Tracing value-added and double counting in sales of foreign affiliates and domestic-owned companies

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Multinational production is an important feature of economic globalisation. Micro-level evidence has emphasised that firms that produce across countries are responsible for a large share of international exchanges of goods, services, capital and knowledge. At the aggregate level, quantitative studies that look at multinational production generally rely on the concept of sales of foreign affiliates, which is a gross concept that includes the value of intermediate inputs. In the case of trade, the literature has recently shifted to a value-added approach that can distinguish in exports the contribution of the different economies supplying inputs. In this paper, we propose a framework to decompose value-added in domestic sales in order to trace the origin of value-added and remove any double counting. Using an inter-country input-output table split according to ownership, such framework can provide an analysis of activities of foreign affiliates of multinational firms in value-added terms.

1. Introduction

Multinational production can be defined as the production carried out by firms outside of their country of origin through foreign affiliates (Ramondo, Rodriguez-Clare and Tintelnot, 2015). Evidence at the micro-level suggests that multinational firms play an important role in international exchanges of goods, services, capital and knowledge (Alfaro and Charlton, 2009; Antràs and Yeaple, 2014; Bernard et al., 2018).

To emphasise the importance of multinational production, empirical studies often compare gross trade flows with sales of foreign affiliates. For example, using BEA data, Yeaple (2013) indicates that in 2009 the sales of foreign affiliates of US firms were about 5 trillion USD, which is almost five times the value of US gross exports the same year (about 1 trillion USD). Quoting data from UNCTAD, Ramondo (2014) highlights that at the world level in 2007 sales of foreign affiliates were almost twice the value of world exports. Moreover, sales of foreign affiliates have increased by a factor of seven in the past two decades, while exports have only increased by a factor of five (Ramondo, 2014).

The concept of sales of foreign affiliates[1] has been used for a long time in the literature on multinational firms (Dunning, 1980; Brainard, 1997; Bergstrand and Egger, 2007). It is regarded as a better measurement of activities of firms that operate abroad as compared to foreign direct investment (FDI) which captures only the

[1] We refer to sales of foreign affiliates, which is generally the main variable used in empirical work on multinational production and the variable of reference in statistics on Activities of Multinational Enterprises (AMNE). However, related variables that can be found in statistics and empirical work are the output and the turnover of foreign affiliates. Although not conceptually identical, they all share the same issue that we describe in terms of being gross concepts that include the value of intermediate inputs used in the production of foreign affiliates.

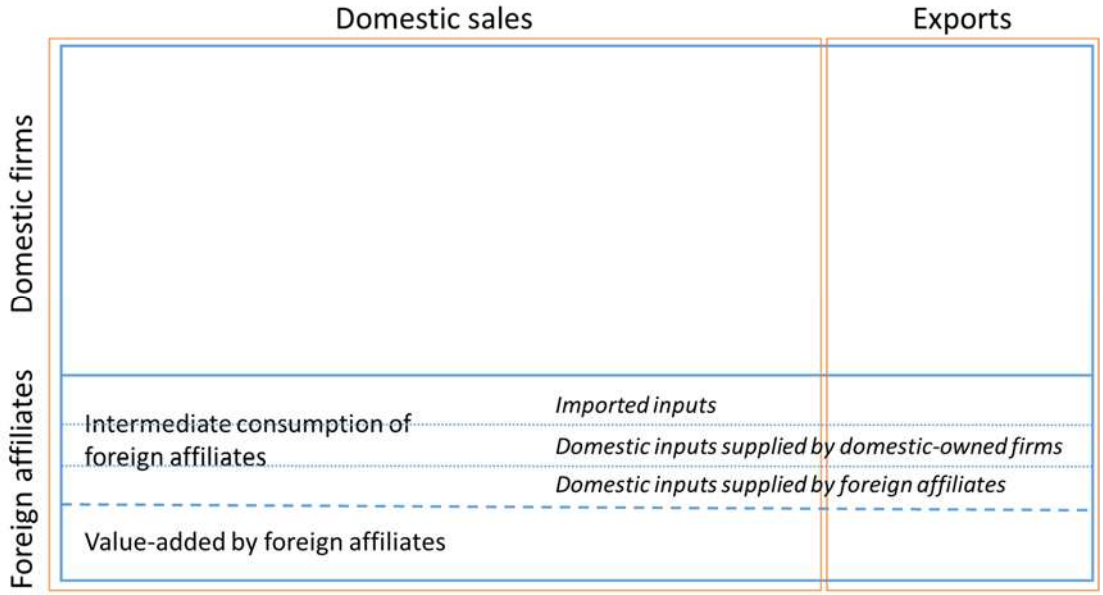
financial flows related to the establishment of foreign affiliates. The economic activity of these affiliates is not always well correlated with the related investment (Beugelsdijk et al., 2010). While data are not easily available for all countries, recent efforts to build cross-country datasets on sales of foreign affiliates have offered new avenues for research (Fukui and Lakatos, 2012; Ramondo et al., 2015; Cadestin et al., 2018a; Alviarez, 2019).

However, sales of foreign affiliates are measured in gross terms. Similarly to gross exports, they are potentially affected by the double counting of intermediate inputs and include the value of activities upward in the value chain. These activities may have taken place in the same economy or in another country.

As illustrated in Figure 1, we can first split the output of a given economy into the production of domestic owned-firms and foreign owned-firms (i.e. foreign affiliates of multinational firms). These firms produce either for consumers in the domestic market (domestic sales) or for consumers abroad (exports). As it can be seen on Figure 1, there is an overlap between exports and sales of foreign affiliates. Therefore, when comparing gross exports with sales of foreign affiliates, one should be aware that some exports are also sales of foreign affiliates. It may be in particular an issue for the analysis of services trade by mode of supply. The WTO General Agreement on Trade in Services (GATS) defines as 'mode 3' trade through 'commercial presence', which corresponds to sales of foreign affiliates in services sectors. Adding at the world level cross-border trade in services (mode 1, 2 and 4 in the terminology of GATS) with sales

of foreign affiliates can result in double counting and an overestimation of total trade in services (Rueda-Cantuche et al., 2016).

Figure 1. Decomposition of the output of a given economy



Then, other potential issues come from the intermediate consumption of foreign affiliates. As seen on Figure 1, three types of inputs are potentially consumed by foreign affiliates: imported inputs (in particular from the parent company or other affiliates in the network of the multinational firm), domestic inputs supplied by domestic-owned firms and domestic inputs supplied by other foreign affiliates in the host economy. The fact that the value of local inputs produced by domestic-owned firms is included in sales of foreign affiliates means that they do not only reflect the activities of foreign firms but also domestic firms. It might be an issue when one is interested in identifying the 'foreign' contribution (foreign in the sense of coming from the production done by foreign affiliates) in a host economy. The literature on productivity spillovers from FDI for example calculates a 'foreign presence' in the host economy, which is sometimes

based on sales of foreign affiliates.[2] The foreign presence in this case already includes an indirect effect of activities of foreign affiliates in the host economy, which is the additional demand for domestic inputs.

Moreover, if the inputs used by the foreign affiliate come from another foreign affiliate in the same host economy, these inputs are likely to be counted twice (or more) when adding all the sales of the different foreign affiliates established (for example first as sales of inputs and then in the sales of final goods). Some multinational firms bring their full network of suppliers when they establish, particularly in the case of horizontal FDI or export-platform FDI where the purpose is to replicate the full production process in a country to serve a large local market or other countries in the region. These suppliers may be owned by the parent company or may belong to another multinational firm. In both cases, they create transactions among foreign affiliates in the host economy leading to double counting. Double counting if not shown on Figure 1 but is found within the intermediate consumption of foreign affiliates.

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[2] See Havranek and Irsova (2011) for a review and meta-analysis of a large sample of empirical studies. While these studies are generally at the firm-level, the foreign presence is calculated for a sector (the same sector or sectors upstream or downstream in the case of vertical spillovers). Some authors use value-added shares or the average of foreign equity in the firms sampled, which is a better option than the share of foreign firms in output.

Finally, through imported inputs, there is also additional potential double counting. One example that comes to mind is the case of 'circular trade' when for example a foreign affiliate produces an input exported and further processed by the parent company and then coming back to the same or another foreign affiliate in the host economy. This back-and-forth trade involving foreign affiliates is for example observed in the case of the automotive industry between the US and Mexico (de Gortari, 2019). But as we will point out in the paper, foreign double counting in domestic sales does not need foreign inputs to come back to the host economy. As long as foreign inputs are used in the production of domestic inputs by foreign affiliates, these inputs and their embodied foreign value-added can be counted several times within the domestic production process.

To address the issue of double counting in trade, a new literature has emerged that decomposes gross exports to distinguish domestic value-added from foreign value-added, as well as measuring double counting (Koopman et al., 2014; Foster-McGregor and Stehrer, 2013; Los et al., 2016; Miroudot and Ye, 2017; Borin and Mancini, 2017; Johnson, 2018). To be clear, the concept of double counting in this literature addresses two issues. First, at the world level, any foreign value-added is by definition domestic value-added in exports of another country and therefore double counted. At the country level, however, one can distinguish in gross exports a domestic and a foreign value-added. But their sum is not equal to gross exports. Because of circular trade and inputs coming back to the exporting economy, there are still some double counting terms (sometimes called 'pure double counting'). There is still some debate on the

measurement of double counting in exports and there are different definitions based on the perspective taken (e.g., the world level versus the perspective of a specific country).

In this paper, we are interested in decomposing not only trade but also domestic sales in a consistent framework that can allow us to identify the activities of foreign affiliates and to look at double counting. When moving to the analysis of sales of foreign affiliates, we need to distinguish the foreign (i.e. imported) value-added from two types of 'domestic' value-added: the value-added by domestic-owned firms and by foreign-owned firms. The value added by foreign-owned firms is included in domestic value-added in the papers decomposing gross exports and in the Trade in Value-Added (TiVA) indicators, such as the ones produced by the OECD. In the rest of the paper, we will still refer to 'domestic' and 'foreign' value-added with the same meaning to be consistent with this literature and we will measure the domestic and foreign value-added in the output of domestic-owned firms and foreign-owned firms.

There are two steps needed in order to provide a value-added analysis of sales of foreign affiliates. First, we need a new value-added decomposition framework for domestic sales. As mentioned above, the literature has focused so far on the decomposition of gross exports. Domestic sales correspond to the share of output that is not exported. But there are additional challenges in decomposing domestic sales and one cannot simply use the formula derived for gross exports. We need also to clarify the meaning of double counting for domestic sales and tackle similar issues to the ones discussed in the literature on the decomposition of gross exports.

To look more specifically at domestic sales by foreign affiliates, we then need some input-output information split according to the ownership of firms. The OECD has recently released inter-country input-output (ICIO) tables based on the TiVA project and official AMNE statistics, which include such information (Cadestin et al., 2018a). We use these new data from the OECD Analytical AMNE database to provide a value-added decomposition of domestic sales of foreign affiliates.

The paper is organised as follows. Section 2 details the methodology, first presenting a new framework to decompose domestic sales and then indicating how to calculate the domestic and foreign value-added, as well as double counting terms, in domestic sales. Section 3 provides numerical examples to illustrate the methodology and to check how it works with simple cases. In Section 4, we apply the methodology to an ICIO table split according to the ownership of firms and look at results for specific countries in 2016. Section 5 concludes.

2. Methodology

This section introduces a new framework for the decomposition of value-added in domestic sales using ICIO tables. The starting point is that gross output consists of domestic sales (i.e. domestic shipments) and exports (i.e. shipments to foreign countries). ICIO tables are precisely organised to separate transactions according to the countries where goods and services are consumed.

Leontief (1936) has established that the amount and type of intermediate inputs needed in the production of one unit of output can be estimated based on the input-

output (IO) structure across industries. Using the linkages across industries, one can trace output in all stages of production needed to produce one unit of final goods. When the gross output flows associated with a specific level of final demand are known, value-added production and trade can simply be derived by multiplying these flows with the value added to gross output ratio in each industry.

In the ICIO framework (G countries and N sectors), all gross output must be used either as an intermediate good or as a final good:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{y} \tag{1}$$

where $\mathbf{x}$ is the $NG \times 1$ gross output vector, $\mathbf{y}$ is the $NG \times 1$ final demand vector, and $\mathbf{A}$ is the $NG \times NG$ I-O coefficients matrix.

To clarify the accounting relationship between domestic sales and final demand in the ICIO, we can extract from the gross output vector the domestic sales. But there are two ways of doing it, with different implications for what we measure and what we will call double counting. If we are interested in the domestic sales of a specific country, we need to define double counting on the basis of what is already accounted for from the perspective of this country. If we are interested in domestic sales at the global level, we need to take into account domestic sales in all economies and define a double counting based on what has already been accounted for in the different economies within their respective domestic sales. We refer to these two perspectives as the 'country consistency' approach and 'global consistency' approach. We introduce below

a simple way of deriving decompositions with both approaches by using a different 'extraction' matrix.[3]

2.1 Extraction matrices for domestic sales: country consistency versus global consistency

For the approach based on the country consistency, we can define a vector **h** with the domestic sales (for all industries) of a given country *i*. The length of this vector equals *G* times *N*, with the sales of all industries in country *i* as corresponding elements $\mathbf{h}_i$ ($N \times 1$ vector) and zeros elsewhere: $\mathbf{h}=[0,\ldots, \mathbf{h}_i,\ldots,0]^{\mathbf{T}}$). Then, the rest of gross output (i.e. the exports of country *i* and the domestic sales and exports of other countries) are in a remaining term vector **r** so that **x=h+r**,

We can then obtain the following accounting equations: $\mathbf{h} = \mathbf{A}^{\mathbf{I}}(\mathbf{h}+\mathbf{r}) + \mathbf{y}^{\mathbf{I}}$ and $\mathbf{r} = \mathbf{A}^{*}(\mathbf{h}+\mathbf{y}) + \mathbf{y}^{*}$, where $\mathbf{A}^{\mathbf{I}}$ is country *i*'s domestic sales matrix as identified by the corresponding domestic coefficients in the global ICIO table (we can name it identification matrix here). $\mathbf{A}^{*}$ can be regarded as a corresponding extraction matrix, so that we have $\mathbf{A} = \mathbf{A}^{\mathbf{I}} + \mathbf{A}^{*}$. $\mathbf{y}^{\mathbf{I}}$ is the domestic final demand for country *i* and $\mathbf{y}^{*}$ is an extraction final demand matrix, so that $\mathbf{y} = \mathbf{y}^{\mathbf{I}} + \mathbf{y}^{*}$.

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[3] Los et al. (2016) use an hypothetical extraction method to derive a formula for the domestic value-added in gross exports. Our methodology is inspired by this approach and relies on an extraction matrix but we do not calculate an hypothetical GDP. We just use the extraction matrix in an accounting framework.

To better understand the nature of the extraction, we can look at a three-country example to see how the original **A** matrix is split for the measurement of value-added in domestic sales. Assuming that we have three countries, *i*, *j* and *k*, the intermediate inputs coefficients matrix is

$$\mathbf{A} = \begin{pmatrix} \mathbf{A}_{ii} & \mathbf{A}_{ij} & \mathbf{A}_{ik} \\ \mathbf{A}_{ji} & \mathbf{A}_{jj} & \mathbf{A}_{jk} \\ \mathbf{A}_{ki} & \mathbf{A}_{kj} & \mathbf{A}_{kk} \end{pmatrix}$$

To extract domestic sales in country *i*, the domestic sales vector is re-arranged as $\mathbf{h}=[\mathbf{h}_i, \mathbf{0}, \mathbf{0}]^{\mathbf{T}}$ and the corresponding domestic inputs flow is identified in the **A** matrix as $\mathbf{A}^{\mathbf{I}} = \begin{pmatrix} \mathbf{A}_{ii} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} \end{pmatrix}$ with $\mathbf{A}^{*} = \begin{pmatrix} \mathbf{0} & \mathbf{A}_{ij} & \mathbf{A}_{ik} \\ \mathbf{A}_{ji} & \mathbf{A}_{jj} & \mathbf{A}_{jk} \\ \mathbf{A}_{ki} & \mathbf{A}_{kj} & \mathbf{A}_{kk} \end{pmatrix}$.

For the global consistency, instead of extracting the domestic sales of country *i*, domestic sales in all countries (*i*, *j* and *k* in the three-country example) are removed from output. The domestic sales vector becomes $\mathbf{h}=[\mathbf{h}_i, \mathbf{h}_j, \mathbf{h}_k]^{\mathbf{T}}$, and the corresponding matrices are $\mathbf{A}^{\mathbf{I}} = \begin{pmatrix} \mathbf{A}_{ii} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{A}_{jj} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{A}_{kk} \end{pmatrix}$ and $\mathbf{A}^{*} = \begin{pmatrix} \mathbf{0} & \mathbf{A}_{ij} & \mathbf{A}_{ik} \\ \mathbf{A}_{ji} & \mathbf{0} & \mathbf{A}_{jk} \\ \mathbf{A}_{ki} & \mathbf{A}_{kj} & \mathbf{0} \end{pmatrix}$.

2.2 The accounting relationship between domestic sales and final demand in the ICIO

Independently of the way we have defined the identification and extraction matrix (country consistency or global consistency), we can further investigate the relationship between domestic sales and final demand in the ICIO.

As mentioned above, we can express the vector **h** and **r** as $\mathbf{h} = \mathbf{A}^{\mathbf{I}}(\mathbf{h}+\mathbf{r})+\mathbf{y}^{\mathbf{I}}$ and $\mathbf{r} = \mathbf{A}^{*}(\mathbf{h}+\mathbf{y})+\mathbf{y}^{*}$. Firstly, solving for **r**, we obtain:

$$\mathbf{r} = (\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{A}^{*}\mathbf{h} + (\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{y}^{*}$$

Merging the expression for **h** and for **r**, we can obtain:

$$\begin{aligned}
&\mathbf{h} = \mathbf{A}^{\mathbf{I}}(\mathbf{r}+\mathbf{h})+\mathbf{y}^{\mathbf{I}} \\
&= \mathbf{A}^{\mathbf{I}}[\mathbf{h} + (\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{A}^{*}\mathbf{h} + (\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{y}^{*}] + \mathbf{y}^{\mathbf{I}} \\
&= \mathbf{A}^{\mathbf{I}}[\mathbf{I} + (\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{A}^{*}]\mathbf{h} + \mathbf{A}^{\mathbf{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{y}^{*} + \mathbf{y}^{\mathbf{I}} \\
&= \mathbf{A}^{\mathbf{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{h} + \mathbf{A}^{\mathbf{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}\mathbf{y}^{*} + \mathbf{y}^{\mathbf{I}} \\
&= \bar{\mathbf{A}}\mathbf{h} + \bar{\mathbf{y}}
\end{aligned}$$

with $\bar{\mathbf{A}} = \mathbf{A}^{\mathbf{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}$ and $\bar{\mathbf{y}} = \bar{\mathbf{A}}\mathbf{y}^{*} + \mathbf{y}^{\mathbf{I}}$.

Therefore, the accounting relationship between the domestic sales vector and final demand in destination countries in the ICIO model can be expressed as:

$$\mathbf{h} = \bar{\mathbf{A}}\mathbf{h} + \bar{\mathbf{y}} \tag{2}$$

We can call $\bar{\mathbf{A}}$ the 'direct domestic sales requirements matrix'. Similar to the Leontief model, we can then define a matrix $\bar{\mathbf{B}}$ providing the 'total domestic sales requirements' with $\mathbf{H} = \bar{\mathbf{B}}\bar{\mathbf{Y}}$, and $\bar{\mathbf{B}} = (\mathbf{I}-\bar{\mathbf{A}})^{-1}$, similar to $\mathbf{B} = (\mathbf{I}-\mathbf{A})^{-1}$ where **B** is the 'total requirements matrix' in the ICIO. We have:

$$\begin{aligned}
&\bar{\mathbf{B}} = (\mathbf{I}-\bar{\mathbf{A}})^{-1} = [\mathbf{I}-\mathbf{A}^{\mathbf{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}]^{-1} = [(\mathbf{I}-\mathbf{A}^{*})(\mathbf{I}-\mathbf{A}^{*})^{-1} - \mathbf{A}^{\mathbf{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}]^{-1} \\
&= [(\mathbf{I}-\mathbf{A}^{*}-\mathbf{A}^{\mathbf{I}})(\mathbf{I}-\mathbf{A}^{*})^{-1}]^{-1} \\
&= (\mathbf{I}-\mathbf{A}^{*})\mathbf{B} = (\mathbf{I}-\mathbf{A}+\mathbf{A}^{\mathbf{I}})\mathbf{B} = \mathbf{I}+\mathbf{A}^{\mathbf{I}}\mathbf{B}
\end{aligned} \tag{3}$$

New notation is introduced here, $\mathbf{B}^{*} = (\mathbf{I}-\mathbf{A}^{*})^{-1}$, we also can show that:

$$\begin{aligned}\mathbf{B}^{*}\overline{\mathbf{B}} &= (\mathbf{I}-\mathbf{A}^{*})^{-1}(\mathbf{I}-\overline{\mathbf{A}})^{-1} = [(\mathbf{I}-\overline{\mathbf{A}})(\mathbf{I}-\mathbf{A}^{*})]^{-1} = \{[\mathbf{I}-\mathbf{A}^{\mathrm{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}](\mathbf{I}-\mathbf{A}^{*})\}^{-1} \\ &= \{[(\mathbf{I}-\mathbf{A}^{*})(\mathbf{I}-\mathbf{A}^{*})^{-1}-\mathbf{A}^{\mathrm{I}}(\mathbf{I}-\mathbf{A}^{*})^{-1}](\mathbf{I}-\mathbf{A}^{*})\}^{-1} \\ &= [(\mathbf{I}-\mathbf{A}^{*}-\mathbf{A}^{\mathrm{I}})(\mathbf{I}-\mathbf{A}^{*})^{-1}(\mathbf{I}-\mathbf{A}^{*})]^{-1} = (\mathbf{I}-\mathbf{A})^{-1} = \mathbf{B}\end{aligned} \tag{4}$$

2.3 Value-added in domestic sales

In accordance with concept of IO, for $\mathbf{h}_i$ ($N\times 1$ vector), the domestic sales in country *i*, all the intermediate inputs needed are $\sum_{j}^{G}\overline{\mathbf{A}}_{ji}\mathbf{h}_i$. We can thus calculate the value-added in domestic sales in country *i* as $\mathbf{VaH}(i)^{\mathrm{T}} = \mathbf{h}_i - \sum_{j}^{G}\overline{\mathbf{A}}_{ji}\mathbf{h}_i$ ($\mathbf{VaH}(i)$ is $1\times N$ vector). This value-added measurement does not only include value-added from country *i* but also value-added from other countries. We can then express the value-added multiplier coefficients in domestic sales in the form of a $1\times NG$ vector $\overline{\mathbf{v}}$, defined as:

$$\overline{\mathbf{v}} = \mathbf{u}(\mathbf{I}-\overline{\mathbf{A}}) = \mathbf{u}(\mathbf{I}-\mathbf{A})(\mathbf{I}-\mathbf{A}^{*})^{-1} = \mathbf{v}(\mathbf{I}-\mathbf{A}^{*})^{-1} \tag{5}$$

where $\mathbf{v}$ is a $1\times NG$, direct value-added coefficients vector. Each element of $\mathbf{v}_i$ ($1\times N$ vector) gives the share of direct domestic value-added in total output. It is equal to one minus the intermediate input share from all countries (including domestically produced intermediates): $\mathbf{v}_i = \mathbf{u}[\mathbf{I} - \sum_{j}^{G}\mathbf{A}_{ji}]$, where $\mathbf{u}$ is a $1\times N$ unit vector. then we can obtain the expression for value-added coefficients in domestic sales in country *i*: $\overline{\mathbf{v}}_i = \mathbf{v}_i\mathbf{B}^{*}_{ii} + \sum_{j\neq i}^{G}\mathbf{v}_j\mathbf{B}^{*}_{ji}$. They can be divided into two parts: the value-added from country *i* (domestic share) $\mathbf{v}_i\mathbf{B}^{*}_{ii}$ and the value-added from other countries (foreign share) $\sum_{j\neq i}^{G}\mathbf{v}_j\mathbf{B}^{*}_{ji}$.

2.4 Double counting terms

In the decomposition of domestic sales, double counting is a subset of intermediate inputs. We can regard double counting in domestic sales as value-added crossing the boundary of domestic sales production more than once. There is then a difference in terms of the definition of the 'boundary' based on the country consistency or global consistency approach. In the case of the country consistency, value-added is double counted only when it comes twice in the production of the country's domestic sales.

In the Leontief model, the value-added multipliers $\mathbf{v}_i\mathbf{B}^*_{ii}$ and $\sum_{j\neq i}^{G}\mathbf{v}_j\mathbf{B}^*_{ji}$ explicitly measure value-added when it enters the production of domestic sales 'for the first time'. The double counting terms (domestic and foreign) can therefore be calculated as residual terms in intermediate inputs going to domestic sales.

In the Leontief insight, the total value-added coefficient (**vB=u**) matrix, or the total value-added multiplier as named in the input-output literatures, merged equation (3) and (4), can be transferred into:

$$\mathbf{h}^T = \mathbf{vB}\hat{\mathbf{h}} = \bar{\mathbf{v}}\bar{\mathbf{B}}\hat{\mathbf{h}} = \mathbf{vB}^*\bar{\mathbf{B}}\hat{\mathbf{h}} = \mathbf{vB}^*(\mathbf{I}+\mathbf{A}^{\mathbf{I}}\mathbf{B})\hat{\mathbf{h}} \qquad (6)$$

Here the notation $\hat{\mathbf{h}}$ signifies $NG\times NG$ diagonal matrix with objective domestic sales on the diagonal. This equation explicates the value-added distribution of value-added in the framework of domestic sales: the value-added measurement $\mathbf{vB}^*$ and the residual (double counting) term $\mathbf{vB}^*(\mathbf{A}^{\mathbf{I}}\mathbf{B})$. The implication of the residual term

is straightforward: $\mathbf{A}^{\mathbf{I}}$ is the identification elements matrix of domestic sales, which implies the domestic production.

Since the identification matrix $\mathbf{A}^{\mathbf{I}}$ describes also the 'boundary' of domestic sales production[4], two different objective vectors above correspond to respective domestic sales decomposition pattern: country consistency and global consistency. In the country consistency pattern, the objective vector just contains the specific country's domestic sales, so the value-added is measured in the country perspective. By contrast, it's measured in the global perspective for the second array. The difference between country and global perspective is that the framework confronts different boundary of 'domestic sales production': the value produced in a certain production stage is accounted as 'value-added' by 'whom' and within 'which domestic production' for the first time. For example, the case in which the value-added produced by country *i* enters directly a foreign supply chain via export, and then sold into country *i*'s domestic production for the first time via re-import. In the country consistency, the portion of value should be labelled as 'domestic value-added' for country *i*. However, in the global consistency, the portion should labelled as 'double counting' term for country *i*'s value-added measurement in the breakdown, because this value already accounted as 'value-added', labelled as 'foreign' by other country since it enter 'global domestic sales production stage via country *i*'s direct export (in the global notion, the boundary of

[4] Here we thank the anonymous reviewer for the comments.

domestic production is extended into global, the process of re-entering the original country domestic sales production implies entering the global domestic sales production for the second times).

The coefficient $\mathbf{A^I B}$ shows the flow entered the same domestic production stage more than once. Therefore, the coefficient $\mathbf{vB^*(A^I B)}$ explicate the value-added that has crossed the given domestic sales production boundary and entered it more than once, which is already accounted in the $\mathbf{vB^*}$ expression.

In summary, based on the above analysis, we propose the following formula for a 4-term decomposition of domestic sales (both adaptable to country and global consistency):

$$\mathbf{uh}_i = \mathbf{v}_i\mathbf{B}^*_{ii}\mathbf{h}_i + \mathbf{v}_i[\mathbf{B}^*\mathbf{A}^\mathbf{I}\mathbf{B}]_{ii}\mathbf{h}_i + \sum_{j\neq i}^{G}\mathbf{v}_j\mathbf{B}^*_{ji}\mathbf{h}_i + \sum_{j\neq i}^{G}\mathbf{v}_j[\mathbf{B}^*\mathbf{A}^\mathbf{I}\mathbf{B}]_{ji}\mathbf{h}_i \quad (7)$$

Equation (7) provides a full decomposition of gross exports with four terms that are respectively: domestic value-added net of any double counting (DVA), domestic double counting (DDC), foreign value-added net of any double counting (FVA)and foreign double counting (FDC) in country *i*'s domestic sales.

2.4 Global GDP and Global consistency

As highlighted above, the accounting relationship between domestic sales vector $\mathbf{h}$ (global consistency array) and final demand in destination in the ICIO model can be written as $\mathbf{h} = \bar{\mathbf{A}}\mathbf{h} + \bar{\mathbf{y}}$. In a similar way, we can also obtain the accounting relationship between gross exports vector (global consistency array) $\mathbf{e}$ and final demand in different destinations in the Inter-Country Input-Output (ICIO) model (The derivation is similar to equation 2):

$$\mathbf{e} = \tilde{\mathbf{A}}\mathbf{e} + \tilde{\mathbf{y}} \quad (8)$$

with $\bar{\mathbf{A}} = \mathbf{A^D(I - A^F)^{-1}}$, $\bar{\mathbf{Y}} = \bar{\mathbf{A}}\mathbf{Y^F} + \mathbf{Y^D}$,$\tilde{\mathbf{A}} = \mathbf{A^F(I - A^D)^{-1}}$ and $\tilde{\mathbf{Y}} = \tilde{\mathbf{A}}\mathbf{Y^D} + \mathbf{Y^F}$. Here, we remark the notation $\mathbf{A^I}$ as $\mathbf{A^D}$ and $\mathbf{A^*}$ as $\mathbf{A^F}$. $\mathbf{A^D}$ is the domestic coefficient in the global ICIO table (The block-diagonal matrix of the **A** matrix in the ICIO table , which means the global domestic sales production). $\mathbf{A^F}$ is the export matrix of **A** matrix for use of intermediate input from one country to another country (which means global export goods production), so we have $\mathbf{A = A^D + A^F}$. $\mathbf{y^D}$ denote the domestic final demand consumed and $\mathbf{y^F}$ is the foreign countries consume the final demand, so $\mathbf{y = y^D + y^F}$.

Re-arranging equations (2) and (8), we can express gross exports and domestic sales as:

$$\mathbf{e = [I - A^F(I - A^D)^{-1}]^{-1}[A^F(I - A^D)^{-1}y^D + y^F]} \quad (9)$$

$$\mathbf{h = [I - A^D(I - A^F)^{-1}]^{-1}[A^D(I - A^F)^{-1}y^F + y^D]} \quad (10)$$

Therefore, in the ICIO model, gross output can be written as:

$$\mathbf{x = A^Dx + y^D + A^Fx + y^F = A^Dx + y^D + e} \quad (11)$$

$$\text{Or} \quad \mathbf{x = A^Dx + y^D + A^Fx + y^F = h + A^Fx + y^F} \quad (12)$$

Rearranging equations (11) and (12), we get:

$$\mathbf{x = (I - A^D)^{-1}y^D + (I - A^D)^{-1}e}$$

$$\text{And} \quad \mathbf{x = (I - A^F)^{-1}y^F + (I - A^F)^{-1}h}$$

The expression $\mathbf{(I - A^D)^{-1}}$ is sometimes described as the local Leontief inverse in the ICIO.

The global GDP can then be calculated as follows:

$$GDP = \mathbf{vx = v(I - A^D)^{-1}y^D + v(I - A^D)^{-1}e} \quad (13)$$

$$\text{Or} \quad GDP = \mathbf{vx = v(I - A^F)^{-1}y^F + v(I - A^F)^{-1}h} \quad (14)$$

According to equation (13), GDP can be divided into two parts. The first part is the share of GDP that does not participate in international trade and is just for domestic

final demand. The second part, $\mathbf{v(I - A^D)^{-1}e}$, is the share of GDP in exports. GDP in exports includes some value-added that can return home. This is why the split is not based on whether final consumption takes place in the domestic economy or abroad. Exports include both intermediate and final products.

From equation (14), GDP can also be decomposed into two parts along another dimension: $\mathbf{v(I - A^F)^{-1}h}$ reflects the value-added in global domestic sales production while $\mathbf{v(I - A^F)^{-1}y^F}$ corresponds to value-added for the foreign final demand and not in any domestic sales production. Again, it does not indicate where value-added is ultimately going as the concept of domestic sales is still a mix of intermediate and final products.

Merging equations (9), (10), (13) and (14), we obtain the following GDP decomposition:

$$\begin{aligned} GDP = {} & \mathbf{vBA^F(I - A^D)^{-1}y^D + v(I - A^D)^{-1}y^D} \\ & \mathbf{+ vBA^D(I - A^F)^{-1}y^F + v(I - A^F)^{-1}y^F} \end{aligned} \tag{15}$$

Terms 1, 3 and 4 are equal to the domestic value-added in exports, as measured by Koopman et al. (2014) or by Los et al. (2016), which includes the value-added in exports coming back to the domestic economy. The second term corresponds to value-added going into domestic final demand without having transited through other countries.

From the above decomposition, we can also provide expressions for the value-added in exports and in domestic sales as follows:

$$\begin{aligned} \mathbf{v(I - A^D)^{-1}e} &= \mathbf{vBA^F(I - A^D)^{-1}y^D + vBA^D(I - A^F)^{-1}y^F + v(I - A^F)^{-1}y^F} \\ \mathbf{v(I - A^F)^{-1}h} &= \mathbf{vBA^F(I - A^D)^{-1}y^D + vBA^D(I - A^F)^{-1}y^F + v(I - A^D)^{-1}y^D} \end{aligned} \tag{16}$$

These equations highlight an important feature of this value-added decomposition. There is an overlap between the value-added in exports and in domestic sales (as some domestic sales are intermediates that are then incorporated into exports). The overlap can be seen in $\mathbf{vBA^F(I - A^D)^{-1}y^D}$ and $\mathbf{vBA^D(I - A^F)^{-1}y^F}$, as these two terms not only

participate in the global domestic production but also in international trade goods production.

3. Numerical examples

We provide in this section simple numerical examples to illustrate the methodology and to further explain the difference between the country consistency and global consistency approaches.

We start with a very simple ICIO table that includes only 2 countries, A and B (and a single industry).

Table 1.1 Case 1: ICIO with 2 countries – no intermediate consumption in B

	A	B	A	B
A	1	0	2	0
B	1	0	0	1
VA	1	2		

In Table 1.1, the first two columns indicate the intermediate consumption of A and B and the last two columns their final demand. Value-added in each country is at the bottom of the table (last row). In this simple example, production in A requires one unit of intermediate inputs from B. Exports of intermediate inputs from B to A are the only international trade flow. We set to zero domestic intermediate inputs in country B so that there is no difference between the country consistency and global consistency approach.

The decomposition of value-added in domestic sales can be found in Table 1.2. Domestic sales are equal to 3 in country A (1 unit of intermediate inputs and 2 units for final demand) and equal to 1 in country B (gross output in B is split between 1 unit of domestic sales and 1 unit of exports).

Table 1.2: Decomposition of value-added in domestic sales for Case 1

	Domestic Sales	DVA	DDC	FVA	FDC
A	3	1	0.5	1	0.5
B	1	1	0	0	0

Since country B only has 1 unit of domestic sales and no intermediate consumption in its production function, we find 1 as domestic value-added (DVA) in country B. For country A, all the production is sold domestically (there are no exports). Since 1 unit of foreign inputs is imported from country B, the foreign value added (FVA) in country A's domestic sales is 1. But in order to produce 3 units of gross output, firms in A require 1 unit of domestic inputs (that are part of domestic sales), 1 unit of foreign inputs and they add 1 unit of value-added. While the example is simple, we are already confronted with some double counting, both domestic and foreign. Since a domestic input is used in the production process, domestic sales record part of domestic value-added twice: a first time in the production of the domestic input and a second time when this input is incorporated in goods for final demand. The domestic double counting (DDC) is 0.5 ($\mathbf{B}^{*}\mathbf{A}^{\mathrm{I}}\mathbf{B} = \begin{pmatrix} 1 & 0 \\ 1/3 & 1 \end{pmatrix}\begin{pmatrix} 1/3 & 0 \\ 0 & 0 \end{pmatrix}\begin{pmatrix} 3/2 & 0 \\ 1/2 & 1 \end{pmatrix}$ 1/3*1*1/3*3/2*3=0.5?). In the case of the foreign input coming from B, it comes only one time to country A and its full value is part of FVA but still it is incorporated in the domestic input produced in A and then the final good. Therefore, there is also some foreign double counting (FDC) (also equal to1*1/3*1/3*3/2*3=0.5??). Unlike what is observed for the decomposition of gross exports, where double counting implies crossing international borders (the off-

diagon*al part of the A matrix), the double counting in the domestic sales decomposition comes from domestic inputs (the diagonal of the A matrix). It is therefore more prevalent since domestic transactions are generally much higher than international transactions (reflecting the fact that intra-national trade and transaction costs are lower than international trade and transactions costs).

To better understand the 'boundary' of domestic sales and the difference between the country consistency and global consistency, we slightly change case 1. Now we assume that country B needs 1 unit of domestic intermediate inputs in its production process. The new ICIO is in Table 2.1.

Table 2.1 Case 2: ICIO with 2 countries and domestic intermediate consumption in B

	A	B	A	B
A	1	0	2	0
B	1	1	0	1
VA	1	2		

Since A and B both have domestically produced intermediate inputs, the 'boundary' of domestic sales is no longer the same for the country consistency and global consistency approach. With the country consistency, the unit of intermediate inputs exported from B to A is still part of FVA for country A since its value-added crosses the boundary of country A only one time. However, in the global consistency decomposition, the same unit originates from country B where it is produced with domestic inputs (i.e. domestic sales). If we look at the production function in country

B, one third of gross output comes from intermediate consumption of domestic inputs. It implies that 1/3 of the value of the unit of intermediate inputs exported from B to A has already entered B's domestic sales production, thus creating some double counting in the global consistency approach. As shown in Table 2.2, the difference between the country consistency and global consistency approach is that FVA is 1 from the perspective of country A's domestic sales while it becomes 0.67 from the global consistency perspective where 1/3 has been shifted to foreign double counting (FDC). Results are unchanged for country B since it does not import anything from A.

Table 2.2: Decomposition of value-added in domestic sales for Case 2

		Country consistency				Global consistency			
	Domestic Sales	DVA	DDC	FVA	FDC	DVA	DDC	FVA	FDC
A	3	1	0.5	1	0.5	1	0.5	0.67	0.83
B	2	1.33	0.67	0	0	1.33	0.67	0	0

The decomposition results in Table 2.2 highlight another difference between the global consistency and country consistency approach. If we sum the value-added across A and B, the total with the global consistency decomposition is 3, which is consistent with the value-added reported in Table 2.1 (1 unit for country A and 2 units for country B). However, if we sum the value-added in the country consistency decomposition, the total is 3.33, which is higher than 3. Only the global consistency approach can provide a total value added consistent with world GDP.

Next, we continue to increase the complexity in the ICIO by adding 1 unit of exports of intermediate inputs from country A to country B. To balance the ICIO, we set A's final demand to 1 and B's to 2.

Table 3.1 Case 3: ICIO with two countries and two-way trade in inputs

	A	B	A	B
A	1	1	1	0
B	1	1	0	2
VA	1	2		

As there is two-way trade in inputs between country A and country B, we now have the case where the value-added produced by one country enters directly a foreign supply chain through exports and is then coming back to domestic production in the original country via re-imports. With the country consistency approach, this value-added is labelled as DVA for country *i*. However, with the global consistency approach, it is labelled as DDC for country *i*. The reason is that this value-added was already accounted for in the FVA of the other country since it entered domestic sales (in the global matrix) first via country *i*'s direct exports. This is what we mean by pointing out that the 'boundary of domestic production' is different in the two approaches. With the global approach, the boundary of domestic production is extended and value-added re-entering the original country in domestic sales is now seen as coming for a second time. This is the main reason why the literature on the decomposition of gross exports has difficulties in reaching a consensus on the right allocation of value-added between FVA

and double counting terms. In the case of the decomposition of domestic sales, we can see in Table 3.2 that it also affects DVA since the focus is on defining the boundary of domestic production. We can see that DVA in each country is no longer the same with the two approaches and is bigger in the case of the country consistency approach.

Table 3.2: Decomposition of value-added in domestic sales for Case 3

		Country consistency				Global consistency			
	Domestic Sales	DVA	DDC	FVA	FDC	DVA	DDC	FVA	FDC
A	2	0.75	0.45	0.5	0.3	0.73	0.47	0.36	0.44
B	3	1.71	0.69	0.43	0.17	1.64	0.76	0.27	0.33

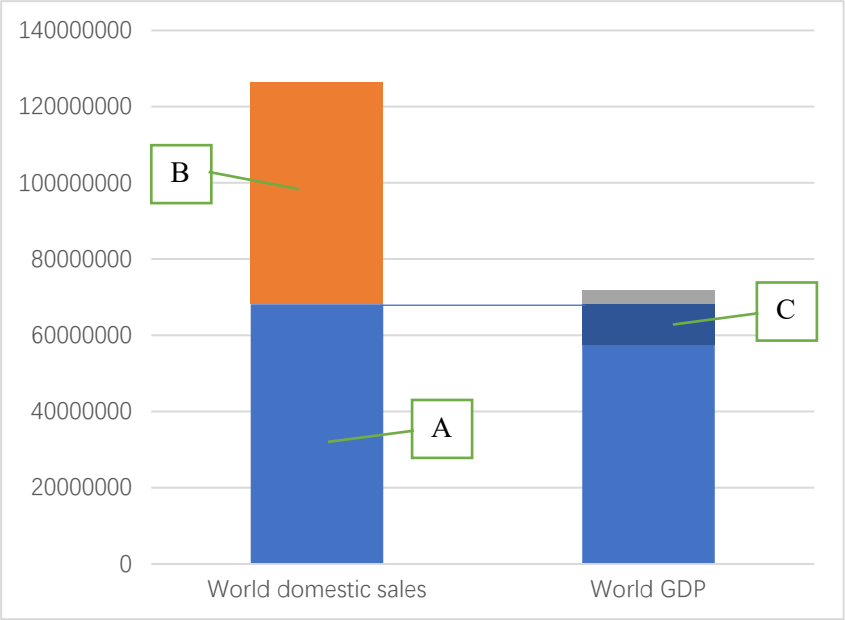
4. Empirical results using the OECD analytical AMNE database

To illustrate how the framework can be used to look more specifically at sales of foreign affiliates, we rely on the ICIO tables that are part of the OECD analytical AMNE database (Cadestin et al., 2018a). These tables are benchmarked on the latest release of the OECD ICIO (December 2018) but are split according to the ownership of firms. OECD has built such tables by using the information from official AMNE statistics and various national sources, complemented with estimates to cover 60 countries and 34 industries over the period 2005-2016. The initial OECD ICIO was not changed but each cell was split for the two groups of firms (foreign-owned and domestic-owned). Similarly to what is done in the regional IO literature, the split was based on a series of assumptions. The initial AMNE data only include matrices of output, value-added,

exports and imports by country, industry and type of firms (foreign-owned or domestic-owned). Starting values are created for each cell in the matrix of intermediate consumption and final demand and an optimisation is run to ensure that the data are consistent with the values by country and industry and that the sum of transactions by domestic-owned firms and foreign-owned firms is always equal to the original OECD ICIO where data are not split.

Because of assumptions and estimates, these data have limitations and cannot be used to go into detailed analysis at the country and industry level. But in order to do some aggregate analysis and discuss the prevalence of MNEs in the world economy, these data seem appropriate. In a version of the ICIO, domestic-owned firms are even further split between domestic MNEs (the parent companies and their affiliates in the domestic economy) and 'non-MNEs' (i.e. firms not involved in international investment). We do not use these data but they allow for a full analysis of activities of MNEs and not just activities of their foreign affiliates.

Figure 2. Global GDP and domestic sales,2015 (million USD)



Source: Authors' calculations based on OECD analytical AMNE database

Figure 2 briefly portray the domestic sales global consistency and GDP according to the section 2.4. In this figure, 'A' means the value-added in the global domestic sales, 'B' means the double counting term, 'C' means the GDP overlap term between domestic sales and exports in equation (16).

Going from the decomposition of domestic sales presented in Section 2.3 to a decomposition for foreign affiliates and domestic-owned firms is straightforward. These two categories of firms can be regarded as different 'industries'. The formula are not changed and just applied to vectors and matrices that have two times the number of industries. Domestic-owned firms versus foreign-owned firms do not change the 'boundary' of what is defined as domestic production (both are regarded as domestic production).

Table 4. Decomposition of domestic sales for selected economies, 2015

Country	Ownership	Domstic Sales (million USD)	Country consisitency				Global consistency			
			DVA(%)	DDC(%)	FVA(%)	FDC(%)	DVA(%)	DDC(%)	FVA(%)	FDC(%)

AUS	Domestic_owned	1,858,553	49.38	41.63	4.13	4.87	49.37	41.63	1.91	7.09
	Foreign_owned	372,088	44.57	40.58	10.30	4.54	44.55	40.60	4.75	10.09
FRA	Domestic_owned	3,222,606	57.26	31.53	6.42	4.79	57.24	31.55	3.41	7.80
	Foreign_owned	392,524	41.29	38.33	14.85	5.53	41.25	38.37	7.93	12.45
DEU	Domestic_owned	4,119,572	56.50	31.36	6.79	5.35	56.46	31.40	3.47	8.67
	Foreign_owned	709,673	43.47	33.74	16.57	6.22	43.39	33.82	8.73	14.06
ISR	Domestic_owned	384,711	61.51	24.58	8.72	5.19	61.51	24.58	4.44	9.47
	Foreign_owned	11,912	48.56	25.48	20.44	5.51	48.56	25.48	10.23	15.73
ITA	Domestic_owned	2,572,020	53.13	34.04	6.45	6.39	53.12	34.04	3.33	9.51
	Foreign_owned	385,829	41.48	36.94	14.97	6.61	41.46	36.96	8.00	13.58
JPN	Domestic_owned	7,308,430	53.68	36.17	5.21	4.94	53.67	36.18	2.60	7.55
	Foreign_owned	207,071	51.76	35.81	8.20	4.23	51.74	35.83	4.07	8.36
KOR	Domestic_owned	2,434,117	44.85	33.12	10.88	11.15	44.83	33.14	5.47	16.56
	Foreign_owned	89,782	38.95	32.12	19.01	9.93	38.92	32.15	9.48	19.46
MEX	Domestic_owned	1,391,810	63.53	25.84	7.13	3.50	63.53	25.85	3.30	7.33
	Foreign_owned	175,057	50.31	28.51	17.23	3.95	50.29	28.53	7.90	13.28
ESP	Domestic_owned	1,585,051	54.44	32.15	6.93	6.49	54.43	32.15	3.63	9.78
	Foreign_owned	297,556	40.81	37.51	13.60	8.07	40.80	37.53	6.86	14.81
GBR	Domestic_owned	3,259,059	59.29	31.72	4.91	4.08	59.28	31.74	2.57	6.42
	Foreign_owned	978,243	46.69	37.66	10.65	5.00	46.66	37.69	5.69	9.96
USA	Domestic_owned	26,696,708	59.68	34.95	3.13	2.24	59.66	34.97	1.57	3.81
	Foreign_owned	2,100,258	34.59	49.86	11.92	3.63	34.49	49.96	5.85	9.70
CHN	Domestic_owned	23,811,861	40.06	49.51	4.11	6.31	40.04	49.53	2.15	8.27
	Foreign_owned	1,172,821	30.83	52.00	9.89	7.28	30.78	52.05	4.96	12.21
IND	Domestic_owned	3,501,130	50.73	34.13	7.54	7.60	50.72	34.14	3.89	11.25
	Foreign_owned	130,645	34.44	36.45	20.27	8.83	34.43	36.47	9.30	19.81
VNM	Domestic_owned	391,502	34.61	31.11	16.88	17.40	34.61	31.11	7.14	27.14
	Foreign_owned	26,964	30.50	18.84	39.69	10.97	30.48	18.85	16.03	34.63

Source: Authors' calculations based on OECD analytical AMNE database.

5. Concluding remarks

Such a decomposition can shed light on the reasons why firms engage in FDI. The literature suggests that foreign affiliates can be involved: (1) in the production of (final) goods for domestic consumers in the case of 'horizontal FDI' (Markusen, 1984); (2) in the production of (final) goods for foreign consumers in the case of 'export platform FDI' (Ekholm et al., 2007); or (3) in the production of inputs for other affiliates in the

host economy or abroad in the case of 'vertical FDI' (Helpman, 1984). More recent work indicates that in many instances firms engage in 'complex FDI' combining horizontal and vertical motives (Alfaro and Charlton, 2009), or set up affiliates for other purposes than contributing to the production process such as 'conglomerate FDI' or FDI for financial purposes (Herger and McCorriston, 2016; Ray, 2016). There is therefore a need for more empirical work on value creation in relation to activities of foreign affiliates.

References

Alfaro, L. and A. Charlton (2009) Intra-Industry Foreign Direct Investment. *American Economic Review*, 99, 2096–2119.

Alviarez, V. (2019) Multinational Production and Comparative Advantage. *Journal of International Economics*, 119, 1–54.

Antràs, P. and S. R. Yeaple (2014) Multinational Firms and the Structure of International Trade. In G. Gopinath, E. Helpman and K. Rogoff (Eds.), *Handbook of International Economics*, Volume 4, Elsevier, 55–130.

Bergstrand, J. and P. Egger (2007) A knowledge-and-physical-capital model of international trade flows, foreign direct investment, and multinational enterprises. *Journal of International Economics*, 73, 278–308.

Bernard, A. B., J. B. Jensen, S. J. Redding and P. K. Schott (2018). Global Firms. *Journal of Economic Literature*, 56, 565–619.

Beugelsdijk, S., J.-F. Hennart, A. Slangen and R. Smeets (2010) Why and How FDI Stocks Are a Biased Measure of MNE Affiliate Activity. *Journal of International Business Studies*, 41, 1444–1459.

Borin, A. and M. Mancini (2017) Follow the Value Added: Tracking Bilateral Relations in Global Value Chains. *MPRA Paper*, No. 82692.

Brainard, S.L. (1997) An Empirical Assessment of the Proximity-Concentration Trade-off between Multinational Sales and Trade. *American Economic Review*, 87, 520–544.

Cadestin, C., K. de Backer, I. Desnoyers-James, S. Miroudot, D. Rigo and M. Ye (2018a) Multinational enterprises and global value chains: the OECD analytical AMNE database. *OECD Trade Policy Papers*, No. 211, OECD Publishing.

Cadestin, C., K. de Backer, I. Desnoyers-James, S. Miroudot, D. Rigo and M. Ye (2018b) Multinational enterprises and global value chains: new insights from the trade-investment nexus. *OECD Science, Technology and Industry Working Papers*, 2018/04, OECD Publishing.

De Gortari, Alonso (2019) Disentangling Global Value Chains. Working Paper, Princeton University and Dartmouth College.

Dietzenbacher, E. (1997) In vindication of the Ghosh Model: A reinterpretation as a price model. *Journal of Regional Science*, 37, 629–651.

Dunning, J.H. (1980) Toward an Eclectic Theory of International Production: Some Empirical Tests. *Journal of International Business Studies*, 11, 9–31.

Ekholm, K., R. Forslid and J. Markusen (2007) Export-Platform Foreign Direct Investment. *Journal of the European Economic Association*, 5, 776–95.

Fukui, T. and C. Lakatos (2012) A Global Database of Foreign Affiliate Sales. US International Trade Commission Office of Economics Working Paper 2012-08A.

Ghosh, A. (1958) Input-Output Approach in an Allocation System. *Economica*, 25, 58–64.

Havranek, T. and Z. Irsova (2011) Estimating vertical spillovers from FDI: Why Results Vary and What the True Effect Is. *Journal of International Economics*, 85, 234–244.

Helpman, E. (1984) A Simple Theory of International Trade With Multinational Corporations. *Journal of Political Economy*, 92, 451–71.

Herger, N. and S. McCorriston (2016) Horizontal, Vertical, and Conglomerate Cross-Border Acquisitions. *IMF Economic Review*, 64, 319–353.

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

Koopman, R., Z. Wang and S.-J. Wei (2014) Tracing value-added and double counting in gross exports. *American Economic Review*, 104, 459–494.

Leontief, W. (1936) Quantitative Input and Output Relations in the Economic System of the United States. *Review of Economic and Statistics*, 18, 105–125.

Los, B., M. P. Timmer and G. J. de Vries (2016) Tracing Value-Added and Double Counting in Gross Exports: Comment. *American Economic Review*, 106, 1958–1966.

Los, B. and M. P. Timmer (2018) Measuring Bilateral Exports of Value Added: A Unified Framework. Paper prepared for CRIW Conference on The Challenge of Globalization in the Measurement of National Account, Washington DC, USA.

Markusen, J. (1984) Multinationals, Multi-plant Economies, and the Gains From Trade. *Journal of International Economics*, 16, 205–26.

Miroudot, S. and M. Ye (2017) Decomposition of Value-Added in Gross Exports: Unresolved Issues and Possible Solutions. *MPRA Paper*, No. 83273.

Nagengast, A. J. and R. Stehrer (2016) Accounting for the Differences Between Gross and Value Added Trade Balances. *World Economy*, 39, 1276–1306.

Ramondo, N. (2014) A quantitative approach to multinational production. *Journal of International Economics*, 93, 108–122.

Ramondo, N., A. Rodríguez-Clare and F. Tintelnot (2015) Multinational Production: Data and Stylized Facts. *American Economic Review*, 105, 530–536.

Ray, A. (2016) Expanding Multinationals – Conglomerate M&A and Activity-Basket Proximity. Paper presented at the 19th Annual Conference on Global Economic Analysis, Washington DC, USA.

Rueda-Cantuche, J. M., R. Kerner, L. Cernat and V. Ritola (2016) Trade in services by GATS modes of supply: Statistical concepts and first EU estimates. DG Trade Chief Economist Note No. 3/2016.

Timmer, M. P., E. Dietzenbacher, B. Los, R. Stehrer and G. J. de Vries (2015) An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production. *Review of International Economics*, 23, 575–605.

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

UNCTAD (2013) *World Investment Report 2013. Global Value Chains: Investment and Trade for Development*. United Nations Conference on Trade and Development, New York and Geneva.