# HOW FRAGMENTED IS THE WORLD ECONOMY: EVIDENCES FROM THE EORA DATABASE

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## Introduction

The reduction (or elimination) of trade barriers, development of technology, differences in factor prices and factor productivities between countries, have strongly grown the international trade and thus contributed to delocalization of production process to countries where costs are relatively low and more efficient, boosting international trade (e.g. Krugman and Venables, 1995; Feenstra, 1998; Jones and Kierzkowski, 2001).

Consequently, world economy has been increasingly characterized by a strong economic interdependence among countries, so that the production of a finished good involves the participation of many countries specialised in different stages of production. Indeed, a country imports goods from other countries, uses them as inputs in the production of its own good, which is then exported to the countries specialised in the next stage of production. This sequence continues until the good reaches its final consumers

In literature this phenomenon is known as "vertical specialization", "slicing the value chain", "production fragmentation" or "outsourcing". Now the phenomena of vertical specialization is considered a fundamental factor that contributes to explain the organization of world production, the degree of globalization of economic systems, being a key issue for international and national policies governing markets and promoting development.

The production fragmentation has been extensively studied in literature and there is an increasing empirical documentation of the rising role of vertical specialization of the country economies. See for example but not limited to: Athukorala and Yamashita (2006), Bridgman (2012), Dean and Lovely (2010), Dixit and Grossman (1982), Feenstra (1998); Feenstra and Hanson (1997), Goh and Henry (2005), Leung (2016), López (2014), Jones and Kierzkowski (2001), Hogan *et al.* (2005), Sanyal (1983), Yücer *et al.* (2014), Vechiu and Makhlouf (2014).

There are three standard methods to measure vertical specialization (Feenstra, 1998). While the first one uses firm surveys, the second approach adopts a fine industrial classification of trade, as in Athukorala and Yamashita (2006). The third and most traditional method uses National Input-Output Tables (NIOT), according

with e.g. Ishii and Yi (1997) and Hummels *et al*. (1998, 2001). Limiting the attetention to this last approach, two different measures of outsourcing based on NIOT have been proposed. The first measure focuses on the foreign content of domestic production and estimates the share of imported intermediate inputs in either production or total input. This measure, originally due to Feenstra and Hanson (1997), has been used to assess to what extent workers at home have been substituted by workers abroad. In other words, this approach evaluates the elasticity of substitution of domestic value-added with respect to imported intermediate inputs. This measure captures the essence of international outsourcing, i.e. the firm's decision to substitute domestic value-added by foreign production (Los *et al*., 2015). The second measure based on NIOT concentrates on the direct and indirect import content of exports and was originally formulated by Hummels *et al*. (1998, 2001). In these papers the authors discussed two ways in which a country can participate in vertical specialization. A first way it use imported intermediate inputs to produce exports. A second way it can export intermediate goods that are used as inputs in goods exported by another country.

As previously stated, the fundamental element of this approach is the use of NIOT to identify the value of the imported intermediate inputs used in the production of each sector. Indeed, the value of imported intermediates is properly accounted in the NIOT, where classification is based on the use of the good and not on its characteristics. Moreover, the NIOT approach allows for a sectorial breakdown of the vertical specialization measure and respect the use of trade data has the advantage of not considering the phenomenon of double recording in trade statistics. Indeed, goods in process can cross multiple national borders before getting embodies in the final product. For example, consider the case of car windshield produced in country A and exported to country B for assembly process, would be counted again as B's exports, although there is no production transformation on that product. High prevalence of cross border shipping of the same product makes this problem worse. Moreover, the use of NIOT allows to avoid another problem related to the use of imported inputs. When import of a particular intermediate input takes place, it is not clear of the use of this product, whether it would be used directly by consumer as a replacement for broken product, or used by a producer for further production process.

This paper, by means of the World Input-Output Table (WIOT) derived from the EORA database, furnishes an analysis of the fragmentation degree of the world's economies applying an alternative measure in the spirit of the Hummels *et al*. (2001) approach, that will be introduced in the next section.

The EORA-WIOT (https://worldmrio.com/) is a multi-region input-output table and is built in current U.S. dollars with a classification for 26 industries (sectors). The database used in this analysis is the simplified EORA26 model that covers 139

countries for the period from 1990 to 2015. In this paper, we limit the analysis only the years 1995 and 2015.

The main results of this analysis show that the production chain of the countries has become increasingly fragmented since 1995. However, the degree of international fragmentation vary considerably across the countries and economic sectors.

## Methodology

Considering the following simplified pattern, in block matrix notation, of a NIOT:

**Figure 1 –** *Pattern of a NIOT*

| | | | |
|---|---|---|---|
| **Z** | **f** | **e** | **x** |
| **M** | | | |
| **v′** | | | |
| **x′** | | | |

Where:

- **Z** is a *n*x*n* matrix whose entries ($z_{ij}$) are the flows for intermediate use from the i-th sector to the j-th sector;
- **f** is a *n*x*1* vector whose entries are the flows from the i-th sector to the final sector;
- **e** is a *n*x*1* vector whose entries are the exportations of the i-th sector;
- **M** is a *n*x*n* matrix whose entries ($m_{ij}$) are the imported flows, for intermediate use, from the i-th foreign sector to the j-th domestic sector;
- **v′** is *1*x*n* vector whose entries are the added value of the i-th sector ( ′ is the transposition symbol);
- **x** is a *n*x*1* vector whose entries ($x_j$) are the total production (gross output) of the j-th domestic sector;

As proposed by Hummels *et al.* (2001) a measure of the vertical specialization of an economic sector of a country R is the value of directly imported intermediates embodied in goods that are exported. Formally:

$$DVS_{Rj}=a_{M.j}e_j\left(\mathbf{i}'\mathbf{e}\right)^{-1} \text{ and } a_{M.j}=\sum_{i=1}^{k} a_{Mij} \quad (1)$$

where, **i** is a vector of 1's, $a_{Mij} = m_{ij}/x_j$ is the generic entry of the $\mathbf{A}_M$ matrix of the direct imported coefficients. Thus, $a_{Mij}$ is the total amount of i-th product imported and used as input for the production of one monetary unit of industry j's output.

For the economic system of a country, vertical specialization is simply the sum of $DVS_j$ across all j. In matrix notation:

$$DVS_R=\mathbf{i}'\mathbf{A}_M\mathbf{e}(\mathbf{i}'\mathbf{e})^{-1} \quad (2)$$

The DVS index is a weighted average of the direct import coefficients using the sectorial exports as weights.

A more detailed index of a sector's vertical specialization is the following (3). Indeed, an intermediate good can be initially imported as input of one domestic sector and then used as an intermediate good in a second domestic sector and so on, until the imported product is finally embodied in a good that is exported:

$$VS_{Rj}=A'_{Mj}\mathbf{L}_j\frac{e_j}{\mathbf{i}'\mathbf{e}} \quad (3)$$

Where $A'_{Mj}$ is the j-th column of the $A_M$ matrix and $\mathbf{L}_j$ the j-th column of the Leontief inverse matrix $\mathbf{L}=(\mathbf{I}-\mathbf{A}_Z)^{-1}$. This last index includes both the directly and indirectly imported input content in exports of a sector. Indeed, equation (3) gives the total amount of imports that is directly and indirectly required to satisfy one unit (1$) of the j-th product exported. The vertical specialization of the economic system of a country is:

$$VS_R=\mathbf{i}'\mathbf{A}_M\mathbf{L}\mathbf{e}(\mathbf{i}'\mathbf{e})^{-1} \quad (4)$$

The $VS_R$ index, similarly to the $DVS_R$, is a weighted average of the import multipliers, with the sectorial exports as weights. A high value of the $VS_R$ index indicates that imported intermediate goods make up a large proportion of the value of an economic sector (or country) exports and consequently indicate a country's greater degree of involvement in global production chains.

In this paper rather than using the index (4) it was decided, accord with De Backer and Yamano (2008), to use the following index (5) which considers the directly and indirectly imported input content in the total production of a country.

$$VS\_OUT_R=\mathbf{i}'\mathbf{A}_M\mathbf{L}\mathbf{x}(\mathbf{i}'\mathbf{x})^{-1} \quad (5)$$

I the other words, index (5) measure the direct and indirect contribution of foreign industries to the national production process. Therefore, similarly to the index (4) it provides a measure of the degree of production fragmentation of a country economy.

## Results and discussion

In this section, the production fragmentation of the world economy in the year 1995 and 2015 is examined by means of the $VS\_OUT_R$ index.

Table 1 depicts same descriptive statistics of the $VS1\_OUT_R$ index for the two years considered. The detailed values are available from the author upon request.

**Table 1 –** *$VS1\_OUT_R$ descriptive statistics for the years 1995 and 2015.*

| | 1995 | 2015 |
|---|---|---|
| Mean | 0.175 | 0.174 |
| Standard Deviation | 0.260 | 0.125 |
| Max value | 0.954 | 1.000 |
| Min value | 0 | 0.001 |
| First quartile (Q1) | 0.005 | 0.095 |
| Median (Q2) | 0.033 | 0.152 |
| Thirth quartile (Q3) | 0.243 | 0.207 |

The $VS1\_OUT_R$ index varies widely across countries. An average degree of outsourcing by 0.175$ was observed in 1995 and one half of the units presented a value not exceeding 0.033$. The lowest values is recorded for Moldova, Samoa and Ruanda (i.e. $VS1\_OUT_R=0$) and the highest values for Germany, Mexico and Greece (i.e. $VS1\_OUT_R>0.89$$).

The mean value remained unchanged in 2015 and Myanmar, Sudan and South-Sudan are the countries with the lowest values (i.e. $VS1\_OUT_R<0.005$$), while Hong Kong, Belarus and Moldova the countries with the highest values (i.e. $VS1\_OUT_R>0.61$$).

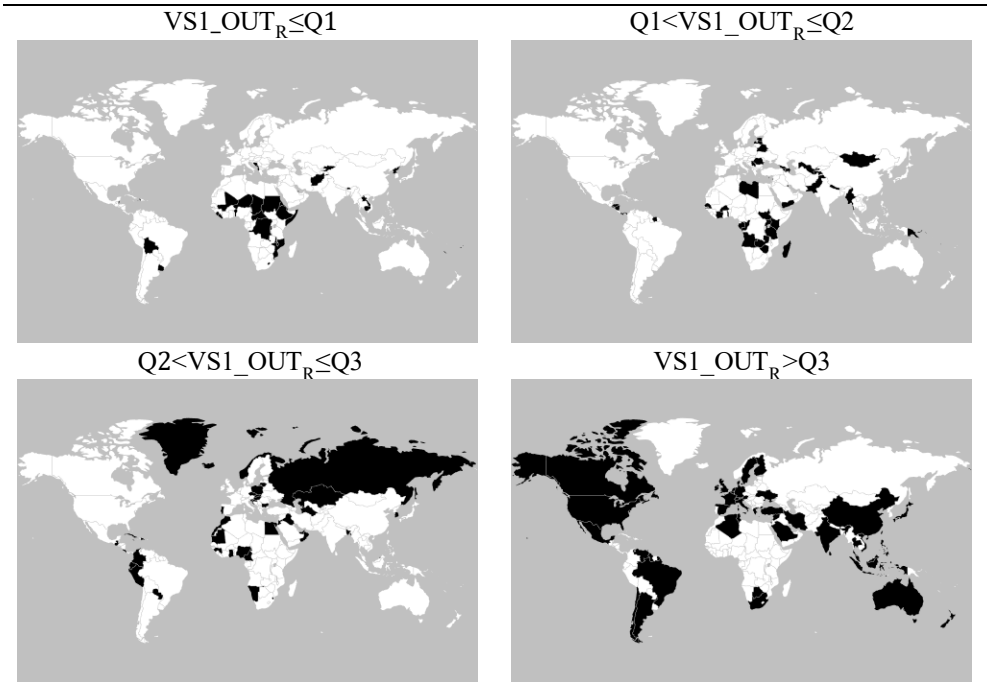
Although the average level of the phenomenon considered remains unchanged between 1995 and 2015, it is possible to note that, the first quartile grows from 0.005$ to 0.095$. The median changes from 0.033$ to 0.152$ and the third quartile from 0.243$ to 0.207$. Therefore, we can assert that the degree of fragmentation has increased in the world economy.

Figure 1 depict a classification of countries respect the quartile values. As is possible to note the countries with the lowest degree of fragmentation are particularly concentrated in the African continent and Eastern Europe. On the contrary, the countries with the highest degree of fragmentation are located in the American, Asian and European continents.

A typical observation that comes out from these international comparisons is that smaller countries have a larger international orientation than larger countries. It is not surprising because smaller countries are typically more dependent on imported inputs for their production than larger countries, which are more self-supporting.

Countries such as Belgium, Hungary, Ireland, Luxemburg, Slovak Republic and Singapore are clear examples of this, while their higher international dependency is also partially due to the large presence of multinational enterprises in these countries.

**Figure 1 –** *Countries classification by quartile values. Year 1995.*



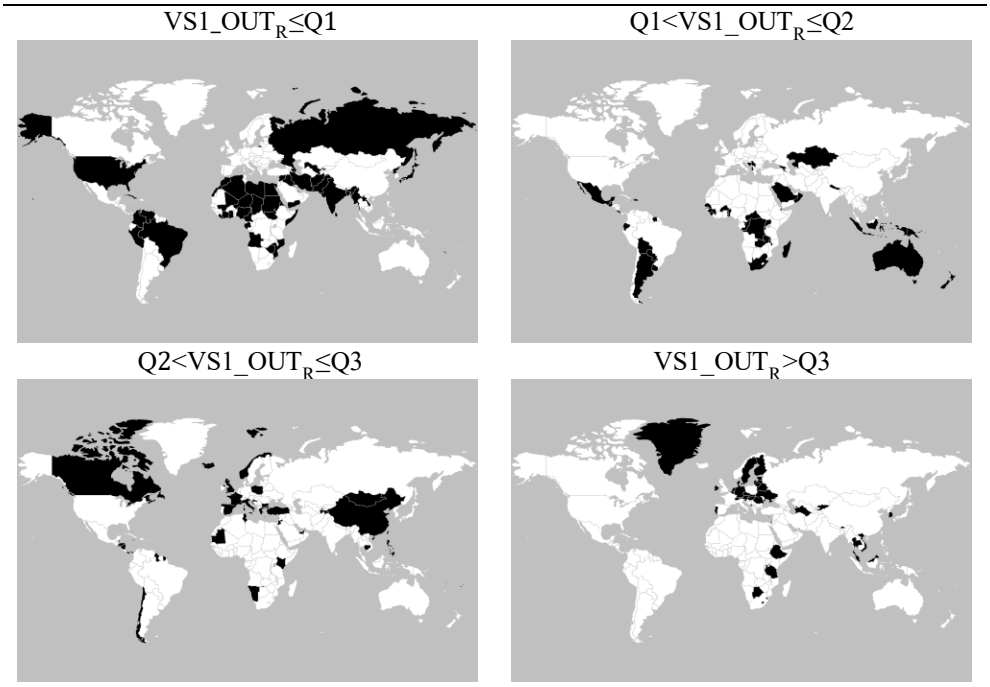

The situation photographed in 2015 (Figure 2) is quite different from that of 1995. Although small countries continue to record the highest degrees of fragmentation and the countries less fragmented still concentrated in the African continent, it is possible to note how larger countries (USA, Australia and Russia) suffers a contraction in the phenomenon under consideration. Also in 2015 the countries with the highest embodied imports are generally located in Europa and Asia.

In larger countries, national production depend relatively less on the imports of intermediates sourced abroad. The increase in vertical specialisation becomes clearest in countries with a high multinational presence like Ireland, Hungary, the Czech Republic and Belgium, as the international sourcing of intermediates within multinational networks drives the development of global value chains.

Within the group of emerging countries, China and Indonesia demonstrate a larger dependence on imported intermediates. The results for China illustrate the

increasing international production sharing within ICT industries, in which the more labour-intensive manufacturing activities are carried out in emerging countries while the more skill-intensive activities remain clustered in developed countries

**Figure 2 –** *Countries classification by quartile values. Year 2015.*




Finally, the following Figure 3 depict a classification of countries respect to growth rate recorded between the two years considered. In grey, there are the countries with a negative growth rate of the embodied imports in the national total production and in black those with a positive growth rate.

In general, the sourcing of intermediates abroad is increased in 68.78% of the countries, with, in some countries, very significant increases clearly illustrating growing interdependence of the economic linkage between the countries.

Countries with low level of fragmentation present relatively higher growth figures. Generally, those countries are localised in the African continent and Eastern Europe.

However, the magnitude of the increase in the degree of vertical integration can be explained by the low initial values in these countries.

**Figura 3 –** *Countries classification by the $VS1\_OUT_R$ growth rate between 1995 and 2011.*

## 4. Conclusions

With the global economic systems becoming more integrated, production processes, previously carried out in one site, are now split up into stages (or fragments), each to be performed in a different location and often beyond national boundaries.

These changes have been extensively studied under different names, such as "disintegration of production", "vertical specialization", "fragmentation", "outsourcing", "offshoring", among others. Thus, one important feature of the new international and globalized economy is the significant increase of intermediate goods trade, crossing several borders along the supply chains.

Using a modified originally measure proposed by Hummels *et al*. (2001), this study has analysed the degree of vertical specialization of the world between the 1995 and 2015.

Our main data source has been the EORA Database, which covers 189 countries with a classification for 26 economic sectors.

Empirical results highlights a growth of foreign intermediate goods content of production in most of all economies particularly concentrates in the African continent and Eastern Europe

The degree of specialization is greatly diversified across countries and those smaller have a larger international orientation than larger countries.

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## SUMMARY

### How fragmented is the world economy: evidences from the EORA database

Fragmentation of vertically integrated production processes (known also as vertical specialization) implies that production blocks are located in different countries and geographical areas across the world countries. This study using a modified originally measure proposed by Hummels *et al*. (2001), has analysed the degree of the production fragmentation of the world economy between the 1995 and 2015.

Our main data source has been the EORA Database, which covers 189 countries with a classification for 26 economic sectors.

Empirical results highlights a growth of foreign intermediate goods content of production in most of all economies particularly concentrates in the African continent and Eastern Europe.

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