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Global value chains, value-added generation and structural change in EU core and periphery economies: An Input-Output approach

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Abstract. Backward and forward integration are growing in most sectors across the European Union (EU). To benefit from this increasing participation in Global Value Chains (GVC), the increase in imports, namely of intermediate inputs, should be followed by adequate growth in exports. The external dependency of many industries and the corresponding low domestic value-added generated in production, combined with relatively weak export potential can cause high trade deficits and growing external debt to GDP ratios. This paper evaluates the inter-industry participation in GVCs considering eight different EU economies and 25 tradable sectors. Based on Input-Output production multipliers and intermediate import coefficients, we propose an empirical method to assess the evolution of vertical specialization, domestic value-added generation and external dependency. After a convenient arrangement of the Leontief inverse matrix, the evolution of backward linkage indicators can be used to detect structural changes, particularly quantifying a "net growth effect" and an "external dependency effect". This method allows the classification of each sector into different areas considering their recent structural evolution and it can be useful as a simple, but suggestive, device to compare different economies in a given period or assess their structural development processes in time. A detailed comparison of one EU periphery country (Portugal) and one EU core country (Germany) is made, based on WIOD data for the period 2000-2014, followed by a brief presentation of six other cases (Austria, Check Republic, Belgium, Finland, Greece, and Netherlands). Particular attention is given to differences within and between countries before and after the global financial crisis.

Keywords: Global Value Chains; Input-Output analysis, External dependency, Structural change

JEL Codes: C67; E01; F14; F62; L60; L70; L96

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1. Introduction

The emergence of the so-called Global Value Chains, accompanied by an increase in imports, namely intermediate inputs, highlights trade's multiple-border-crossing. This disintegration of production involves value-added sharing during the production process among trade partners (Baldwin & Venables, 2013). Accordingly, the GVC integration process depends heavily on each country's comparative advantages in these international production networks. Yet, conventional statistics on trade flows may no longer be informative enough given this new global trade configuration (Koopman et al, 2014; Los et al, 2015).

The primary measurement challenge is that GVCs are not directly observable in the data and need to be inferred from information on the linkages between the various production stages. In that sense, the last two decades can be seen as an exceptional period in the global economy, as multinational firms benefitted from reduced labour costs through offshoring, while capitalising on existing firm-specific intangibles, such as brand names (Chen et al, 2018).

The recent vertical specialisation process led to a substantial increase in international trade of intangibles and intermediate products, which in turn increases the difference between each country exports and imports in absolute value and the total amount of exports and imports in value-added (Amaral & Lopes, 2018). In methodological terms, intangibles are on the rise, yet their measurement is elusive. The income share of labour in GDP has been declining, and it is widely shared across industries and countries (Dao et al, 2017). Meanwhile, the residual that remains after subtracting measured payments to labour and imputed cost of capital from GDP (the factorless income) is on the rise (Karabarbounis & Neiman, 2018). This phenomenon reflects the increasing importance of intangible capital that is currently unmeasured in national accounts statistics. Contrary to tangible assets and labour that have a physical presence, the uses of intangibles cannot be uniquely attributed to a geographical location. Therefore, it is hard to infer the income that accrues to these intangibles in national accounts statistics as their use cannot be uniquely attributed to a geographical location (Haskel & Westlake, 2017).

In a single monetary union, the elimination of exchange rate risk and transaction costs and the reduction of uncertainty produced by inflation distortion contributed to the intensity and changing geography of trade. Since the Eurozone foundation, member states' exports and imports trade volume of goods and services increased at an average annual growth rate of 4.3 and 3.7 per cent, respectively, over 2000-2014.

This paper evaluates the inter-industry participation in GVCs, considering eight different EU economies and 25 tradable sectors. Based on Input-Output production multipliers and intermediate import coefficients, we propose an empirical method to assess the evolution of vertical specialisation, domestic value-added generation and external dependency. After a convenient arrangement of the Leontief inverse matrix, the evolution of backward linkage indicators can be used to detect structural changes, particularly quantifying a "net growth effect" and an "external dependency effect". This method allows the classification of each sector into different areas considering their recent structural evolution, and it can be useful as a simple, but suggestive, device to compare different economies in a given period or assess their structural development processes in time (Lopes et al, 2011).

In this paper, a detailed comparison of one EU periphery country (Portugal) and one EU core country (Germany) is made, based on WIOD data for the period 2000-2014, followed by a brief presentation of 6 other cases (Austria, Check Republic, Belgium, Finland, Greece, and the Netherlands). Particular attention is given to differences within and between countries, before and after the global financial crisis.

The rest of the paper is organised as follows. Section 2 describes the basic Input-Output assumptions. Section 3 presents our vertical specialisation measure. Section 4 presents our backward linkages measurement. Section 5 summarises the classification of sectors according to "net growth" and "external dependency" effects. Sections 6, 7 and 8 present the application of our method to Portugal, Germany, and six other EU economies, respectively. Finally, section 9 concludes.

2. Basic Assumptions and Input-Output Relationships

The Input-Output (IO) analysis explores inter-industry relationships within an economy by capturing all financial market transactions between industries in a given time. The mathematical solution of the Leontief model allows for a better understanding of the effects of a change in one (or several) economic activities on the entire economy.

The IO model was initially developed by Wassily Leontief in the first half of the 20th century and is based on a mathematical system that stems from the General Equilibrium Theory, initially formulated by Léon Walras in the late 19th century. Although it has been replaced mainly by general equilibrium models, its use has recently regained importance particularly in the evaluation of macroeconomic policies as well as studies of international trade.

Like any other model, the IO is based on a set of assumptions, such as: i) constant returns to scale and fixed input structure (changes in the economy will affect the industry's output level but not the mix of commodities and services it requires to produce that output.); ii) no supply constraints (there are no restrictions on raw materials and employment); iii) constant industry technology (an industry uses the same technology to produce each of its products), and iv) static linear relationships (relationships for a given year do not change unless more data is considered).

The Rasmussen tradition method of using compact indicators from the production multipliers matrix (Leontief inverse) is one of the classical references for the analysis of intersectoral relations (Rasmussen, 1956). It is well known that this matrix is obtained by solving an equations system that equates sector productions to possible uses: intermediate and final demand. For a detailed analysis of the IO model see (Milner & Blair, 2009) and (Amaral & Lopes, 2018). The system can be represented as follows:

$$x = Ax + y \quad (1)$$

Where x is the column vector of gross output values of the j sectors of the economy, y is the final demand vector, and A is the technical coefficients matrix. The final solution of this system is:

$$x = B y \quad (2)$$

Where $B = (I - A)^{-1}$ is the so-called Leontief inverse matrix of output multipliers. Each element of B is a production multiplier that gives the total (direct and indirect) effect in one's sector production of a unit increase in domestic final demand of a given sector. That is, b_{ij} is the global impact on the sector i production caused by an additional unitary final demand directed to sector j .

Particular interest in this context is the notion of backward linkage indicators:

$$b_{0j} = \sum_{i=1}^n b_{ij} \quad (j = 1, 2, 3, n) \quad (3)$$

This indicator results from summing up the n values of column j and gives the effect on total production (of all sectors) of a unitary change in the final demand directed to sector j . The larger the value of this coefficient, larger will be the impact of this increase of the final demand on the sector concerned and on all the others.

The vector of (total) final demand can be afterward divided into two vectors: the domestic final demand d (public and private consumption plus investment), and the external final demand e (exports of goods and services).

3. Measuring Vertical Specialization

The emergence of the so-called GVCs emphasizes the multiple-border-crossing of trade. According to (Hummels, Ishii, & Yi, 2001), vertical specialization involves value-added sharing during the production process among different trade partners. Hence, the general tendency for disintegration and fragmentation of production has been contributing to the increasing use of imported intermediate inputs in the production of goods and services that are exported afterwards.

According to this trade arrangement, the production of goods and services are made in many countries, each one specializing in "tasks" or different stages of production. Therefore, the integration in GVCs depends heavily on the comparative advantages each country has in these complex international production networks (Johnson and Noguera, 2012).

Given this new configuration of international trade, conventional statistics on trade flows may no longer be informative enough. It is therefore relevant to assess with some precision the participation of each economy along the GVCs. Accordingly, the recent process of vertical

specialization led to a substantial increase in international trade flow of intermediates (also intangibles), which in turn increases the difference between each country exports and imports in absolute value and the total amount of exports and imports in value-added (Amaral and Lopes, 2018).

Several reasons support the use of the vertical specialization measure introduced by Hummels. First, the increasing importance of vertically integrated multinationals is not captured by trends in intermediate goods trade because the share of intermediate goods in trade has been declining (Hummels et al, 1998). Second, the classification of goods into intermediates and final categories is by necessity somewhat arbitrary. For example, given that Portugal uses imported wool and polyester, namely from India and China, to produce cloth and shoes, some of which are exported, how should they be classified? Avoiding this problem, vertical specialization builds on the IO structure that fully captures the differences in the nature of goods and services.

According to (Hummels, Ishii, & Yi, 2001), inter-industry vertical specialization can be defined as the weight of imported inputs in the sector's exports, that is:

$$VS_j = \sum_{i=1}^n a_{ij}^m X_j \quad (4)$$

Where a_{ij}^m is the $n \times n$ matrix of imported intermediate input coefficients, representing the proportion of imported input i used to produce output Y_j , and X_j is the value of exports of sector j . Thus, VS_j measures the import content of exports, namely the external value-added that is embodied in industry's j exports. Vertical specialization (of country k) corresponds to the sum of each j sector vertical specialization in the overall economy.

For simplicity purposes, it is useful to compute the vertical specialization as a share of total exports of country k . Thus, assuming that $X_k = \sum_{j=1}^n X_j$ corresponds to the total exports of country k , the vertical specialization share of total exports can be expressed as:

$$\frac{VS_k}{X_k} = \frac{\sum_{j=1}^n VS_j}{\sum_{j=1}^n X_j} = \sum_{j=1}^n \left[\left(\sum_{i=1}^n a_{ij}^m \right) \frac{X_j}{X_k} \right] \quad (5)$$

Additionally, IO tables allow us to compute a more accurate measure of vertical specialization by considering also the imported inputs used indirectly in exports, since one intermediate input can be first used in sector j , whose outputs are employed in sector $j + 1, j + 2$, etc, until it is fully embodied in a final exported good. That way, intermediate inputs are set to circulate freely

through different stages (tasks) of the economy, before there is an actual export of the final product/service. Since we are modelling IO tables, one can compute the final measure of vertical specialization, that is the total vertical specialization of exports in country k , as:

$$\frac{VS_k}{X_k} = uA^m B \frac{X}{X_k} \quad (6)$$

Where $B = (I - A)^{-1}$ is the so-called Leontief inverse matrix, that is composed by the identity matrix I and by the $n \times n$ matrix of domestic technical coefficients, A . Accordingly, after multiplying the matrix of imported (direct) intermediate input coefficients by the Leontief inverse matrix we get the matrix of total requirements of imported inputs. Each element (i, j) of the matrix $A^m(I - A)^{-1}$ represents the total imports of product i required to satisfy one unit of exports for sector j . As it was shown previously in this work, this equation represents the sum of vertical specialization from all sectors and can be easily reformulated to each j sector of the economy.

This vertical specialization measure works as a proxy for the backward integration of sectors (and economies) in the GVCs, enabling the construction of a comprehensive framework considering the process of value-added sharing. It should be noted that this measure does not incorporate the domestic value-added content of imports, known as "forward participation". Nonetheless, recent evidence suggests a residual effect of this type of participation, especially for small open economies like Portugal (Nagengast & Stehrer, 2016).

4. Measuring Backward Linkages

Backward linkage indicators can be used to evaluate the gains in the capacity to generate value-added as well as the changes in external dependency of an economy (or sector) from one year to another. The overall effect of a unitary change in final demand is the sum of three terms: interindustry flows, value-added and imported inputs. Moreover, an important property applies: the second and last terms sum up to unity, precisely the value of the initial (exogenous) stimulus, and this is so because in equilibrium the total value of sectoral final demand equals the gross value added plus imported inputs of all sectors (Lopes et al, 2011).

Using this property, and after a convenient arrangement of terms, the evolution of backward linkage indicators, value-added and imported input coefficients can be used to detect structural changes in the economy over time. Notably, we can quantify the capacity of each sector to

generate more (or less) domestic value-added by unity of final demand (what in some sense we can call an “efficiency effect”, although a peculiar one). Also, we can compute the need to import more (or less) intermediate inputs (a certain kind of “external dependency effect”). Having these measures, we can therefore classify each sector according to the particular combination of both effects.

These conceptualizations can be formally expressed as follows. Considering a unitary increase in sector j final demand, its effects on total production are:

$$\sum_i \Delta x_i = \sum_i b_{ij} = b_{0j} \quad (7)$$

By the equilibrium condition between total sectoral final demand and total primary inputs, we have:

$$\Delta y_i = \mathbf{1} \xrightarrow{\text{yields}} \Delta \left(\sum_i v_i + \sum_i m_i \right) = \mathbf{1} \quad (8)$$

Where v_i and m_i are the value-added and the value of imported inputs used by sector i . Defining, and assuming as constants, the value-added coefficients ($a_i^v = \frac{v_i}{x_i}$) as well as the imported inputs coefficients ($a_i^m = \frac{m_i}{x_i}$), we have:

$$\mathbf{1} = \sum_i b_{ij} a_i^v + \sum_i b_{ij} a_i^m \quad (9)$$

Dividing both sides by b_{0j} , we get:

$$\frac{\mathbf{1}}{b_{0j}} = \frac{\sum_i (b_{ij} a_i^v)}{\sum_i b_{ij}} + \frac{\sum_i (b_{ij} a_i^m)}{\sum_i b_{ij}} \quad (10)$$

Representing by v_j^* and m_j^* the terms in the right hand we finally arrive at:

$$\mathbf{1} = b_{0j} (v_j^* + m_j^*) \quad (11)$$

These expressions can be used in a dynamic (or, as presented here, in a comparative static) exercise to detect and quantify the changes in the productive structures. This application of the IO model allows the evaluation of the evolution of different productive structures and identifies the sectors exhibiting the most significant potential to generate domestic value-added and those

that show an increasing tendency for external dependency. Based on this we build a comprehensive link connecting inter-industry value-added generation, external dependency and vertical specialization enabling an in-depth assessment of each sector integration in the GVC.

5. Measuring Net Growth and External Dependency effects

Equation 11 serve as a benchmark in the identification and quantification of structural changes in the productive processes regarding different sectors of the economy.

Suppose that, for each sector j , we have, between two given years, a decrease in b_{0j} . This means that in order to satisfy a unitary increase in sector j final demand, a smaller increase in the global production of the economy is needed. It is also true that, in this case, we must have $\Delta m_j^* + \Delta v_j^* > 0$, and so four situations are possible, in a two-dimensional space with axes Δv_j^* and Δm_j^* :

- **Area A:** $\Delta v_j^* > 0$ and $\Delta m_j^* < 0$. In this case, the decrease in b_{0j} goes with larger capacity to generate value-added (“net growth effect”) and a lower necessity of imported inputs (“external dependency effect”).
- **Area B:** $\Delta v_j^* > 0$, $\Delta m_j^* > 0$ and $\frac{\Delta v_j^*}{\Delta m_j^*} > 1$. Here, there is a simultaneous increase in “net growth effect” and “external dependency”, with the first dominating the second.
- **Area C:** $\Delta m_j^* > 0$, $\Delta v_j^* > 0$ and $\frac{\Delta m_j^*}{\Delta v_j^*} > 1$. In this case, the increase in “external dependency” is relatively more significant than the increase in “net growth effect”.
- **Area D:** $\Delta m_j^* > 0$ and $\Delta v_j^* < 0$. The decrease in b_{0j} is totally due to an increase in “external dependency”, with a simultaneous decrease in the capacity to generate domestic value-added.

For the case of a b_{0j} increase we must have $\Delta m_j^* + \Delta v_j^* < 0$, a worse situation for the economy, at least from the capacity to generate more domestic value-added point of view. The four possible areas now are:

- **Area A'**: $\Delta v_j^* > 0$ and $\Delta m_j^* < 0$, with $\Delta v_j^* < |\Delta m_j^*|$. In this case, the increase in b_{0j} goes with a larger capacity to generate value added with a beneficial “net growth effect” and a lower “external dependency effect”.
- **Area B'**: $\Delta v_j^* < 0$ and $\Delta m_j^* < 0$, with $|\Delta v_j^*| < |\Delta m_j^*|$. Here, there is a simultaneous decrease in “net growth effect” and “external dependency”, with the second dominating the first.
- **Area C'**: $\Delta v_j^* < 0$, $\Delta m_j^* < 0$, with $|\Delta v_j^*| > |\Delta m_j^*|$. In this case, there is also a simultaneous decrease in “net growth effect” and “external dependency”, while the first dominates the second.
- **Area D'**: $\Delta v_j^* < 0$, $\Delta m_j^* > 0$, with $|\Delta v_j^*| > \Delta m_j^*$. The decrease in b_{0j} is totally due to an increase in “external dependency” with a simultaneous decrease in the capacity to generate value-added.

In practical terms, a suggestive way of analysing the results is through the graphical representation of Δv_j^* and Δm_j^* values in the two dimensional space defined above, distributing the position of the sectors in the possible areas A, B, C, D (for a b_{0j} decrease) and A', B', C', D' (for a b_{0j} increase). As described above, the structural change is supposed to be more beneficial to an economy when more sectors concentrate on A, A', B' and B' areas and less on C, C', D and D' areas.

The identification of different areas from equation 11 allows us to classify the recent evolution of the various sectors of the economy in terms of value-added and external dependency. This conceptual analysis assesses the productive structure through a set of fundamental equations, from which the two previously listed effects are stressed ("net growth effect" and "external dependency effect").

Though, recent technological advances in logistics and transport, and the increasing elimination of trade barriers have led to the emergence of a new international trade organization. The total value-added in final production is somehow expected to be increasingly diluted through a wide range of economies and sectors, which also explains the increasingly specialized supply in the markets. It is therefore essential to understand the macroeconomic fundamental behaviour of inter-industry production and trade across time. The considerable growth in the sectors' external dependency, which derives from the increasing insertion in the GVC's, must be accompanied

by an adequate rise in the global value of exports. Moreover, this assessment is also important to evaluate and compare the recent evolution of each sector (and country) with a particular focus on strategic industries.

The next section presents the results obtained for Portugal according to the different areas identified here, combining them with the results obtained for vertical specialization, our proxy for backward integration.

6. Application to Portugal

This section empirically applies our method to the Portuguese economy for three different periods: 2000-2007, 2007-2014 and the overall period 2000-2014 using data from the 2016 edition of the World Input-Output Database (WIOD). For a complete understanding of the WIOD project, see (Timmer, Dietzenbacher, R., & Vries, 2015) and (Dietzenbacher, Los, Stehrer, Timmer, & Vries, 2013).

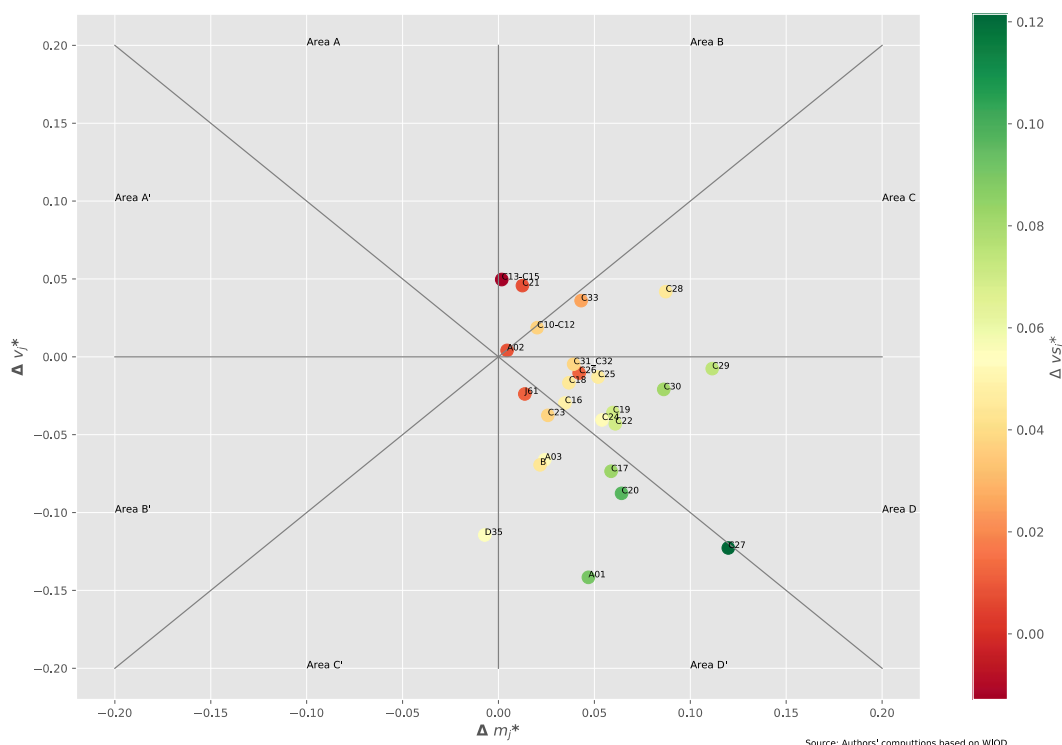
We only considered tradable sectors, namely those related to the primary industry, manufacturing, energy supply and telecommunications. Following a standard methodology of classifying tradable sectors (Gouveia & Canas, 2016) we end up analysing 25 tradable industries out of 54 considered in the WIOD.

One main novelty of this paper is the inclusion of the vertical specialisation measure along with the backward linkages indicators. This inclusion is particularly relevant because of the increasing importance of GVCs in the organisation of international trade and production, allowing an in-depth reflection regarding cross-industry structural changes. Thus, this section presents the application of the previously explained conceptual framework, enabling the classification of each sector in their respective areas. We additionally include a third dimension (beyond delta Δv_j^* and Δm_j^*) representing the individual results for the vertical specialization measure (represented by ΔVS_j^*) that were included in color scales.

Period 2000-2014

The main conclusion drawn from our results is the apparent global deterioration of the Portuguese productive system between 2000 and 2014, with very few sectors locating in virtuous areas A, A', B, and B'. For the overall 2000-2014 period (see table 1 in the appendix and figure 1 below) 18 of 25 sectors were located in areas D and D', one is located in area C', four in area C, and only two were placed in area B. Note that no sector is located in the most virtuous areas A, A' and B'.

Figure 1 – Portugal (2000-2014)



From areas D and D' we emphasise the following sectors: *A01-Crop and animal production, hunting and related service activities; C27-Manufacture of electrical equipment; C20-Manufacture of chemicals and chemical products; C17-Manufacture of paper and paper products; C30-Manufacture of other transport equipment; and C29-Manufacture of motor vehicles, trailers and semi-trailers.* During the period 2000-2014, these sectors experienced a sharp deterioration in the domestic value-added content of exports while becoming more dependent on trade partners' value-added (higher "external dependency effect"). This deterioration in the domestic value-added was led by an increasing vertical specialization share of exports, i.e. higher import content of national exports.

We can also identify sector *D35-Electricity, gas, steam and air condition supply* in area C'. The previous conclusion (from areas D and D') applies, despite a small increase in the "net growth effect" that was entirely dominated by higher "external dependency" effect.

The main conclusion for this group of sectors is that they experienced a structural deterioration regarding the share of value-added that is produced domestically. Compared to 2000, each euro of exports implies a smaller national value-added content which also translates in higher levels of vertical specialization. This is particularly alarming if these sectors are failing to make up for this decline in the share of value-added with higher levels of exports.

After analyzing the evolution of real export growth in the sectors in question, we conclude that all of them experienced considerable growth in exports, especially during the period 2000-2014. Among this set of sectors, we highlight sector A01, which experienced a growth rate of its exports exceeding 500%, indicating that its position in the least virtuous area of value can be offset by a significant increase in the volume of exports. (see figures 4 and 5)

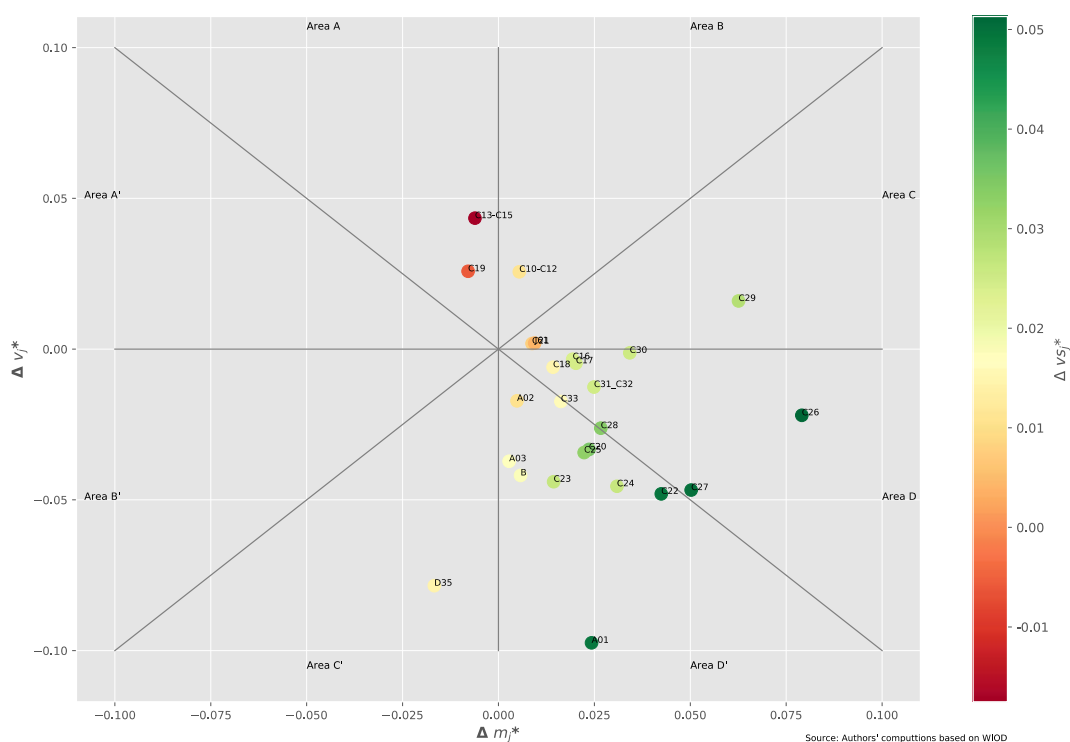
In contrast, we can identify sectors *C13_15-Manufacture of textiles, wearing apparel and leather products*; and *C21-Manufacture of basic pharmaceutical products and preparations* in area B. These two sectors experienced an increase in the "external dependency effect" that was dominated by an even more significant increase in the "net growth effect". Contrary to the previous ones, these sectors were able to generate higher shares of national value-added in production over time. Consequently, compared with 2000, each euro of exports retains a more significant share of domestic value-added. We can therefore identify these two as strategic sectors (or main drivers) of the Portuguese economy as far as value-added is concerned, given that both also experienced significant increases in the real value of exports during the period 2000-2014.

Additionally, the Portuguese pharmaceutical sector showed a slight increase in the vertical specialization share of exports, indicating that, despite growing its integration in the GVCs, the industry was able to concentrate in production phases that generate higher value-added. This is particularly relevant given the substantial increase of Portuguese Pharmaceutical exports (from 118M dollars in 2000 to 645M in 2014). The same applies to the Portuguese textile industry that experienced a substantial increase in exports (from 5.4B dollars in 2000 to 6.5B dollars in 2014).

Periods 2000-2007 and 2007-2014

Along with the analysis previously carried for the entire period 2000-2014, it is also important to stress the evolution of the Portuguese inter-industry productive structure in two different periods, namely 2000-2007 and 2007-2014. This view is particularly crucial since it investigates the impact of the international crisis of 2008-2009, that produced a shock in the European industrial production across different countries since 2007-2008.

Figure 2 – Portugal (2000-2007)



The evolution of the Portuguese production and trade was quite diverse in the two periods in question. In the period 2000-2007, only three sectors were located in virtuous areas. Sectors *C13_15-Manufacture of textiles, wearing apparel and leather products* and *C19-Manufacture of coke and refined petroleum products* were located in area A, and sector *C10-Manufacture of food products, beverages and tobacco products* in area B. These sectors were the only ones that, during the period 2000-2007, were able to increase the generation of domestic value-added in exports. As it would be expected, in contrast to the other ones, these three sectors did not show increasing vertical integration shares. The other exception was sector *C21-Manufacture of basic pharmaceutical products and preparations* since despite being in area C, exhibited low values of GVC integration.

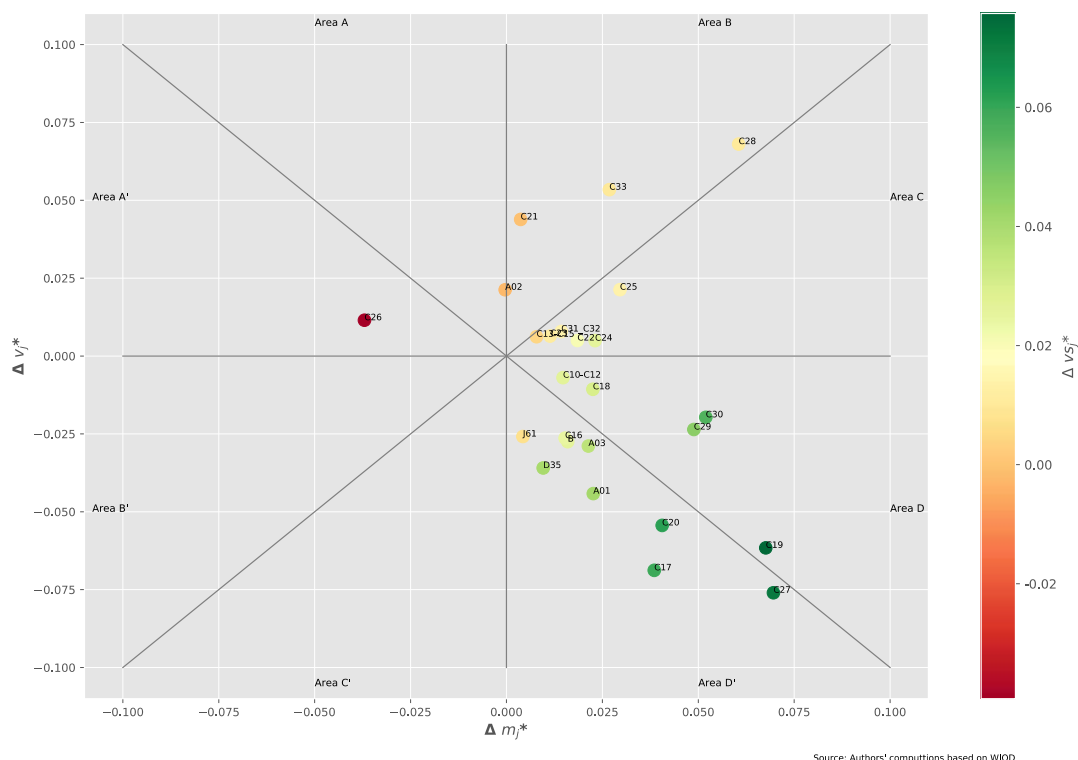
After analyzing the evolution of real export growth in the above sectors, we conclude that all of them experienced significant growth in exports (in real terms) even though with different magnitudes. In particular, sector C19 exports grew more than 300% in the period 2000-2007 (from 360M in 2000 to 1.6B), which reflects the increasing importance of coke and petroleum products in the Portuguese economy. Also, sector C21 exports grew by more than 400% in the period 2000-2007 (from 118M to 270M).

All other sectors were located in less virtuous areas in terms of their structural evolution. We underline sector *C29-Manufacture of motor vehicles, trailers and semi-trailers* in area C, sectors *C26-Manufacture of computer, electronic and optical products* and *C27-Manufacture of electrical equipment* in area D, sectors *C22-Manufacture of rubber and plastic products* and *A01-Crop and animal production, hunting and related service activities* in area D', and sector *D35-Electricity, gas, steam and air conditioning supply* in region C'. This deterioration in the domestic value-added was led by significant increasing levels of vertical specialization, with the exception of sector *D35-Electricity, gas, steam and air conditioning supply* that presented a relatively stable integration in the GVCs during this period.

It should also be noted that sectors *C28-Manufacture of machinery equipment*, *C20-Manufacturing of chemicals and chemical products* and *C25-Manufacture of fabricated metal products*, all located in less virtuous areas D and D', also exhibited significant positive variations in vertical specialization, indicating increasing participations in the GVCs. During the 2000-2007 period, we highlight sectors A01 and C26 that experienced significant growth in real exports (220% and 130%, respectively). In particular, the primary industry showed a robust growth, highlighting an increasing integration in the GVCs.

The 2007-2014 period exhibited a distinct pattern in terms of the evolution of the Portuguese productive structure. During this period, five sectors were located in the more virtuous areas A, A', B and B', namely sector *C26-Manufacture of computer, electronic and optical products* in area A', sector *A02-Forestry and logging* in area A, and sectors *C21-Manufacture of basic pharmaceutical products and preparations*, *C33-Repair and installation of machinery and equipment* and *C28-Manufacture of machinery equipment* in area B.

Figure 3 – Portugal (2007-2014)



Source: Authors' computations based on WIOD

It should be noted that none of the sectors that were located in the virtuous areas during the period 2000-2007 remained in the period 2007-2014. In this respect, it is important to highlight the distinct evolution of sectors *C26-Manufacture of computer, electronic and optical products* and *C19-Manufacture of coke and refined petroleum products*. While sector C26 moved from area D (with high vertical specialization value) to area A' (showing a significant decrease in integration in the CVGs), sector C19 showed an opposite evolution, moving from area A to area D, evidencing a drastic increase in the import content of its exports.

In contrast, we highlight the sectors *A01-Crop and animal production, hunting and related service activities*, *C20-Manufacturing of chemicals and chemical products*, *C17-Manufacture of paper and paper products*, and *C27-Manufacture of electrical equipment* in area D'; and sectors *C30-Manufacture of other transport equipment*, *C29-Manufacture of motor vehicles, trailers and semi-trailers*, and *C19-Manufacture of coke and refined petroleum products* in area D. All these sectors, except sector A01, experienced an abrupt increase in the import content of exports, indicating increasing participation in CVGs.

As a result of the 2007 crisis during the 2007-2014 period, all sectors have decreased their growth rate of exports. Among these, we highlight the sectors A01 and C19 with a growth rate of exports of 92% and 156%, respectively.

In summary, the results presented here show a very unfavourable evolution of the Portuguese productive structure concerning the creation of value-added. During the period 2000-2014, most of the Portuguese industries were located in the less virtuous areas D and D'. As expected, there is a clear trend for sectors located in more virtuous areas to show negative variations in vertical integration.

However, there are some exceptions, so we must place the focus of our analyses in specific sectors given its recent structural evolution. In this regard, it is crucial to highlight sectors C13_15 and C21 due to their very favourable structural evolution since 2000. Both sectors were able to achieve significant increases in their exports, followed by higher generation of domestic value-added. These industries can be considered as strategic sectors to the national production of the Portuguese economy.

By other hand, sectors A01 and C20 experienced high growth rates in exports during the period of analysis. The primary industry increased its exports by more than 500%, while the C20 sector increased its exports by more than 250%. Despite a tendency to locate in areas with the lower value-added generation, these sectors were able to benefit from growing participation in the GVCs.

Finally, we highlight the sectors C26 and C19, that showed a different evolution in the two periods. It is interesting to note that sector C19 slowed its growth rate of exports in the period 2007-2014 (compared to the period 2000-2007) and still presented an overall growth rate of over 1000% in the period 2000-2014. Contrarily, sector C26, after growing above 100% in 2000-2007, pointed a drop of almost 50% of its exports in the period 2007-2014. This drop in exports was, however, offset by the decline in vertical specialization.

7. Application to Germany

This section empirically applies our method to the Germany economy for three different periods: 2000-2007, 2007-2014 and the overall period 2000-2014 using data from the 2016 edition of the World Input-Output Database (WIOD). As before, we have considered 25 tradable sectors, namely those related to the primary industry, manufacturing, energy supply and telecommunications.

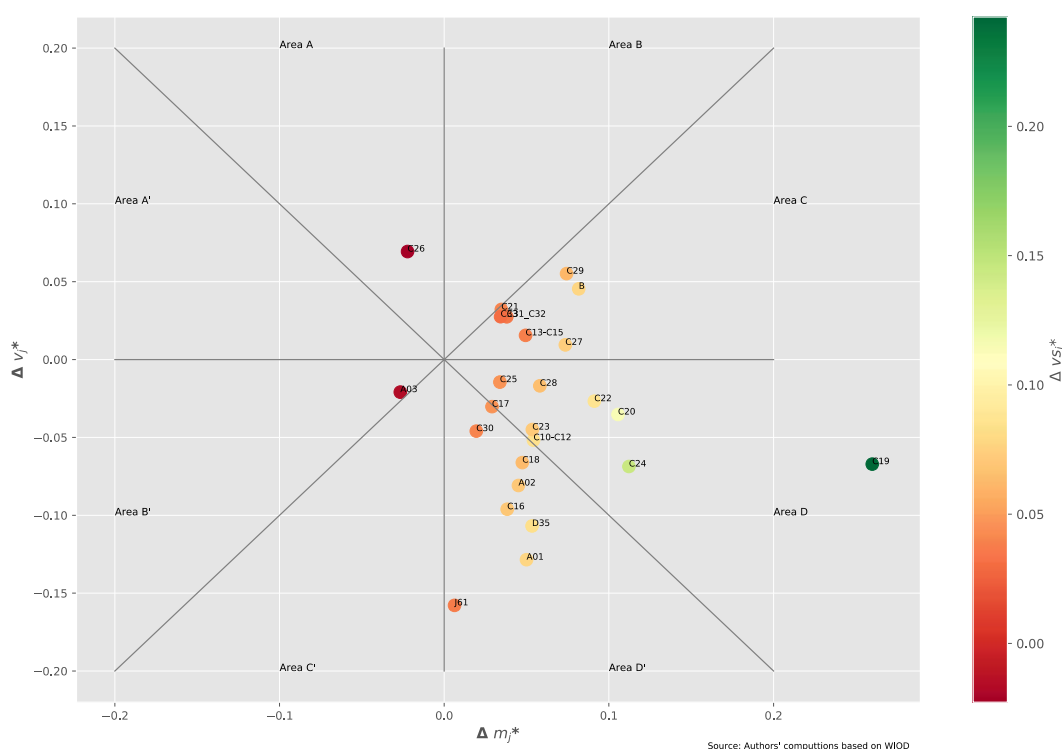
In the context of European integration, it is particularly interesting to compare the evolution of different productive structures, especially those of EU core and periphery economies. To this end, we decided to extend the analysis carried out in the previous chapter for the German

economy to assess the recent structural evolution of the different sectors in both countries regarding the creation of added value, external dependence, and participation in global value chains.

Period 2000-2014

Our results for the Germany economy indicate that during the period 2000-2014 few industries located in virtuous areas A, A', B, and B'. For the overall 2000-2014 period (see table 1 in the appendix and figure 4 below) 14 of 25 sectors were located in areas D and D', seven were located in area C, one in area B' and one in area A.

Figure 4 – Germany (2000-2014)



From areas D and D' we emphasise the following sectors: C19 – Manufacture of coke and refined petroleum products; C24 – Manufacture of basic metals; A01-Crop and animal production, hunting and related service activities; J61 – Telecommunications; D35 – Electricity, gas, steam and air conditioning supply; and C20 – Manufacture of chemicals and chemical products. During the period 2000-2014, these sectors experienced a sharp deterioration in the domestic value-added content of exports while becoming more dependent on trade partners' value-added (higher "external dependency effect"). This deterioration in the domestic value-added was led by an increasing vertical specialization share of exports, i.e. higher import content of national exports. Especially sector C19 has shown a very favourable structural evolution, with increasing participation in CVG.

The main conclusion for this group of sectors is that they experienced a structural deterioration regarding the share of value-added that is produced domestically. Compared to 2000, each euro of exports implies a smaller national value-added content which also translates in higher levels of vertical specialization. This is particularly alarming if these sectors are failing to make up for this decline in the share of value-added with higher levels of exports.

In contrast, we can identify sector A03 – Fishing and aquaculture in area B'; and sector C26 – Manufacture of computer, electronic and optical products in area A. These two sectors experienced an increase in the "net growth effect". Contrary to the previous ones, these sectors were able to generate higher shares of national value-added in production over time. Consequently, compared with 2000, each euro of exports retains a more significant share of domestic value-added. We can therefore identify these two as strategic sectors (or main drivers) of the Germany economy as far as value-added is concerned, given that both also experienced significant increases in the real value of exports during the period 2000-2014.

Both sectors also showed low integrations in the global value chains while experiencing significant increases in their exports. In particular, sector C26 managed to combine structural improvement with an increase of more than 40% in the real value of exports during the period 2000-2014.

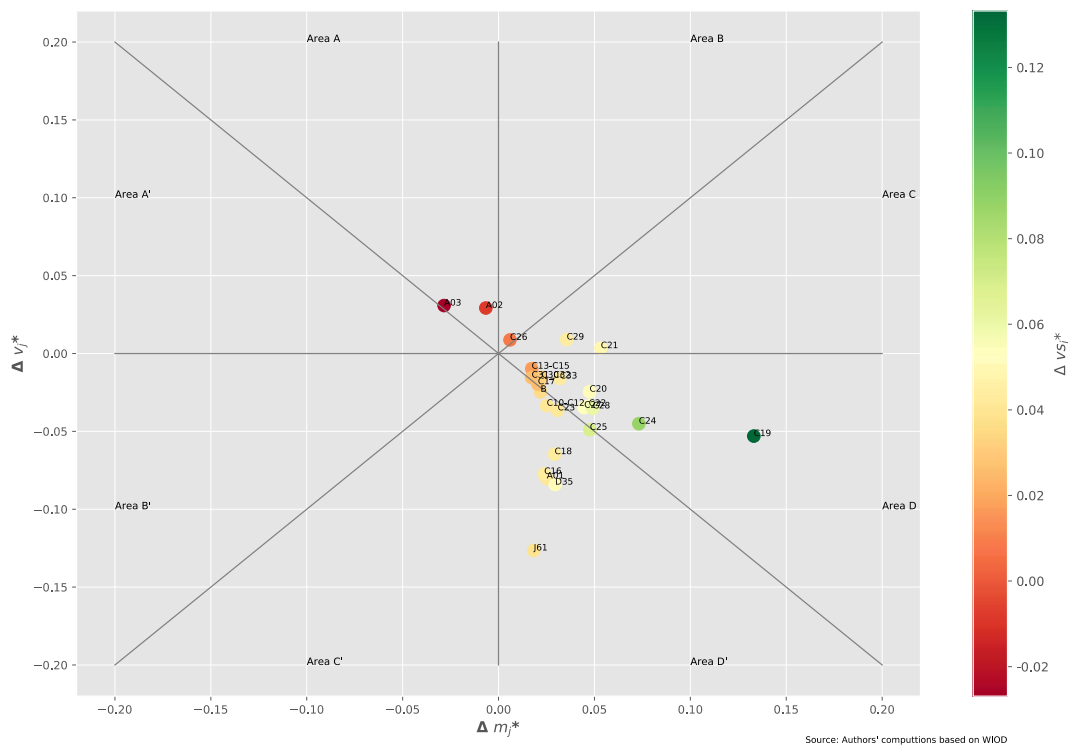
Periods 2000-2007 and 2007-2014

Along with the analysis previously carried for the entire period 2000-2014, it is also important to stress the evolution of the Germany inter-industry productive structure in two different periods, namely 2000-2007 and 2007-2014. This view is particularly crucial since it investigates the impact of the international crisis of 2008-2009, that produced a shock in the European industrial production across different countries since 2007-2008.

The evolution of the Germany production and trade was relatively diverse in the two periods. In the period 2000-2007, only three sectors were located in virtuous areas. Sectors A03 – Fishing and aquaculture; and A02 – Forestry and logging were located in area A, and sector C26 – Manufacture of computer, electronic and optical products in area B. These three sectors were the only ones that, during the period 2000-2007, were able to increase the generation of domestic value-added in exports. As it would be expected, in contrast to the other ones, these three sectors did not show increasing vertical integration shares. The other exception was sector

C13_15 – Manufacture of textiles, wearing appeal and leather products that despite being in area D, exhibited low values of GVC integration.

Figure 5 – Germany (2000-2007)



After analyzing the evolution of real export growth in the above sectors, we conclude that all of them experienced significant growth in exports (in real terms) even though with different magnitudes. In particular, sector A02 exports grew more than 100% in the period 2000-2007 (from 355M in 2000 to 872M), which reflects the increasing importance of forestry and logging activities in the Germany economy.

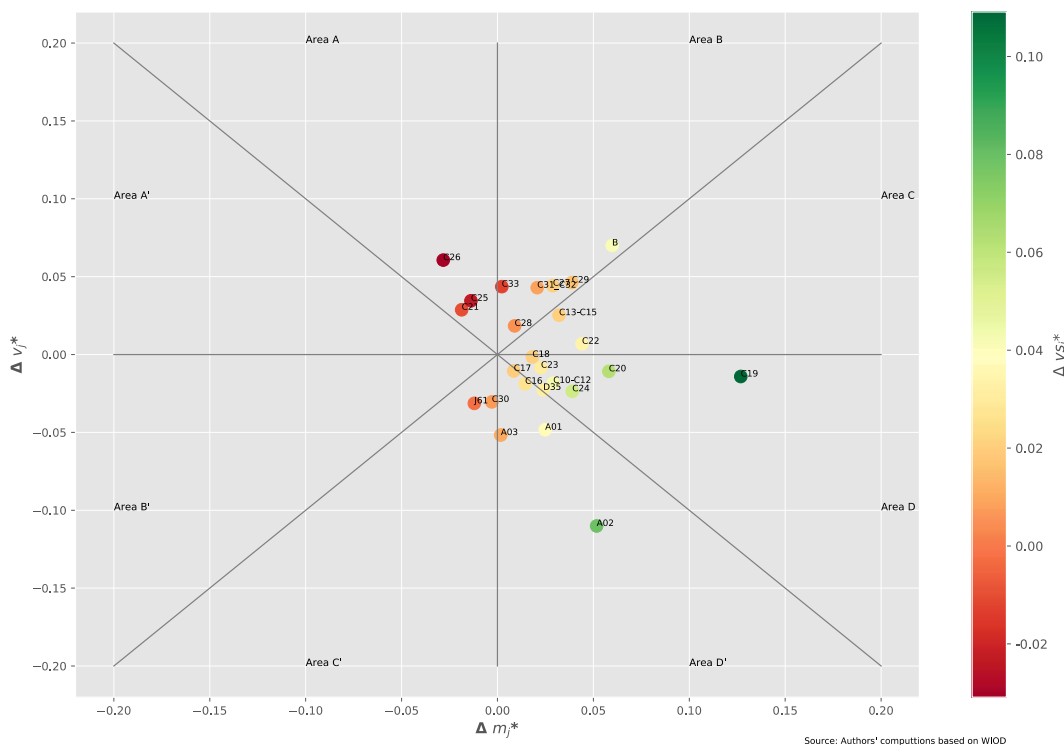
All other sectors were located in less virtuous areas in terms of their structural evolution. We underline sector C19 – Manufacture of coke and refined petroleum products; C24 – Manufacture of basic metals; C25 – Manufacture of fabricated metal products in area D, and sector J61 – Telecommunications; D35 – Electricity, gas, steam and air conditioning supply; and sector C16 – Manufacture of wood and cork products in area D'. This deterioration in the domestic value-added was led by significant increasing levels of vertical specialization, with the exception of sector J61 – Telecommunications that presented a relatively stable integration in the GVCs during this period.

It should also be noted that sectors C19 – Manufacture of coke and refined petroleum products, C24 – Manufacture of basic metals; C25 – Manufacture of fabricated metal products, all located

in less virtuous area D, exhibited significant positive variations in vertical specialization, indicating increasing participations in the GVCs. During the 2000-2007 period, we highlight that these industries experienced significant growth in real exports.

When we analyse the period 2007-2014 (post international crisis), we conclude that Germany's productive structure suffered some structural changes, although less evident when compared with Portugal. During this period, nine sectors were located in the more virtuous areas A, A', B and B'. From those we highlight sector C26 - Manufacture of computer, electronic and optical products; C25 - Manufacture of fabricated metal products; and C21 - Manufacture of basic pharmaceutical products in area A; and C33 – Repair and installation of machinery and equipment; C28 – Manufacture of machinery and equipment; and C31_32 – Manufacture of furniture in area B. It should be noted that only C-26 were located in the most virtuous areas during the period 2000-2007 and remained in the period 2007-2014.

Figure 6 – Germany (2007-2014)



In contrast, we highlight the sectors *C19-Manufacture of coke and refined petroleum products*; *C20 - Manufacturing of chemicals and chemical products*; and *C24 – Manufacture of basic metals* in area D; and sectors *A02 – Forestry and logging*, *A01 – Crop and animal production*, and *A03 – Fishing and aquaculture* in area D'. All these industries, except sector A03 experienced a significant increase in the import content of exports, indicating increasing participation in CVGs.

In summary, the results presented here evidence a different evolution of the Germany productive structure when comparing with the Portuguese economy. During the period 2000-2014, despite some Germany industries were located in the less virtuous areas D and D', several industries were also located in more virtuous areas, especially after 2007.

In this regard, it is crucial to highlight sectors C26 and A03 due to their very favorable structural evolution since 2000. Both sectors were able to achieve significant increases in their exports, followed by higher generation of domestic value-added. Additionally, industries C19, C24, and C20 despite experiencing decreasing domestic value-added shares, they faced increasing participation in GVC's which may offset the evident increase in their structural dependency.

8. Application to Other European Union Economies

As we previously did for Portugal and Germany in more detail, this section presents the results we get when expanding this analysis to other Eurozone economies, namely Austria, Finland, Greece, Netherlands, Belgium and Check Republic.

EU countries have experienced distinct structural changes over the past two decades. The diverse structural developments are visible especially when we analyse among the core and the periphery of the EU and with a particular interest for the periods before and after the 2008 international crisis. The analysis carried out in this chapter seeks to disseminate the main results obtained for other six EU economies in terms of structural evolution, participation in the Global Value Chains, domestic value-added generation and external dependence.

One should note that over the past two decades, the EU has experienced an increasing economic integration process at the same time that the growing globalization and liberalization of international trade has transformed and fragmented the way production and trade are organized. Therefore, it is essential to understand how the domestic production of the different EU countries (notably the EU core and periphery) has evolved over the past few years. We chose the countries based on the division between EU core and periphery, and we gave a particular interest to economies with a population similar to Portugal (except Germany).

Figure 7 presents an overview of each sector of the six countries under analysis according to the previously described evaluation method. During the period 2000-2014, there was a clear trend towards an increase in the participation of sectors in the Global Value Chains (most sectors marked in green), with a large part of the sectors located in less virtuous areas in terms

of domestic value-added (D and D'), with few exceptions for industries located in areas A and A'.

Although expected given the increasing integration of European economies into CVGs, this result indicates that European industry production has become increasingly dependent on the outside, which must be carefully analysed.

Additionally, **Table 1** and **Table 2** summarize the sector classifications' main results for the three periods considered (2000-2007; 2007-2014; 2000-2014). As analysed in figure 7, most of the industries are located in D and D' areas. Nonetheless, it is possible to identify different structural developments across the EU economies, focusing on the periods 2000-2007 and 2007-2014. It is also possible to extend this analysis in greater detail, allowing to identify and compare the evolution of different sectors over time and compare the same industry's position across different countries.

Figure 7 – All countries (2000-2014)

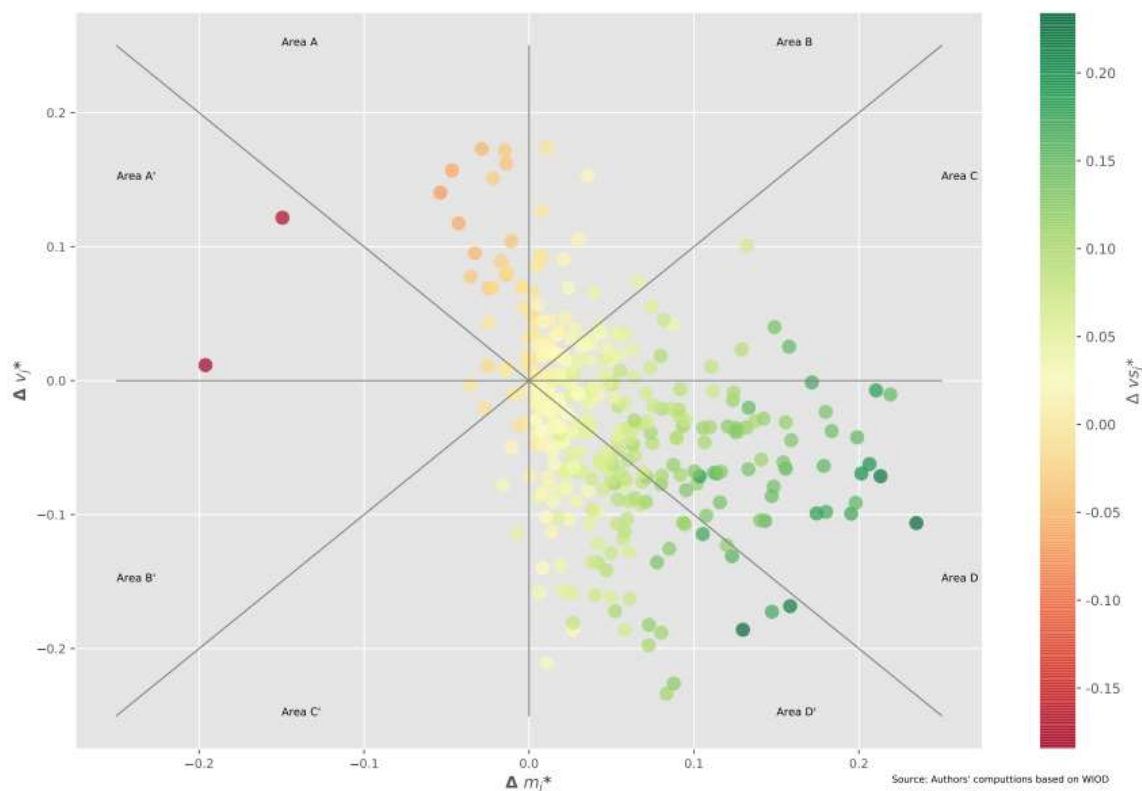


Table 1 – All countries (2000-2014)

Sector		Austria			Belgium			Check Republic			Finland		
		2000-2007	2007-2014	2000-2014	2000-2007	2007-2014	2000-2014	2000-2007	2007-2014	2000-2014	2000-2007	2007-2014	2000-2014
A01	Crop and animal production	D	D'	D'	D	D'	D'	D'	D	D	D'	D	D'
A02	Forestry	D'	A	D'	A	D'	D'	D'	B	C	D'	A'	D'
A03	Fishing	A'	D	C	D'	D	D'	B	D	D	D'	C	C
B	Mining and quarrying	D	B	C	D'	C	D'	D	D	D	B	D'	D
C10-C12	Food products, beverages and tobacco	D	D'	D'	C	D	D	D'	C	D	B	D	D
C13-C15	Textiles, wearing apparel and leather	D	D	D	C	D	D	D	D	D	D	D	D
C16	Wood and cork	D'	D'	D'	A'	D	D	D'	D	D	D	C'	D'
C17	Paper	D'	D	D	D	D	D	C	D	D	D'	C'	D'
C18	Printing	D'	D	D'	D'	D	D	D'	C	D'	D	D	D
C19	Coke and refined petroleum	D	D	D	C'	D	D	D'	D	D	C	D	D
C20	Chemicals	D	D	D	D	D	D	D	D	D	D	D'	D
C21	Pharmaceutics	A	D	D	B	D'	D	D'	D	D	B	B	B
C22	Rubber and plastic	D	C	D	C	C	C	D	C	D	D	D	D
C23	Non-metallic and minerals	D	D'	D	D'	D	D	D'	C	D	D	D'	D'
C24	Metal	D	D'	D	D	C'	D	D	D	D	C	C'	D'
C25	Metal products	D'	A'	D'	D	C'	D	D	C	D	D	B'	D
C26	Computer, electronic and optical products	A	A	A	A	D	C	D	B	D	B	D'	D
C27	Electrical equipment	D'	A	C	A	D	D	D	C	D	D'	C	C
C28	Machinery and equipment	D'	A'	D'	C	C	C	D	C	D	D	C	D
C29	Motor vehicles	D'	A'	D'	C'	D	D	D	D	D	D	D'	D'
C30	Transport equipment	C	B'	B'	D	D	D	D	C	D	D	B	B
C31_C32	Furniture	D	D'	D'	A	D	C	D	D	D	D	D	D
C33	Repair and installation of machinery and equipment	D'	D'	D'	A	D'	A'	D'	C	D	A	D	C
D35	Electricity, gas, steam and air conditioning supply	D'	D	D'	D'	D'	D'	A	B	A	A	C'	A'
J61	Telecommunications	A	D	B	A'	D'	D'	A	D	D	D	A	B

Table 2 – All countries (2000-2014)

Sector		Germany			Greece			Netherlands			Portugal		
		2000-2007	2007-2014	2000-2014	2000-2007	2007-2014	2000-2014	2000-2007	2007-2014	2000-2014	2000-2007	2007-2014	2000-2014
A01	Crop and animal production	D'	D'	D'	D'	D'	D'	D	D'	D'	D'	D'	D'
A02	Forestry	A	D'	D'	D'	A	C	D'	D	D	D'	A	C
A03	Fishing	A	D'	B'	B	D'	D	D	D'	D'	D'	D'	D'
B	Mining and quarrying	D'	B	C	D'	D'	D'	C	B'	D'	D'	D'	D'
C10-C12	Food products, beverages and tobacco	D'	D	D	B	A	B	C	D'	D	B	D	C
C13-C15	Textiles, wearing apparel and leather	D	C	C	C	C'	D'	A'	D	D	A	C	B
C16	Wood and cork	D'	D'	D'	A	D'	D'	D'	D	D	D	D'	D
C17	Paper	D	D'	D'	A	D'	C	A	D	D	D	D'	D'
C18	Printing	D'	D	D'	A	D	B	A	D	D	D	D	D
C19	Coke and refined petroleum	D	D	D	D'	C'	D'	C	B'	D	A	D	D
C20	Chemicals	D	D	D	D'	A	B	B	D	D	D'	D'	D'
C21	Pharmaceutics	C	A	C	C'	C'	D'	C'	C	D	C	B	B
C22	Rubber and plastic	D	C	D	D'	D'	D'	D'	D	D	D'	C	D
C23	Non-metallic and minerals	D'	D	D	B	B'	A'	C	D'	D	D'	C	D'
C24	Metal	D	D	D	D'	A	B	C	D'	D'	D'	C	D
C25	Metal products	D'	A	D	D'	D'	D'	D'	D	D	D'	C	D
C26	Computer, electronic and optical products	B	A	A	D'	D'	D'	C'	D	D	D	A'	D
C27	Electrical equipment	D	B	C	B	D'	D'	A'	D	D	D	D'	D'
C28	Machinery and equipment	D	B	D	D'	A	D'	B	D	D	D	B	C
C29	Motor vehicles	C	B	C	D'	B'	D'	A	D	D	C	D	D
C30	Transport equipment	D	C'	D'	A'	A	A'	A	D	D	D	D	D
C31_C32	Furniture	D	B	C	A	D'	B	A	D	C	D	C	D
C33	Repair and installation of machinery and equipment	D	B	C	D'	A	A	D	D	C	D'	B	C
D35	Electricity, gas, steam and air conditioning supply	D'	D	D'	D'	B'	D'	D	B'	D'	C'	D'	C'
J61	Telecommunications	D'	C'	D'	D'	A	D'	A	D	C	C	D'	D'

Core EU countries tend to delegate production tasks to periphery countries where manufacturing costs are lower. However, there is a clear tendency for specific industries in the core EU countries to be located in areas A and A', especially the sectors 26 - Manufacture of computer, electronic and optical products, D35 - Electricity, gas, steam and air conditioning supply, and sector J61 - Telecommunications.

Alternatively, periphery countries such as Portugal, and mainly Greece, tend to have a higher number of sectors located in areas A and A', indicating less integration in the Global Value Chains. Moreover, there was a generalized tendency for EU sectors to be located in areas A and

A' during the period 2007-2014. This shift was essentially due to the break-in worldwide trade and production that has led countries to significant drops in their exports.

The COVID-19 pandemic reinforced the idea that any analysis regarding international trade and integration within global value chains should be done with caution. The results presented here seek to assess the fundamental evolution of the EU's tradable industries. As previously mentioned, a sector located in area D and D 'is effectively more dependent on the outside and can retain a smaller portion of the economy's added value. However, the gains from integration in global value chains come from significant increases in exports' total value. Greater integration in the Global Value Chains translates into higher external dependency and less creation of domestic added value for each euro of production. Countries tend to seek more significant integration in the Global Value Chains precisely in the phases that retain more significant value-added such as the design and commercialization of products. In a context of increasing European integration, it is therefore essential to assess how the various member states' different productive sectors compare and evolve over time.

9. Concluding Remarks

This paper has proposed a simple method to study the structural changes across the EU economies, using the traditional Rasmussen indicators based on the production multipliers matrix or Leontief inverse along with vertical specialisation measure. This method is appropriate to assess industries' external dependency (strong reliance on imported inputs), and the associated low value-added generated in domestic production, a critical vulnerability in several EU open economies. One main novelty of this paper is the inclusion of the vertical specialisation measure along with the backward linkages indicators, which quantifies the insertion of EU industries in the GVCs.

We used the method to analyse the evolution of different core and periphery EU economies between 2000 and 2014, divided into two sub-periods, until and post the international financial crises of 2007. We made a detailed comparison of one EU periphery country (Portugal) and one EU core country (Germany) and gave particular attention to differences within and between countries before and after the global financial crisis.

Our main conclusion is the apparent global deterioration of the Portuguese productive system between 2000 and 2014, with very few sectors locating in virtuous areas A, A', B, and B'. However, we highlight the positive evolution of C13_15, C21, A01, C20, C26, and C19.

When analysing the remaining EU economies, our results point to a mixed pattern. On the one hand, it is possible to see a tendency for EU sectors to be located in less virtuous areas of value-added creation, leading to an increase in external dependency. Even so, we can see structural differences between the core countries and the periphery of the EU.

External dependency is not necessarily harmful. It may be the result of increased benefits from the international division of production. Still, the external dependency of many industries and the corresponding low domestic value-added generated in production combined with relatively weak export potential can cause high trade deficits and growing external debt to GDP ratios.

Additionally, impact on climate change of these tendencies, potentially harmful because of growing needs of transportation of physical goods is currently being assessed, mainly in what concerns the impact of the internalization of environment costs on the present pattern of specialization. We think that some of the findings of the present paper may be helpful for that assessment.

The COVID-19 pandemic has reinforced the appetite for a reshaping of Global Value Chains. Especially in peripheric open economies like Portugal, it is essential to ensure that national production is not entirely replaced by imports, and so an effort must be made to preserve a set of strategic industries in order to ensure the sufficient generation of domestic value-added.

References

- Amaral, J. F., & Lopes, J. C. (2018). *Análise Input-Output*. Lisboa: Almedina.
- Baldwin, R. & Venables, A. (2013). Spiders and Snakes: Offshoring and Agglomeration in the Global Economy. *Journal of International Economics*. 90(2): 245 –54.
- Chen, W., Los, B. & Timmer, M. (2018). Factor incomes in global value chains: The role of intangibles. NBER Working Paper No. 25242.
- Dao, M., Das, M., Z., K. & Lian, W. (2017). Why is labor receiving a smaller share of global income? *IMF working papers*.
- Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M. & de Vries, G. (2013). The construction of world input–output tables in the WIOD project. *Economic Systems Research*, 25(1):71-98.

- Gouveia, A. & Canas, F. (2016). Reallocation of Resources between Tradable and Non-Tradable Sectors in Portugal: Developing a new Identification Strategy for the Tradable Sector. *GEE Papers* 60.
- Haskel, J. & Westlake, S. (2017). *Capitalism without capital: the rise of the intangible economy*. Princeton, N.J.: Princeton University Press.
- Hummels, D., Ishii, J. & Yi, K. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics*, 54: 75-96.
- Johnson, R. C. and Noguera, G. (2012). Accounting for Intermediates: Production Sharing and Trade in Value Added, *Journal of International Economics*, 86(2): 224-236.
- Karabarbounis, L. & Neiman, B. (2018). Accounting for factorless income. *NBER Macroeconomics Annual*, Volume 33.
- Koopman, R., Wang, Z. & Wei, S. (2014). Tracing Value-Added and Double Counting in Gross Exports, *American Economic Review*, 104(2): 459-494.
- Lopes, J. C., Amaral, J. F. & Dias, J. (2011). External dependency, value added generation and structural change: an interindustry approach". *Notas Económicas*, 33: 6-19.
- Los, B., Timmer, M. & de Vries, G. (2015), How Global are Global Value Chains? A new Approach to Measure International Fragmentations, *Journal of Regional Science*, 55(1): 66-92.
- Milner, R. & Blair, P. (2009). *Input-output analysis: foundations and extensions*. Cambridge: Cambridge University Press.
- Nagengast, A. J. & Stehrer, R. (2016). Collateral imbalances in intra-European trade? Accounting for the differences between gross and value-added trade balances, *The World Economy*.
- Rasmussen, P. (1956). *Studies in international relations*. North:holand.
- Timmer, M., Dietzenbacher, B., R., S. & de Vries, G. (2015). An illustrated user guide to the world input–output database: the case of global automotive production. *Review of International Economics*, 23(3): 575-605.

Appendix

Table 3 – Sectors

ISIC code	Sector
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C10-C12	Manufacture of food products, beverages and tobacco products
C13-C15	Manufacture of textiles, wearing apparel and leather products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non-metallic mineral products
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi-trailers
C30	Manufacture of other transport equipment
C31_C32	Manufacture of furniture; other manufacturing
C33	Repair and installation of machinery and equipment
D35	Electricity, gas, steam and air conditioning supply
J61	Telecommunications

Figure 8 – Real growth rate of Portuguese exports

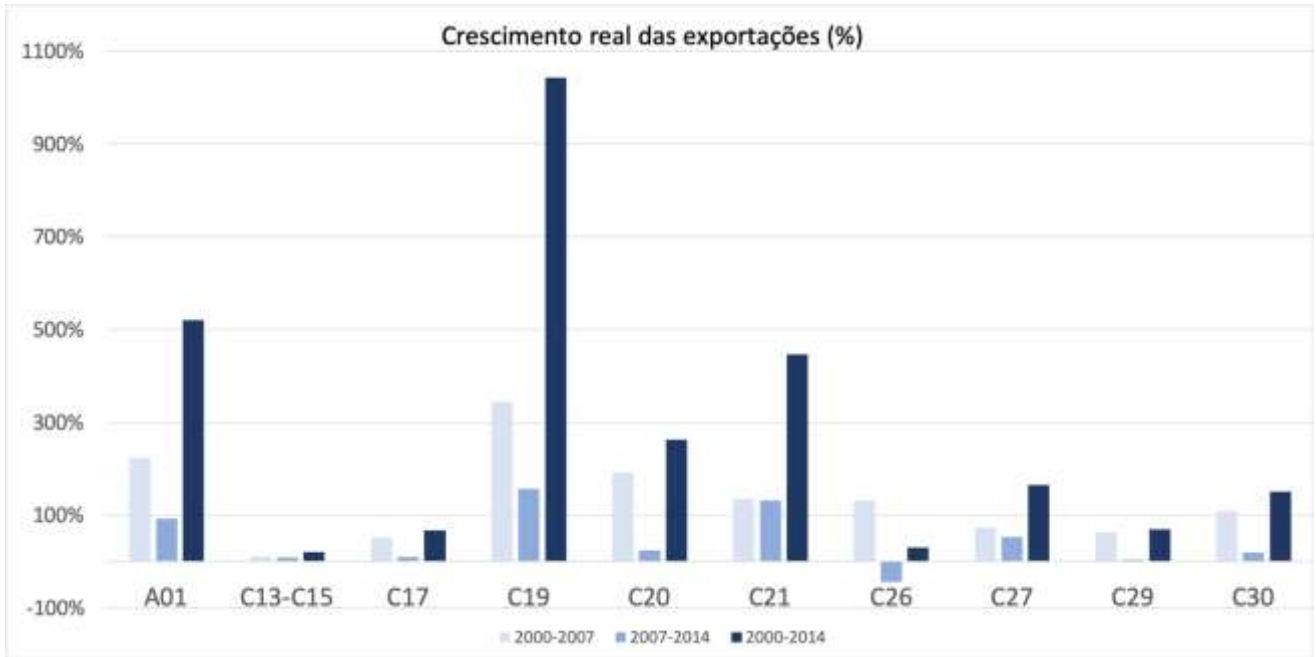


Figure 9 - Portuguese exports (Euros)

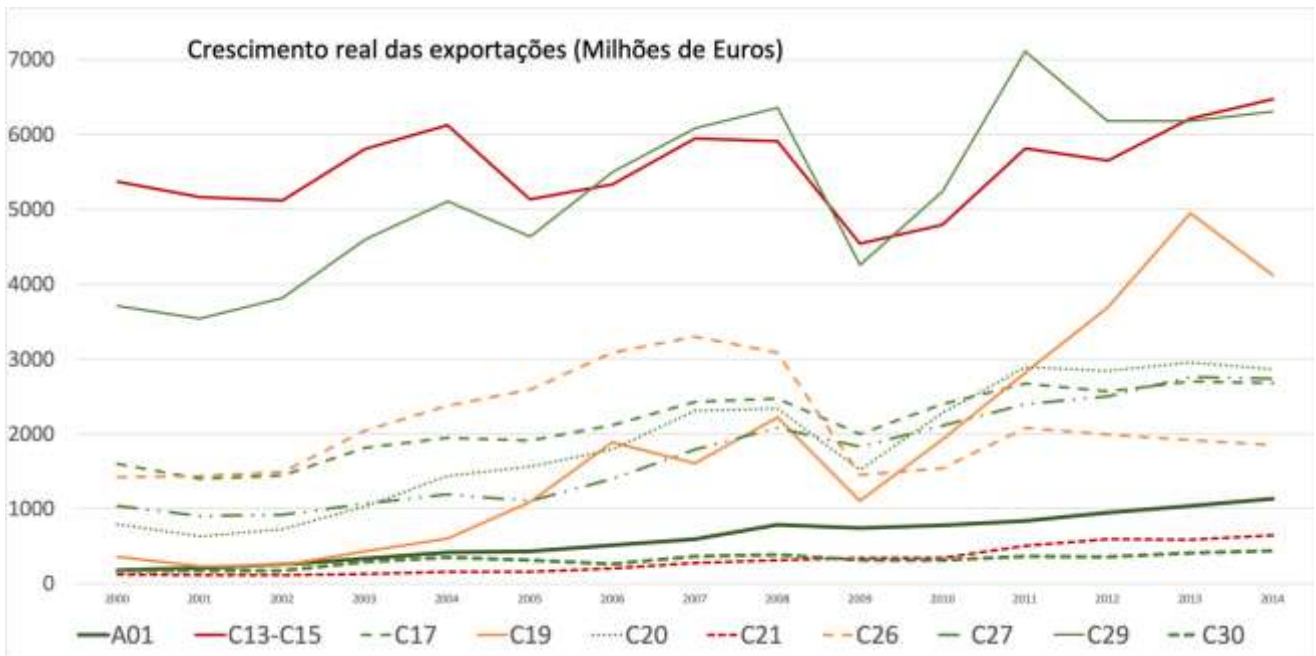


Figure 10 - Austria (2000-2014)

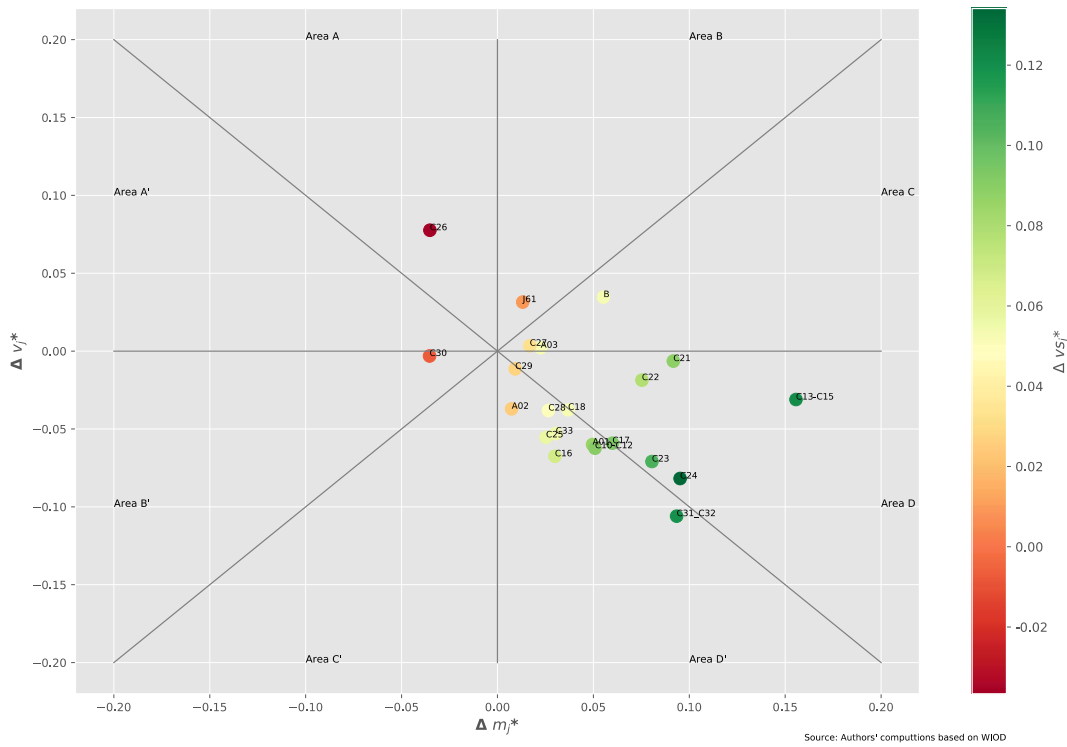


Figure 11 - Belgium (2000-2014)

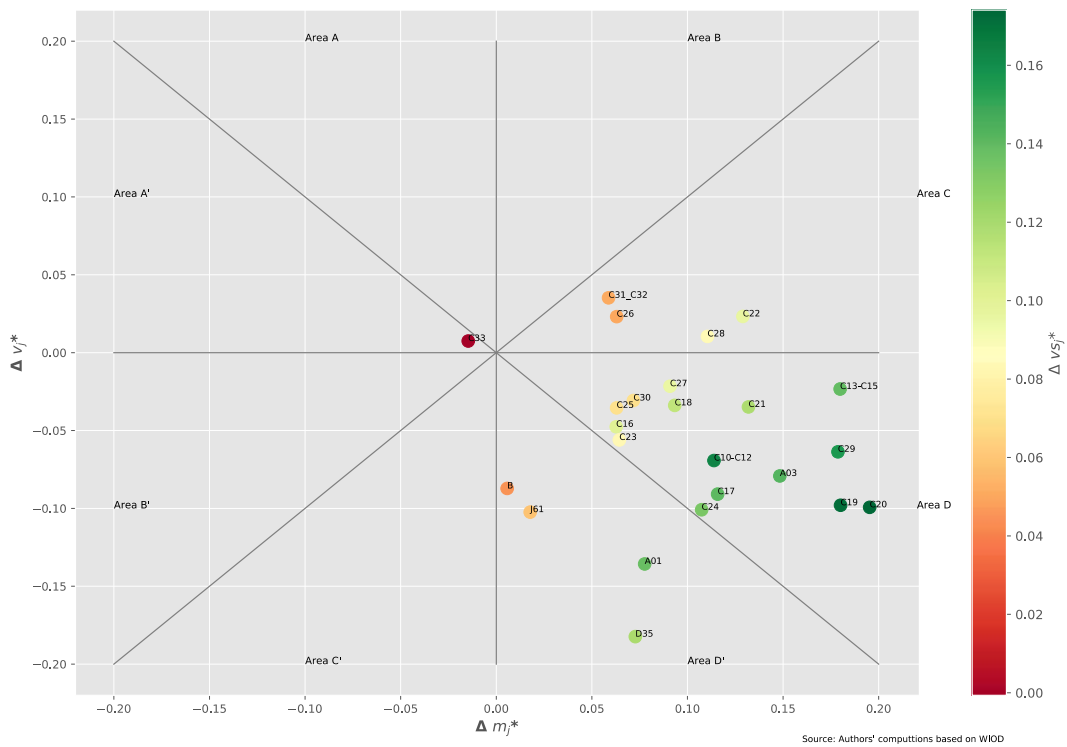


Figure 12 - Czech Republic (2000-2014)

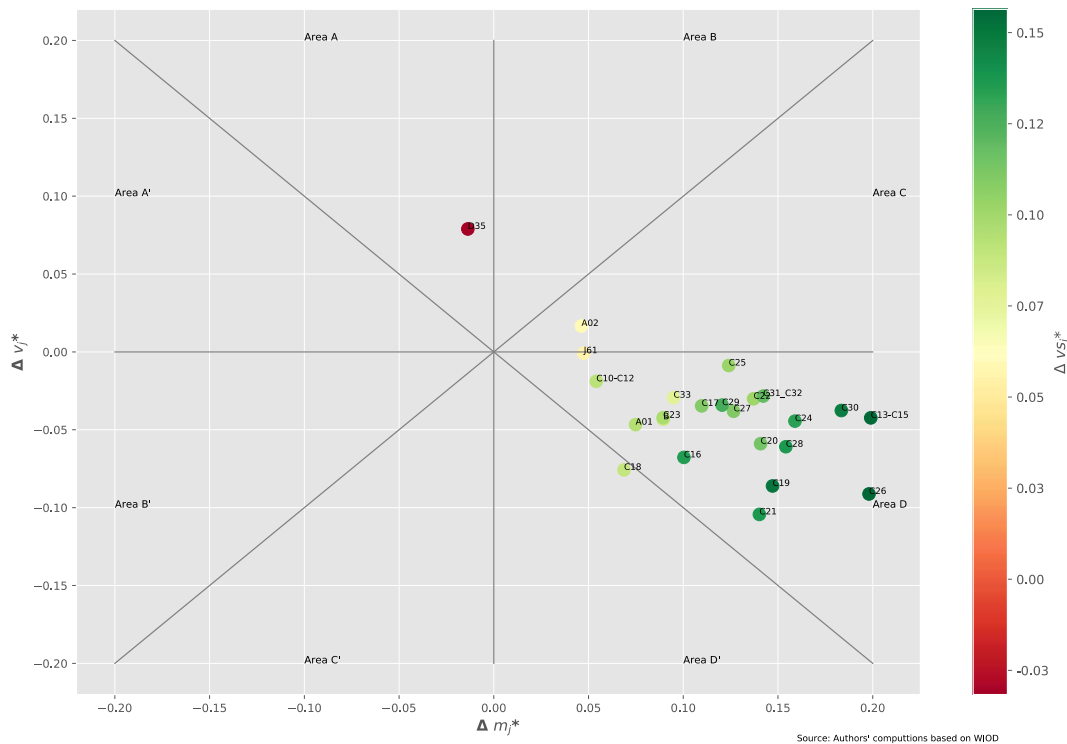


Figure 13 - Finland (2000-2014)

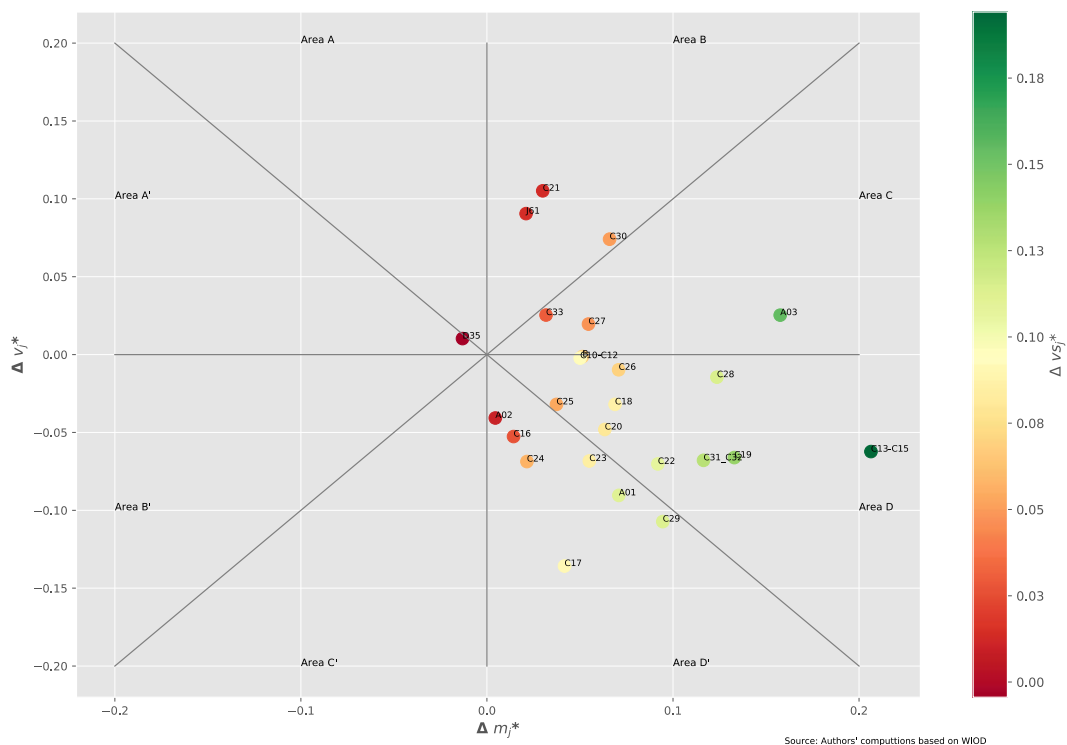


Figure 14 - Greece (2000-2014)

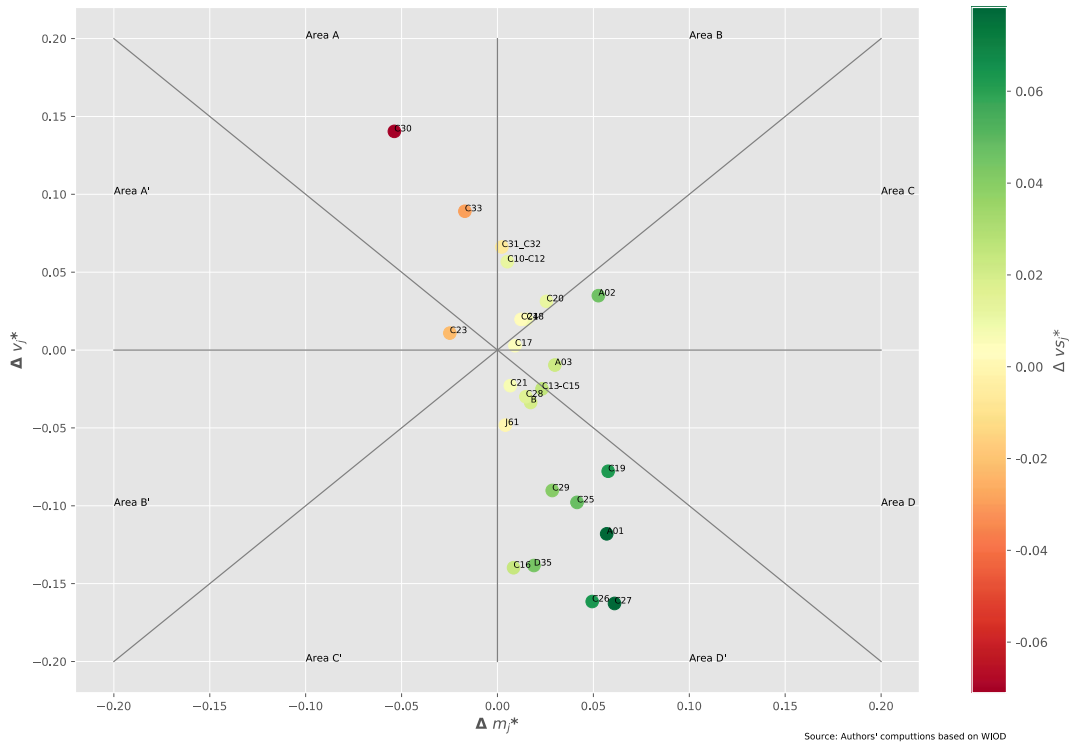


Figure 15 - Netherlands (2000-2014)

