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Exploring the bidirectional relationship between participation and position of the European regions in GVCs

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ABSTRACT

Globalization has increased the interconnection and interdependence of countries emerging the so-called Global Value Chains (GVCs). Approaching the economic performance of economies regarding their engagement in GVCs has been often assessed trough the concepts of *participation* and *position* in GVCs. While literature has often focused on the assessment of the determinants of either participation or position of economies in GVCs, it can be the case both dimensions may be endogenously related, in other words, that policies and strategies aiming at a certain specialization on some parts of GVCs influences participation and/or similarly, broad strategies of trade openness also favor changes in the positioning of economies in GVCs. In this paper, this bidirectional relationship between *participation* and *position* in GVCs is explored at the regional level in Europe, also studying the underlying factors affecting the regional outcomes on these dimensions. Empirically, our approach is based on the value chain indicators provided by a multiregional input-output model (MRIO) for the European regions. Our results confirm the existence of a bi-directional relationship between these two concepts. Therefore, those policies and strategies improving the participation of regions in GVCs also affect the way in which regions specialize within the chain, which may have implications on their international interdependence, exposure and vulnerability to international shocks.

1. Introduction

In recent decades, the process of globalization and its relationship with the economic growth of countries and regions has received increasing attention in literature. The emergence of global value chains (GVCs) has dramatically changed the organization of world production processes, affecting competitiveness and macroeconomic outcomes. It is well known that the reduction of trade barriers, transport and communication costs, the acceleration of technological change and the diffusion of ICT technologies have driven a worldwide process of globalization and production fragmentation (Escaith and Inomata, 2013; Oosterhaven et al., 2001). Indeed, the rapid expansion of GVCs has challenged traditional development policies by recognizing the crucial importance of engaging in GVCs and seizing opportunities from emerging markets to strengthen external competitiveness. As noted in Johnson (2014), the study of GVCs is key to providing better answers to some economic policy questions, such as the evolution of specialization patterns, trade policy analysis or the international transmission of shocks.

At the regional level, it has been also acknowledged that regional economic growth increasingly depends on the capacity to identify and capture the opportunities from globalization (European Commission, 2010) and that the integration between Europe's regions and with their neighbors, and, even, worldwide is a key challenge for any territorial policy in the EU. Thus, the debate on the role of regions in GVCs becomes relevant for the definition of territorial policies. That is, the promotion of global cities and regions as vehicles to improve Europe's position in the global economy may compete with the objectives of territorial cohesion reducing the long-lasting territorial gap. Thus, to understand how regions are involved in these international chains and to characterize different patterns of engagement and its impact on the economy is crucial to identify opportunities and risks linked to the current globalization trends.

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The economic performance of the economies regarding their engagement in GVCs has been often assessed through the concepts of *participation* and *position* in GVCs, being the input-output methodology one of the main approaches to find metrics capturing the relevance of the value-added content of trade, and the location of industries and countries in these global chains (see Johnson, 2018 for a review). Broadly speaking *participation* refers to the capacity of countries and/or regions to capture the value added generated in GVCs, through their trade specialization, while the *position* alludes to the specialization on upstream versus downstream industries in these chains.

Regarding the metrics to account for participation in GVCs, one of the most well-known measures of a country's participation in GVCs was established by Koopman et al. (2010), summarizing the domestic value added in foreign export (forward participation) and foreign value added in domestic export (backward participation). Besides, Chen et al. (2005); and Hummels et al. (2001) approached participation through measures of vertical specialization. Recently, Los et al. (2015) proposed an indicator based on the share of value-added embodied respect to total value added or GDP per capita while Bolea et al. (2022) computed participation in global value chains as the share of a country in the global value added embodied in trade.

On the other side, the concept of *position* in GVCs has also been studied in the recent literature in the input-output framework to measure the production-staging distance from final demand and from primary inputs, (*upstreamness* and *downstreaness*, respectively), being representative the contributions of Dietzenbacher and Romero, (2007); Antràs et al., (2012); Antràs and Chor, (2013); and Ing and Yu, (2021), among others.

From an empirical perspective, different factors have been studied as determinants of a higher participation of countries and/or sectors in these GVCs. This is, for instance, the case of Orlic (2016) that included determinants of GVC participation at the micro (firm) level. Similarly, Kersan-Škabić (2019) analyzed the behavior of the participation of EU countries within the GVCs, carrying out a study of their potential drivers where the GDP growth was the most significant indicator. More recently, Ndubuisi and Owusu (2022) explored the importance of countries' participation in the GVC to improve the quality of exports, finding that greater participation leads to producing higher quality intermediate inputs and more technology-intensive final goods.

Despite the relevance of these two concepts, participation and position in value chains, highly linked with the globalization and production fragmentation processes, have been studied as different items, and the specific relationship between them has not been considered. However, some papers established that both participation and position are explained by similar factors. As discussed in Hillberry (2011), it is difficult to separate the drivers of the increase in international trade from those with a specific impact on the fragmentation of production. Particularly, declining international trade costs (including tariff rates, transportation, information and communication costs), the degree of industrialization of the economy, the increase in technological progress and lower political and economic barriers to trade are pointed out as the main drivers of GVCs in the last two decades, affecting both participation and position (Blinder, 2007; Hummels and Schaur, 2013; Kowalski et al., 2015; Sun et al., 2019).

Moreover, while previous literature has often focused on the study of GVCs at the national level, the study at the regional level has just recently initiated with very interesting insights. For instance, Meng and Yamano (2017) have studied the different regional integration processes, concluding that integration in GVCs widely varies across regions, with regions more oriented towards the domestic demand, and others more specialized in the provision of inputs to exporting regions. They also find that the involvement of regions in these GVCs is not always direct, but indirect, through the provision of intermediate inputs and services to more export-oriented regions. Bolea et al., (2022), also at the regional level in Europe, found that the spatial dependence between regions conditioned the participation and position in GVCs, suggesting that global production processes are influenced by regional and local factors. Also, they show how some characteristics associated to the degree of proximity and the neighboring situation of regions condition their specialization, participation and positioning in GVC. Moreover, recent works have also explored the link between position and value-added gains (Capello and Dellisanti, 2024b), and the way in which regions can upgrade within the chain (Hernández-Rodríguez et al., 2025b, 2025a). The performance of regions in the new context of uncertainty has also been studied, including the reconfiguration of the international supply chains (Capello et al., 2025; Capello and Dellisanti, 2024a), the transmission of international shock through the prices change (Somé and Zidouemba, 2025), or the role of certain network characteristics, such as centrality, nodes strength, and others, in the economic resilience of regions (Giannakis et al., 2024).

In summary, empirical evidence suggests the existence of factors that favour the involvement of economies in GVCs and their specialization in trade, at the time that facilitate the adoption of different technologies and innovative processes, which contribute to a positioning more or less upstream/downstream in the GVCs. Empirically this will mean an endogenous relationship between both variables. Our work shows that ignoring these structural and territorial characteristics can have important biases in the definition and assessment of certain strategies and policies.

More specifically, this paper contributes to the literature aiming at answering the following research questions: Is there a bidirectional relationship between the participation and position of regions in GVCs? Is this robust to different specifications of the variables? Which are the main factors explaining both variables at the regional level for the EU regions? Are there spatial, structural and/or technological components relevant in Europe defining the regional outcomes regarding these variables?

Methodologically, based on the information provided by a multiregional input-output model at the regional level, we study the potential endogeneity between the participation and position variables using the specification of a Simultaneous Equation (SE) model (Allers and Elhorst, 2011; Omri et al., 2014). This methodology is commonly used to investigate the endogenous linkages among the variables, considering the potential unobserved heterogeneity affecting these relationships. Empirically, we use the regional input-output database EUREGIO for the period 2000–2010 (Thissen et al., 2018). The data provides information at the NUTS2 level and covers 249 European regions and 17 non-European countries at the country level with a disaggregation of 14 economic sectors.[1] One of the main advantages of this database is that it is fully consistent with the WIOD database and has equal row and column totals.

The remainder of this paper is structured as follows. In Section 2 we present the methodology along with a description of the metrics for *participation* and *position* in a MRIO framework, as well as of the explicative variables that will be introduced in the study. In Section 3, the main results are discussed, with a focus on the potential bidirectional relationship between our variables of interest. Section 4 concludes the paper and offers some future direction for further research.

2. Methodology and data

Our starting point is the representation of a closed global economy with n industries and m regions, where $\mathbf{x}$ denotes the total output, being

[1] The classification of economic sectors is: S1 (Agriculture); S2 (Mining, quarrying and energy supply); S3 (Food, beverages and tobacco); S4 (Textiles and leather); S5 (Coke, refined petroleum, nuclear fuel and chemicals etc.); S6&S7 (Electrical, optical and transport equipment); S8 (Other manufacturing); S9 (Construction); S10 (Distribution); S11 (Hotels and restaurants); S12 (Transport, storage and communications); S13 (Financial intermediation); S14 (Real estate, renting and business activities); and S15 (Non-market services).

Table 1
Variables description.

Variables	Definition	Unit of measurement
Participation (PAR)	Level of participation of the region in the European GVC	Ratio
Position (POS)	Level of position (upstream or downstream) of the region in the European GVC	Ratio
SBS	Structural Business Statistics: monetary, business demography and employment aspects of the region.	Index
People in Science and Technology	Employment in technology and knowledge-intensive sectors by region	Thousands of people
SI_RR	Specialization index in intra-regional trade	Ratio
POP_activeenterprises	Population of active enterprises refers to all companies that were active at any time during the reference period, even for a limited time.	Number of active enterprises
IRC	% of trade with regions from the same country	Percentage
VAemb_textil	Value added embodied generated directly by the textile and leather sector of European regions over the total VA embodied generated by each EU region.	Ratio
VAemb_chem	Value added embodied generated directly by the coke refined petroleum nuclear fuel and chemicals sectors of European regions over the total VA embodied generated by each EU region.	Ratio
VAemb_elect	Value added embodied generated directly by the electrical and optical equipment and transport equipment sectors of European regions over the total VA embodied generated by each EU region.	Ratio
VAemb_const	Value added embodied generated directly by the construction sector of European regions over the total VA embodied generated by each EU region.	Ratio
Border	It takes value 1 if the region shares border with another country.	Dummy
NorthEU, SouthEU, EastEU and WestEU	Dummy variables to control regional effects	Dummies

Source: Own elaboration

x^r the total output generated by region r, and $\boldsymbol{Z} = z_{ij}^{rs}$ the matrix of multiregional intermediate flows in a period t.[2]

$$\boldsymbol{x} = \boldsymbol{Ze} + \boldsymbol{y} \tag{1}$$

where **y** is the vector of total final demand of countries, each element representing the final demand of region *r*, and **e** is a unitary vector of the appropriate dimension. Let us denote by **A** the matrix of technical coefficients in the multiregional framework. Each representative element shows the volume of intermediate input *i* of a region *r* that is needed to produce a unit of output *j* in region *s*. Following this methodology, Eq. (1) can be expressed on the basis of **A** and in terms of the Leontief inverse **L** for the whole multiregional economy.

$$\boldsymbol{x} = \boldsymbol{Ax} + \boldsymbol{y} \rightarrow \boldsymbol{x} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y}$$

$$\boldsymbol{x} = \boldsymbol{Ly} \tag{2}$$

Each element in $\boldsymbol{L} = l_{ij}^{rs}$ shows all the production generated in sector *i* and region *r* to fulfill the demands of inputs incorporated in all the steps of the production chain and ending in the final demand of sector *j* in region *s*. In this regard, the elements in **L** capture the production embodied in all the economic flows linking sectors *i* and *j*, and regions *r* and *s* through the international supply chains.

Moreover, considering the value-added directly generated by the European regions, we can define the following value-added coefficients:

$$\boldsymbol{v}' = \boldsymbol{w}'(\widehat{\boldsymbol{x}})^{-1}, \text{and their corresponding diagonal form} \widehat{\boldsymbol{v}} \tag{3}$$

being **w** the vector of direct value-added generated by regions. Following this structure, we can define the matrix Ω that contains the global value-added generated and incorporated in all goods (domestically consumed and traded with other regions), that is to say, it contains the value added generated in each region-industry involved in a supply chain:

$$\boldsymbol{\Omega} = \left(\omega_{ij}^{rs}\right) = \widehat{\boldsymbol{v}}\boldsymbol{L}\widehat{\boldsymbol{y}} \tag{4}$$

Our interest in this paper is the study of the European regions as units of analysis, so we aggregate the sectoral information for each one of them, obtaining:

$$\boldsymbol{\Phi} = (\boldsymbol{\Phi}^{rs}) = \mathbf{E}\boldsymbol{\Omega}\mathbf{E}' \tag{5}$$

where **E** is a sectorial aggregation matrix of appropriate dimension, and, matrix $\boldsymbol{\Phi}$ includes value-added flows between all the regions in the global economy. Note that the reading by rows and columns of the matrix provides information on the origins and destinations of value added through the global production chains. For each region r, reading by rows, the regional value addeed can be broken down into the value added incoporated in the domestic production $\phi^{r,r}$ and $\sum_{s \neq r}\phi^{r,s}$, that is, the regional value added incorporated in the intermediate inputs directly and indirectly sold to other regions and countries to fulfill their final demands that is, the regional VA embodied in exports. By definition $\phi^{r,r} + \sum_{s \neq r}\phi^{r,s} = \phi^{r}$. Reading by columns, the value added embodied in regional final goods for a region r, also consist of the domestic $\phi^{r,r}$ and the value adeed embodied in imports $\sum_{s \neq r}\phi^{s,r}$.

To check the existence of a bidirectional relationship between participation and position in these chains, first, five usual metrics of *participation* are used and applied to the European regions. From Eq. (5) we derived the metrics based on Johnson and Noguera, (2012); Los et al., (2015) and Bolea et al., (2022). Johnson and Noguera (2012) proposal (PAR_1 from now on) is defined here, for each EU region as the ratio of domestic VA respect the VA embodied in exports (see expression (6)). The second measure (PAR_2 from now on) is obtained as the share of the VA embodied in exports over each region GDP (see expression (7)), while the third (PAR_3 from now on) is the share of the VA embodied in exports by each region (reading by rows) over the total VA embodied in exports worldwide (see expression (8)).

$$PAR\_1^r = \frac{\boldsymbol{\Phi}^{r,r}}{\sum_{s \neq r}\boldsymbol{\phi}^{r,s}} \tag{6}$$

$$PAR\_2^r = \frac{\boldsymbol{\Phi}^{r}}{\boldsymbol{GDP}^{r}} \tag{7}$$

$$PAR\_3^r = \frac{\boldsymbol{\Phi}^{r}}{\sum_{r}\boldsymbol{\phi}^{r}} \tag{8}$$

The higher is the value of PAR_2 and PAR_3, the higher is the participation in GVCs. In contrast with previous measures, in

[2] Temporal subindex is avoided at this first stage for clarity.

participation PAR_1, high values indicate a low degree of integration in the global chains.

The other two measures used as a proxy of participation are ratios based on the vertical specialization concept (Hummels et al., 2001). For obtaining these ratios, the initial matrix of intermediate inputs is also aggregated at the regional level $\widetilde{\mathbf{Z}} = \left(\widetilde{Z}^{rs}\right) = \mathbf{EZE}'$. More specifically, PAR_4 is defined here, for a region r, as the value of its imported inputs in its overall exports, while PAR_5 is calculated as the value of exports to other regions and countries in the overall region's imports. Thus, aggregating the sectoral data for each region, now the original matrix (see expressions (9) and (10)).

$$PAR\_4^r = \frac{\sum_{s\neq r}\widetilde{Z}^{s,r}}{\sum_{s\neq r}\widetilde{Z}^{r,s}} \tag{9}$$

$$PAR\_5^r = \frac{\sum_{s\neq r}\widetilde{Z}^{r,s}}{\sum_{s\neq r}\widetilde{Z}^{s,r}} \tag{10}$$

Regarding the *position of regions* in GVCs, and based on the proposal of "upstreamness" measure explained in Antràs et al., (2012), we calculate the (weighted) average position of a region's output in the value chain:

$$POS^r = \frac{y^r}{x^r} + 2 * \frac{\sum_s a^{rs}y^s}{x^r} + 3 * \frac{\sum_s\sum_k a^{rk}a^{ks}y^s}{x^r} + 4 * \frac{\sum_s\sum_k\sum_p a^{rk}a^{kp}a^{ps}y^s}{x^r} + 5 * \frac{\sum_s\sum_k\sum_p\sum_d a^{rk}a^{kp}a^{pd}a^{ds}y^s}{x^r} \tag{11}$$

A higher value of this variable denotes a more upstream position of the region in the global value chain, with production more concentrated on intermediate inputs and greater distance from final demand.

In the empirical application, in addition to the endogenous variables presented, built on the basis of the information provided by the EUROREGIO database (see Thissen et al., 2018), all other data for explicative variables are obtained from the regional statistics of EUROSTAT database. Table 1 presents the definition of the variables used. The data used in this analysis covers the period from 2000 to 2010 and for the 249 European regions. The period and the regions are selected according to the availability of all the data series.

Following previous literature, the regression includes controls of education, technology, production specialization and trade characteristics.

A group of main hypotheses will be checked in this work. First, our first hypothesis will be the existence of a bidirectional relationship between our endogenous variables, participation and position in global value chains, meaning that the performance of regions in their engagement in global markets is a dynamic and multidimensional process affecting these two relevant dimensions. Secondly, as has been established in the previous literature, it is expected that the business environment of the region affects both the level of *participation* and *position* in the GVCs. We approach this aspect by including the Structural Business Statistics (SBS) index as a proxy for the performance of enterprises in each region. It includes monetary, business demography and employment aspects, calculated as an index (Hansen, 2008; Sturgeon et al., 2008). The higher the value of the index, the better the performance is. Morover, we also check that human capital is a relevant factor to explain the evolution of the *participation* and *position* at the regional level. The relevance of these variables has been also checked in other contexts (Basile et al., 2012). We use the variable People in Science and Technology (People_ST) as a proxy of human capital, reflecting the employment in high technology and knowledge-intensive sectors. As specific variables for participation we include the SI_RR specialization index which represents the specialization of the regions in interregional trade within the country. It is expected that regions more specialized in this intra-country trade also provide a better environment to foster international trade, driving in consequence a higher participation. We also include the level of active enterprises as a proxy of the economic level of the region as an explanatory factor for participation. Morevover, it can be hypothesized that different bechavious can be found among the regions regarding their border or inland character, due to the different regulatory, fiscal and even infrastructural characteristics that may act as drivers or barriers in their global integration. To account for this, we introduced a dummy variable (Border) that takes value 1 when the region shares border with another region in another country.

Besides, geographical area dummy variables are included to control for broader regional effects. More specifically, the different performance among south, north, east and west Europe is considered by creating a dummy variable per geographical group and added as explicative variables in the Participation equations. The reason for including these variables only in the participation equations is the use of simultaneous equations method (SE), explained below, which determines the existence of bidirectional relationships between variables. This circumstance leads to the use of a series of "control" or different variables among the equations for the variables that exhibit endogeneity in an attempt to measure their behavior.

Therefore, when position is the dependent variable, the specialization of the four key categories of manufacturing sectors as a proxy of the state of development and industrial maturity is introduced. Specifically, we introduce as explanatory variables the value added embodied generated by the textile, chemicals, electrical and construction sectors. Moreover, we include the IRC variable which measures the percentage of trade with regions from the same country, to consider the weight of trade within the country. All these variables capture the heterogeneity of EU regions and their different performance if GVCs (Almazán-Gómez et al., 2023; Capello et al., 2023). Table 1 shows the variables included in the model and their definition.

In this study, the existence of a possible endogeneity is tested. To do this, first, we apply the Harris–Tzavalis test to check the existence of a unit root in our panel data with the endogenous variables of *participation* and *position*. The null hypothesis is that the series contains a unit root against the alternative that the series is stationary. In our case, the null hypothesis is rejected, which indicates our endogenous variables are stationary (and in consequence we can work in levels).

Moreover, the Granger causality test (Dumitrescu and Hurlin, 2012) is used to check for endogeneity between the variables of interest, as can be seen in Table 2. It shows the results using the metric proposed by Bolea et al., (2022). Results of Granger causality test for the rest of measures of participation are available upon request.

The null hypothesis of no causality is rejected in both cases, or, in other words, there is a two-way causal relationship between the endogenous variables of the analysis. Therefore, Simultaneous Equation (SE) models are used to examine the nexus between the variables of concern and the potential explicative factors. Based on previous works

Table 2
Results for Granger causality test.

Null hyphothesis	F Stadistics (Marginal Significant Value)	Direction
PA does not Granger-cause POS	0.00001	PA–>POS
POS does not Granger-cause PA	0.00001	POS–>PA

Source: Own elaboration

(Duarte et al., 2007; Radmehr et al., 2021), the SE models are used in this study to examine the two-way linkages between our two endogenous variables.[3]

The simultaneous equations are presented as follows:

$$PA_{i,t} = \propto_0 + \propto_{1i} POS_{i,t} + \propto_{2i} SBS + \propto_{3i} People_{ST} + \propto_{4i} SI_{RR}$$

$$+ \propto_{5i} POP_{activeenterprises} + \propto_{6i} SouthEU + \propto_{7i} EastEU + \propto_{8i} WestEU$$

$$+ \propto_{9i} Border + \delta_{i,t} \quad (12)$$

$$POS_{i,t} = \gamma_0 + \gamma_{1i} PA_{i,t} + \gamma_{2i} SBS + \gamma_{3i} People_{ST} + \gamma_{5i} VAemb_{textil}$$

$$+ \gamma_{6i} VAemb_{chem} + \gamma_{7i} VAemb_{elect} + \gamma_{8i} VAemb_{const} + \gamma_{9i} IRC + \gamma_{10i} Border + \varepsilon_{i,t} \quad (13)$$

where the subscripts i = 1, 2, …, 249, stand for European regions, t = 1, 2, …, T, are for the years 2000–2010

As we have seen previously, the hypothesis of a two-way relationship between the *participation* and *position* of the European regions is not rejected. Also, the Hansen test is used to check that the included explicative variables are valid and appropriate to test the endogeneity issue, showing that we could not reject the null hypothesis in both cases.[4]

Once we have verified that the explicative variables incorporated in the models are appropriate, in the next section we present the main results derived from the panel data model for the variables of interest.

3. Results and discussion

3.1. Initial findings on the evolution of participation and position measures

Let us start with some insights on the evolution of the participation and position of the EU regions in GVCs. In Fig. 1 we show two maps corresponding to *participation,* defined as the value added incorporated in exports respect the total value added generated in the economy (Bolea et al., 2022), in the first and last year available of the database.

Given the short period studied, as expected, the changes that have occurred in absolute terms of *participation* in the GVC have not been very significant. It can be seen that some regions of France, Italy, Austria, Germany and the UK stand out for their *participation* in the GVC. It should be noted that in 2010 (compared to 2000) more Italian regions appear at the top of the *participation* values, showing a commercial openness of the entire country. By contrast, in UK tend to be a general decrease of participation as well as in Denmark.

Moreover, as can be seen in Table 3, using traditional growth rates for the *participation* we can observe that the Eastern European regions show a higher speed for integration into the European GVC over the period studied. The case of the Spanish regions, the Basque Country and Catalonia also stands out. These results clearly show the integration of Eastern Europe into intra-European trade. It shows how since they joined the EU in 2002, they have experienced growth in the global European value chain, increasing their trade with the rest of the European regions (also shown in Bolea et al., 2021).

Regarding position, in Fig. 2 we can observe that, in general, European regions move towards a more finalist productive character. We can see how the regions that, at the beginning of the period, were in the most primary positions of the chain (some regions of France, Germany and the UK), at the end of the period studied (2010) are in more advanced positions, that is, in final stages of the chain. Moreover, in 2010, we can observe the border regions acquired a more intermediate behavior,

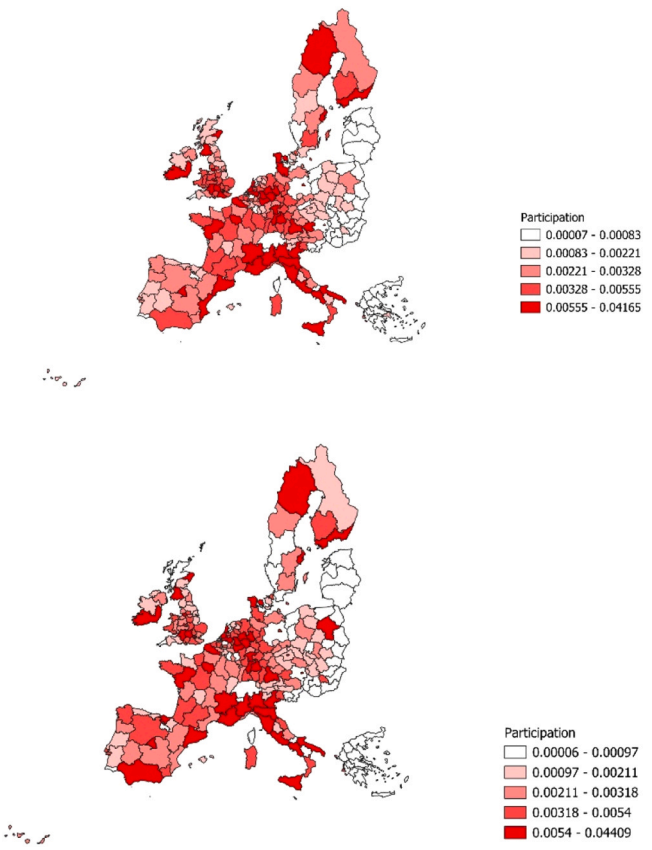

Fig. 1. Mapping *participation* in the European GVC. Note: The maps correspond to 2000 and 2010 respectively. Source: Elaborated with QGis.

Table 3
Evolution of the *participation* values in GVCs in the top 20 European regions, from 2000 to 2010.

	2000–2010
Pais_Vasco (ES21)	218.325 %
Bratislavsky_kraj (SK01)	168.593 %
Zapadne_Slovensko (SK02)	140.662 %
Luxembourg_GrandD (LU00)	131.841 %
Stredne_Slovensko (SK03)	128.391 %
Vychodne_Slovensko (SK04)	115.573 %
KozepMagyarorszag (HU10)	115.324 %
Praha (CZ01)	114.767 %
Mazowieckie (PL12)	111.461 %
Wien (AT13)	94.777 %
Dytiki_Makedonia (EL53)	92.893 %
Moravskoslezko (CZ08)	91.102 %
Stredni_Cechy (CZ02)	89.153 %
Jihovychod (CZ06)	86.201 %
Lietuva (LT00)	86.048 %
Stredni_Morava (CZ07)	76.839 %
Jihozapad (CZ03)	75.369 %
Dolnoslaskie (PL51)	73.396 %
Severovychod (CZ05)	65.494 %
Cataluna (ES51)	57.649 %

Source: Own elaboration

especially on the border of Italy with France, Austria with Germany, or Germany and some Eastern European regions, suggesting the existence of regions acting as suppliers of inputs to other regions more oriented to international trade.

In relative terms, Table 4 shows the European regions that present the highest and lowest growth rates for the position variable, being relevant the direction of the change. If the region has tended to move

[3] See Appendix A to check the correlation matrix and the results of the Harris- Tzavalis (1999) test for the stationary issue.

[4] Hansen test results are available upon request.

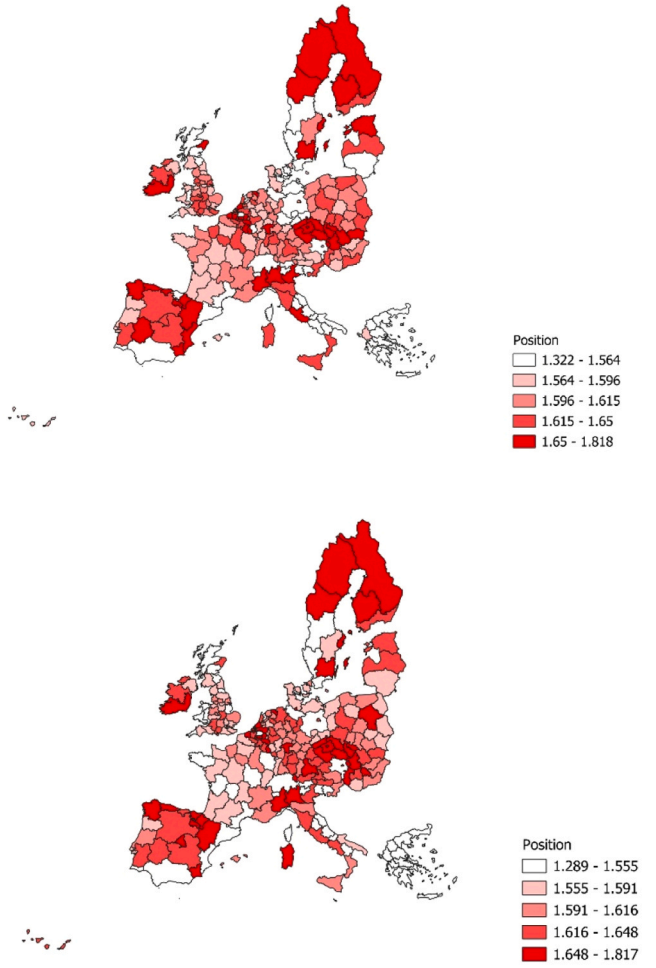

Fig. 2. Mapping *position* in the European GVC. Note: The maps correspond to 2000 and 2010 respectively. Source: Elaborated with QGis.

Table 4
Evolution of the *position* values in GVCs in the top 20 European regions, from 2000 to 2010.

2000–2010	
Upstreamness	**Downstreamness**
Pais_Vasco (ES21)	West_Wales_and_The_Valleys (UKL1)
Brandenburg_Nordost (DE40)	LansiSuomi (FI19)
KozepMagyarorszag (HU10)	Eesti (EE00)
Magdeburg (DEE3)	Zapadne_Slovensko (SK02)
Aland (FI20)	Outer_London (UKI2)
Dessau (DEE1)	Bedfordshire_Hertfordshire (UKH2)
Dytiki_Makedonia (EL53)	Kent (UKJ3)
Thuringen (DEG0)	Norra_Mellansverige
Dresden (DED2)	Lombardia (ITC4)
Campania (ITF3)	Stredne_Slovensko (SK03)
MecklenburgVorpommern (DE80)	Vychodne_Slovensko (SK04)
Vorarlberg (AT34)	ItaSuomi (FI1D)
Mazowieckie (PL12)	Anatoliki_Makedonia_Thraki (EL51)
Lietuva (LT00)	Sterea_Ellada (EL61)
Leipzig (DED3)	Dytiki_Ellada (EL62)
Dusseldorf (DEA1)	Thessalia (EL63)
Karnten (AT21)	Ipeiros (EL64)
Wien (AT13)	Kentriki_Makedonia (EL52)
Puglia (ITF5)	Peloponnisos (EL65)
Comunidad_de_Madrid (ES30)	Comunidad_Valenciana (ES52)

Source: Own elaboration

towards more primary (upstream), it presents higher positive growth rates, while more finalist positions in the global value chain (downstream) presents negative variation rates.

The results in Table 4 show the change in position experienced by European regions over the period analyzed. It is observed that the regions in central Europe (Germany and Austria) and the peripheral regions (Spain and Italy) have moved to more primary positions in the chain. Looking at the right-hand column, mainly the regions of the United Kingdom, Greece and some Eastern countries have experienced a downward shift, moving to more final positions. Therefore, it seems that the European regions have moved in two directions, some have moved to more primary positions (more upstreamness) and others to more finalist positions (more downstreamness).

3.2. Econometric results

The results of the estimations of Eqs. (12) and (13) based on 3SLS model [5] are presented in Table 5. As can be seen in the table, the endogenous variables are the five different measures of participation and position (measuring as upstream position), being the rest the exogenous variables.

First, the bidirectional relationship between participation and position in GVCs is confirmed when participation considers the value added incorporated along the chain (columns 1–6) and when participation considers the value of imported inputs in the overall exports and vice versa (columns 7–10). If participation refers to the proposals of Los et al. (2015) and Bolea et al. (2022) (PAR_2 and PAR_3 respectively), participation is significant in explaining position at 1 % level. Particularly, it is observed a positive relation between them, position fosters participation, and participation fosters position. Thus, the results show that when regions are located in the early stages of the chain, with production processes highly focused on the production of primary and intermediate inputs, they have higher levels of participation in them, and greater openness to international trade. More upstream regions could be linked to more commercial partners, as they act as suppliers. Then, these regions are involved in more steps of the chain, making their involvement in it stronger. At the same time, participation seems to favor more upstream positions due to the outsourcing processes especially frequent in the period analyzed. The bidirectional relationship is also positive when PAR_5 (the value of exports in the overall imports) is considered as a measure of participation.

When Johnson and Noguera (2012) metric (PAR_1) and vertical specialization (PAR_4) are analyzed, the bidirectional relationship between participation and position is negative and significant at 1 % and 5 % level, respectively. These results are consistent with the ones obtained before, as both measures are interpreted on the opposite side. That is, the higher they are, the lower the participation in GVCs. Thus, the bidirectional and significant relationship between participation and position is confirmed in both directions. All these results show that both dimensions of GVCs, participation and position, are not independent phenomena, and their relation should be considered.

If we focus on the coefficients of control variables, which behave equally in all the estimations, we can observe that SBS is negatively associated with the value of *participation* in the GVCs, being positively with the value of *position*. On the other hand, the coefficient of the educational variable (people in science and technology) is significant and positive for *participation* as for *position* for most relationships (being negative for PAR_2 and PAR_4). According to panel 3SLS, a rise in the

[5] 3SLS method is the three-stage least-squares method that generalizes the two-stage least-squares method to take account of the correlations between equations. It contains three stages: first-stage regressions to get predicted values for the endogenous regressors; a two-stage least-squares step to get residuals to estimate the cross-equation correlation matrix; and the final 3SLS estimation step (Zellner, 1962)

Table 5
Results for the simultaneous Eqs. 12 and 13 (3SLS model).

	1	2	3	4	5	6	7	8	9	10
	Eq. (12)	Eq. (13)	Eq. (12)	Eq. (13)	Eq.(12)	Eq.(13)	Eq. (12)	Eq. (13)	Eq. (12)	Eq. (13)
VARIABLES	**PAR_1**	**POS**	**PAR_2**	**POS**	**PAR_3**	**POS**	**PAR_4**	**POS**	**PAR_5**	**POS**
POS	−3.821***		0.0321**		0.0202***		−0.225**		0.196**	
	(0.417)		(0.01386)		(0.001288)		(0.117)		(0.101)	
PAR		−0.0621**		1.5424***		1.9448***		−0.141***		0.281***
		(0.00619)		(0.218)		(1.5437)		(0.0194)		(0.043)
SBS	0.00224***	0.000155***	−6.37e−05***	0.00012***	1.74e−07	−5.90e−05**	0.00010*	7.07e−05***	−0.000158*	0.000701***
	(0.00225)	(2.19e−05)	(7.28e−06)	(2.79e−05)	(7.55e−07)	(0.000258)	(6.16e−05)	(2.12e−05)	(5.35e−05)	(2.25e−05)
People_ST1000	−0.0014**	6.36–05	0.00011*	0.00037	6.35e−05***	0.000722	−0.00102***	−0.00011	0.00158***	−0.00038***
	(0.00577)	(5.55e−05)	(1.86e−05)	(0.00059)	(1.93e−06)	(0.000128)	(0.000157)	(6.83e−05)	(0.00135)	(1.05e−05)
Border	−0.095**	−0.00212	−0.00098	0.0037**	−0.00041***	−0.00051**	−0.0391***	−0.00185	0.0035	−0.0078*
	(0.0437)	(0.00474)	(0.00139)	(0.00488)	(0.000149)	(0.00512)	(0.0117)	(0.00476)	(0.00101)	(0.00512)
SI_RR	−0.509***		0.01655***		0.00613**		−0.0741***		0.0539***	
	(0.0797)		(0.00257)		(0.00025)		(0.0218)		(0.0187)	
POP_actenterprises	−2.28e−06***		8.97e−08***		2.20e−08***		−7.39e−07***		4.33e−07***	
	(2.86e−07)		(9.74e−09)		(9.71e−10)		(8.02e−08)		(6.88e−08)	
IRC		−0.125***		−0.1545***		−0.1453***		−0.0984***		−0.0981***
		(0.0129)		(0.0136)		(0.01476)		(0.0137)		(0.0157)
SouthEU	0.883***		−0.03807***		−0.00122***		0.334***		−0.208***	
	(0.07146)		(0.00231)		(0.000211)		(0.0195)		(0.0151)	
EastEU	0.3104***		−0.00801***		0.000937***		−0.0623***		0.0361***	
	(0.0534)		(0.00175)		(0.000161)		(0.0146)		(0.0127)	
WestEU	0.212***		−0.0188***		−0.00148***		0.100***		−0.0355*	
	(0.0643)		(0.00215)		(0.000198)		(0.0179)		(0.0135)	
VAemb_textil		−1.021***		−0.9857***		−1.2398**		−0.837**		−0.362
		(0.2751)		(0.2998)		(0.2782)		(0.2991)		(0.3436)
VAemb_chem		0.0702		0.1061		0.3073***		0.315***		0.398***
		(0.07605)		(0.0738)		(0.0619)		(0.0671)		(0.0726)
VAemb_elect		0.2411**		0.5191***		0.511***		0.345***		0.489***
		(0.0095)		(0.0951)		(0.08704)		(0.0961)		(0.0991)
VAemb_const		0.692***		1.2188***		1.1534***		0.912***		1.346***
		(0.1059)		(0.1333)		(0.12274)		(0.1155)		(0.159)
Constant	8.922***	1.7309***	0.1832***	1.3122***	0.0306***	1.518***	1.207***	1.683***	1.421***	1.228***
	(0.659)	(0.0235)	(0.0219)	(0.0347)	(0.00203)	(0.0124)	(0.185)	(0.0232)	(0.159)	(0.0503)
Observations	2739	2739	2739	2739	2739	2739	2739	2739	2739	2739
R-squared	0.275	0.244	0.175	0.199	0.424	0.152	0.278	0.221	0.202	0.129

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

level of people in science and technology leads to a positive increase in the *participation* value, being positive for the *position* too. This result indicates that those European regions that have a high level of education and investment in technology also present a higher degree of globalization (greater *participation* in the global value chain) and are in more "upstream" positions, closer to the production of intermediate inputs.

The rest of the explicative variables are significant as well. In the first equation for the different models (corresponding to Eq. 12 in the text), when the *participation* is the endogenous variable, the coefficient of specialization in regional trade is positive and significant (being negative for PAR_1 and PAR_4 because these participation indicators are interpreted oppositely). This result implies that a high level of intra-regional trade leads to an increase in the level of *participation* of the local region.

In addition, in the first simultaneous equation, the coefficient associated with the variable population of active enterprises (POP_activeenterprises) is positive and significant (being negative for PAR_1 and PAR_4), showing that the European regions that have a greater number of active enterprises over the analyzed period, present higher levels of *participation* in GVCs. This result is in line with what we would expect. Those regions with stronger economies are those that show higher levels of *participation*, in other words, regions that are more integrated in the globalization process and in international trade. Moreover, another explanatory variable appearing in both equations is the "Border" variable, which takes into account whether the region borders another region in another country. It is observed that it presents a negative and significant coefficient for most of the equations when the endogenous variable is participation. This means that regions that border regions in other countries have lower levels of participation in supply chains than interior regions. This result may be attributed to some regulatory, taxation or infrastructural discontinuities across national borders, which could increase transaction costs, weaker transport connectivity which limit the development of cross-border production linkages. Moreover, many border regions in the context of the EU are rural or less economically developed which make them less attractive places for the development of global supply chains. When the dependent variable is position, the explicative variable “Border” appears positive and significant in regression 4.6 and 10, thus, those regions that share border tend to be more upstream. Probably, these regions act as intermediate suppliers for other regions in the global supply chains

In this same line, in the second simultaneous equation for the different models (corresponding to Eq. 13), the results show that the coefficients of the different specialization variables of value added embodied in manufacturing sectors are significant in most cases. Specifically, the coefficients associated with the value added embodied in textile sector are negative and significant for most of the equations. This means that the European regions with a higher participation of this manufacturing sector in their economies, present more "downstream" positions. In other words, their production processes are more associated with the production of final products, being in the last steps of the value chain. Manufacture closer to final demand tends to generate higher value added and involve more qualified labor inputs, what could help to explain this result. Finally, the coefficient of the variable intra-country trade index (IRC) is negative and significant. This result would suggest that regions more focused on trade within their own country tend to exhibit a less upstream position, that is, they are in the final stages of the chain. Trade within the country would imply more finalistic regions, i.e., regions involved in shorter chains.

In summary, our results suggest a strong interconnection between the participation and position of European regions in global value chains, showing that both phenomena are correlated at the regional level. European regions seem to behave according to how we would expect. The variables of scale and productive specialization are those that present greater importance in the evolution of the endogenous variables in the models. The European regions that present higher levels of *participation* (more integrated in the globalization processes), and consequently, more developed economies and less focused on the technological sectors, are those that are in more upstream positions of the GVCs. On the contrary, those European regions that present greater production specializations, with a large participation of the technological sectors in their production processes, are those that are in downstream positions of the GVCs. The results obtained in this work indicate that there are differentiate groups between European regions, and a significant linkage between the values of their *participation* and *position* in the GVCs in this context.

4. Conclusions

The acceleration of globalization processes, technological change and the interdependencies that have arisen between different areas have focused attention on the study of GVCs. In this field, we analyze the existence of an endogenous relationship between the well-known concepts of *participation* and *position* in GVCs. Besides, we also explore the main determinants that make this relationship stronger and more robust, as well as its implications in the implementation of economic policies.

The results suggest that both globalization dimensions are endogenously related, explained and favored by a group of similar underlying factors. In consequence, policies and strategies aiming at a certain specialization on some parts of GVCs also affect the appropriation of value added in trade (participation) and/or similarly, broad strategies of trade expansion, also favor changes in the positioning of economies in GVCs. In consequence, strategic sectoral specialization at the regional level should be guided by an understanding of how both dimensions may interact, in order to maximize the capture and retention of value added.

The consideration of the heterogeneity of unobserved regional and structural factors and the way in which they affect participation and position variables is important to identify complementarity or substitutability effects between variables that amplify or limit the effects of different strategies and policies. Our results confirm the relationship between participation and position for different measurements of participation. Independently of it, more upstream positions foster participation, and otherwise, higher participation induces upstream positions. On the one hand, more upstream regions are more connected within the chain, as they are suppliers of intermediate inputs, and could be involved in different steps of the chain. On the other, higher participation in GVCs could lead to a stronger intermediary role due to the outsourcing processes, as could be the case of Eastern EU regions. As a consequence, more tailored regional development strategies which consider local structural advantages or constraints, especially regarding task and labour specializations, technological capabilities and synergies, transport and general trade infrastructures, would facilitate a more in-depth integration of regions in GVCs.

As we already commented, all in all, these results show that the two concepts of *participation* and *position* feed into each other, Therefore, policy makers should coordinate different kinds of policies and consider the mutual impact of both dimensions of GVCs in the design of economic strategies. Besides, trade policies should go hand in hand with strong industrial policies that could help regions not only to increase their trade openness, but also to locate the region within the international production chain.

Our results also show the importance of institutional and educational factors in explaining the performance of EU regions in the global context; thus, national and regional coordination in policies to boost human capital development and keep favorable environments would also contribute to enhace regional development in the global world.

Moreover, the regional dummies included in the analysis (South, North, Weast and East EU) also reveal significant. In consequence, our findings also highlight the value of designing regional strategies that reflect and accompany the common structural and productive realities, development trajectories and new challenges faced by broader EU areas (such as Eastern or Southern Europe) to foster more effective, coordinated and cohesive integration in GVCs.To sum up, this paper contributes to the literature with the finding of an endogeneity relationship between *participation* and *position* in GVCs. As stated above, these results have some relevant economic and political implications that may inform regional policies and strategies. also opening the door to further analysis and extensions. Particularly, our work has focused on analyzing the relationship between regional participation and position within GVCs. However, as some of our results suggest, there may have spillover effects between regions that can either boost or hinder their potential to engage in these GVCs and the associated outcomes. Failure to consider the spatial component of the analysis could have a slight or moderate impact on the results, conclusions, and policy implications, depending on the weight of the indirect effects. Therefore, a deeper exploration of these spillovers and their simultaneous impact on both dimensions represents an important next step in this line of research. Moreover, the proposed methodology can be naturally extended to confirm these results and updated timeframes, offering new insights into the dynamics of global value chains.

CRediT authorship contribution statement

Sofía Jiménez: Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rosa Duarte:** Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Lucía Bolea:** Writing – review & editing, Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Rosa Duarte reports financial support was provided by Spanish Scientific Research Council. Rosa Duarte reports financial support was provided by Government of Aragón. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Testing the multicollinearity and stationary issues

First, to check the existence or not of multicollinearity between the variables, we made the correlation matrix.

	PAR_1	PAR_2	PAR_3	PAR_4	PAR_5	POS	SBS	People in	SI_RR	POP of act	IRC	Vaemb text	Vaemb chem	Vaemb elect	Vaemb const
PAR_1	1.00														
PAR_2	-0.84	1.00													
PAR_3	-0.18	0.33	1.00												
PAR_4	0.54	-0.62	-0.40	1.00											
PAR_5	-0.43	0.65	0.58	-0.83	1.00										
POS	**-0.44**	**0.52**	**0.45**	**-0.41**	**0.51**	1.00									
SBS	0.12	-0.10	0.45	-0.06	0.08	0.03	1.00								
People in	-0.04	0.13	0.47	-0.33	0.40	0.08	0.35	1.00							
SI_RR	0.09	0.01	0.17	0.19	-0.13	-0.19	0.21	0.02	1.00						
POP of act	-0.01	0.03	0.58	0.17	0.20	0.07	0.69	0.57	0.18	1.00					
IRC	0.10	0.00	0.17	0.20	-0.13	-0.22	0.21	0.01	1.00	0.17	1.00				
Vaemb_text	-0.06	0.14	0.68	-0.16	0.23	0.02	0.54	0.44	0.19	0.70	0.20	1.00			
Vaemb_chem	-0.08	0.09	0.47	-0.21	0.22	0.09	0.23	0.44	-0.10	0.38	-0.09	0.36	1.00		
Vaemb_elect	-0.02	0.08	0.48	-0.34	0.38	0.08	0.24	0.74	-0.08	0.40	-0.08	0.46	0.52	1.00	
Vaemb_const	0.07	0.05	0.51	-0.30	0.38	0.05	0.56	0.78	0.14	0.76	0.14	0.57	0.49	0.64	1.00

Figure A.1. Matrix of correlations

Source: Elaborated with Stata

We can verify that there is no positive and strong correlation between any of the exogenous variables of the models. Therefore, these results indicate that each variable defines different characteristics.

Second, we apply the Harris–Tzavalis (1999) test to verify the existence of a unit root or stationary in the exogenous variables. As we established before, the null hypothesis is that the series contains a unit root, and the alternative is that the series is stationary. In Table A.1., we can observe the results of this test.

Table A.1
Results for exogenous variables of the Harris-Tzavalis test

	NO TREND				TREND			
	Statistic	Z	p-value		Statistic	Z	p-value	
PAR_1	0.6372	−7.0130	0.0000	Stationary	0.3382	−4.005	0.0000	Stationary
PAR_2	0.5389	−13.131	0.0000	Stationary	0.2125	−9.9421	0.0000	Stationary
PAR_3	0.5300	−13.683	0.0000	Stationary	0.2292	−9.1543	0.0000	Stationary
PAR_4	0.5578	−11.954	0.0000	Stationary	0.2995	−5.8329	0.0000	Stationary
PAR_5	0.5001	−15.541	0.0000	Stationary	0.2235	−9.4209	0.0000	Stationary
POS	0.4985	−15.643	0.0000	Stationary	0.0114	−19.4356	0.0000	Stationary
SBS	0.5947	−9.661	0.0000	Stationary	0.1241	−14.115	0.0000	Stationary
People_ST (1000)	0.4696	−17.441	0.0000	Stationary	0.2267	−9.272	0.0000	Stationary
IRC	0.6483	−6.324	0.0000	Stationary	0.4092	−6.5332	0.0000	Stationary
POP_actenterprises	0.9664	13.456	1.0000	Non-Stationary*	0.154	−12.7049	0.0000	Stationary
d.POP_actenterprises	0.0264	−40.124	0.0000	Stationary	0.0477	−14.4596	0.0000	Stationary
SI_RR	0.627	−7.652	0.0000	Stationary	0.3406	−3.8926	0.0000	Stationary
Vaemb_textil	0.2696	−13.855	0.0000	Stationary	0.2269	−4.9008	0.0000	Stationary
Vaemb_chem	0.3665	−12.924	0.0000	Stationary	0.2914	−6.217	0.0000	Stationary
Vaemb_elect	0.4847	−12.610	0.0000	Stationary	0.2003	−10.5161	0.0000	Stationary
Vaemb_const	0.6039	−9.089	0.0000	Stationary	0.406	−4.4421	0.0000	Stationary

Source: Own elaboration
*Non-Stationary when no trend is applied

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