Spanish regions in Global Value Chains: How important? How different?

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This draft: November 19, 2019

Abstract

The recent release of EUREGIO, a novel global input-output database with regional detail for EU countries, allows to analyze the participation of EU regions in Global Value Chains and their implications for the propagation of sector-specific shocks. We focus on Spanish regions to exploit the granular information embedded in this database. We first characterize foreign and domestic trade inter-linkages of Spanish regions and sectors. Using an extended version of the *Leontief* scheme, we compute upstream output and value added multipliers. Then, we calculate indicators developed in the Global Value Chain literature to breakdown each region trade flows, both exports and outflows, into value added components. Finally, by means of examples, we analyze the role of networks (domestic or foreign) in the propagation of demand shocks (from customers to suppliers), to evaluate the heterogeneous impact across regions and to illustrate the potential of this approach. Our findings indicate that Spanish regions participate differently in Global Value Chains and this fact may have important implications in the propagation of shocks. By merging these two strands of the literature at the regional level, we can assess whether region-industries that are important from a value added perspective may not necessarily be from an input-output perspective and vice-versa. According with our results, the strongest user-supplier linkages are usually within the same sector, and, in general, with industries within the same region or other Spanish regions. The Basque Country is the region with sectors with the largest total output-multipliers and Catalonia with the lowest ones. Concerning their participation in Global Value Chains, Catalonia has a low participation compared to other Spanish regions, while the Basque Country and Madrid are the most integrated in the international segment of the value chain.

Keywords: Global Value Chains, input-output structure, networks, EUREGIO.
JEL-Codes: F14, F15

*We are very grateful to Bart Los for supplying to us the EUREGIO dataset. We also thank Javier Sánchez Bachiller and Paloma Villanueva for providing essential tools at early stages of this project, being an input with high value added. Mailing address: Banco de España, Calle Alcalá 48, Madrid, Spain; corresponding authors: elvira.prades@bde.es and patry.tello@bde.es. The views expressed in this paper are those of the authors and should not be attributed to Bank of Spain.

1 Introduction

Globalization and, in particular, the reallocation of the several stages of a production process across the world (the so-called Global Value Chains, GVCs), has intensified linkages between countries. The decline in transportation costs and the reduction in barriers to trade have made easier for firms to locate their production and to source their inputs across national borders. This fragmentation of the production process has significantly increased trade in intermediate goods and services, making gross exports a less significant measure of their economic relevance for a country. And, at the same time, it has made input-output linkages more intense and more complex across countries, and also within a country. As the OECD paraphrases "what a country or region does", that is, the activities a firm or region is involved in, matters more for growth and employment than "what a country or region sells". On this background, a proper assessment of domestic and foreign linkages of regions within and outside a country becomes more relevant (see Los and Timmer (2018)).

Notwithstanding, the process of fragmentation of production is not only taking place at the country level. Also the regions within countries are participating differently in this process. Some regions may export directly to a foreign country, while others do it indirectly, by providing parts, components or intermediate services to more export-oriented regions. However, despite being fragmented and extended at domestic regional level, studies that take into account the regional dimension in the analysis of GVCs are relatively scarce and focused on a few countries. This is explained by the lack of data and the difficulties to extend at a regional level the methodology usually employed at a country level. An input-output (IO) table, that synthesizes all flows of goods and services into and out an economy, as well as, their origin and destinations, provides an appropriate framework to analyze both within and inter-country linkages.[1] Until very recently, only national IO tables and international IO tables (such as the World Input Output Database, WIOD), with no information about the regional distribution of trade flows within a country, were available. If the focus of the analysis is at the country or inter-country level, these IO tables may be sufficient. However, in countries where regions differ significantly in terms of, for example, their production structure, their size or geographical location, the regional dimension gains relevance to explain, for example, differences in firms´ participation in GVCs or in the impact of demand or supply shocks, both across regions and at aggregate level.

The increasing interlinkages among countries and regions affect the propagation of shocks. The propagation of shocks throughout the Spanish regions does not only depend on the nature of the shock *per se*, whether it is demand or supply driven, it also depends on the industry specific supplier-user domestic and international linkages. The IO structure of the Spanish regions´ production network is key to understand how external and domestic shocks propagate across Spain and how much each regions´ output, as well as, the aggregate one, is affected.[2] As Spanish regions differ in many dimensions taking into account input-output interlinkages could be particularly relevant.[3] One way to address this issue is to extend the available global input-output table (the above mentioned WIOD) to include the regional dimension.

[1]Input-output analysis allows taking multiple cross-national border movements of the same goods and services, as well as, local supply chains into account.

[2]see Caliendo et al. (2017) and Acemoglu et al. (2015).

[3]For more details on Spanish regional differences see Artola et al. (2018).

The release of a novel database EUREGIO built by Los et al. (2018) allows to explore for each EU region their participation in Global Value Chains and to analyze the propagation of sector-specific shocks through the production chain. In this dataset, they extend the WIOD 2013 release with regional detail for EU countries at the NUTS2 level. This global input-output dataset provides information on trade linkages across the EU regions, as well as, with other non-EU countries, from 2000 to 2010. The sectoral breakdown, 14 sectors, is less detailed than in WIOD in favor on a detailed regional data. This database can be used to improve our knowledge of input-output linkages of Spanish regions within Spain, but also with regions in other European countries. On this background, in a first step, we compute region-industry specific output multipliers to characterize inter-linkages among sectors and regions, both within Spain and with other countries, as in Izquierdo et al. (2019). This framework allows to trace out the effect of demand and supply shocks and to assess their impact on each Spanish region and at national level. This approach also allows to identify the most systemic sector-region pair in Spain in term of its economy-wide impact. Next, to better understand the channels (that is, regional, domestic or international) through which these effects propagate, we exploit the richness of the EUREGIO database to build some basic indicators of GVC participation at regional level. Basically, we decompose gross exports and outflows into different value added components following an extended version of the Koopman et al. (2014) decomposition approach, that is extensively used in the GVC literature at country level.

As far as we know, this is the first paper that explores Spanish domestic and foreign intersectoral-interregional trade linkages, to better understand Spanish regions dependence of both national and international inputs, as well as, their participation in GVCs. For the sake of simplicity, we will focus the analysis to four selected regions (The Basque Country, Canary Islands, Catalonia and Madrid). The main findings of our analysis could be summarized as follows:

- The strongest user-supplier linkages are usually within the same sector, and, in general, with industries within the same region or other Spanish regions. This pattern is quite similar across the four analysed Spanish regions, although there are some differences, being the Basque Country the region showing the highest dependence on national inputs (both from the same region and from other Spanish regions) and Catalonia, the lowest.

- The propagation of sector-specific demand shocks through input-output linkages, and their aggregate economic impact, differs across Spanish regions. The *output upstream multipliers* (that is, shocks that propagate from customers to suppliers), that are computed at region-sector pair level, reflect differences in the regional production network. By regions, the Basque Country is the region with sectors with the largest total output-multipliers and Catalonia with the lowest ones. Being Madrid and the Basque country the regions with show larger spillover effects to other countries. By type of sectors, services show lower total output multipliers than manufacturing. Finally, value added multipliers confirm that services show a larger domestic (and regional) multiplier than manufacturing, being Catalonia the region that, on average, presents the largest domestic value added multipliers and the Basque Country and Canary Island, the largest regional ones. Madrid shows high domestic multipliers in the services sectors.

- GVC participation (measured as *backward* linkages) varies strongly across Spanish regions and it has remained relatively stable along 2000 and 2010. Catalonia is the region with lowest participation in GVCs. The Basque Country and Madrid are the most integrated in the international segment of the value chain, that is, with higher foreign value added in their trade flows. Canary Islands and the Basque Country are the most involved in the inter-regional segment, with higher regional value added embed in their flows.

- Finally, based on Spanish regions input-output linkages, we find that an increase in US import tariff is expected to impact more negatively on Madrid´s and the Basque Country´s value added, while Canary Islands is one of the least affected. As regards the degree of exposure to Brexit, Madrid and Catalonia are the most exposed, while Canary Islands is among the least one.

The paper is organized as follows. First, in **section 2** we present the motivation of the paper and an overview of the literature in this field. In **section 3** we explain the main features of the EUREGIO dataset and the methodology used to decompose gross flows into value added terms and the methodology applied to compute upstream output multipliers. Next, in **section 4** using the EUREGIO database, we identified the Spanish regions and sectors with higher propagation effects -within the same region, to other regions and countries- and build a basic GVC integration indicator for Spanish regions from trade flows measured in value added terms. In **section 5**, based on these linkages, we explore the spillover effects derived from some specific demand shocks, such as, a decline in the US demand driven by an increase in tariffs, a decline in the demand from the United Kingdom due to Brexit and regional specific shocks within Spain. And, finally in **section 6**, the main conclusions and a follow up are presented.

2 Motivation and literature review

This paper is related to two strands of the literature. The first one focuses on the role of global value chains in shaping international trade flows and the second one on the role of input-output network linkages in propagating sectoral shocks within and across countries. By merging these two approaches at the regional level, we can assess if a given region is highly interconnected, or not, to other regions in the same country or in a foreign one, as well as, to measure the actual value added generated by a region in its trade flows. Overall, we can assess whether region-industries that are important from a value added perspective may not necessarily be from an input-output perspective and vice-versa.

The fast expansion of Global Value Chains has increased the interest for understanding its role in shaping global trade flows, as well as, for properly measuring *backward* and *forward* trade linkages between sectors across countries. The fragmentation of the production process in various stages, which are often located in different countries, causes intermediate goods and services cross national borders several times before being finally consumed. Under this production scheme, value is added at each stage of the chain. As official statistics measure international trade in gross flows, and inputs are counted any time they cross a border, they mask the real value added by a country to its exports. Similarly, input-output linkages among sectors, both within and across countries, are deeply affected by the fragmentation of production implied by GVCs. On this background, the use of value added trade flows and of GVCs indicators, to complement the conventional measures of trade, has received an increasing attention in international trade literature. Nevertheless, research on the role of regions, at sub-national level, on GVC participation, as well as, on shaping the national production network, is relatively new.[4]

In **figure 1** we provide a simple example of a stylized value chain across three regions within country A. This figure describes the production process of a final product, in which the last stage of production takes place in Region 3. This simple example illustrates how the participation of the three regions in the production process can be different. The producers of intermediate inputs in Region 2 sell directly to the industry-of-finalization in Region 3, and are considered as first tier suppliers. These first tier suppliers also use intermediate inputs from other region (Region 1, as well as, from the same region) so as to produce their intermediate goods. Region 1 will be considered a second tier suppliers. In this example, industries in Region 2 (and Region 1) also add value to the production of the final product sold by the industry-of-finalization in Region 3. And, the final product can be consumed within the same region (Region 3), in other region in the same country -outflow- or in other country -export- (Region 4 in country B).

Since the early 2000s, when the first global IO table was available, different measures to assess *participation* and *position* of countries along the Global Value Chains have been built (see Hummels et al. (2001) and Koopman et al. (2014)). It is well documented that countries´ involvement in GVCs was steadily expanding since the 1990s up to the Great Recession, when their expansion stalled. According to ECB calculations, the foreign value added (FVA) embedded in euro area exports, a measure of the *backward* or downstream participation in GVCs, rose from about 15% of gross exports at the onset of the 1990s to around 25% before the global trade collapse, and it remained relatively close to that level in 2016. In this context of higher globalization, a new strand of international trade literature has emerged, analyzing the role of GVCs in the transmission of shocks (such as the global financial crisis in 2008) and their impact for trade, productivity and economic development at country or country-sector level (Huidrom et al. (2019), and ECB-WorkingGroup (2019)).[5] However, if the globalization process has impacted regions differently, GVCs and IO indicators at national level may hide important disparities at regional level.

So far, while the importance of GVCs and the participation of countries have received a lot of attention by researchers, the analysis at regional level is relatively scarce. Case studies focused on China and Japan (see Meng and Yamano (2017)) show that GVC integration varies widely across regions, with some regions providing inputs mainly to attend the domestic demand, but other regions export indirectly providing inputs to direct exporting regions. In fact, even if a domestic region is not engaged in much direct trade with foreign countries, it can nonetheless be an important supporting player of global production networks by providing parts, components, and intermediate services to more export-oriented regions within the country. For example, if a firm located in a Spanish region supplies a

[4] Acemoglu et al. (2012) and Caliendo et al. (2017) highlight the importance of sectoral and regional linkages to explain the aggregate impact of a productivity shock in the US.

[5] Based on the World Input-Output database (WIOD), 2016 release, the ECB has built several measures of the euro area participation in GVCs, in particular, the valued-added content in exports, which captures the domestic content of exports. The foreign value added in euro area exports mentioned in this paragraph has been calculated as the inverted of the domestic content of exports.

German car manufacturer with a component -e.g car seats- and the German firm sells this car to a British consumer, the Spanish region relies on the final demand of UK instead on the German one. Similarly, if the Spanish firm decides to source the textile required to manufacture that seat from China instead from a firm located in other Spanish region, the economic dependence between these two Spanish regions weakens. Ultimately, regional trade linkages, and the fact that materials produced in a region might be used as inputs in others, are key in propagating external and domestic shocks spatially and across sectors. Therefore, typical GVC and IO indicators at country-level may hide important differences at sub-national level.

Research focused on OECD countries also finds a huge variation in regions´ participation in GVCs. They estimate that the value-added produced within GVCs by a region, as a share of total value added, fluctuates by around 10 percentage points across regions within a country, being especially large in the case of Spain (see OECD (2018)). Differences in specialization patterns, as well as, in labour force skills, across Spanish regions and geographical location (inland or coastal region), among other factors, may contribute to explain discrepancies in the degree and pattern of internationalization of each Spanish regions, as well as, in industry supplier-user linkages. On this background, it seems crucial to improve our knowledge of Spanish regions´ involvement in GVCs and of the input-output structure of the national production network at regional level.

Based on the accumulated empirical evidence, the role of GVCs in shaping a region structure production and their economic performance has increased the interest of both economists and politicians in better understanding inter-regional and international trade linkages, as a potential drivers of economic divergences between regions within a country.[6] [7] This interest has also led to the academy to develop a proper theoretic framework. Based on the empirical evidence from Acemoglu et al. (2012) and Acemoglu et al. (2015), that production networks amplify regional-local shocks, Caliendo et al. (2017) for the US and Frohm and Gunnella (2017) for euro area countries build a model that integrates both sectoral and regional linkages.[8] This theoretical framework serves to rationalize the mechanism behind the industry-regional IO multipliers calculated in this paper.

The lack of a publicly available global IO table with regional details explains the existence of only few studies at regional level. Conventional global IO tables only contain information of foreign trade linkages at country level, and data on the regional distribution of trade flows within and across countries were not available, ignoring the regional heterogeneity within the country and, then, limiting their use to study the participation of regions in

[6]Chapter 3:"Global trends and regional links: Jobs, clusters and global value chains" in OECD (2018) finds that higher GVC participation is positively correlated with stronger economic performance at regional level. And, greater integration of regional economies into GVCs is associated with an increase of regional productivity and employment rates (Rusticelli et al. (2017)).

[7]Gains and costs from trade are not equally distributed across different regions of the same country, leading to an increased in regional inequality if mechanism for regions loosing from globalisation are not implemented.

[8]Caliendo et al. (2017) build a quantitative model of the U.S. economy disaggregated across regions and sectors. For this purpose, they develop a static two factor model - labour and a composite factor comprising land and structures- with N regions and J sectors. Labour can freely move across regions and sectors. Land and structures are a fixed endowment of each region but can be used by any sector. A given sector may be either tradable, in which case goods from that sector may be traded at a cost across regions, or non-tradable. Throughout the article, they abstract from international trade and other international economic interactions.

GVCs, as well as, regional production networks.[9] Despite its limitations, it is important to highlight that the global IO table allowed to better understand inter-country linkages through international networks, providing policy makers new insights into the commercial relations between nations.[10]

In recent years, some progress has been made in the construction of global IO tables with regional detail but limited to few countries. For example, Dietzenbacher, Guilhoto and Imori (2013) included Brazilian regions in the WIOD and, similarly, Cherubini and Los. (2012) extended the WIOD to include four Italian NUTS1 regions. Wang et al. (2017) did the same for China and Meng and Yamano (2017) present analytical results based on regional disaggregation of China and Japan. To fill this data gap a new database (EUREGIO) has been built by Los et al. (2018).

The next section includes a short description of the EUREGIO dataset, as well as, the methodology used in this paper to assess trade linkages, both at the national and international level of Spanish regions. Briefly, we use this dataset to compute the output multipliers that take into account the IO sectoral-regional linkages. These calculations rely on the so-called Leontief matrix that will be described next. The approach used to build GVC participation indicators is also briefly described in the following section.

3 Data and methodology

In this section we describe the main characteristics of EUREGIO dataset, the IO table with regional breakdown, as well as, the methodology used to calculate input-output multipliers (that is, the technical coefficients and total requirements at industry-regional level). Following the GVC literature, we compute regional trade flows and decompose gross flows into value added terms. The total requirement coefficients allow to assess how domestic and external demand-supply shocks propagate through Spanish regions. And, regional trade flows in value added, both outflows (that is, trade with other regions within the same country) and exports (that is, trade with other countries), allow to better understand the participation of Spanish regions in domestic and international production networks.

[9]In the absence of a world IO tables with regional details, the WIOD has been used, for example, to assess the impact of an external shock in a specific region within a country. This requires, first, to evaluate the inter-country impact and then to conduct a top-down analysis at the domestic regional level. Nevertheless, this procedure may potentially lead to a biased estimation if the country has domestic regions with differences in terms of regional economic endowments, geographic locations, developmental stages, industrial structures, and foreign dependency. Global IO tables with a regional dimension capture all these interdependences, allowing a more realistic assessment of interregional and international linkages than the one based on gross trade figures, because enable researchers to measure the net value added in each region or country.

[10]In addition to the WIOD, there are others global input-output databases that can be used to identify input-output linkages across countries and sectors and generating standard measures of GVC participation and value-added exports consistent with the literature. Among these databases are the Trade in Value-Added Statistics (TiVA), which covers 64 countries and 36 sectors; WIOD 2016 release, which covers 43 countries and 56 sectors; and the EORA MRIO database, which provides data on input-output linkages for 190 countries and 26 sectors. For a detailed review of global input-output tables developments look at the Global Trade Analysis Project, https://www.gtap.agecon.purdue.edu/databases/default.asp.

3.1 The database: EUREGIO

The EUREGIO dataset is constructed using the WIOD 2013 release as a benchmark, in which the EU countries are geographically disaggregated into regions at the NUTS 2 level. The dataset incorporates regional details in global input-output tables relative to the production structure and trade for all major EU countries for the time span 2000 to 2010. It includes 249 regions from 24 European countries and 16 non-EU countries, a rest of the world and 14 industries at NACE REV. 1 classification. This is a unique longitudinal and consistent dataset on trade across EU regions. A detailed description of the construction methodology can be found in Los et al. (2018) and a brief summary of the different steps to construct the dataset can be found in **annex 1**. The results reported in the rest of the paper are based on the year 2010 tables, the most recent data available. Since 2011 no significant changes have been observed in the international fragmentation of production, both across time and across countries, the year 2010 is a good approximation of current GVC links because most of the growth in GVC integration took place before that year.

The EUREGIO dataset is recently being extensively used among researchers to exploit its country-regional dimension to explore a wide variety of issues.[11] For example, it has been employed to analyze the short run effects of Brexit on European regions (see Los et al. (2017) and Los and Chen (2016)) or to better understand voters behavior in Brexit referendum (see Wannicke (2018)). Not only to better understand the regional impact of shock the EUREGIO database is being used, but also in econometric modeling. The EUREGIO database was also central in the European Commission´s regional CGE model (see Mercenier et al. (2016)).

As far as we are aware, this dataset is the first one that provides geographical disaggregation of multiple countries within global input-output tables. Still, it is not free from limitations, associated mostly with some simplification assumptions used in their construction.[12] Basically, the indicators computed using the EUREGIO rely on the the following assumptions: (i) homogeneity in output production technology within each industry;[13] (ii) zero rates of substitution between inputs across industries; (iii) absence of economies of scale; (iv) static framework in which IO linkages do not react to shocks; and (v) absence of capacity constraints. It is important to bear in mind that these assumptions will affect the sectoral and regional multipliers estimated and, therefore, the impact from the simulated shocks, as well as, the computed GVCs indicators.[14]

[11]The structure of the EUREGIO table differs from both a National IO and a global IO. In a country´s national input-output table, the domestic inter-industry relationships are explicitly considered, but imports and exports are treated as exogenous variables. That means that spillover effects from the rest of the world can not be analyzed. A international IO table solves this problem by combining countries´s national IO table and trade statistics. An international database, such as WIOD, contains detailed information of both inter-country (trade data) and inter-industry (national IO tables) linkages. The EUREGIO database adds the regional dimension, including trade between domestic and foreign regions.

[12]Note that the following limitations apply to all IO tables, for more details on this see Izquierdo et al. (2019)and Miller and Blair (2009).

[13]Indicators based on IO database implicitly assume that exporters and non-exporters in a specific industry share the same technology. Bernard et al. (2003) showed that technologies are often quite different (see Tybout (2008) for an overview articles). One of the reasons for this is that differences between exporters and non-exporters are not confined to input requirements per unit of output, but also relate to prices paid for production factors, affecting *Leontief* coefficients.

[14]One way to reduce the bias introduce for some of these assumptions would be to include more industry detail in the EUREGIO table, since indicators derived from relatively aggregated tables tend to be affected by aggregation bias, see Miller and Blair (2009).

Despite the previous drawbacks, the EUREGIO keeps clear advantages compared to the official trade statistics. We highlight the following: (i) it includes inter-regional gross trade, which is usually not included in official sources (such as, customs data on foreign trade) and (ii) trade in value added can be computed, both for inter-regional (outflows and inflows) and foreign trade (exports and imports).[15]

Prior to any calculation, we made some quality checks to assess to what extent the EUREGIO database offers a right picture of the Spanish regions. Basically, we compare the main variables in the database with official statistics (see **figure 2**). Overall, data related to Spanish regions fit relatively well the official data in terms of value added (**Panel A**) and sectoral breakdown into agriculture, industry, construction, market and non-market services (**Panel B**). As regards exports (**Panel C**) and inter-regional flows (**Panel D**), the official data only provides information on trade in goods, therefore we expect EUREGIO flows to be above the ones reported by official sources. Overall, the fit seems quite reasonable, notwithstanding, there is one exception, that is Catalonia as official data points to higher trade flows.

3.2 Methodology

The IO table provides information about the economic transactions that each sector made by buying or selling inputs from/to other sectors located in other regions within the same country or in different countries. In an IO framework the structure of an economy is characterized by the trade flows across sectors. The world input-output table with regional dimension provides information about the user-supplier linkages along the value chain like those depicted in **figure 1**. In some cases, intermediate inputs purchased from industries in the region itself may be much more important in value terms than imported intermediate inputs. There are differences across industries and regions that affect the way each region participates in the production chain, as well as, the way contributes to the aggregate impact of a specific shock.

A stylized version of a multi-regional and a multi-country IO table is represented in **table 1**. It describes a world consisting of two countries (A and B) plus an aggregate of countries labeled the Rest of the World (RoW). A and B both consist of two regions (A1 and A2 and B1 and B2, respectively) and the economy of each of these regions and RoW is divided into two industries (I1 and I2). Z is a $(RI \times RI)$ matrix that contains the amount of sales of intermediate products by each industry in the rows to the industries in the columns (expressed in a common currency, Euros in our paper). R stands for the number of regions and I for the number of industries.[16] Matrix Y accounts for a $(RI \times RD)$ matrix that contains the values of sales by each region-industry pair for each final use

[15] In this paper, we classify each transaction according the first final destination when it crosses the border: as outflows (exports) those flows that have as a first destination other Spanish regions independently if these flows are finally absorbed in that region (country) or crosses the regional (national) border again once they have been transformed or assembled. For example, if a good exported from Madrid to Germany (gross export) is then exported by Germany to Catalonia for final absorption there, it is classified initially as an export from Madrid to Germany and not an outflows of Madrid to Catalonia. Nevertheless, the EUREGIO database allows to follow each flow until the region or country where is finally absorbed and, therefore, to properly measure where the final demand comes from, as well as, the value added along the production chain.

[16] In the simplified **table 1** R is equal to 5 regions and I equal to 2 industries. Note that the above mentioned limitations apply to all IO tables.

purpose. D accounts for the number of final demand components (that its, private and public consumption, investment and changes in inventories). For simplicity, we collapse all the demand components into one, so it results in a vector y of final demand. Row-wise summation of supplies for intermediate use and for final use gives gross output of each industry in all regions, represented by the last column x ($RI \times 1$). Its values are obtained by summing over the elements in the corresponding rows of the blocks Z and Y. The row vectors $v\acute{}$ comprise information about remuneration for production factors (including labour and profits on physical and intangible capital). These vectors contain the value added by industries in each of the regions and countries. $x\acute{}$ is a row of elements which are obtained by summing over the elements in the corresponding column. Thus, it gives the value of all the inputs used in a production process. Double-entry bookkeeping ensures that the values in the bottom row ($x\acute{}$) are equal to the values in the rightmost column (x).

We can use matrix notation to represent IO inter-linkages. From the market clearing assumption we get the following identity, gross output (X) equals intermediate goods (Z) and final goods (Y) sold:

$$X = Z + Y \tag{1}$$

We define A as the matrix of intermediate input required per unit of output. This is obtained as $A = Z/X$, and has the same dimension as matrix Z ($RI \times RI$). Matrix A is the direct requirement matrix or the technical coefficient matrix per unit of production. Intuitively, any element in matrix A, a_{ij}, captures the importance of an specific industry (for example j) as a direct supplier for any industry (for example i), proxied by the cost share of intermediate inputs using to produce a unit of output. In other words, a_{ij} measures the Euros required by industry i from industry j ($p_j x_{ij}$) for producing one Euro of output ($p_i y_i$), that is, a_{ij}=$(p_j x_{ij})/(p_i y_i)$. A gives a quantitative description of the global production network. This is not only determined by technology, but also by interregional and international sectoral linkages.

However, industry i requirements from industry j are not restricted to those captured by a_{ij}, because industry i also uses inputs from e.g. industry k, which at the same time requires inputs from industry j. This indirect input requirements, as well as, the direct ones, are captured by the so-called *Leontief* matrix (B). Substituting in **equation 1** and after some re-arrangements we get to the well-known expression:

$$X = (I - A)^{-1} Y = BY \tag{2}$$

Under the described IO framework, each cell in the *Leontief* ($RI \times RI$) matrix provides information about the importance of a given industry (in a Spanish region or in a foreign one) as a direct and indirect input-supplier to any other industry within the same country or in the rest of the world. For example, we can assess if a specific industry in Madrid relies more on domestic (within the Madrid region), on other Spanish regions or on foreign input-suppliers.

3.2.1 Calculation of multipliers

The described *Leontief* matrix can be used to characterize how sector-specific shocks propagate to the rest of the economy through IO linkages and to evaluate their aggregate impact on economic performance. Based on these matrices we can compute IO multipliers that summarize the aggregate impact that can be expected from a given shock, such as a one-Euro increase in the output of a specific sector. Depending of the nature of the shock that leads to this increase, either a demand or a supply shock, its propagation along the production network will be different. A supply shock propagates *downstream* (from suppliers to costumers), while a demand shock propagates *upstream* (from costumers to suppliers), this requires to build different multipliers to estimate its aggregate economic impact in any of these cases.[17] In this paper, we will focus on demand shocks (from customer to suppliers) and their aggregate impact on gross output and on value added in Spain. Therefore, we build two multipliers: upstream-output multipliers and upstream-value added multipliers.

In practice, the *upstream* indicators are computed summing the columns of the *Leontief* matrix, properly weighted depending of the outcome. Output multipliers estimate the aggregate increase in gross output, measured in Euros, due to an additional Euro demand of output from industry i. Value added multipliers estimate the aggregate increase in value added (GDP), measured in Euros, per Euro of additional output in industry i. The difference between both multipliers is that, in the second one, each cell in the summing columns has to be weighted by the ratio of value added over gross output in the supplier sector, while in gross output multipliers no weights are required. Therefore, value added multipliers are driven not only by propagation though sectoral linkages but also by the VA-output ratio of the sector.

Actually, by pre-multiplying **equation 2** with the diagonal $\hat{V}$ matrix ($RI \times RI$), that contains the generated value added by unit of output, we obtain the VA vector by region-sector pair:[18]

$$VA = \hat{V}X = \hat{V}BY \tag{3}$$

Intuitively, we subtract from the output multiplier the part of the gross increase in each sector that is devoted to purchase intermediate inputs from the same industry or other industries. Similarly to gross output upstream multipliers, we can compute value added upstream multipliers by summing up the columns of the matrix $\hat{V}B$.[19] By definition, the sum of each column equals to one. When an extra Euro of demand for industry i is injected into the economy, total additional income, as measured by value-added changes in all sectors, increases exactly by one Euro (see Sancho (2018)).[20]

[17]Note that the differences between value added and output multipliers can only be explained by the value added to output ratios used when adding-up the requirement from all the other industries (i.e. the corresponding terms of the *Leontief* matrix) because these requirements are the same in both types of multipliers. Therefore, a change in the ranking of output and value added multipliers must be due to industries that have large value added to output ratios and/or require inputs from industries with large value added to output ratios.

[18]Any diagonal element of the $\hat{V}$ matrix is obtained by subtracting all the intermediate inputs either from the same industry or from other industries required for producing a unit of output. For region s, this element is given by $v_s = u(I - \sum_r A_{rs})$, where the (1×RI)$vector u represents the unit row vector.$

[19]In short, value added multipliers are computed as the product of a vector of ratios of value added to total output, i.e. $v_{si} = VA_{si}/X_{si}$ and the matrix B capturing direct and indirect production interdependencies, while output multipliers are obtained by summing up the columns of the matrix B.

[20]This makes perfect sense since in a static model with no technical progress there cannot be endogenous growth. Value injected in i is exactly equal to value created (i.e. 1 Euro) in the economy although its

In our regional extended IO framework we use these indicator to estimate the aggregate upstream impact that can be expected from a one-Euro increase in the output of a given sector in a Spanish region or in the rest of the world. For technical details of how the *Leontief* matrix is calculated in a global IO table with regional extension see Chen et al. (2018) and Bentivogli et al. (2018).

3.2.2 Decomposition of regional gross trade flows into Value Added

Apart from computing the above described multipliers, that are useful to assess across sectors spillovers, the IO framework can be used to obtain quantitative indicators of GVC participation, by keeping track of the inter-industrial relationship. The global IO table allows to calculate trade flows in value added, complementing the official trade figures measured in gross terms. In this paper, we employed the methodology proposed by Koopman et al. (2014) (KWW) for measuring international trade flows in value added. In an interregional-intercountry framework the KWW approach to decompose gross trade flows has to be adapted to take into account the fact that regions´ trade flows can be directed both to other countries (gross exports) and to other regions within the same country (gross outflows). In this paper, regional flows have been classified as outflows or exports according to the first final destination after leaving the Spanish regions. Based on Meng and Yamano (2017), that introduce interregional trade into the general KWW framework, we decompose each Spanish regions exports and outflows into three components: the Domestic Value Added (from the same region, DVA) embedded in any bilateral gross trade flows, the value added from abroad (other countries, Foreign Value Added, FVA) and from other regions within the same country (the Regional Value Added, RVA) (see **figure 3**). The last two components tell us how much a region´s exports (that is, sales outside the country) or outflows (that is, sales to other regions in the same country) depend on intermediate inputs and services from other countries -imports- or from other regions within the same country -inflows-. These indicators provide information about the degree of integration of a region in domestic or international networks and, to some extent, allow to assess their participation in GVCs.[21] If these indicators differ across regions, the sub-national dimension become key in explaining the aggregate and regional effects of supply and demand shocks.

As an example, we present the equations for the bilateral flows connecting a source region s and a recipient region r (gross trade outflows O_{sr} or gross exports E_{sr}) and derive separately the domestic value added ($DVA = VA_{ss}$), the value added created in other regions within the country ($RVA = VA_{js}$), and the foreign value added ($FVA = VA_{fs}$).[22] In this

sectoral distribution will be unequally distributed.

[21] Paraphrasing Koopman et al. (2014) pag 10: "Intuitively, there are at least two reasons for a country´s exports of value added to be smaller than its gross exports to the rest of the world. First, the production for its exports may contain foreign value added or imported intermediate goods. Second, part of the domestic value added that is exported may return home after being embodied in the imported foreign goods rather than being absorbed abroad. In other words, exports of value added are a net concept; it has to exclude from the gross exports both foreign value added and the part of domestic value added that is imported back to home". The pure double-counting terms concerns intermediate inputs that cross regional or foreign borders several times.

[22] Bilateral measures of value added in trade are provided in Wang et al. (2013) building upon the original KWW decomposition, Hummels et al. (2001) for their Vertical Specialization (VS) measure and by Johnson and Noguera (2012) for value added absorbed abroad.

decomposition the double counted term is embedded in the three components.[23]

$$Gross\_trade\_flows_{sr} = DVA_{ss} + RVA_{js} + FVA_{fs}, j \neq s \tag{4}$$

These three components can be obtained from the previous Value Added matrix, fixing zeros in the required cells in the $\hat{V}$ matrix in equation **equation 3**. As the DVA_{ss} component is concerned:

$$DVA_{ss} = v_s B e_{sr} \tag{5}$$

where e_{sr} is a vector that contains the trade flows from the source region s to the recipient region r and v_s is the vector of value added coefficients of region s, that is the value added created per unit of gross output in region s. This $(1 \times RI)$ vector contains the value-added coefficients for each industry in region s and zeros otherwise. Basically, the DVA_{ss} picks the on-diagonal block in the *Leontief* inverse (B) for region s. A similar approach is followed to get the other two components RVA_{js} and FVA_{fs}, that takes the appropriate off-diagonal blocks of matrix (B) for region s. A detailed description of how obtain the KWW breakdown of gross trade flows from IO tables is found in Amador et al. (2015) and in Bentivogli et al. (2018). Note that this breakdown bridges with the literature on GVCs that uses the blocks of the inverse of the *Leontief* matrix to develop measures on GVC participation, either *backward* (e.g. imported inputs used to produce exported goods) or *forward* (e.g. exported inputs incorporated in other countries exports), position among others.

In the next section, we describe the main results obtained from implementing the previous methodology by using the EUREGIO database.

4 Spanish regions within and between cross country linkages: Main stylised facts

The EUREGIO dataset will be used to estimate region-specific IO multipliers, which allow to study how sector-specific shocks propagate through the Spanish economy and impact the aggregate output, as well as, to compute flows in value added useful to assess a Spanish region integration in production networks, at regional or international level -GVCs-.

[23]Double counting arises when an intermediate input crosses the same border more than once. This includes the domestic content that returns home embodied in imports or inflows, as well as, the part of the FVA and the RVA that crosses the region border several times and is a source of multiple counting in official trade statistics. This component of gross exports is greater in countries which play a prominent role in the supply-chain trade of their regions, which lead to greater back and forth trade in intermediates recorded in official gross statistic. According to the available estimates at country level (see Solaz (2018)), the "double-counted intermediate exports produced at home" term accounted about 0.2% of total Spanish gross exports in 2010, and this share has remained relatively stable between 1995 and 2011. By contrast, the "double-counted intermediate exports produced abroad" has increased its weight on total exports along that period, from 3.6% in 1995 to 7.0% in 2011, but still hardly accounted about a 24% of the total FVA. Bentivogli et al. (2018) provide some evidence at regional level, they estimate that for Italian regions the double counting term in gross exports and outflows is low and quite homogeneous across regions.

4.1 Domestic and international input-output linkages

4.1.1 Direct requirements

Regional inter-sectoral linkages are crucial to understand how (domestic or foreign) demand and supply shocks propagate across sectors and regions. **Figure 4** depicts the graphical representation of the direct requirement matrices A, that is, the technical coefficients, computed from the EUREGIO database for selected Spanish regions: Madrid, Catalonia, Canary Islands and the Basque Country. We choose these regions because they differ in features, such as sectoral specialization or geographic location, that may explain differences in the way a given shock impact each region and the country as a whole, as well as, in their participation in GVCs. As it was described in section **3.2.1**, the technical coefficients a_{ij} capture the importance of an specific industry (for example j) as a direct supplier for any industry (for example i). In the above mentioned figure, any node represents the calculated technical coefficient for a recipient-supplier industry pair for selected regions. For example, a recipient sector (the vertical axis) in a specific Spanish region (for example, Madrid) requires to produce one unit of output inputs from a supplier sector (the horizontal axis), that can be located in Spain (for example Catalonia) or in a foreign country (for example, Germany).

Total direct requirements are depicted in the blue panels in **column A**. The darker the color of the node, the stronger the linkage between the supplier and the recipient sector is. White or pale nodes point to a low user-supplier connection between two sectors. The horizontal color bar on the right displays the relationship between the intensity of the color and the technical coefficient values.[24] For example, in Canary Islands, sector ss2-*Mining, quarrying and energy supply* spends about 2 cents Euro on purchases from sector ss5-*Coke, refined petroleum, nuclear fuel, etc.* to produce a Euro of output. The main stylized facts are the following: (i) the strongest linkages are usually within the same sector, that is, the recipient-supplier pair shows the darkest node on the diagonal; (ii) the manufacturing sector uses more inputs from other industries to produce a unit of output than the service sector does; (iii) the service content in manufacturing is high, as indicated by nodes being more intense bellow the 45 degree diagonal; (iv) services are less dependent on intermediate inputs from other industries, as they are more reliant on labor and capital inputs than material inputs; and, finally, (v) among manufacturing, sectors ss5-*Coke, refined petroleum, nuclear fuel and chemicals* and ss8-*Other manufacturing industry* are more frequently used as inputs in other sectors for production.[25]

In columns **B**, **C** and **D** we breakdown the technical coefficients by geographical origin of inputs. Intuitively, these coefficients capture the dependence of industry i from suppliers industries j located in any of the three areas. The red panels account for the inputs provided by industries within the same region and the purple panels the direct requirements from other regions within Spain. Finally, the green panels depict the requirements from abroad, that is, from foreign suppliers. We can observe that, on average, Spanish industries rely more on domestic and other regions inputs than on the imported ones.[26] One

[24] For technical issues, in these charts, sectors numbering are slightly different from the one described in **annex 1**. Sectors ss6&ss7 are named as sector ss6, and, consequently, sector ss7 corresponds to ss8 in the annex and so on. For simplicity, and to keep homogeneity along the paper, in the text, but not in these charts, when a specific sector is mentioned, the numbering of the annex is the reference.

[25] On this background, needless to say, the importance to take into account a larger breakdown at sectoral level than the one used in this paper.

[26] Similarly, Luu et al. (2019) found that internal linkages among domestic sectors are generally much

exception is the energy sector (sector ss5-*Coke, refined petroleum, nuclear fuel, etc.*) where inputs are sourced mainly from foreign countries, in line with the large dependence of the Spanish economy from imported energy. On the opposite side, the construction sector (ss9), as expected, uses intensively Spanish inputs, mainly, domestic ones.

The described pattern is quite similar across the four analyzed regions, although the input-output linkages across the 14 considered sectors seem to be less intensive in the case of Catalonia. In other words, on average, the Catalan industry depends less on other sector inputs than industries in other Spanish regions do. This finding suggests that a decline in the production of a Catalan sector, that is provoked by a decrease in the final demand of Catalan products, is expected to have a lower direct impact on other sectors production compared to a similar shock to the same sector in other regions outside Catalonia. By contrast, the Basque Country´s industry shows the strongest national sectoral linkages, specially within the same region (panel B), reflecting the well developed industrial sector in this area and their coastal location. This finding points at some agglomeration effect in the industrial sector in the Basque Country, where firms have strong linkages with other firms in the same region compared to the ones observed in other Spanish regions.[27] Similarly in Madrid and Canary Islands both domestic and regional dependencies are relevant, although linkages between domestic sectors are less stronger than in the Basque Country. One exception, it seems to be sector ss10-*Distribution*, that uses inputs from other domestic sectors in Canary Islands at a greater extent than in the Basque Country. This partly reflects the fact that in Canary Islands, the tourist sector (a sector closely related to this *ss*11-*Hotels and restaurants*), a crucial economic activity in the region, relies strongly on domestic inputs from the same sector (a dark node). Interestingly, in Madrid input-output networks are particularly strong in the services sector, mainly, in the *business* (ss14), *financial* (ss13) and *non-market services sectors* (ss15)(partly related with its role as capital of Spain but also as headquarter of multinational firms). Finally, Madrid´s and the Basque Country´s industries source services from other regions but also from other countries.[28]

4.1.2 Total requirements

The previous analysis is based on the technical coefficient matrix that only captures the direct requirement from each sector to produce a unit of output in a given sector, that is, the importance of industry j as a direct supplier of industry i. However, with the fragmentation of production across regions and countries, indirect linkages gain relevance. On this background, it is crucial to look also at the so-called inverse *Leontief* matrix, where each element (i, j) measures the importance of industry j as a direct and indirect supplier of industry i. **Figure 5** shows the graphical representation taking into account both direct and indirect requirements.[29] As expected, the inclusion of indirect linkages across sectors leads to an increase in the intensity of the nodes in comparison with **Figure 4**, where

denser than the external linkages with sectors in different countries.

[27] Ramos and Moral-Benito (2018), using a unique administrative dataset of Spanish exporters to document the existence of exporters´ geographical agglomeration by export destination, find that firms selling to countries with worse business regulations, a dissimilar language and a different currency tend to cluster significantly more.

[28] In Madrid imported services are broadly spread across sectors while in the Basque Country is mainly used as input by *the energy sector* (ss5) and, to a lesser extent, by *the financial sector* (ss13).

[29] This figure presents the requirement coefficients, that is, the total inputs required to produce one Euro of output. In general terms, the main messages from the technical coefficients remain unchanged, although additional nodes appear in the requirement figures illustrating the indirect linkages.

only direct linkages are represented. These two figures easily illustrate how important is to consider all existing linkages across sectors is when spillover effects from sector-specific shocks are analyzed.

4.1.3 Upstream multipliers and its implications for shock propagation

In **table 2** and **table 3**, **Panel A**, we summarize the total input requirements needed to produce a Euro of output of a specific sector, i.e. the *upstream multiplier*, for selected regions and sectors. An upstream output multiplier is the sum of each column of the *Leontief* matrix for each sector-region pair, allowing quantify the propagation of demand shocks (from consumers to suppliers) along the production chain and their aggregate impact. Total **upstream** output multipliers are reported in column **a**. As calculations are based on the global IO table with regional detail, we can breakdown the total multipliers according to the supplier´s region of origin. The upstream propagation will affect the output in the same region (column **b**), in other regions within Spain (column **c**) and in a foreign country (column **d**). We show the 3 most and the 3 less systemic industries in terms of upstream propagation effects on foreign countries. We follow this criteria because one of the aim of this paper is to investigate Spanish regions linkages with other countries through GVCs and the expected impact from a demand shock (domestic or foreign) that might filter to other countries.

On average, Catalan-sectors record the lowest upstream output multipliers, specially, to other Spanish regions. While the Basque Country, is the region with sectors with larger multipliers, both domestic and regional ones. Looking at region-industry pair multipliers, both ss05-*Coke, refined petroleum, nuclear fuel and chemicals* and ss6&ss7-*Electrical, optical and transport equipment* have the largest output multipliers, but about half of its value filters to foreign countries. For example, the pair ss6&ss7-the Basque Country shows an output multiplier of 3. If there is an exogenous increase in the demand of transport equipment produced in the Basque country Cars by Germany by 1 million euros, this will lead to an increase in the production of that industry-region production to meet this increase in demand. Thus, the rise in production requires additional inputs from industries located in the Basque country, from other Spanish regions and from other countries. The upstream propagation would result in a final increase of 1.60 million of euros of total output in the Basque Country, 0.58 million of euros in other Spanish regions output and 0.83 million euros of output in other countries.[30]

As regard services, output multipliers are lower, but usually this reflects higher linkages across the domestic networks than manufacturing sectors do. Here the domestic multipliers are much more larger than the foreign ones.[31]

In tables **table 4** to **table 7**, the upstream multipliers for the 14 sectors and the 4 analyzed regions are presented in **Panels A**. Turning to total output multipliers, the highest value usually corresponds to sector ss9-*Construction* (that ranges from 3.17 in the Basque

[30]The output multipliers are affected by a double-counting problem, but they are the ones capturing propagation effects trough out the IO network *per se*. Other multipliers (such as, employment of value added) alleviate this problem but they are driven by other factors apart from the IO structure, as the VA-output ratio of sectors in the VA multiplier.

[31]Madrid seems to have low upstream propagation effects to other industries. This result is not unexpected, providing Madrid production structure is biased to services, in particular, public services, that usually do not rely so much on inputs from other industries.

Country to 2.88 in Canary Island). The largest domestic output multiplier is also showed by sector ss9, followed by sectors ss12-*Transport, storage and communication* and ss6&ss7-*Electrical, optical and transport equipment*. This is quite common across the four analyzed regions. As expected, ss5-*Coke, refined petroleum, nuclear fuel and chemicals* and ss6 &ss7 show the highest foreign output multipliers. However, there is not a clear common pattern across regions in the case of the highest regional multiplier: ss2-*Mining, quarrying and energy supply* in Madrid, ss3-*Food, beverages and tobacco* in the Basque Country, and ss4-*Textiles and leather* and ss6&ss7 in Canary Islands.

To get a sense of the advantage of a global IO as compared to a national one we compute in **column b.1** the domestic multipliers when using the domestic IO table and in **column b.2** the ripple effect when using the global IO table. The ripple effects refers to the impact on domestic activity due to an increase in demand on a specific domestic output which, at the same time, require inputs from these sector by other regions or sector to produce the inputs required by the initially shocked region. The higher the ripple effects in a region, the larger the indirect impact on other sectors output from a demand sector-specific shock. These ripple effects are specially relevant for Madrid and the Basque Country, being almost negligible in other regions.[32]

However, to properly assess the aggregate impact of a regional-sector specific demand shock on Spanish VA (or GDP), not only the above mentioned propagation pattern of the shock is relevant, but also the sector size. The combination of both, input-output linkages and sector size, are embedded in the so-called value added multipliers. These multipliers estimate the aggregate increase in value added -measured in Euros- per Euro additional of output in a sector in a given region.[33]

Similarly, for each region, in tables **table 4** to **table 7**, in **Panels B** we compute the multipliers in value added and decompose it by geographical origin. By construction total value added per unit of production equals to one.[34] As expected, in the 4 selected regions, services sectors rely less on foreign inputs than the manufacturing sectors do. Similarly, ss1-*Agriculture* and ss9-*Construction* show a large fraction of domestic value added. Sector ss6&ss7-*Electrical, optical and transport equipment* and ss8-*Other manufacturing industries* are the industries that require more foreign inputs to produce a unit of output. As regards regional multipliers, again a larger disparity is observed across regions being sectors ss2-*Mining, quarrying and energy supply* in Madrid, ss3-*Food, beverages and tobacco* in The Basque Country and ss4-*Textiles and leather* in Canary Island, the ones showing the highest regional multipliers.

In sum, the propagation through input-output linkages of sector-specific shocks, and their aggregate impact, differs across Spanish regions. An exogenous demand shock that affect the manufacturing sector will generate a larger aggregate impact on total (domestic and foreign) output than a similar shock on services. However, while in the last case spillover

[32]Cross-sector spillovers also depend on the degree to which some sectors purchase inputs from other sectors and on how they bring sectors than do not otherwise trade directly closer to each other, acting as conduction of shocks and causing cascade effects. These sectors are known as "'hub"' in the literature.

[33]The aggregate impact of a sector-specific shock on national GDP will also depend on the VA to output ratio of this sector. For example, a demand shock in a sector that requires relatively little input from other industries may have a large aggregate impact in terms of GDP (of the country) if this sector have a large value added to output ratio. That is the reason why output multipliers are better indicators to capture propagation across sectors.

[34]For more details on this see Koopman et al. (2014) and Miller and Blair (2009).

effects have an effect mainly on Spanish aggregate output, demand shocks on manufacturing also affect foreign aggregate output.

4.2 Trade flows

4.2.1 Gross trade flows

Figure 6 in **panel A** shows each region exports and outflows in goods and services in gross terms in 2010, as a share of total Spanish exports or outflows.[35] As expected Catalonia was the largest exporter, while Madrid was the Spanish region with the highest outflows. Madrid is mainly a provider of intermediate inputs, both to other regions in Spain and also abroad (see **panel B**). Trade flows in Catalonia and in the Basque Country also show a bias toward intermediate inputs, although less pronounced in the case of exports. Interestingly, Canary Islands ships mainly final goods and services to other Spanish regions, while intermediate inputs weigh more in exports.

A sectoral breakdown highlights significant differences in regional trade. Madrid and the Basque country present a lower concentration of outflows across sectors than Catalonia and Canary Islands do. In particular, Catalonia´s sales to other Spanish regions are concentrated in two sectors (ss14-*Real state, renting and business activities* and ss15-*Non-market-services*), that account about 65% of total outflows in 2010. Similarly, in Canary Islands only two sectors (ss11-*Hotels and Restaurants* and ss15-*Non-market-services*) made up near to 51%. Finally, concerning exports, Catalonia and the Basque Country are more oriented toward manufactures, while services have a higher weight in Madrid and Canary Island total exports.

Differences in trade flows partly reflect heterogeneity in regional economic structure, as well as, in its geographic location and its role as a multinational hub or the region where the capital of Spain is located.[36] For example, in Madrid, market-services accounted for about 70% of total region value added in 2010, well above the national average (close to 50%), while in Catalonia and, mainly, in the Basque country the industrial sector made up around 20% and 25% of each region value added compared to 10% in Madrid. By contrast, the non-market service sector largely contributes to the value added in Canary Islands (21% of the total), as well as the market-service sector (60%) compared to the national average.

In **figure 6 panel C** exports and outflows are re-sized in terms of regional value added to better compare across regions. Outflows clearly outweighed exports in all regions, except in Catalonia where both types of flows were quite similar. The share of gross outflows and exports of goods and services over regional value added ranges from 87% of the regional value added for the Basque Country to 66% for Catalonia, compared to the all regions average (79%). In Madrid, this share is clearly above the non-weighted all Spanish regions

[35] In this section, we have modified Catalonia´s gross trade to correct the undervalued bias identified in EUREGIO data for this region. The share of intermediate and final goods and services in total trade flows have been kept in line with EUREGIO original data. Similarly, it is assumed that linkages across sector and geographical areas do not be affected by the re-scale of flows.

[36] In Spain, a highly decentralized country, the role of Madrid as the core of the public administration weakens. For example, in 2016 about 36% of general government expenditure was made by regional governments in Spain.

average (83%) while Canary Islands places bellow (68%). Concerning outflows, the national average on value added is 54%, about 30 percentage points higher than for exports. Madrid and the Basque Country are on the upper side, while Catalonia and Canary Islands are below the all regions average. Inter-regional trade in market services in Madrid and in manufacturing in the Basque Country (here the outflows of oil-derived products are relevant) explain the large weight of regional sales in these two regions. By contrast, the relatively low outflows in the construction sector in Catalonia and in manufacturing in Canary Islands explain the relative low share of outflows compared to the national average. Being Catalonia and the Basque Country, the regions with the highest share of exports over regional VA.

Finally, concerning the degree of external openness (i.e. the share of total gross exports and imports over regional VA (see **figure 6 panel D**), Catalonia is placed at the top (33% of the regions value added), followed by the Basque Country (30% of regional value added) and Madrid (27% of regional value added), and, at the bottom, Canary Islands (20% of regional value added), compared to a non-weighted regional average of 25%. In line with gravity trade, bilateral trade between two countries is proportional to country size, and inversely proportional to distance. Catalonia and the Basque Country -foreign borders- clearly have a above-average degree of trade openness.

In short, gross outflows clearly outweighed exports in all regions, except in Catalonia where both type of flows were quite similar. As expected Catalonia was the largest exporter, while Madrid was the Spanish region with the highest outflows in absolute terms. Being Madrid mainly a provider of intermediate inputs, both in exports and outflows, as well as, Catalonia and the Basque Country, while Canary Islands show a bias towards final goods and services in outflows. A sectoral breakdown highlights significant differences in regional trade. Madrid and the Basque country present a lower concentration of outflows in a few sector than Catalonia and Canary Islands do. Finally, the Basque Country and Madrid are mainly oriented to the regional markets (share of regional sale on VA), while Catalonia present the highest degree of external openness.

4.2.2 Trade in value added

The structure of the EUREGIO dataset allows to decompose a Spanish region´s gross trade flows into value added components by source. We applied the above described KWW gross export decomposition method adapted to take into account the regional dimension embedded in the international IO table. Following KWW, a region´s gross exports and outflows can be broken into three components: the DVA, the FVA and the RVA. The last two components provide useful information about the degree of *backward* participation of Spanish regions in production networks, as well as, the inter-regional or international nature of their dependence on inputs.

The international and interregional fragmentation of production process has led to significant differences between exports and outflows in gross and value added terms. **Figure 7** summarizes the evolution of the three estimated components (DVA, FVA and RVA) in the 19 Spanish regions *exports* (**panel A**) and outflows (**panel B**) since 2000 to 2010.[37] The data confirms that there are large differences in GVC integration across Spanish regions

[37] The EUREGIO database includes data for Ceuta and Melilla, that have been excluded for the analysis due to its small size and the volatility of their trade.

and these differences remained relatively stable over the analyzed period. Looking at the most recent period, the share of DVA in regional gross exports modestly declined between 2007 and 2010, as well as, the FVA content in regional exports. By contrast, an increase in the RVA embedded in regional exports was observed in the same period. Both manufacturing and, to a lesser extent, the service sector, explain these trends. This result may be pointing at the starting of an importing switching process in Spain during the past economic recession. Differences across regions remained large, although regions in the lower percentile increased the share of DVA in their exports along that period- the bottom 25th of regions in terms of the share of DVA in exports increased this ratio-.

As regards *outflows*, the share of DVA grew over the 2000 to 2010 period, and the dispersion across regions declined modestly, but remained large. Similarly to exports, the FVA content of outflows decreased while the RVA increase marginally. Both manufacturing and services sectors drove the above described performance of the FVA and RVA content of regional outflows in that period.

Next, we examine in detail the four selected Spanish regions. **Figure 8**, in **panels A** and **B**, presents the share of DVA embedded in gross exports and in gross outflows in regional VA.[38] This share provides a measure of the overall importance of exports and outflows for the regional economy. The data reveal that there are notable differences across Spanish regions. According to this indicator, Madrid and the Basque Country are the regions that incorporate more DVA in their sales outside the region (61.8% and 60.4% of regional VA, respectively), followed by Catalonia (57.6%) and Canary Islands (49.8%). The aggregate figure hides a different pattern when exports and outflows are considered separately.

As regard *exports*, in Catalonia the share of DVA over regional VA is at the top (25.8%), followed by the Basque Country (18.5%) and with Canary Islands at the bottom (12.8%). A large disparities also emerge in the case of *outflows*, with DVA shares ranging from 45% and 41.9% of regional value added in Madrid and the Basque country, respectively, to 37% in Canary Islands and to 31.8% in Catalonia at the bottom.[39] As it was expected, the DVA in outflows as a share of regional VA is significantly larger than the same share of DVA for exports in all regions, reflecting that, on average, regional linkages are more important than the foreign ones.[40] Finally, the share of FVA outpaces the RVA one, both in exports and outflows, except in Canary Islands, where the share of both RVA and FVA are quite similar, reflecting the sector structure in this area (ss9-*Construction* and ss11−-*Hotels and restaurants* are quite important-). The last finding illustrates the well known high import dependence of the Spanish economy.

The DVA in exports and outflows as a share of regional VA is an indicator of the economic importance of these flows for the economic performance of the region, but not of its degree of participation of GVCs, neither the inter-regional or the international segment of the chain. For example, a region might have a high share of DVA of exports in regional VA

[38] As in the previous section, for Catalonia, the decomposition refers to the modified figures for gross exports and outflows. Here it is assumed that the three components keeps the proportion in total trade flows estimated from the original EUREGIO data no matter the absolute level.

[39] These disparities can be partly explained by the specialization patterns of these regions. Focusing on outflows, in Madrid, the large share of DVA over the regional value added reflects the importance of services in their sales, highlighting that the capital of Spain is located in this region and, therefore, it sells central government services to other Spanish regions. Differently, in the Basque Country, the larger share of DVA it is related with the location of oil refineries in this area, as well as, of strong industrial districts.

[40] This applies to both intermediate and final goods and services.

only because exports account for a large fraction of their output, no matter how much the import (or regional) content of each unit of exports is. In this example, a high share of DVA may not be related with a low participation in GVCs, but the opposite. To overcome this drawbacks, Hummels et al. (2001) proposed to compute a vertical specialization indicator. In that paper vertical specialization was defined as the import content of gross exports, that is, the value of imports needed to produce a country´s exports. The higher this value, the more a country relies on imports to produce its exports and the higher its participation in GVCs is. Domestic value added in exports is the complement of the import content of exports.[41] In our paper, we compute the ratio on exports (and outflows) for the three components: DVA, FVA and RVA. The FVA and RVA ratios can be used to evaluate each regions´s *backward* participation in international and interregional value chains.[42]

Figure 8 presents the share of DVA, of FVA and of RVA on gross regional exports (**panel C**) and on gross outflows (**panel D**). The highest DVA ratio is observed in Catalonia, both for exports (78.6%) and, mainly, for outflows (95.7%). The other three Spanish regions show a quite similar ratios (ranging from 61% to 63% in exports and from 73% to 78.3% in outflows), being the share of the DVA in the Basque Country the lowest (see **Figure 8**, **panel C and D**). According to this measure, Catalonia would be the Spanish region that is less integrated in GVCs. This is mainly explained by the lowest RVA embedded in both exports and outflows, compared to the other four regions, while the FVA is quite similar in case of exports but lower in outflows. The Basque country is the region that employed more intensively foreign inputs, both in exports (23.6%) and outflows (14.4%), closely followed by Madrid (23.4% and 11.4%, respectively), while Canary Islands present the largest share of RVA (17.6% in exports and 12.4% in outflows), followed by the Basque country(15.7% in exports and 12.2% in outflows). To summary, Catalonia is the Spanish region less involved in GVCs, the Basque Country and Madrid the most integrated in the international segment of the value chain, wile the Canary Islands and the Basque Country the most involved in the interregional segment.

Despite its simplicity, the computed vertical specialization indicator has some drawbacks. For example, two regions with similar DVA per euro of exports would have similar vertical specialization indicator regardless of the percentage of exported output (50% or 1%). Second, the indicator values can be biased by construction if regions are strongly specialized in upstream activities. For example, if a region specialized in mining activities with a low import content, would be pointed as a low integrated in value changes, although its exports are used as intermediate inputs in other countries exports. The *forward* participation in GVCs is missing in this previous indicator. Finally, the measure does not devote attention to the geography of value chains. If a Spanish region would mainly import from China and export to the U.S., the region should be considered to participate in truly global value chains, while it would not be the case if it would import from Portugal and export to France.

To solve these drawbacks, Los and Chen (2016) compute a novel GVC participation indicator, that measure the value added by a region to truly global value chains. This GVC Value Added is expressed as a ratio of regional GDP. According to this indicator, in Spain, richer regions like the Basque Country, Navarra, Madrid and Catalonia tend to have slightly

[41] This is the case when the pure-double counting, that is the intermediate input that cross the same border several times, is low, as it seems the case in Spain.

[42] When interpreting the results, it is important to bear in mind that in our decomposition of gross trade flows, the double-counting term is included in both the FVA and the RVA components. These is not necessarily a problem if these double-counting terms are small, like it seems to be the case in EU countries. See Bentivogli et al. (2018) for Italian regions and Solaz (2018) for Spain.

higher GVC participation levels than poor regions like Extremadura and Castilla-La Mancha. In any case, the Spanish regions with the higher index are well below the German and the Italian ones, and quite similar to the French ones.

In short, according to the vertical specialization indicator used in this paper, Catalonia is the Spanish region less involved in GVCs, the Basque Country and Madrid the most integrated in the international segment of the value chain, while the Canary Islands and the Basque Country the most involved in the interregional segment.

5 Case studies

In this section we study the role of regional and global input-output linkages in the transmission of economic disturbances to the Spanish economy and its regions. The nature of this exercise is an accounting exercise and with very strong assumptions. Notwithstanding, it is a useful tool to analyze the propagation of disturbances among Spanish regions taking into account both direct and indirect effects. If these indirect linkages are not taken into account, we could miscalculated the true aggregate impact from a given shock.

To streamline the analysis we will focus in a pair of shocks originating outside the euro area, namely the United States and United Kingdom, which are also interesting cases to consider given the current conjuncture and their relevance as main trading partners of the euro area. More specifically, we use the input-output framework to estimate the short-term economic impact of two demand shocks and how they propagate *upstream* (from clients to supplier): [A] a decline in US final demand driven by an increase in US tariffs to imports, [B] a similar decline in final demand in UK as a consequence of the Brexit. Finally, we trace out the effect of a similar sector-specific demand shock in two Spanish regions. We focus on shocks on demand for goods or services by region of completion, that is on final goods as Timmer et al. (2015).

5.1 A decline in US final demand

The uncertainty surrounding the announcement of the US to increase tariffs on some EU imports has raised the interest to evaluate the economic impact of that increase. Although the direct commercial exposure of Spain to US is very low, input and output linkages may be hiding a larger negative effect than the one suggested by the official statistics. According to the TiVA database, Spanish exports of goods and services to the US amounted about 7% of total Spanish gross exports, accounting the DVA about 75% of gross exports in 2015 (the last available data). These figures point to a low impact on Spanish exports at aggregate level, although there might be significant differences across sectors and across regions.

Under the assumption that the structure of value chains remained similar to what they were in 2010, the EUREGIO input-output table allows us to estimate the direct and indirect impact on regional GDP of a 10% (y-o-y) contraction in the US final demand.[43]

[43]For simplicity, and following Huidrom et al. (2019), in this exercise we assume that a 10% increase in tariffs on imports of a certain good implies a declines in demand for that good by 8 percent. It is important to mention that these elasticities differ across countries when specific product characteristics are take into

This decline in US final demand will lead to a decline in production to meet such demand. The first two columns (A and B) in **table 8** present the impact of a 10% decline in US final demand on gross output -over value added- and on value added for Spain and all its regions. We assume that US demand will keep the proportionality, that is it will reduce its structure of consumption. A decline in US final demand of this size will lead to an fall in output of the Spanish Economy of -0.65% in gross terms and by -0.27% in value added. We observe that there is substantial heterogeneity among Spanish regions. Looking at the gross output, the Basque Country, Murcia and Navarre are the regions more negatively affected by the demand shock in US, while Andalusia, Catalonia and Valencian Community the least ones. However, when the shock is considered in value added terms, that is, excluding the intermediate inputs, the previous rank suffers some changes, being the Basque Country and Madrid the most negatively impacted by the contraction in the US final demand, while Andalusia and Canary Islands are the least ones.

It is also interesting to identify which sectors explain the previous findings. To this aim **table 9** presents the sector-region/country pairs that would be more affected by a decline in the US final demand. **Panel A** ranks the top 10 sector-country pairs most exposed to this decrease, while **panel B** does the same only taking into account the Spanish regions. As expected, US sectors are the most affected by a decline in the US final demand, being services sectors in the highest positions, reflecting the large share of services in GDP in developed economies. Concerning Spanish regions, **panel B** shows that Madrid and Catalonia are the most affected regions. Sector ss14-*Real state, renting and business activities* drives the decline in Madrid and ss8-*Other manufacturing* in Catalonia. Valencian Community, Andalusia and the Basque Country are the following regions in the rank, being the decline lead by the above mentioned two sectors.

This result comes from a simple accounting exercise, but it captures all the *spillover* effects to other sectors in other Spanish regions and in other countries, and gives an idea about the short term economic impact causes by a decline in US final demand following a rise in US tariffs on EU products.[44]

5.2 A decline in UK final demand

Since the UK decided to leave the EU in June 2016, a lot of uncertainty still persists about the deal that will rule the new relationship between UK and the EU in the near future. Whatever agreement might be reached, an asymmetric impact is expected across EU countries and regions within each country. The available evidence about the impact of Brexit on regions in the EU is relatively scarce. Here we use the EUREGIO to assess the exposure of Spanish regions to Brexit. As in the preceding example we use the EUREGIO database to simulate the impact of a 10% decline in final demand by the UK regions, assuming, as previously, that this decline keeps the proportionality in terms of sectors and regions. This decline leads to a fall of 0.15% in gross output and of 0.08% in value added in the case of Spain.[45] Columns C and D in **table 8** show the decline, in percentage, in both

account. According to the above mentioned elasticities, a rise of import tariffs of 12.5% to EU products (goods and services) would lead to a decline of about 10% in the demand for EU products from the US.

[44] Please bear in mind that this analysis suffers from important limitations, among others, it ignores the reaction of other trading partners that could generate trade diversion effects, as well as, confidence effect affecting negatively global trade.

[45] Bank of Spain has estimated the possible effects on the Spanish economy of the United Kingdom´s withdrawal from the EU (see *Brexit* current situation and outlook, Occasional paper, 2019). According to

the gross output and the VA of each Spanish region following a 10% decline in UK final demand. It is worth to mention that this shock has a more symmetric impact across the Spanish regions than the previous one. The impact oscillates between −0.22% to −0.09% on the regional gross output after the UK negative demand shock against a range between −1.10% to −0.29% in case of a similar shock in US.[46] Concerning the impact on gross output, the Basque Country, Murcia and Madrid are the regions more negatively affected by the demand shock in UK, while Canary Islands, Catalonia and Andalusia the least ones. However, in terms of VA, Madrid, Catalonia and Valencian Community are the regions suffering a larger decline, while Galicia, Castilla Leon and Canary Islands are the less exposed.

Turning to **table 9**, panels A and B present the top 10 most affected sector-region/country pairs across the world and within Spain. The UK regions are the most affected ones. Within Spain, panel B shows that some sectors in Madrid and Catalonia are the most affected by the shock. Sector ss14- *Real state, renting and business activities* and ss12-*Transport, storage and communications* are the most exposed to the UK demand shock. To a lesser extent, other sectors are expected to be negatively affected by the UK final demand decline, such as ss1-*Agriculture* or ss5-*Coke, refined petroleum, nuclear fuel an chemicals*.

As in the previous example, this analysis should be seen as an accounting exercise, that is useful to illustrate which Spanish regions are the most exposed to Brexit. However, as in the previous example, it has some limitations, for example, to what extent consumer and firms in the UK and the EU will react to the future deal are ignored.

5.3 A decline in demand for final goods assembled in Madrid and the Basque Country in a specific sector

Finally, we evaluate the impact on Spanish regions of a sector-specific demand shock that impacts two Spanish regions individually. This example helps to easily illustrate that two similar shocks may have a different impact on other Spanish regions, reflecting disparities in trade and input-output sectoral linkages at domestic, regional and international level. Columns E to H in **table 8** show the estimated impact from a production decline, following a decline in final goods demand, in sector ss6-*Electrical, optical and transport equipment* in Madrid and in the Basque Country. We choose this sector because it presents one of the highest upstream output multipliers in both regions and its relevance in the export sector.

As expected, the largest impact, both in terms of gross output and VA, is observed in the region where the negative demand shock takes place. Nevertheless, the shock propagates and other Spanish regions are negatively affected, specially, when the shock comes from Madrid. Interestingly, while the sector-region pairs most affected by the shock in the Basque Country are sectors within the region or in other Spanish regions, when the shock occurs in Madrid, the most affected sector-region pairs are in other countries (**table 9**). This last finding reflects the importance of the input-output linkages that the Basque Country keeps with other Spanish regions, and the international linkages keeps by Madrid. Apart from the primary sector, in particular, ss2-*Mining, quarrying and energy supply*, illustrating the

the simulations, in the worst scenario, annual average Spanish GDP growth would decline by between 0.1 pp and 0.2 pp.

[46] It is important to have in mind that the US and the UK shocks differ in scale, consequently the size of their impact is not directly comparable.

Spanish dependence on imported energy, a negative demand shock in Madrid would generate negative spillovers effects on sector ss6-*Electrical, optical and transport equipment*, sector ss14-*Real State, renting and business activities* and sector ss10-*Distribution* in US and France. The location of multinationals in Madrid explains this result.

This exercise confirms that changes in production in a given sector (here sector ss6) have an economic impact that extends far beyond this sector´s share in value added. Any shock in Madrid seems to have larger international spillovers than a similar shock in the Basque country, with strong domestic and regional IO linkages.

6 Conclusions

The increasing importance of GVCs as mode of production is well documented at international level and has gained a lot of attention in recent years. However, GVCs can be fragmented and extended not only at the international level -i.e. across countries- but also at the domestic regional level -i.e. within a country-. In this paper we have analyzed the role and participation of Spanish regions in this process of fragmentation in production. Their degree of participation has important implications in terms of propagation of shocks. This analysis has been possible thanks to the availability of EUREGIO, a novel global Input-Output database extended to include EU regions. The database has been an useful tool to better understand linkages between industrial sectors within Spain and with other countries, in particular, in GVCs. This is particularly interesting for Spain where structural differences across regions may drive to divergences in the degree and pattern of participation in GVCs.

In this paper, we first describe each Spanish region input-output linkages with other regions within Spain and with foreign countries. Then we applied an adaptation of the KWW gross export decomposition method, that takes into account the regional dimension, to Spanish regions trade flows, both exports and outflows. This methodology allowed us to better understand how global production is fragmented and extended across Spanish regions and sectors, where the value added are created and where inputs comes from, that is, the same region, other Spanish region or the rest of the world. Then we examine how demand shocks propagate *upstream* along the network chain (through out the domestic, regional and international input-output linkages). And finally, using indicators, commonly employed in the GVCs literature at country level, we assess the participation of Spanish regions in the GVCs process, distinguishing between the domestic and the foreign segment.

The empirical finding confirms there are substantial disparities in the degree of participation in both the domestic -with other Spanish regions- and the international segment-with other countries- of the value chain. We use the regional value added (RVA) and the foreign value added (FVA) embedded in a Spanish regions *exports* and *outflows* as a measure of their involvement in value chain networks. The results suggest that the degree of input-output interconnectedness of some regions -or region-sector pair- are an additional variable to take into account when analyzing the propagation and impact on aggregate economic activity of shocks.

In short, we highlight the main findings from our analysis. First, the strongest user-supplier linkages are usually within the same sector, and, in general, with industries within the same region or other Spanish regions, being the Basque Country the region showing the highest dependence on national inputs and Catalonia, the lowest. Second, the propagation of sector-specific demand shocks through input-output linkages, and their aggregate economic impact, differs across Spanish regions and sectors, showing sectors in the Basque Country the largest output-multipliers. Services present lower total output multipliers than manufacturing. The breakdown of total multipliers according to the input geographical origin confirms that services show a larger domestic multiplier than manufacturing, while these sectors present a higher foreign one. Third, GVC participation (measured as *backward* linkages) varies strongly across Spanish regions, being the Basque Country and Madrid the most integrated in the international segment of the value chain and Canary Islands and the Basque Country the most involved in the inter-regional segment. Finally, a 10% decline in US or UK demand affect Spanish regions differently. And, a similar sector-specific shock (ss6ss7) in Madrid and the Basque Country has a different impact on economic outcome in Spain and abroad. if the shock takes place in the Basque Country, it has the largest impact on sectors within this region or in other Spanish regions, while when the shock occurs in Madrid, the most affected sector-region pairs are in other countries.

Although the findings described in this paper are affected by the strong assumptions implicit in the I-O framework, they allow us to illustrate how heterogeneous the industrial linkages across Spanish regions are, both within Spain and with industries in other countries. Consequently, spillovers from a demand shock in a region may differ completely from a similar shock in other region. Similarly, a foreign shock impacts differently on Spanish regions.

This paper provides some examples on how the EUREGIO database can be used to improve our knowledge of Spanish regions involvement in GVCs, but the database as well as the indicators built in this paper can be used:

1. To better assess the position of Spanish regions in GVCs. The economic benefits that regions get from GVC participation will depend on where they are located along the value chain. *Forward* indicators (that measure if a region inputs are used in other region production process that will be sold to a third region) would complement the *backward* measure described in this paper.

2. To investigate to what extent a different degree of participation in GVC could contribute to explain economic differences across regions in the same country. This analysis adds a new perspective to the discussion on the drivers behind inequality across regions taking into consideration regional heterogeneity in terms of GVC participation.

3. And, also to assess economic policy measures. The European Union's regional Cohesion funds aim at reducing the gap between the most prosperous regions and those lagging behind in terms of per capita GDP. Input-output networks may affect the final impact from EU structural funds on economic variables.

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Annex I

EUREGIO: The construction of a global I-O database with regional detail for Europe for 2000-2010

The methodology used to build the EUREGIO is described in Los et al. (2018). EUREGIO is the first time-series (annual, 2000-2010) of global IO tables with regional detail for the entire large trading bloc of the European Union. This database allows for regional analysis at the level of so-called NUTS2 regions. The EUREGIO tables merge data from WIOD (the 2013 release) with, regional economic accounts, and interregional trade estimates developed by PBL Netherlands Environmental Assessment Agency (PBL/Regional Trade), complemented with survey-based regional input-output data for a limited number of countries. All used data are survey data and only non-behavioral assumptions have been made to estimate the EUREGIO dataset. These two general rules of data construction allows for empirical analysis focused on impacts of changes in behavior (of economies, firms, policies) without endogenously having this behavior embedded already by construction.

The construction of the time series of multi regional NUTS2 input-output tables is based on a top-down approach where national accounts in the format of national supply and use tables have been taken as given. All transactions (in current prices) have been converted to Euro values, using market exchange rates.

The different steps taken to build the EUREGIO database can be summarized as follows:

> [1] **Adjustment of World Input Output Database (WIOD)**. The WIOD international supply and use tables were taken as the starting point of the analysis.[47] The WIOD database (Timmer et al. (2013); Dietzenbacher, Los, Stehrer, Timmer and de Vries (2013)) makes a detailed distinction between final and intermediate goods trade. The supply and use tables provide detailed information on bilateral trade for 40 countries and the rest of the world. The data include 59 product categories, among which services, according to the European Statistical Classification of Products by Activity (CPA) 2002. The data are consistent with countries national accounts. The WIOD international supply and use tables are first adjusted so as: (1) to account for the distribution of the re-exports over (most likely) origin and destination countries; (2) to ensure consistency in bilateral trade flows (i.e., trade matching: exports from i to j equal imports of j from i); and (3) to guarantee that exports and imports of each country add up to their national accounts totals as presented in the WIOD database. Both adjustments have to be done before the regionalization because otherwise inconsistencies would have to be regionalized as well. The regionalization of inconsistencies is theoretically not possible since they do not exists in reality and therefore cannot be based on actual information.
> [2] **Regional information**. Subsequently, information on sector production, investment and income developments from the Eurostat regional accounts was incorporated. After these have been made consistent with the above mentioned national accounts, the data were used to regionalize the national tables. As the outcome of this regionalization procedure, regional supply and use tables for each of the 249 European NUTS2 regions, for 14 sectors and 59 product groups for the years 2000 to

[47] The use the 2013 release instead of the 2016 release which has more up-dated information but it has different accounting rules and classifications which makes the construction of the regional database more complicated.

2010, are obtained. Where available, regional survey based information on supply and use of different sectors was added. In particular, regional supply and/or use tables are available for Scotland and Wales, as well as Italy (five NUTS1 regions), Finland (21 NUTS3 regions) and Spain (15 NUTS2 regions). These tables were added as additional priors to the estimation. Regional trade is taken from the PBL Netherlands Environmental Assessment Agency regional trade data for the year 2000 as a prior to the estimations for 2000-2010.
[3] **Construction of tables**. Taking the regionalized supply and use tables, the PBL regional trade data and the survey based regional supply and use tables as a prior, the EUREGIO supply and use tables are estimated for the years 2000-2010. The estimation approach is based on a constraint non-linear minimization approach that guarantees consistency of the regional tables with the national tables (the WIOD database). This consistency implies that adding up the regionalized supply and use tables results in the corrected national WIOD supply and use tables. The interregional supply and use tables that have trade, matched bilateral trade flows and no re-exports.

Tables 11 and **12** summarize the main data provide by the EUREGIO database at country and at regional level for Spain, respectively.
Concerning the industry classification in 14 economic sectors, these are the following: ss1-Agriculture; ss2-Mining, quarrying and energy supply; ss3-Food, beverages and tobacco; ss4-Textiles and leather; ss5-Coke, refined petroleum, nuclear fuel and chemicals etc.; ss6&ss7-Electrical, optical and transport equipment; ss8-Other manufacturing industry; ss9- Construction; ss10-Distribution; ss11-Hotels and restaurant; ss12-Transport, storage and communications; ss13-Financial intermediation; ss14-Real state, renting and business activities; and, ss15-Non-market services.

Annex II

Spanish regions: some economic features

To better understand how similar shocks could affect Spanish regions differently, it is useful to analyze how some economic variables varies across them. One indication, that regions differs in some local characteristics is that GDP growth rates vary considerably across the 19 CCAA: from an accumulated growth of 1.8% in Asturias over the period 2007-2018 to 20% in Balearic Islands and 18% in Madrid, reflecting the high degree of heterogeneity of regional business cycles within Spain.

Turning to more structural issues, GDP per capita also vary significantly across regions, with Madrid and the Basque Country as the richest regions -with real GDP per capita above 30.000 in 2018- and the regions in the South (Andalusia and Extremadura) the poorest) -with a real GDP per capita below 20.000-.

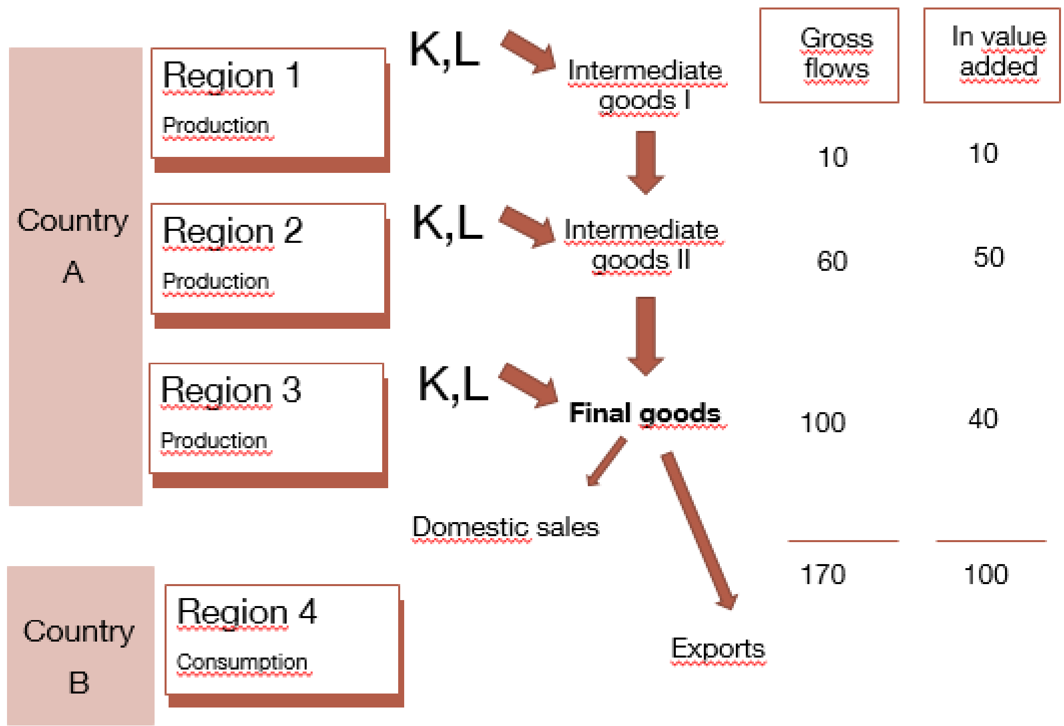
The specialization pattern of economic activity also differs across regions. The geographical concentration of some activities in some regions may reflect differences in regional productivity but also in natural resources or in geographical location. In 2017, agriculture accounts for 3% for Spain as a whole, with Castilla-La Mancha, Extremadura and Andalusia more specialized in relative terms in these activities (9%, 9% and 7% respectively), while at the other end of the spectrum lies Madrid, with less than 0.1% of its production located in primary industries. Almost 20% of Spanish Value Added (VA) is generated in industrial activities including Mining, manufacturing and Energy. The highest specialization is found in the North-East regions (Navarre, the Basque Country and La Rioja), with a share in VA above or close to 30%. Balearic and Canary Islands are the lowest industrialized regions (less than 10% of VA). Non-market services represent almost 20% of GDP in Spain taken as a whole, with a maximum in Extremadura at almost 30% of GDP, and a minimum in Catalonia at about 15%. Market Services in Spain account for more than half of GDP (55% of GDP in 2017), with larger shares in Madrid and the two insular CCAAs (between 66% and 70%), and the lowest in Navarre (20%). Finally, the construction sector contributes around 6% of Spanish GDP, with similar shares across regions. Therefore, the non-market service activity is the sector that show a larger concentration in some regions, while the construction one is the most uniformly distributed industry.[48]

In conclusion, there is a significant degree of heterogeneity among Spanish regions. Differences in the spacial distribution of economic activity for different sectors (for example, the car industry across regions) imply that sectoral shocks of similar magnitude will affect regions differently and, therefore, their aggregate impact will differ as well.

[48] A more detail description of some economic features of Spanish regions can be found in Artola et al. (2018).

7 Figures and tables

Figure 1: A stylized Value Chain



Notes: This diagram illustrates how a regional value chain works. Region 1 produces an intermediate good or service which is sold to Region 2. This is computed as an *outflow*. Region 2 makes use of this intermediate input together with capital and labor to produce an intermediate good or service which is sold to Region 3. This region uses this material input to produce a final good or service which can be either consumed within the same region, sold to another region within Country A or exported to a fourth region outside country A, e.g. to Country B.

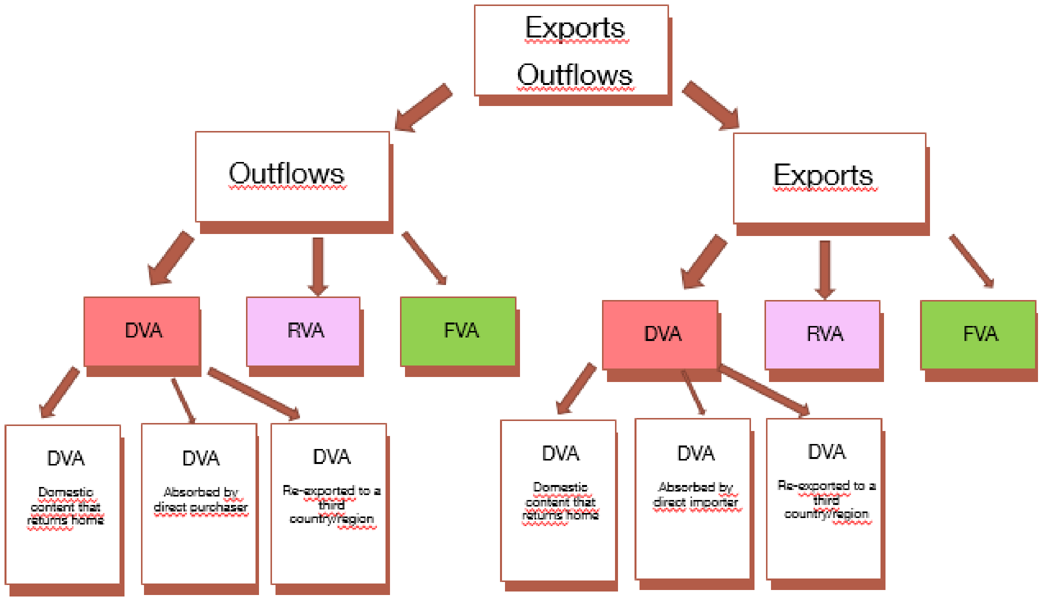
Source: Own elaboration.

Figure 2: Euregio Data Quality Check for 2010

Notes: In these graphs we compare the information on regional value added, outflows and exports according to EUREGIO to national official data. Note that official exports and outflows only refer to goods while EUREGIO accounts for goods and services.

Source: EUREGIO 2018 release, INE, Ministerio de Industria, Comercio y Turismo, C-intereg and own calculations.

Figure 3: Gross Exports and Outflows accounting system



Notes: Decomposition of *exports* and *outflows* into different value added components according to Koopman14.

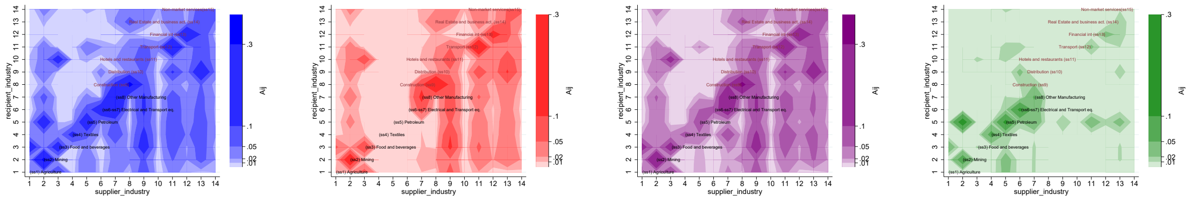
Source: Own elaboration.

Figure 4: Technical coefficients for selected regions in 2010

[A]	[B]	[C]	[D]

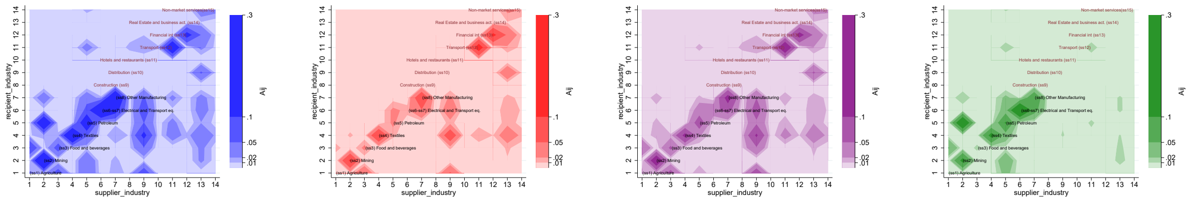
Canary Islands (70)

Total	Domestic	Regional	Imported



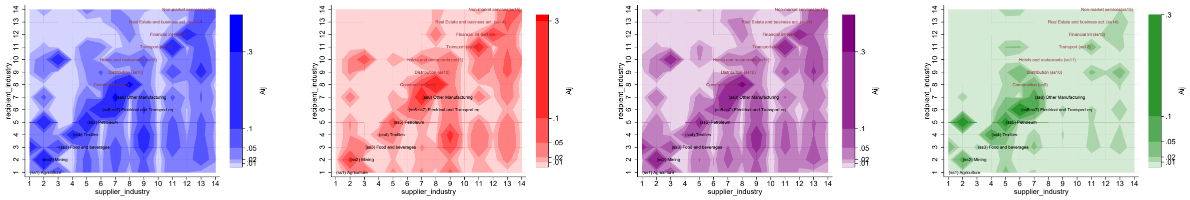
Catalonia (51)

Total	Domestic	Regional	Imported



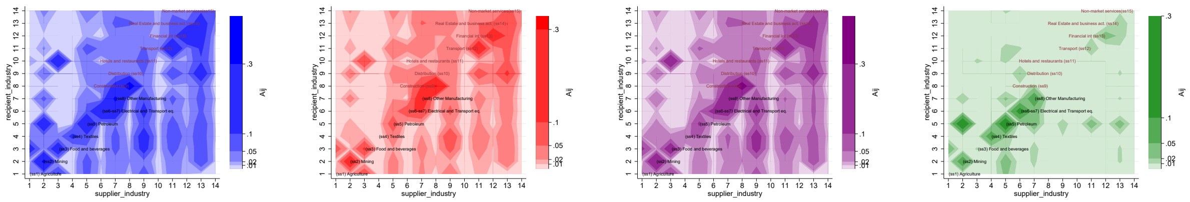
Madrid (30)

Total	Domestic	Regional	Imported



The Basque Country (21)

Total	Domestic	Regional	Imported



Notes: These graphs depict the *technical coefficients*, that is, the direct requirement of inputs by industry i. Element i, j represents the amount of euros spent by industry i in goods or services from industry j as a fraction of gross output in industry i. Total technical coefficients are depicted in the blue panels, while in the red panels are depicted the technical coefficients that originate within the same region. The coefficients from other regions and from abroad are depicted in the purple and green panels respectively. Darker nodes indicate stronger linkages across sectors and regions. A contour plot method is used, showing only those shares greater than 1, 2, 5, 10 and 30 percent. Note that sectors 1 to 14 correspond to ss1 to ss15, sector 6 include ss6 and ss7.

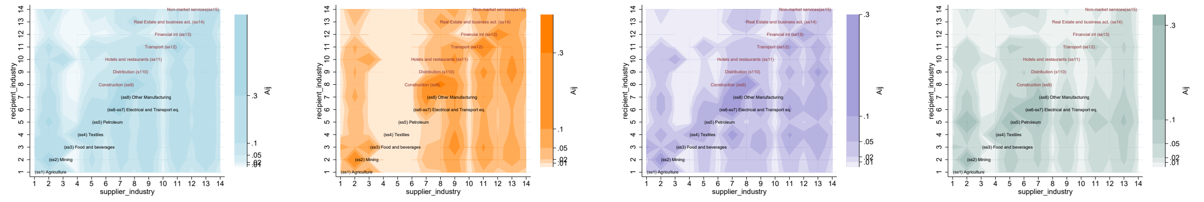
Source: EUREGIO 2018 release and own calculations.

Figure 5: Total input requirements for selected regions in 2010

[A]	[B]	[C]	[D]

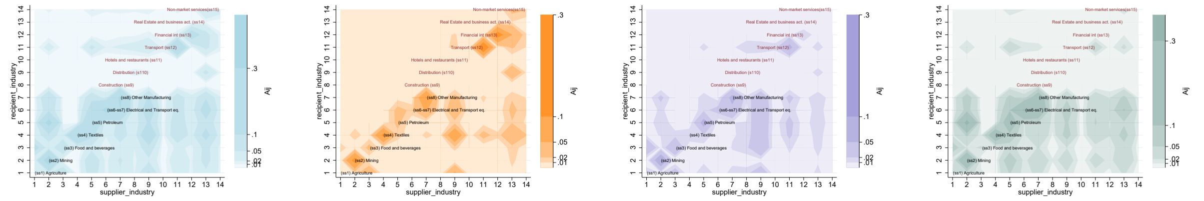
Canary Islands (70)

Total	Domestic	Regional	Imported



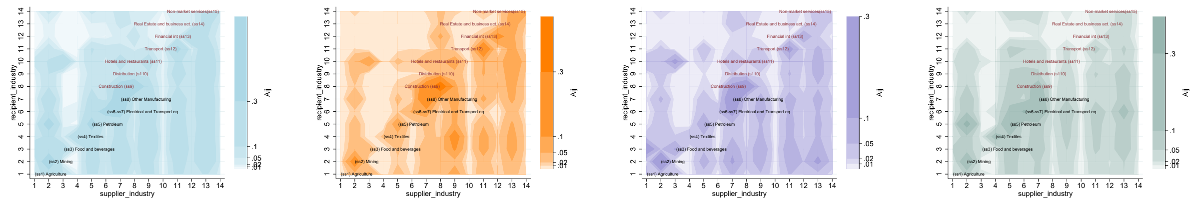
Catalonia (51)

Total	Domestic	Regional	Imported



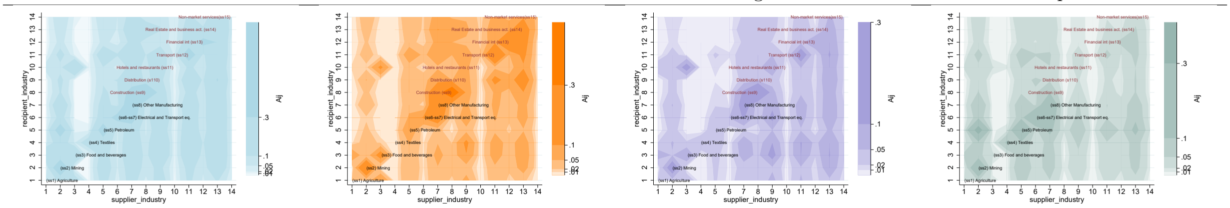
Madrid (30)

Total	Domestic	Regional	Imported



The Basque Country (21)

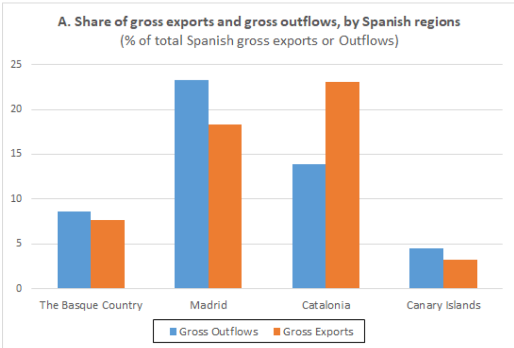
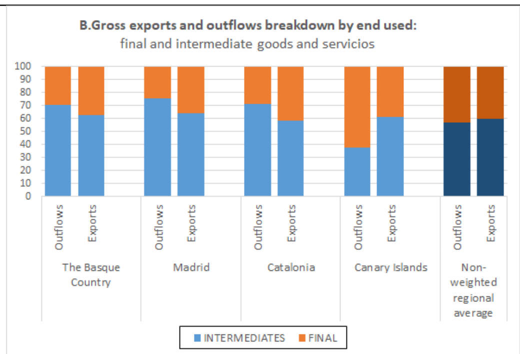
Total	Domestic	Regional	Imported

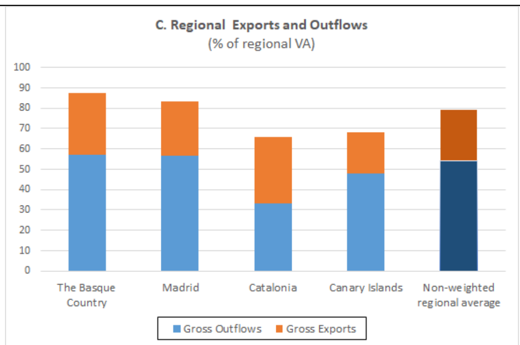
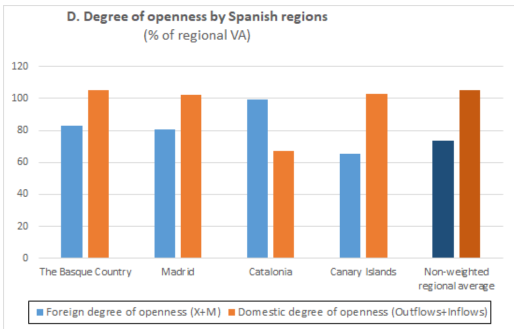


Notes: These figures represent the *total input requirements* of each Spanish region constructed from the EUREGIO input-output tables for 14 industries. A darker shade implies that an industry is used by another at a higher rate that an industry-pair with a lighter color. A contour plot method is used, showing only those shares greater than 1, 2, 5, 10 and 30 percent. Note that sectors 1 to 14 correspond to ss1 to ss15, sector 6 include ss6 and ss7.

Source: EUREGIO 2018 release and own calculations.

Figure 6: Gross Outflows and Exports

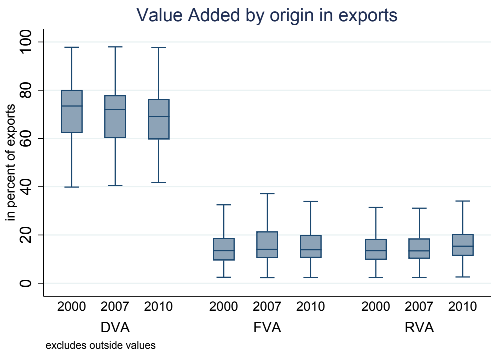
Panel A	Panel B
	

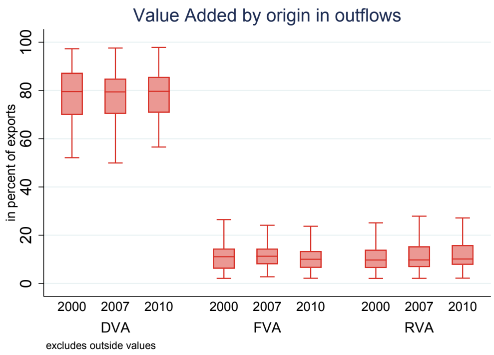
Panel C	Panel D
	

Notes: Main characteristics of trade flows from selected regions.

Source: EUREGIO 2018 release and own calculations.

Figure 7: Value Added by origin embedded in Spanish exports

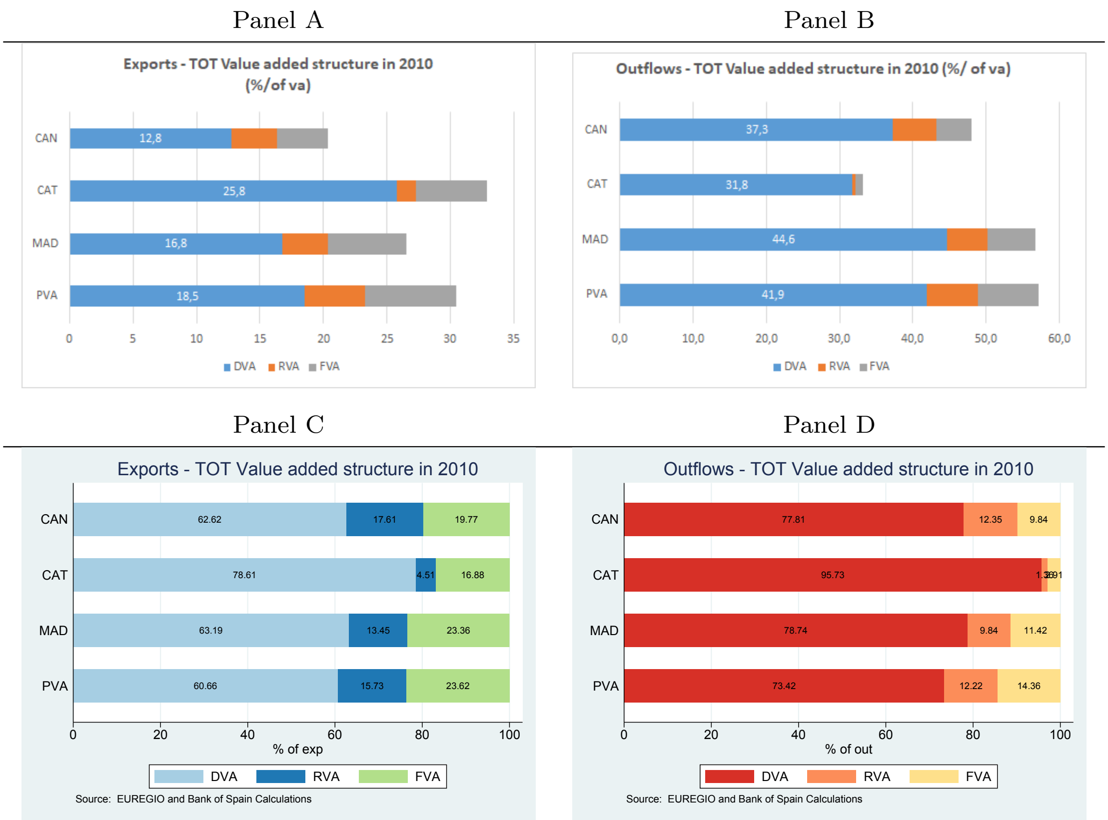




Notes: These figures (box) plot the 25th and the 75th percentile and the median of the different types of Value Added generated per unit of export or outflow by Spanish regions and sectors over time.

Source: EUREGIO 2018 release and own calculations.

Figure 8: Value added decomposition of exports and outflows for selected regions



Notes: In **panel A** we decompose total exports into three Value Added components as a percentage if each regions value added. In **panel B** we decompose outflows. Panels **panel C** and **panel D** show exports and outflows value added components as a share of total exports or outflows respectively.

Source: EUREGIO 2018 release and own calculations based on KWW 14.

Table 1: Stylized representation of euregio Input Output Table

			Country A				Country B				RoW		Country A		Country B		ROW	Gross
s			Reg A1		Reg A2		Reg B1		Reg B2				Reg A1	Reg A2	Reg B1	Reg B2		Output
			I1	I2	I1	I2	I1	I2	I1	I2	I1	I2	FD	FD	FD	FD	FD	
Country A	Reg A1	I1																
		I2																
	Reg A2	I1																
		I2																
Country B	Reg A1$_1$	I1					Z								Y			x
		I2																
	Reg A2	I1																
		I2																
ROW		I1																
		I2																
Value Added							v´											
Gross Output							x´											

Notes: Own elaboration. Where Z is a $RI \times RI$ matrix of inter-industry and inter-region transactions of intermediate consumptions. Y is a $RI \times RD$ matrix of final demands by each region-country. x is the gross output column vector by each sector-region. v' is a row vector with value added for each sector-pair. Note that R is the number of regions, I the number of industries and D the number of final demand components (either consumption or investment). All flows are measured in current Euros.

Table 2: UPSTREAM MULTIPLIERS AND VALUE ADDED DECOMPOSITION BY SECTOR

ES70 - CANARY ISLANDS							
PANEL A: UPSTREAM MULTIPLIERS							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss04	Textiles and leather	2.79	1.37	1.36	0.01	0.85	0.58
ss05	Coke refined petroleum nuclear fuel and chemicals	2.83	1.31	1.31	0.00	0.35	1.17
ss06ss07	Electrical and optical equ. and Transport equ.	3.04	1.40	1.39	0.01	0.85	0.80
ss12	Transport storage and communication	2.57	1.72	1.72	0.00	0.46	0.39
ss13	Financial intermediation	1.71	1.35	1.35	0.00	0.22	0.15
ss14	Real estate renting and business activities	1.75	1.36	1.36	0.00	0.26	0.13
PANEL B: SHARES AND VALUE ADDED MULTIPLIERS							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss04	Textiles and leather	0.1	1.4	1.00	0.40	0.36	0.25
ss05	Coke refined petroleum nuclear fuel and chemicals	0.9	21.1	1.00	0.33	0.15	0.52
ss06ss07	Electrical and optical equ. and Transport equ.	0.4	12.1	1.00	0.34	0.34	0.32
ss12	Transport storage and communication	8.1	10.7	1.00	0.62	0.21	0.17
ss13	Financial intermediation	4.8	2.7	1.00	0.80	0.12	0.08
ss14	Real estate renting and business activities	17.1	9.5	1.00	0.81	0.12	0.06
ES51 - CATALONIA							
PANEL A: UPSTREAM MULTIPLIERS							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss04	Textiles and leather	2.20	1.38	1.37	0.01	0.18	0.64
ss05	Coke refined petroleum nuclear fuel and chemicals	2.12	1.09	1.08	0.01	0.20	0.83
ss06ss07	Electrical and optical equ. and Transport equ.	2.37	1.20	1.19	0.01	0.19	0.99
ss12	Transport storage and communication	1.57	1.23	1.23	0.00	0.17	0.18
ss13	Financial intermediation	1.29	1.22	1.22	0.00	0.04	0.03
ss14	Real estate renting and business activities	1.02	1.02	1.02	0.00	0.00	0.00
PANEL B: SHARES AND VALUE ADDED MULTIPLIERS							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss04	Textiles and leather	1.1	6.0	1.00	0.66	0.07	0.26
ss05	Coke refined petroleum nuclear fuel and chemicals	4.1	20.0	1.00	0.56	0.07	0.37
ss06ss07	Electrical and optical equ. and Transport equ.	2.9	23.1	1.00	0.55	0.07	0.38
ss12	Transport storage and communication	6.8	8.0	1.00	0.86	0.07	0.08
ss13	Financial intermediation	4.8	2.7	1.00	0.97	0.02	0.01
ss14	Real estate renting and business activities	18.9	6.3	1.00	1.00	0.00	0.00

Notes: **Panel A:** Total output multipliers takes into account regional and international feedback effects. Domestic multipliers take into account the output requirements at the region level. We further breakdown this multiplier into the pure local effect and the ripple effects. **Panel B:** We include value added multipliers. Note that as all value added must be either domestic, regional or foreign the sum along each column is unity.

Source: EUREGIO 2018 release and own calculations.

Table 3: Upstream multipliers and Value Added decomposition by sector

ES30 Madrid							
Panel A: Upstream multipliers							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss04	Textiles and leather	2.65	1.46	1.42	0.04	0.47	0.72
ss05	Coke refined petroleum nuclear fuel and chemicals	2.85	1.34	1.31	0.04	0.44	1.06
ss06ss07	Electrical and optical equ. and Transport equ.	3.01	1.29	1.24	0.04	0.51	1.22
ss12	Transport storage and communication	2.10	1.35	1.32	0.03	0.36	0.39
ss13	Financial intermediation	1.61	1.32	1.31	0.01	0.17	0.12
ss14	Real estate renting and business activities	1.42	1.13	1.12	0.01	0.14	0.15
Panel B: Shares and value added multipliers							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss04	Textiles and leather	0.4	4.6	1.00	0.50	0.20	0.31
ss05	Coke refined petroleum nuclear fuel and chemicals	2.3	20.5	1.00	0.34	0.18	0.47
ss06ss07	Electrical and optical equ. and Transport equ.	2.4	23.0	1.00	0.31	0.20	0.49
ss12	Transport storage and communication	10.0	10.2	1.00	0.67	0.16	0.17
ss13	Financial intermediation	4.5	2.3	1.00	0.85	0.09	0.06
ss14	Real estate renting and business activities	23.4	12.4	1.00	0.86	0.07	0.07
ES21 - The Basque Country							
Panel A: Upstream multipliers							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss04	Textiles and leather	2.78	1.49	1.47	0.02	0.67	0.61
ss05	Coke refined petroleum nuclear fuel and chemicals	2.92	1.30	1.29	0.01	0.30	1.32
ss06ss07	Electrical and optical equ. and Transport equ.	3.00	1.60	1.58	0.02	0.58	0.83
ss12	Transport storage and communication	2.79	1.82	1.81	0.01	0.51	0.46
ss13	Financial intermediation	2.35	1.70	1.69	0.01	0.35	0.30
ss14	Real estate renting and business activities	2.28	1.71	1.70	0.01	0.30	0.27
Panel B: Shares and value added multipliers							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss04	Textiles and leather	0.3	3.6	1.00	0.44	0.30	0.26
ss05	Coke refined petroleum nuclear fuel and chemicals	5.5	24.5	1.00	0.27	0.14	0.58
ss06ss07	Electrical and optical equ. and Transport equ.	3.7	22.0	1.00	0.42	0.25	0.33
ss12	Transport storage and communication	7.2	7.8	1.00	0.55	0.25	0.20
ss13	Financial intermediation	4.8	2.5	1.00	0.67	0.19	0.15
ss14	Real estate renting and business activities	18.2	9.2	1.00	0.73	0.15	0.13

Notes: **Panel A:** Total output multipliers takes into account regional and international feedback effects. Domestic multipliers take into account the output requirements at the region level. We further breakdown this multiplier into the pure local effect and the ripple effects. **Panel B:** value added upstream multipliers by geographical breakdown are reported as well as the sector weight in total value added and the weight in total exports. Note that as all value added must be either domestic, regional or foreign the sum along each column is unity.

Source: EUREGIO 2018 release and own calculations.

Table 4: Upstream multipliers and Value Added decomposition by sector: Canarias

Panel A: Upstream multipliers							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss01	Agriculture	1.99	1.34	1.34	0.00	0.32	0.33
ss02	Mining quarrying and energy supply	2.60	1.60	1.60	0.00	0.42	0.57
ss03	Food beverages and tobacco	2.80	1.67	1.66	0.01	0.68	0.45
ss04	Textiles and leather	2.79	1.37	1.36	0.01	0.85	0.58
ss05	Coke refined petroleum nuclear fuel and chemicals	2.83	1.31	1.31	0.00	0.35	1.17
ss06-ss07	Electrical and optical equ. and Transport equ.	3.04	1.40	1.39	0.01	0.85	0.80
ss08	Other manufacturing	2.76	1.55	1.55	0.01	0.72	0.48
ss09	Construction	2.88	1.97	1.97	0.01	0.57	0.34
ss10	Distribution	2.20	1.52	1.52	0.00	0.42	0.25
ss11	Hotels and restaurant	2.26	1.59	1.59	0.00	0.36	0.31
ss12	Transport storage and communication	2.57	1.72	1.72	0.00	0.46	0.39
ss13	Financial intermediation	1.71	1.35	1.35	0.00	0.22	0.15
ss14	Real estate renting and business activities	1.75	1.36	1.36	0.00	0.26	0.13
ss15	Non Market Services	1.85	1.45	1.45	0.00	0.22	0.18
Panel B: Shares and value added multipliers							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss01	Agriculture	1.9	4.1	1.00	0.73	0.13	0.14
ss02	Mining quarrying and energy supply	3.9	2.4	1.00	0.57	0.17	0.26
ss03	Food beverages and tobacco	2.7	12.5	1.00	0.50	0.29	0.20
ss04	Textiles and leather	0.1	1.4	1.00	0.40	0.36	0.25
ss05	Coke refined petroleum nuclear fuel and chemicals	0.9	21.1	1.00	0.33	0.15	0.52
ss06-ss07	Electrical and optical equ. and Transport equ.	0.4	12.1	1.00	0.34	0.34	0.32
ss08	Other manufacturing	3.3	22.1	1.00	0.50	0.30	0.21
ss09	Construction	10.6	0.4	1.00	0.64	0.21	0.15
ss10	Distribution	11.0	0.6	1.00	0.68	0.20	0.11
ss11	Hotels and restaurant	10.7	0.0	1.00	0.72	0.14	0.13
ss12	Transport storage and communication	8.1	10.7	1.00	0.62	0.21	0.17
ss13	Financial intermediation	4.8	2.7	1.00	0.80	0.12	0.08
ss14	Real estate renting and business activities	17.1	9.5	1.00	0.81	0.12	0.06
ss15	Non Market Services	24.7	0.3	1.00	0.81	0.11	0.08

Notes: **Panel A:** Total output multipliers takes into account regional and international feedback effects. Domestic multipliers take into account the output requirements at the region level. We further breakdown this multiplier into the pure local effect and the ripple effects. **Panel B:** value added upstream multipliers by geographical breakdown are reported as well as the sector weight in total value added and the weight in total exports. Note that as all value added must be either domestic, regional or foreign the sum along each column is unity.

Source: EUREGIO 2018 release and own calculations.

Table 5: UPSTREAM MULTIPLIERS AND VALUE ADDED DECOMPOSITION BY SECTOR: CATALUNA

PANEL A: UPSTREAM MULTIPLIERS							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss01	Agriculture	1.56	1.16	1.15	0.00	0.18	0.22
ss02	Mining quarrying and energy supply	1.84	1.16	1.15	0.00	0.14	0.55
ss03	Food beverages and tobacco	1.56	1.08	1.08	0.00	0.22	0.26
ss04	Textiles and leather	2.20	1.38	1.37	0.01	0.18	0.64
ss05	Coke refined petroleum nuclear fuel and chemicals	2.12	1.09	1.08	0.01	0.20	0.83
ss06-ss07	Electrical and optical equ. and Transport equ.	2.37	1.20	1.19	0.01	0.19	0.99
ss08	Other manufacturing	1.94	1.19	1.19	0.01	0.22	0.53
ss09	Construction	1.00	1.00	1.00	0.00	0.00	0.00
ss10	Distribution	1.13	1.07	1.07	0.00	0.04	0.02
ss11	Hotels and restaurant	1.00	1.00	1.00	0.00	0.00	0.00
ss12	Transport storage and communication	1.57	1.23	1.23	0.00	0.17	0.18
ss13	Financial intermediation	1.29	1.22	1.22	0.00	0.04	0.03
ss14	Real estate renting and business activities	1.02	1.02	1.02	0.00	0.00	0.00
ss15	Non Market Services	1.20	1.06	1.06	0.00	0.05	0.08
PANEL B: SHARES AND VALUE ADDED MULTIPLIERS							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss01	Agriculture	1.9	5.7	1.00	0.84	0.07	0.09
ss02	Mining quarrying and energy supply	2.3	0.6	1.00	0.70	0.04	0.25
ss03	Food beverages and tobacco	2.2	3.4	1.00	0.79	0.09	0.12
ss04	Textiles and leather	1.1	6.0	1.00	0.66	0.07	0.26
ss05	Coke refined petroleum nuclear fuel and chemicals	4.1	20.0	1.00	0.56	0.07	0.37
ss06-ss07	Electrical and optical equ. and Transport equ.	2.9	23.1	1.00	0.55	0.07	0.38
ss08	Other manufacturing	6.5	16.7	1.00	0.69	0.08	0.23
ss09	Construction	9.5	0.9	1.00	1.00	0.00	0.00
ss10	Distribution	11.3	3.9	1.00	0.98	0.02	0.01
ss11	Hotels and restaurant	7.5	0.2	1.00	1.00	0.00	0.00
ss12	Transport storage and communication	6.8	8.0	1.00	0.86	0.07	0.08
ss13	Financial intermediation	4.8	2.7	1.00	0.97	0.02	0.01
ss14	Real estate renting and business activities	18.9	6.3	1.00	1.00	0.00	0.00
ss15	Non Market Services	20.2	2.4	1.00	0.94	0.02	0.03

Notes: **Panel A:** Total output multipliers takes into account regional and international feedback effects. Domestic multipliers take into account the output requirements at the region level. We further breakdown this multiplier into the pure local effect and the ripple effects. **Panel B:** value added upstream multipliers by geographical breakdown are reported as well as the sector weight in total value added and the weight in total exports. Note that as all value added must be either domestic, regional or foreign the sum along each column is unity.

Source: EUREGIO 2018 release and own calculations.

Table 6: UPSTREAM MULTIPLIERS AND VALUE ADDED DECOMPOSITION BY SECTOR: PAIS VASCO

PANEL A: UPSTREAM MULTIPLIERS							
sector		Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss01	Agriculture	2.14	1.41	1.40	0.01	0.38	0.35
ss02	Mining quarrying and energy supply	2.65	1.54	1.53	0.01	0.47	0.63
ss03	Food beverages and tobacco	2.94	1.67	1.65	0.02	0.74	0.53
ss04	Textiles and leather	2.78	1.49	1.47	0.02	0.67	0.61
ss05	Coke refined petroleum nuclear fuel and chemicals	2.92	1.30	1.29	0.01	0.30	1.32
ss06-ss07	Electrical and optical equ. and Transport equ.	3.00	1.60	1.58	0.02	0.58	0.83
ss08	Other manufacturing	2.82	1.57	1.56	0.02	0.55	0.69
ss09	Construction	3.17	2.11	2.09	0.02	0.66	0.39
ss10	Distribution	2.33	1.70	1.70	0.01	0.32	0.31
ss11	Hotels and restaurant	2.41	1.49	1.48	0.02	0.55	0.36
ss12	Transport storage and communication	2.79	1.82	1.81	0.01	0.51	0.46
ss13	Financial intermediation	2.35	1.70	1.69	0.01	0.35	0.30
ss14	Real estate renting and business activities	2.28	1.71	1.70	0.01	0.30	0.27
ss15	Non Market Services	2.03	1.52	1.51	0.01	0.26	0.25
PANEL B: SHARES AND VALUE ADDED MULTIPLIERS							
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss01	Agriculture	1.2	3.1	1.00	0.69	0.16	0.15
ss02	Mining quarrying and energy supply	2.2	0.4	1.00	0.50	0.22	0.29
ss03	Food beverages and tobacco	1.6	5.4	1.00	0.44	0.33	0.24
ss04	Textiles and leather	0.3	3.6	1.00	0.44	0.30	0.26
ss05	Coke refined petroleum nuclear fuel and chemicals	5.5	24.5	1.00	0.27	0.14	0.58
ss06-ss07	Electrical and optical equ. and Transport equ.	3.7	22.0	1.00	0.42	0.25	0.33
ss08	Other manufacturing	9.3	20.7	1.00	0.45	0.25	0.30
ss09	Construction	9.3	0.0	1.00	0.58	0.26	0.17
ss10	Distribution	9.9	0.3	1.00	0.70	0.16	0.14
ss11	Hotels and restaurant	6.2	0.0	1.00	0.61	0.24	0.16
ss12	Transport storage and communication	7.2	7.8	1.00	0.55	0.25	0.20
ss13	Financial intermediation	4.8	2.5	1.00	0.67	0.19	0.15
ss14	Real estate renting and business activities	18.2	9.2	1.00	0.73	0.15	0.13
ss15	Non Market Services	20.7	0.3	1.00	0.75	0.13	0.11

Notes: **Panel A:** Total output multipliers takes into account regional and international feedback effects. Domestic multipliers take into account the output requirements at the region level. We further breakdown this multiplier into the pure local effect and the ripple effects. **Panel B:** value added upstream multipliers by geographical breakdown are reported as well as the sector weight in total value added and the weight in total exports. Note that as all value added must be either domestic, regional or foreign the sum along each column is unity.

Source: EUREGIO 2018 release and own calculations.

Table 7: UPSTREAM MULTIPLIERS AND VALUE ADDED DECOMPOSITION BY SECTOR: COMUNIDAD DE MADRID

	PANEL A: UPSTREAM MULTIPLIERS						
	sector	Total	Domestic	local	ripple	Reg	For
		a	b	b1	b2	c	d
ss01	Agriculture	2.21	1.37	1.33	0.03	0.42	0.43
ss02	Mining quarrying and energy supply	2.77	1.38	1.32	0.06	0.85	0.55
ss03	Food beverages and tobacco	2.88	1.46	1.40	0.06	0.79	0.63
ss04	Textiles and leather	2.65	1.46	1.42	0.04	0.47	0.72
ss05	Coke refined petroleum nuclear fuel and chemicals	2.85	1.34	1.31	0.04	0.44	1.06
ss06-ss07	Electrical and optical equ. and Transport equ.	3.01	1.29	1.24	0.04	0.51	1.22
ss08	Other manufacturing	2.82	1.58	1.52	0.05	0.60	0.64
ss09	Construction	2.95	1.89	1.85	0.04	0.51	0.55
ss10	Distribution	2.05	1.30	1.28	0.02	0.27	0.48
ss11	Hotels and restaurant	2.38	1.54	1.51	0.04	0.52	0.32
ss12	Transport storage and communication	2.10	1.35	1.32	0.03	0.36	0.39
ss13	Financial intermediation	1.61	1.32	1.31	0.01	0.17	0.12
ss14	Real estate renting and business activities	1.42	1.13	1.12	0.01	0.14	0.15
ss15	Non Market Services	1.65	1.25	1.23	0.01	0.18	0.22
	PANEL B: SHARES AND VALUE ADDED MULTIPLIERS						
		value added share	export share	Multipliers in value added			
				total	dom	reg	for
ss01	Agriculture	0.2	1.5	1.00	0.64	0.17	0.19
ss02	Mining quarrying and energy supply	2.0	0.9	1.00	0.39	0.36	0.25
ss03	Food beverages and tobacco	0.9	4.2	1.00	0.38	0.34	0.28
ss04	Textiles and leather	0.4	4.6	1.00	0.50	0.20	0.31
ss05	Coke refined petroleum nuclear fuel and chemicals	2.3	20.5	1.00	0.34	0.18	0.47
ss06-ss07	Electrical and optical equ. and Transport equ.	2.4	23.0	1.00	0.31	0.20	0.49
ss08	Other manufacturing	4.2	17.4	1.00	0.48	0.24	0.28
ss09	Construction	9.1	0.0	1.00	0.57	0.19	0.24
ss10	Distribution	11.6	0.6	1.00	0.66	0.13	0.21
ss11	Hotels and restaurant	6.6	0.0	1.00	0.65	0.21	0.14
ss12	Transport storage and communication	10.0	10.2	1.00	0.67	0.16	0.17
ss13	Financial intermediation	4.5	2.3	1.00	0.85	0.09	0.06
ss14	Real estate renting and business activities	23.4	12.4	1.00	0.86	0.07	0.07
ss15	Non Market Services	22.5	2.5	1.00	0.81	0.09	0.10

Notes: **Panel A:** Total output multipliers takes into account regional and international feedback effects. Domestic multipliers take into account the output requirements at the region level. We further breakdown this multiplier into the pure local effect and the ripple effects. **Panel B:** value added upstream multipliers by geographical breakdown are reported as well as the sector weight in total value added and the weight in total exports. Note that as all value added must be either domestic, regional or foreign the sum along each column is unity.

Source: EUREGIO 2018 release and own calculations.

Table 8: Spillover effects on Spanish regions

		USA		GBR		Madrid		Basque Country	
						ss06ss07		ss06ss07	
		[A]		[B]		[C]			
[D]									
ISO	region	GO	VA	GO	VA	GO	VA	GO	VA
	SPAIN	−0.65	−0.27	−0.15	−0.07	−0.08	−0.02	−0.04	−0.01
ES11	GAL	−0.88	−0.27	−0.16	−0.05	−0.04	−0.01	−0.02	−0.00
ES12	AST	−0.81	−0.26	−0.19	−0.06	−0.03	−0.01	−0.01	−0.00
ES13	CTB	−0.78	−0.27	−0.18	−0.06	−0.07	−0.02	−0.02	−0.01
ES21	PVA	−1.10	−0.34	−0.22	−0.07	−0.07	−0.02	−0.51	−0.13
ES22	NAV	−0.91	−0.30	−0.19	−0.07	−0.07	−0.02	−0.03	−0.01
ES23	RIO	−0.80	−0.29	−0.19	−0.07	−0.07	−0.02	−0.02	−0.01
ES24	ARA	−0.85	−0.28	−0.15	−0.06	−0.06	−0.02	−0.03	−0.01
ES30	MAD	−0.80	−0.35	−0.19	−0.08	−0.32	−0.08	−0.03	−0.01
ES41	CYL	−0.73	−0.24	−0.15	−0.05	−0.02	−0.01	−0.01	−0.00
ES42	CLM	−0.78	−0.27	−0.16	−0.06	−0.04	−0.02	−0.02	−0.01
ES43	EXT	−0.87	−0.30	−0.15	−0.06	−0.05	−0.02	−0.02	−0.01
ES51	CAT	−0.43	−0.29	−0.12	−0.08	−0.01	−0.01	−0.01	−0.01
ES52	VAL	−0.43	−0.25	−0.14	−0.08	−0.00	−0.00	−0.00	−0.00
ES53	BAL	−0.70	−0.26	−0.14	−0.06	−0.02	−0.01	−0.01	−0.00
ES61	AND	−0.29	−0.16	−0.09	−0.06	−0.00	−0.00	−0.00	−0.00
ES62	MUR	−0.97	−0.30	−0.20	−0.07	−0.06	−0.02	−0.03	−0.01
ES63	CEU	−0.76	−0.33	−0.13	−0.06	−0.00	−0.00	−0.00	−0.00
ES64	MEL	−0.73	−0.31	−0.13	−0.06	−0.01	−0.00	−0.00	−0.00
ES70	CAN	−0.65	−0.24	−0.12	−0.05	−0.02	−0.01	−0.01	−0.00

Notes: In column [GO] we report the impact on trade in gross output over each region value added, while in column [VA] we report the impact on trade in value added terms over each region value added. In column [A] we report the decline in final demand in USA by 10 percent, in column [B] a decline in final demand in UK by 10 percent. In column [C] a decline in demand from exports in Madrid of final goods assembled in sector ss-6 and ss-7 by 10 percent. Finally, we report the pulling effects from [C] a decline in exports of final goods assembled in the Basque Country in sector ss-6 and ss-7 by 10 percent.

Source: EUREGIO 2018 release and own calculations.

Table 9: Spillover Effects on Sectors and Regions

United States USA	United Kingdom GBR	Madrid MAD	Basque Country PVA
Ranked pulling effects on sector-region pairs			
United States ss15 Non-Market Service	GBR- Inner London ss14 Real estate renting and business activities	Madrid ss6-ss7 Electrical and optical equipment and Transport equipment	Basque Country ss6-ss7 Electrical and optical equipment and Transport equipment
United States ss14 Real estate renting and business activities	GBR-Inner London ss15 Non-Market Services	Madrid ss10 Distribution	Basque Country ss8 Other manufacturing
United States ss-10 Distribution	GBR-Outer London ss15 Non-Market Service	Madrid ss14 Real estate renting and business activities	Basque Country ss10 Distribution
United States ss13 Financial intermediation	GBR-Outer London ss14 Real estate renting and business activities	Rest of the World ss2 Mining quarrying and energy supply	Basque Country ss14 Real estate renting and business activities
United States ss12-Transport storage and communication	GBR- Inner London ss13 Financial intermediation	Madrid ss8 Other manufacturing	Madrid ss14 Real estate renting and business activities
United States ss9 Construction	GBR-Inner London ss10 Distribution	United States ss6-ss7 Electrical and optical equipment and Transport equipment	Madrid ss10 Distribution
United States ss2 Mining quarrying and energy supply	GBR- Berkshire Bucks and Oxfordshire ss14 Real estate renting and business activities	United States ss14 Real estate renting and business activities	Rest of the World ss2 Mining quarrying and energy supply
United States ss11 Hotels and restaurants	GBR Berkshire Bucks and Oxfordshire ss15 Non-Market Services	Catalonia ss14 Real estate renting and business activities	Basque Country ss12 Transport storage and communication

United States USA	United Kingdom GBR	Madrid MAD	Basque Country PVA
Ranked Pulling Effects on Spanish regions-sector pairs			
Madrid ss14 Real estate renting and business activities	Madrid ss12 Transport storage and communication	Madrid ss6-ss7 Electrical and optical equipment and Transport equipment	Basque Country ss6-ss7 Electrical and optical equipment and Transport equipment
Catalonia ss8 Other manufacturing	Catalonia ss12 Transport storage and communication	Madrid ss10 Distribution	Basque Country ss8 Other manufacturing
Catalonia ss14 Real estate renting and business activities	Madrid ss14 Real estate renting and business activities	Madrid ss14 Real estate renting and business activities	Basque Country ss10 Distribution
Madrid ss8 Other manufacturing	Madrid ss15 Non-Market Service	Madrid ss8 Other manufacturing	Basque Country ss14 Real estate renting and business activities
Valencia ss8 Other manufacturing	Catalonia ss5 Coke refined petroleum nuclear fuel and chemicals etc	Catalonia ss14 Real estate renting and business activities	Madrid ss14 Real estate renting and business activities
Andalusia ss8 Other manufacturing	Catalonia ss14 Real estate renting and business activities	Basque Country ss8 Other manufacturing	Madrid ss10 Distribution
Catalonia ss5 Coke refined petroleum nuclear fuel and chemicals etc	Andalusia ss12 Transport storage and communication	Catalonia ss15 Non-Market Services	Basque Country ss12 Transport storage and communication
Basque Country ss14 Real estate renting and business activities	Catalonia ss1 Agriculture	Madrid ss12 Transport storage and communication	Catalonia ss14 Real estate renting and business activities

Notes: In column [A] we report the most affected regions and sectors worldwide due to a decline in production led by a drop in Final Demand in the United States. In column [B] we report the most affected regions and sectors due to a decline in production led by a drop in Final Demand in the United Kingdom by 10.0%. In columns [C] and [D] we report the region-sector pairs due to a decline in production as a result of a decline for final products assembled or produced in Madrid or in the Basque Country regions by 10.0%. For all these scenarios we report the most affected sectors affected within the Spanish economy.

Source: EUREGIO 2018 release and own calculations.

Table 10: Sector analysis

ss06ss07 Electrical and optical equ. and Transport equ.			
Exports			
region	Total	Final	Interm
ESP	52660.9	22207.2	30453.7
Madrid	11064.6	4433.2	6631.4
Catalonia	9511.9	4204.6	5307.3
Andalusia	5516.0	2288.0	3228.0
Comunidad Valenciana	4627.2	1972.8	2654.4
Basque Country	4427.9	2105.9	2322.0
Galicia	3262.6	1330.7	1932.0
Castilla y Leon	3166.3	1249.4	1917.0
Aragon	2333.1	956.4	1376.7
Castilla la Mancha	2149.4	884.6	1264.7
Region de Murcia	1180.8	501.8	679.0
Navarra	1158.5	500.9	657.6
Principado de Asturias	1024.4	438.7	585.7
Canary Islands	1015.2	424.7	590.5
Cantabria	753.7	321.9	431.8
Extremadura	511.8	209.1	302.7
Illes Balears	485.6	195.0	290.6
La Rioja	319.9	145.4	174.6
Ceuta	87.3	25.7	61.5
Melilla	64.8	18.5	46.3
Outflows			
ESP	7312.1	1561.3	5750.7
Madrid	3228.6	333.4	2895.2
Basque Country	1920.5	776.2	1144.3
Aragon	879.0	214.9	664.2
Navarra	595.5	150.4	445.1
Cantabria	263.5	73.1	190.4
Catalonia	248.2	0.5	247.7
Castilla la Mancha	132.6	7.2	125.4
La Rioja	12.1	1.4	10.7
Galicia	11.7	2.1	9.6
Region de Murcia	6.7	0.8	5.9
Extremadura	5.3	0.4	4.9
Ceuta	2.0	0.3	1.7
Andalusia	1.9	0.0	1.9
Comunidad Valenciana	1.9	0.0	1.9
Illes Balears	0.8	0.2	0.6
Melilla	0.7	0.2	0.5
Principado de Asturias	0.5	0.2	0.3
Castilla y Leon	0.3	0.0	0.3
Canary Islands	0.3	0.1	0.2

Notes: This table shows the importance of each region in producing goods in the ss-6 and ss-7 sector that are exported or sold to another region within Spain.

Source: EUREGIO 2018 release and own calculations.

Table 11: Country aggregates in 2010

Euro area

cty_name	Sum				
	va	go	tic	reg sales	exports
Austria (n=9)	272,005.2	544,195.0	272,189.7	78,487.1	135,107.3
Belgium (n=11)	342,538.3	750,745.5	408,207.1	169,728.6	243,331.6
Finland (n=5)	167,049.1	355,402.9	188,353.8	83,837.2	70,385.1
France (n=22)	1,868,691.4	3,554,564.1	1,685,872.7	507,974.1	459,435.6
Germany (n=41)	2,391,414.4	4,589,690.3	2,198,275.9	731,173.9	1,049,814.4
Greece (n=13)	215,742.4	344,081.2	128,338.7	60,248.4	32,319.9
Ireland (n=2)	151,329.0	342,129.8	190,800.8	12,740.4	149,159.4
Italy (n=21)	1,471,822.4	2,997,296.7	1,525,474.3	1,426,744.6	387,846.1
Luxembourg (n=1)	39,337.9	108,520.2	69,182.3	0.0	61,149.5
Malta (n=1)	5,757.4	12,211.1	6,453.6	0.0	3,799.2
Netherlands (n=12)	566,962.9	1,138,926.9	571,964.0	232,288.8	353,268.4
Portugal (n=5)	161,772.8	319,021.4	157,248.6	49,100.9	41,732.5
Spain (n=19)	1,023,564.7	2,049,092.3	1,025,527.6	425,902.0	243,016.7
Total (n=162)	8,677,988.0	17,105,877.3	8,427,889.2	3,778,225.9	3,230,365.6

Eastern europe

cty_name	Sum				
	va	go	tic	reg sales	exports
Bulgaria (n=1)	31,667.8	78,694.5	47,026.7	0.0	16,092.6
Cyprus (n=1)	16,028.7	27,624.7	11,595.9	0.0	3,412.9
Czech Republic (n=8)	140,241.6	362,357.6	222,116.0	62,976.5	103,232.7
Estonia (n=1)	13,280.8	27,875.1	14,594.3	0.0	7,418.9
Hungary (n=7)	91,129.8	208,829.3	117,699.5	29,342.0	73,555.2
Latvia (n=1)	17,207.4	35,557.4	18,350.0	0.0	6,761.8
Lithuania (n=1)	25,611.4	47,383.3	21,771.9	0.0	13,248.4
Poland (n=16)	334,553.4	713,170.9	378,617.4	96,610.6	144,513.4
Roumania (n=1)	117,392.0	236,126.4	118,734.4	0.0	35,391.9
Slovakia (n=4)	64,499.9	146,596.6	82,096.7	18,589.9	42,964.4
Slovenia (n=1)	33,158.9	68,881.0	35,722.0	0.0	17,901.2
Total (n=42)	884,771.7	1,953,096.6	1,068,324.9	207,519.1	464,493.4

Other EU

cty_name	Sum				
	va	go	tic	reg	exp
Sweden (n=8)	327,568.0	660,005.9	332,438.0	107,040.5	160,010.8
United Kingdom (n=37)	1,638,614.6	3,108,163.5	1,469,548.9	846,587.7	465,835.8
Total (n=45)	1,966,182.6	3,768,169.5	1,801,986.9	953,628.2	625,846.6

Asia

cty_name	Sum				
	va	go	tic	reg	exp
China (n=1)	4,519,796.8	13,630,904.3	9,111,107.5	0.0	1,315,143.9
India (n=1)	1,247,301.6	2,415,523.6	1,168,222.0	0.0	232,764.5
Indonesia (n=1)	539,216.8	1,050,883.5	511,666.8	0.0	129,492.2
Japan (n=1)	4,068,705.3	7,853,647.4	3,784,942.2	0.0	630,124.7
Korea (n=1)	741,662.0	1,953,157.3	1,211,495.3	0.0	392,056.1
Taiwan (n=1)	321,010.1	750,107.0	429,096.8	0.0	235,070.6
Total (n=6)	11,437,692.5	27,654,223.1	16,216,530.6	0.0	2,934,652.1

Other

cty_name	Sum				
	va	go	tic	reg	exp
Australia (n=1)	934,559.3	1,851,886.7	917,327.4	0.0	206,482.1
Brazil (n=1)	1,484,974.9	2,675,424.4	1,190,449.5	0.0	175,742.7
Canada (n=1)	1,137,260.5	2,178,709.0	1,041,448.4	0.0	338,899.8
Denmark (n=3)	217,535.9	414,576.1	197,040.2	51,959.8	107,017.2
Mexico (n=1)	769,068.3	1,308,772.8	539,704.5	0.0	215,950.3
Russia (n=1)	1,031,259.0	1,987,703.4	956,444.4	0.0	280,412.8
Turkey (n=1)	520,906.2	997,534.4	476,628.2	0.0	97,612.1
USA (n=1)	11,004,564.5	19,469,039.8	8,464,475.3	0.0	1,232,896.0
Total (n=10)	17,100,128.5	30,883,646.6	13,783,518.0	51,959.8	2,655,012.9

Rest of the world

cty_name	Sum				
	va	tic	go	reg	exp
row (n=1)	8,859,797.8	20,897,387.0	12,037,589.2	0.0	1,137,823.2
Total (n=1)	8,859,797.8	20,897,387.0	12,037,589.2	0.0	1,137,823.2

Notes: In brackets the number of EU regions for which there is detailed regional information. In column [1] value added produced by each country [2] gross output [3] total intermediate consumption [4] sales to other regions withing the country (outflows) and [5] sales abroad (exports).

Source: EUREGIO 2018 release.

Table 12: Spanish Regions

Region	VA	GO	TIC	Outflows			Exports		
				tot	fin	int	tot	fin	int
GAL	56980.5	157874.3	100893.8	24195.2	15598.1	8597.1	14849.9	8993.6	5856.3
AST	23048.7	59667.8	36619.1	10968.6	6887.9	4080.6	5778.6	3565.5	2213.1
CTB	12905.0	31425.5	18520.4	7579.7	4589.1	2990.6	3328.2	2012.7	1315.4
PVA	65922.2	186881.8	120959.6	37650.4	26678.3	10972.1	20105.2	12578.9	7526.3
NAV	18173.1	47007.9	28834.7	12294.2	7750.2	4544.0	4896.3	2975.7	1920.5
RIO	7902.9	19064.8	11161.9	6550.7	4348.0	2202.7	1957.8	1165.1	792.8
ARA	34071.7	87664.8	53593.0	20518.7	12354.2	8164.4	8729.0	5262.2	3466.7
MAD	180784.7	393913.7	213129.0	102541.7	77654.5	24887.3	48020.5	30817.7	17202.8
CYL	55567.0	146206.9	90639.8	21723.4	12260.4	9463.0	14228.9	8403.7	5825.2
CLM	37871.4	96595.1	58723.8	19875.2	12125.3	7749.9	10426.7	6179.9	4246.8
EXT	17184.6	42609.0	25424.4	15938.6	9894.7	6043.9	4049.7	2373.7	1676.0
CAT	184203.7	233661.9	49458.3	47081.4	33481.7	13599.7	41145.5	24038.0	17107.5
VAL	96830.0	130201.0	33371.0	5873.8	1924.6	3949.2	20782.2	12356.9	8425.2
BAL	26123.2	59904.8	33781.5	13081.0	5829.6	7251.4	5473.1	3394.8	2078.3
AND	133867.0	177507.1	43640.0	30419.9	15584.6	14835.4	23394.3	12137.1	11257.2
MUR	28152.3	78524.7	50372.4	28284.6	19224.8	9059.9	6811.6	4067.1	2744.5
CEU	1491.5	2852.7	1361.2	871.8	244.3	627.5	353.0	215.9	137.0
MEL	1326.7	2550.3	1223.7	721.5	292.5	428.9	305.2	188.9	116.3
CAN	41158.5	94978.3	53819.9	19731.7	7465.0	12266.7	8381.1	5164.3	3216.9

Notes: [VA] Value added [GO] Gross Output [TIC] total intermediate consumption. Total exports and total outflows are further breakdown into final an intermediate flows.

Source: EUREGIO 2018 release and own calculations.