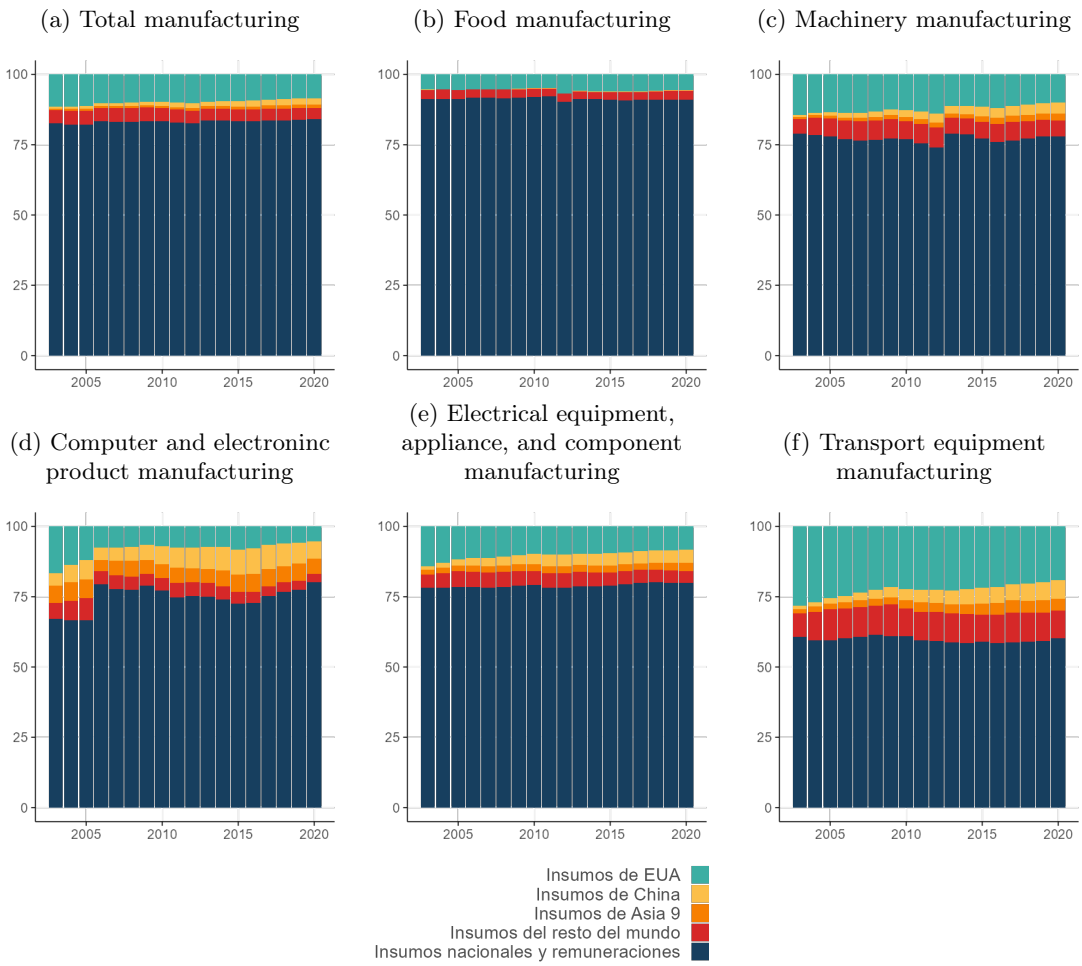


Note: For each subsector, the weighted average of each measure within the total production basket of the INPP is graphed, using the weights of each item within this basket, normalized so that they sum to 1 for the total of manufactured goods in the sample. The sample is limited to items associated with industrial classes whose series can be chained throughout the entire period. Indirect imported content corresponds to the estimated imported content in domestic inputs used in national production. National content includes the domestic component of domestic inputs plus total wage bill.

Figure 8 shows the composition of directly imported content by origin. Once again, it is observed that the share of the United States has remained relatively constant, and there is even a noticeable decline in its

importance as a supplier of inputs, which appears to have been compensated by supply from other countries. The figure illustrates that although China has gained importance in the inputs used by domestic producers, particularly in the transportation equipment subsector (panel (f)), the growth in its share is less pronounced than in the case of finished goods shown in Figure 6.

Figure 8: **Composition of the manufactured goods in the PPI basket by the origin of inputs used in production during 2019**
Percentage share

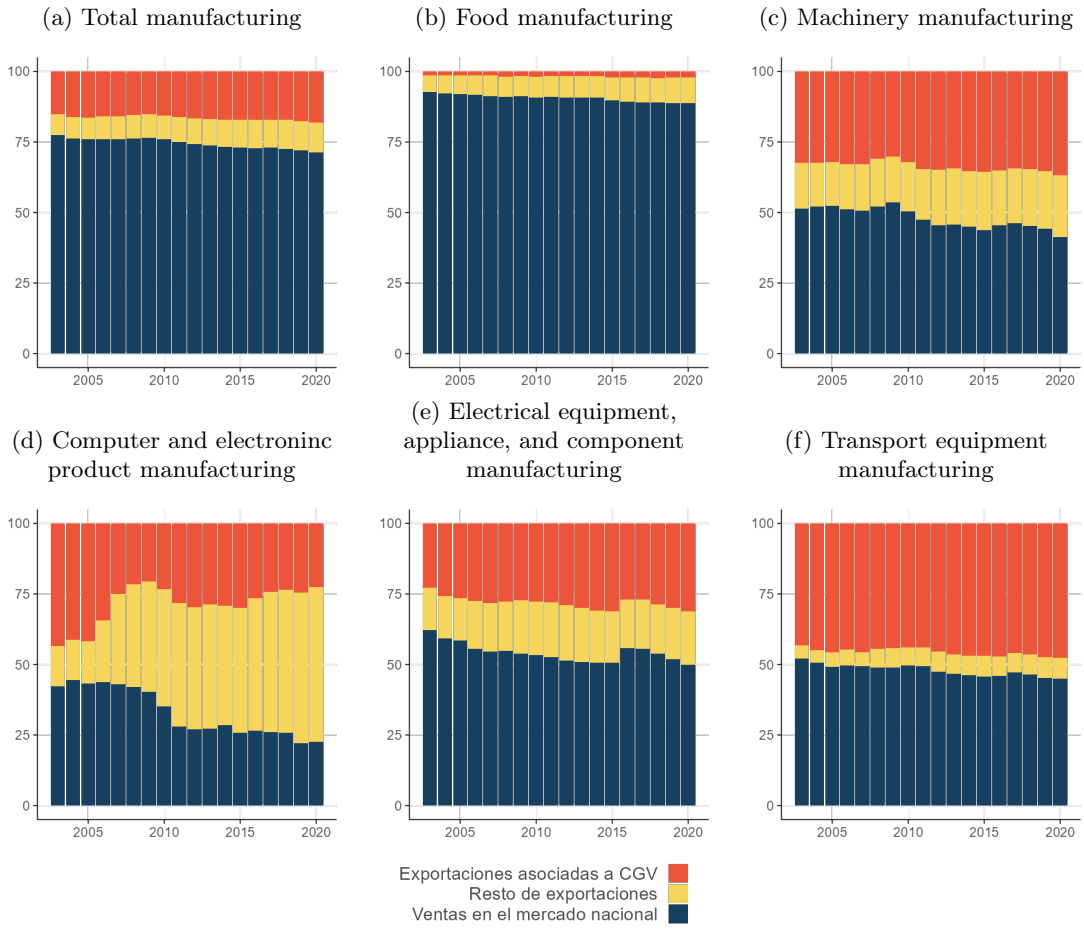


Note: For each subsector, the weighted average of each measure within the total production basket of the INPP is graphed, using the weights of each item within this basket, normalized so that they sum to 1 for the total of manufactured goods in the sample. The sample is limited to item associated with industrial classes whose series can be chained throughout the entire period. Domestic inputs include both their national and imported content.

Figure 9 illustrates the composition of the INPP basket according to whether the sales of the industries producing these goods are destined for the domestic market or for export, distinguishing among exports those associated with Global Value Chains (GVCs) from the rest. It is notable that, for the aggregate manufacturing sector, the largest share of sales is destined for the domestic market (panel (a)), although exports of products from the machinery and equipment, computing and electronic accessories, electrical apparatus and equipment, and transportation equipment sectors have clearly increased (panels (c) to (f)). Regarding the importance of exports associated with GVCs, this appears to be particularly relevant for the

last four subsectors, especially for transportation equipment, where it has gained importance over the study period, reflecting the development of the export-oriented automotive industry. In contrast, exports associated with GVCs in the computing and electronic accessories subsector seem to have lost importance. This suggests that this sector in Mexico has specialized in goods whose production is not fragmented. However, it is worth noting that, as shown in Figure 5, domestic production represents a very small fraction of national consumption, suggesting that Mexico has not integrated into the international production chains of this sector.

Figure 9: **Composition of the manufactured goods in the PPI basket by the destubatuib of sales during 2019**
Percentage share



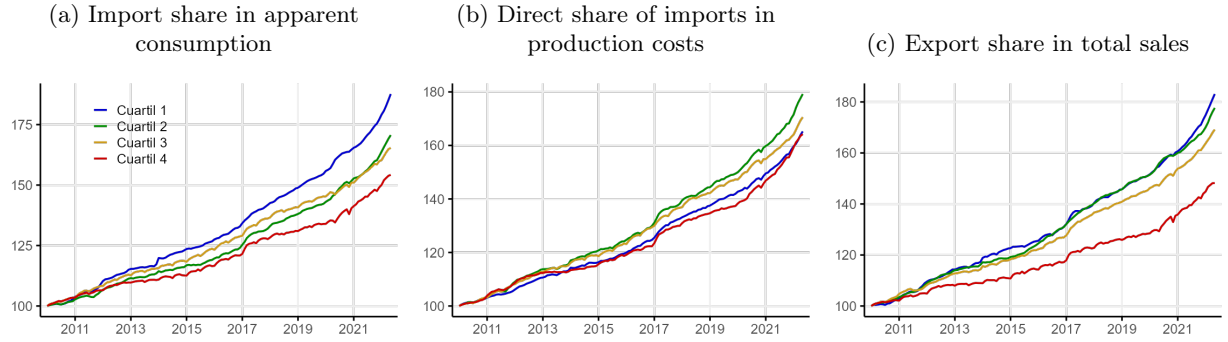
Note: For each subsector, the weighted average of each measure within the total production basket of the INPP is graphed, using the weights of each generic item in this basket, normalized so that they sum to 1 for the total of manufactured goods in the sample. The sample is limited to items associated with industrial classes whose series can be linked throughout the entire period.

5.2 Evolution of the price indices of baskets of goods according to their exposure to international trade

To assess whether there is a relationship between international trade participation and price evolution, in this section we divide the manufactured goods of each index into different baskets according to some of the trade participation measures calculated for the year 2019.[37] We then illustrate the evolution of the average price indices of these baskets over the period 2010-2022.

First, we divided the items in the INPC basket into quartiles based on their measures of import participation in apparent consumption, direct import participation in production costs, and export participation in sales, all calculated for 2019. The evolution of the price index for these baskets (the simple average of the price index of all items in each quartile) is illustrated in Figure 10. In panel (a), it is observed that the price index of quartile 4 for import participation in apparent consumption (i.e., those items with the highest participation, represented by the red line) has been the quartile with the lowest cumulative growth during the period 2010-2022. In contrast, quartile 1 (the items with the lowest import participation in apparent consumption, represented by the blue line) has accumulated the highest growth. A similar pattern is seen for the quartiles based on export participation in sales (panel (c)), meaning that the prices of items with the highest export participation have had lower cumulative growth since 2010. For the quartiles based on direct import participation in production costs, no clear pattern is observed, as the price indices for quartiles 1 and 4 are below those of quartiles 2 and 3.

Figure 10: **Consumer price index of manufactured goods baskets by quartile of international trade importance**
Index January 2010=100



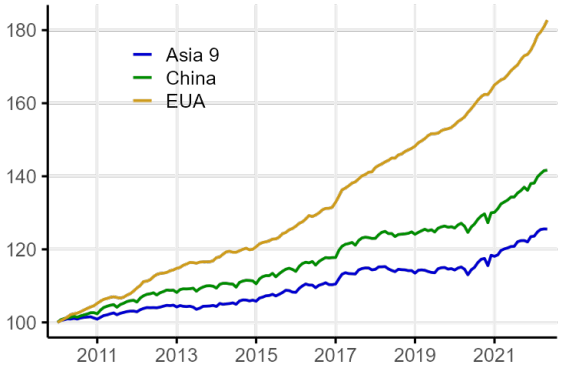
Note: The simple average of the price index of the items in each basket is calculated. Items for which complete price information is not available for the entire period are excluded from the calculation.

We constructed three additional baskets of items intensive in imports in apparent consumption according to the origin of the imports. For each origin o, we define the basket of items exposed to imports from o as those for which $\mu^o_{i,t} \geq 20\%$. The evolution of the average price index of these baskets is shown in Figure 11. This illustrates that goods primarily originating from Asia have experienced lower levels of inflation compared to those from the United States, suggesting that the behavior of quartile 1 shown in panel (a) of

[37] We decided to use 2019 as the base year to avoid outlier values in the measures that may have occurred in 2020 due to the COVID-19 pandemic. Although the graphs shown in this section regarding the composition of the indices suggest there were no noticeable distortions (atypical jumps in the composition), we prefer to be conservative and take the most recent pre-pandemic year as the base.

Figure 10 could be due to the importation of goods mainly from Asia.

Figure 11: **Consumer price index of manufactured goods baskets that are intensive in imports from different origins**
Index January 2010=100

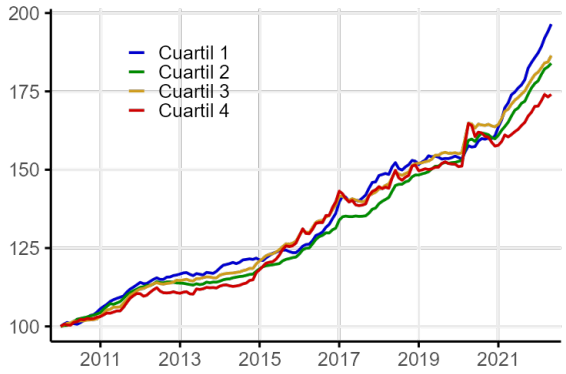


Note: The simple average of the price index of the items in each basket is calculated. Items for which complete price information is not available for the entire period are excluded from the calculation.

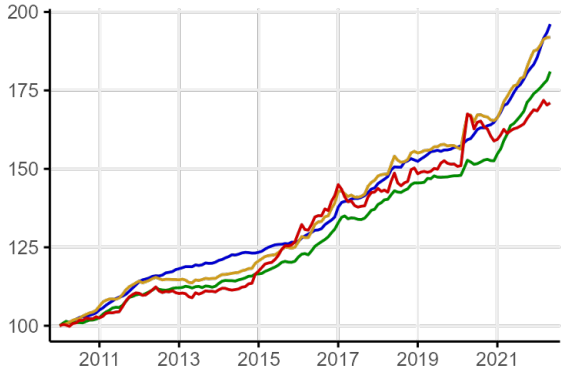
Finally, Figure 12 presents an analysis analogous to that of Figure 10, but now for the items in the INPP basket. Panel (a) shows the quartiles based on the share of imports in production costs and, consistent with the results shown in Figure 10, there does not appear to be a clear pattern in the differences in the price behavior of items across different baskets. Panel (b) displays the quartiles according to the share of exports in production costs. In the period 2010-2015, there seems to be some evidence confirming that the prices of the items most exported correspond to those that experienced lower levels of inflation. However, from 2015 onward, this pattern disappears. A plausible explanation is the mechanical impact that the exchange rate has on the construction of the INPP, since export prices are quoted in dollars, and while the exchange rate was stable during 2010-2015, it experienced a constant depreciation in 2016, followed by another sharp and abrupt depreciation at the beginning of 2020.

Figure 12: **Producer price index of manufactured goods by quartile of international trade importance**
Index January 2010=100

(a) Direxts share of imports in production costs



(b) Export share in total sales



Note: The simple average of the price index of the items in each basket is calculated. Items for which complete price information is not available for the entire period are excluded from the calculation.

Overall, the results shown in the figures suggest that consumer prices for products with a higher share of imports in apparent consumption and exports in sales have experienced lower growth, indicating that the most traded goods have exhibited lower levels of inflation. This behavior could be the result of various factors, such as international trade enabling production fragmentation and greater specialization, thereby contributing to higher productivity gains. Additionally, trade could be inducing greater competition in domestic markets. However, the trade participation measures presented might be capturing other intrinsic characteristics of the goods that involve lower inflation levels, but not as a consequence of trade. Although this document does not explore the channels determining the observed behavior, the descriptive evidence can serve as a starting point for future research investigating these mechanisms.

6 Conclusions

International trade and the global fragmentation of production can have significant, though complex, macroeconomic implications for economies. Understanding these complexities requires a deeper comprehension of countries' trade integration. This document is a step in that direction by proposing measures of its importance in manufacturing industires. These serve as tools that can deepen the analysis of the multiple implications of trade openness, as it is illustrated for the case of Mexico. The framework proposed in this work may be used for the analysis in other economies, although it may need to be adapted depending on data availability at hand. However, this work may provide a conceptual framework that allows researchers to build on these measures. By doing this, we hope to stimulate a debate on how these measures may be improved or best used to enhance economic analysis.

In terms of policy implications, this document shows that Mexico's trade openness has been reflected in the growing importance of imports and exports in the composition of the manufactured goods baskets used in the price indices. We also present evidence that the prices of goods with greater exposure to international trade, across its different dimensions, have experienced lower levels of inflation over the past two decades.

Although this study does not analyze the specific mechanisms behind this outcome (e.g., whether international trade has played a causal role), the evidence presented suggests that examining these dimensions is a relevant area of research from a public policy perspective.

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Appendix

A Descriptive statistics

Table A1: Descriptive statistics of the importance of international trade for the classes in the manufacturing sector

	Minimum	Median	Maximum	Standard deviation
Participation of imports in apparent consumption				
Total	0	57.8	99.9	32.1
From USA	0	19.5	69.4	17.6
From China	0	5.9	72.8	15.4
From 9 Asian countries [a]	0	2.8	52.3	7.3
From the rest of the world	0	11.4	68.6	13.9
Participation of imports in production costs				
Direct	0	11.3	63.2	14.2
Total	1.1	16.9	65.5	14.5
Direct participation of imports in costs by origin				
From USA	0	5.6	38.1	7.7
From China	0	1.2	22.1	2.9
From 9 Asian countries[a]	0	0.8	11.2	1.8
From the rest of the world	0	2.5	26.5	3.9
Participation of exports in sales				
Total	0	22.4	98	25.1
To USA	0	15.5	95.5	21.1
Participation of GVC-associated exports in sales	0	10.2	92.4	21.6
Participation of international trade in production	0	27.3	131.8	28.3

[a] Includes South Korea, Malaysia, Taiwan, Thailand, Vietnam, India, Philippines, Singapour and Indonesia.

Figura 1:

Pensemos que el consumo está compuesto por contenido nacional e importaciones
¿cuál es nuestra aproximación de la participación de las importaciones en el consumo de un genérico?

El consumo nacional consiste en importaciones más ventas en el mercado nacional de

$$C = M + VN$$

Queremos descomponer el consumo nacional por origen, ver qué proporción es importada y cuál es nacional sabemos que

$$1 = \frac{M}{C} + \frac{VN}{C}$$

Sabemos que, directamente la fracción $\frac{M}{C}$ es importada. Pero también sabemos que la producción nacional tiene contenido importado, tanto directa como indirectamente. Entonces lo que vamos a decir es que del 100% del consumo de bienes producidos nacionalmente, los insumos importados directa o indirectamente son contenido importado, y el resto es contenido nacional. Ahora, sabemos que:

$$Insumosimportadosdirectamente + Insumosimportadosdirectamente + contenidonacional = Y \Rightarrow$$

$$\frac{Insumosimport.dir.}{Y} + \frac{Insumosimport.indir.}{Y} + \frac{cont.nacional}{Y} = 1$$

Nota que el contenido nacional incluye insumos de origen nacional y el valor agregado Partiendo de

$$1 = \frac{M}{C} + \frac{VN}{C}$$

Lo que graficamos es lo siguiente:

$$100 = 100 \cdot \left(\frac{M}{C} + \frac{Y}{C} \cdot \left[\frac{Insumosimport.dir.}{Y} + \frac{Insumosimport.indir.}{VN} + \frac{cont.nacional}{Y} \right] \right)$$

Estirando mucho la liga, aproximamos cada uno de los elementos en esta ecuación con los datos que tenemos

$$100 = 100 \cdot \left(\underbrace{\frac{M}{C}}_{part.Menconsumo} + \underbrace{\frac{VN}{C}}_{1-\frac{M}{C}} \cdot \left[\underbrace{\frac{Insumosimport.dir.}{Y}}_{\text{participación M directa}} + \underbrace{\frac{Insumosimport.indir.}{Y}}_{\text{participación M indirecta}} + \underbrace{\frac{cont.nacional}{Y}}_{1-\text{part. directa - part. indirecta}} \right] \right)$$

AHORITA QUE HICE LA NOTA, NOTÉ QUE TAL VEZ TENEMOS UN ERROR CONCEPTUAL, EN REALIDAD DEBERÍAMOS CONSTRUIR MEDIDAS AUXILIARES, NO USAR LA PARTICIPACIÓN DIRECTA E INDIRECTA TAL CUAL, SINO UTILIZAR UNA DE PARTICIPACIÓN DE INSUMOS IMPORTADOS EN PRODUCCIÓN. ¿PUEDES VER POR QUÉ?

Ahora, esto fue pensando en hacerlo por genérico. Para hacer las canastas en agregado, simplemente

multiplicas el dato de todos los genéricos que entran en cada canasta por su ponderador (reponderado de modo que en cada canasta sume 1- o sea para cada canasta se repondera cada vez que lo vayas a hacer).
Figura 2:
Para la composición por origen (figura 6)
Aquí si te fijas solamente estamos diciendo que es composición de consumo aparente. entonces aquí no vamos a descomponer la producción nacional. Solo descomponemos el primer componente por origen

Partiendo de

$$1 = \frac{M}{C} + \frac{VN}{C}$$

tenemos que

$$100 = 100 \cdot \left(\frac{M}{C} \cdot \left[\frac{M_{EUA}}{M_{tot}} + \frac{M_{China}}{M_{tot}} + \frac{M_{Asia9}}{M_{tot}} + \frac{M_{resto}}{M_{tot}} \right] + \frac{VN}{C} \right)$$

Similar a lo que hacemos antes,

$$100 = 100 \cdot \left(\underbrace{\frac{M}{C}}_{\text{part. M en cons}} \cdot \left[\underbrace{\frac{M_{EUA}}{M_{tot}}}_{\text{part.M EUA cons}} + \underbrace{\frac{M_{China}}{M_{tot}}}_{\text{part.M China cons}} + \underbrace{\frac{M_{Asia9}}{M_{tot}}}_{\text{part.MAsia9 cons}} + \underbrace{\frac{M_{resto}}{M_{tot}}}_{\text{part.M resto cons}} \right] + \underbrace{\frac{VN}{C}}_{1-\text{part. dir - part. indir}} \right)$$

PEro cada uno de los términos del primer paréntesis, multiplicados por $\frac{M}{C}$ es la participación de las importaciones por origen en el consumo aparente.
Figura 3:
Para las gráficas del PPI
Recuerda que el PPI son precios productor, la canasta no es una canasta representativa del consumo (o sea, no nos interesa de dónde viene lo que se consume), sino la composición por origen de lo que se produce. Entonces nos interesan los insumos importados directa e indirectamente

Entonces sabemos que la producción es:

$Y =$ Insumos importados directamente + insumos comprados en el mercado nacional + valor agregado

nos enfocamos en el origen de los insumos.
Sabemos que

$$1 = \frac{\text{Insumos importados directamente}}{Y} + \frac{\text{insumos comprados en el mercado nacional}}{Y} + \frac{\text{Valor agregado en México}}{Y}$$

Pero, como la producción nacional utiliza insumos importados, los insumos comprados en el mercado nacional tienen contenido (importado indirectamente). Esta es la intuición de nuestra medida de participación indirecta.
Usamos el hecho de que ya tenemos para cada industria la estimación de los insumos importados directamente

e indirectamente. El contenido nacional es un residual, de forma que:

$$100 = \frac{\text{Insumos importados dir.}}{Y} + \frac{\text{cont. importado en insumos nac.}}{Y} + \underbrace{\frac{\text{cont. nacional en insumos nac.}}{Y} + \frac{\text{Valor ag. en Mex}}{Y}}_{\text{Contenido nacional}}$$

El contenido nacional lo sacamos del residual de esta identidad.

$$100 = \underbrace{\frac{\text{Insumos importados dir.}}{Y}}_{\text{Participación directa en costos}} + \underbrace{\frac{\text{cont. importado en insumos nac.}}{Y}}_{\text{Participación indirecta en costos}} + \underbrace{\frac{\text{contenido nacional}}{Y}}_{\text{1-part.directa - part indirecta}}$$

TENEMOS MISMO PROBLEMA QUE CON LA FIGURA 1

Figura 4:
Misma intuición que para la de origen del CPI, solo vemos el contenido importado directamente
Partiendo de

$$1 = \frac{\text{Insumos importados directamente}}{Y} + \frac{\text{insumos comprados en el mercado nacional}}{Y} + \frac{\text{Valor agregado en México}}{Y}$$

(nota que la leyenda de la barra azul es incorrecta, debe ser insumos nacionales, remuneraciones y ganancias)
tenemos que

$$100 = 100 \cdot \left(\frac{\text{insumos importados directamente}}{Y} \cdot \left[\frac{M_{EUA}}{M_{tot}} + \frac{M_{China}}{M_{tot}} + \frac{M_{Asia9}}{M_{tot}} + \frac{M_{resto}}{M_{tot}} \right] + \frac{\text{Contenido nacional}}{Y} \right)$$

PEro cada uno de los términos del primer paréntesis, multiplicados por $\frac{\text{insumos importados directamente}}{Y}$ es la participación directa por origen. Similar a lo que hacemos antes,

$$100 = 100 \cdot \left(\underbrace{\frac{M}{C}}_{\text{part. M en cons}} \cdot \left[\underbrace{\frac{M_{EUA}}{M_{tot}}}_{\text{part.M EUA cons}} + \underbrace{\frac{M_{China}}{M_{tot}}}_{\text{part.M China cons}} + \underbrace{\frac{M_{Asia9}}{M_{tot}}}_{\text{part.MAsia9 cons}} + \underbrace{\frac{M_{resto}}{M_{tot}}}_{\text{part.M resto cons}} \right] + \underbrace{\frac{VN}{C}}_{1-\text{part. dir - part. indir}} \right)$$

Figura 5:
Partimos del supuesto:

$$\text{Ventas totales} = \text{Ventas en el mercado nacional} + \text{Exportaciones}$$

y de

$$\text{Exportaciones} = \text{Exportaciones asociadas a CGV} + \text{Resto de exportaciones}$$

$\Rightarrow$

$$100 = 100 \cdot \left(\frac{\text{Ventas en el mercado nacional}}{\text{Ventas totales}} + \frac{\text{Exportaciones asociadas a CGV}}{\text{Ventas totales}} + \frac{\text{Resto de exportaciones}}{\text{Ventas totales}} \right)$$

Utilizando nuestras medidas, sabemos que

$$100 = 100 \cdot \left(\underbrace{\frac{\text{Ventas en el mercado nacional}}{\text{Ventas totales}}}_{100-\kappa_{i,t}} + \underbrace{\frac{\text{Exportaciones asociadas a CGV}}{\text{Ventas totales}}}_{CGV_{it}} + \underbrace{\frac{\text{Resto de exportaciones}}{\text{Ventas totales}}}_{\kappa_{i,t}-CGV_{it}} \right)$$

TENEMOS PENDIENTE DEFINIR LOS SUBSECTORES QUE USAREMOS