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Abstract

We explore the propagation of sector-specific shocks through the Spanish input-output network. First, we outline a theoretical framework borrowed from the networks literature that allows us to distinguish between downstream (from suppliers to customers) and upstream (from customers to suppliers) propagation depending on the nature of the shocks considered, either supply- or demand-driven. Second, we compute industry-specific domestic multipliers and compare the propagation features of the Spanish production network with those of other countries using the National Input-Output Tables (NIOTs) for the year 2014. According to our findings, the electricity sector in Spain is the most systemic industry in terms of its economy-wide impact, which is significantly larger than in other European countries. We also find that the introduction of the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) in the second half of 2018 and its propagation through input-output linkages might have a larger aggregate impact in Germany than in Spain.

Keywords: input-output tables, networks, shock propagation.

JEL classification: F14, F15.

Resumen

Este artículo explora los efectos para el conjunto de la economía que pueden tener perturbaciones en sectores específicos, así como su proceso de transmisión a través de las tablas *input-output* de la economía española, en comparación con otros países europeos. En primer lugar, se plantea un marco teórico que permite distinguir entre la transmisión «aguas abajo» (de proveedores a clientes) y la propagación «aguas arriba» (de clientes a proveedores) según sea el origen de la perturbación de oferta o de demanda. En segundo lugar, se calculan los multiplicadores de cada sector de actividad y se comparan con los de otros países de nuestro entorno sobre la base de las tablas *input-output* nacionales para el año 2014. Según los multiplicadores obtenidos, el sector eléctrico en España sería la industria más sistémica en términos de impacto sobre el conjunto de la economía, que es, a su vez, significativamente mayor que en otros países. Asimismo, el efecto agregado de una perturbación de oferta en el sector del automóvil sería menor en España que en Alemania.

Palabras clave: tablas *input-output*, propagación, redes, sectores.

Códigos JEL: F14, F15.

1 Introduction

The Spanish economy consists of a linked web of industries,[1] each relying on inputs from their supplier sectors to produce their own output that is sold to their customer industries. The input-output structure of this production network is key in determining whether and how industry-specific shocks propagate throughout the economy and shape aggregate outcomes. Therefore, understanding the structure of this input-output (I-O) structure can better inform policymakers on the origins of aggregate fluctuations and on how to prepare for and recover from adverse sector-specific shocks.

This paper explores explores the I-O structure of the Spanish economy in comparison with other countries. More specifically, we first outline a basic model of networks that allows us to explain the differences between downstream multipliers (from supplier industries to customer industries) useful when the shock is supply-driven, and upstream multipliers (from customers to suppliers) for quantifying the impact of demand-driven shocks. We then compute industry-specific multipliers that summarize the aggregate impact that can be expected from a change in a given industry's economic activity. For that purpose, we use the National Input-Output Tables (NIOTs) containing fully homogenized I-O tables for 43 countries and 56 industries in the year 2014.

Our main findings are as follows: (i) the Spanish domestic I-O structure is similar to that of Italy and Portugal; (ii) the most systemic industry in Spain is the electricity sector; (iii) the electricity multipliers for the Spanish economy are much larger than those of other European countries; (iv) the introduction of the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) in September 2018 can account for a non-negligible fraction of the stronger slowdown in Germany than in Spain because automobile industry is more systemic within the German economy.

Nonetheless, it is worth acknowledging from the onset that the multipliers presented in this study crucially rely on the following assumptions: (i) homogeneity of output within each industry; (ii) zero rates of substitution between inputs across industries; (iii) absence of economies of scale; (iv) static framework in which I-O flows do not react to shocks; (v) absence of capacity constraints. Section 3.4 provides an in-depth discussion of these caveats.

The paper is structured as follows. In Section 2 we describe the theoretical framework that allows us to distinguish between downstream and upstream propagation as well as to rationalize the mechanisms behind the industry multipliers in the paper. Section 3 explains the nuts and bolts of our computation of industry-specific multipliers as well as the limitations inherent to those multipliers. Section 4 describes the I-O data and Section 5 presents our main findings in terms of multipliers and how they can be used to assess the economy-wide impact of industry-specific shocks such as those hitting the automobile industry in 2018. Finally, Section 6 provides some concluding considerations.

[1] Throughout the paper we use the terms industry and sector interchangeably.

2 Conceptual framework

In this section, we outline a simple model of production networks borrowed from Carvalho and Tahbaz-Salehi (2018), which is based on previous work by Long and Plosser (1983), Acemoglu et al. (2012), and Acemoglu et al. (2016). This conceptual framework serves to understand the mechanics of both downstream (from suppliers to customers) and upstream (from customers to suppliers) propagation of sector-specific shocks.

The environment is defined by a perfectly competitive economy consisting of n sectors (or industries), each producing a different product under Cobb-Douglas technologies. Moreover, each sector requires for production both labor and the intermediate inputs produced by the other sectors.[2] Turning to the consumption side of the economy, it is characterized by a representative household who supplies labor and has some preferences over the n products.

Formally, the production function in equation (1) and the utility function in equation (2) fully characterize this economy as follows:

$$y_i = e^{z_i} l_i^{\alpha_i^l} \prod_{j=1}^{n} x_{ij}^{a_{ij}} \tag{1}$$

where l_i is the amount of labor hired by firms in industry i, x_{ij} refers to the quantity of good j used for production of good i, and z_i is a Hicks-neutral productivity shock. The assumption that each industry operates under constant returns to scale implies that $\alpha_i^l + \sum_{j=1}^{n} a_{ij} = 1$. $\alpha_i^l > 0$ denotes the share of labor in industry i's production, and the exponents a_{ij} formalize the idea that firms in an industry may need to rely on the goods produced by other industries as intermediate inputs for production. In particular, a larger a_{ij} means that good j is a more important input for the production of good i. Therefore, the notation implies that industry j is the supplier and industry i is the customer, which is crucial for the computation of the different types of multipliers (see section 3 for more details).

Note also that, in general, $a_{ij} \neq a_{ji}$, which is crucial for the differences in upstream and downstream propagation discussed below. Intuitively, industry i's reliance on industry j as an input-supplier is expected to be different from industry j's dependence on i.[3]

$$u(c_1, c_2, ..., c_n, l) = \gamma(l) \prod_{i=1}^{n} c_i^{\beta_i} \tag{2}$$

where $\beta_i \in (0, 1)$ refers to the weight of good i in the utility function with $\sum_{i=1}^{n} \beta_i = 1$, and $\gamma(l)$ is a decreasing (differentiable) function capturing the disutility of labor supply. Note that one can also assume that the representative household supplies labor inelastically with no impact on the predictions below (see Carvalho and Tahbaz-Salehi (2018)).

[2] We abstract from physical capital as an additional factor of production to facilitate the discussion. The main results also hold in the presence of capital input as discussed for instance in Acemoglu et al. (2016).

[3] It may also be the case that $a_{ii} > 0$, as good i may itself be used as an intermediate input for production by firms in industry i.

The equilibrium of this economy is defined as a set of prices and quantities such that the representative household maximizes her utility, the representative firm in each sector maximizes profits, and all markets clear. In particular, households decide labor supply (l) and the consumption bundle $(c_1, ..., c_n)$ by maximizing the utility function in (2) subject to the budget constraint $wl - T = \sum_{i=1}^{n} p_i c_i$ for a given collection of prices $p_1, ..., p_n$ and the wage w. The representative firm in industry i maximizes profits ($\pi_i = p_i y_i - wl_i - \sum_{j=1}^{n} p_j x_{ij}$) and take prices $p_1, ..., p_n$ and the wage w as given.

Rearranging the first order conditions from these optimization problems yields a system of n equations (one for each industry) to solve for all relative prices in terms of productivity shocks (see for instance Carvalho and Tahbaz-Salehi (2018) for more details). Also, the market clearing condition implies that the output produced in each industry should be either used as intermediate input by other sectors or consumed by someone:

$$y_i = \sum_{j=1}^{n} x_{ji} + c_i + G_i \tag{3}$$

We highlight the presence of two different sector-specific shocks. First, supply shocks given by exogenous changes in productivity z_i that affect relative prices (if industry i becomes more productive, its relative price will change). Second, demand shocks given by exogenous changes in the demand of product i and included in the model through the G_i term in the market clearing condition (3). Acemoglu et al. (2016) rationalize this type of demand shocks as sector-specific government consumption shocks in which government purchases G_i are wasted or spent on goods households do not directly care about and financed by lump sum taxes (T) entering the households budget constraint above. Alternatively, one might think in terms of a foreign shock such as an exogenous increase in the demand of Spanish wine from China. These demand-side shocks are used here as a simple way to illustrate the differences between downstream propagation through prices (from suppliers to customers) of supply shocks and upstream propagation through quantities (from customers to suppliers) of demands shocks as we discuss below.

2.1 On the propagation of sector-specific shocks

In order to characterize the propagation of supply and demand shocks above, we consider two alternative exercises. First, we set $G_i = 0 \forall i$ and explore the effect of a productivity/supply shock to sector j (dz_j). Second, we set $z_i = 1 \forall i$ and explore the effect of a demand shock to sector j (dG_j).

The impact on sector i of a productivity shock of sector j is given by (see Proposition 1 in Acemoglu et al. (2016) for a formal proof of this result):

$$d \ln y_i = \underbrace{\sum_{j=1}^{n} h_{ij} dz_j}_{\text{total effect}} = \underbrace{dz_j}_{\text{direct effect}} + \underbrace{\sum_{j=1}^{n} (h_{ij} - \mathbf{1}_{j=i}) \times dz_j}_{\text{downstream propagation}} \tag{4}$$

The impact on sector i of a demand shock of sector j is given by:[4]

$$d \ln y_i = \underbrace{\sum_{j=1}^{n} h_{ji} dG_j}_{\text{total effect}} = \underbrace{dG_j}_{\text{direct effect}} + \underbrace{\sum_{j=1}^{n} (h_{ji} - \mathbf{1}_{j=i}) \times dG_j}_{\text{upstream propagation}} \tag{5}$$

Note that the only difference between equations (4) and (5) are the terms h_{ij} and h_{ji}, which capture downstream and upstream propagation, respectively. To be more concrete, h_{ij} and h_{ji} refer to the (i, j) and (j, i) elements of the so-called Leontief inverse matrix. Section 3.1 provides a thorough description of this matrix.

Therefore, the only different between the propagation of supply and demand shocks in (4) and (5) is that supply shocks propagate downstream (from suppliers to customers) as captured by the h_{ij} element of the Leontief matrix, while demand shocks propagate upstream (from customers to suppliers) as measured by the h_{ji} element. Intuitively, a positive productivity (supply) shock hitting industry j leads to an increase in production y_j and a reduction in price p_j. The reduction in price benefits customers of industry j that will demand higher quantities of good j at lower prices.[5] Moreover, the prices of j's customer industries will be also reduced, creating an indirect positive effect on their own customer industries, and so on. The fact that productivity/supply shocks do not propagate upstream is because the price of industry j is equal to its marginal cost, which only depends on productivities of industry j and its suppliers. The absence of upstream effects on relative prices implies the absence of upstream propagation in quantities. While this is the case under Cobb-Douglas technologies and constant returns to scale, it can be shown that stronger downstream propagation from productivity shocks remains with more general production technologies featuring elasticities of substitution different from 1 (see e.g. Acemoglu et al. (2016)). Turning to demand shocks, they propagate upstream. An exogenous increase in demand of sector j affects quantities and thus the input demand from industry j's suppliers, which represents a positive demand shocks to those suppliers, and so on.

2.2 On the aggregate impact of sector-specific shocks

While equations (4) and (5) capture the effects of a given industry j's shock on industry i, we are interested in the economy-wide impact of sector-specific shocks that we next discuss. Under the conceptual framework outlined above, the aggregate effect of industry-specific shocks is given by:

[4] Note that demand shocks modeled in the form of government spending would have an additional income effect in sector i because the additional government purchases must be financed with taxes that reduce available income of the representative household. We abstract here from this effect for ease of exposition (see Acemoglu et al. (2016) for more details).

[5] Note that the traditional input-output literature also interprets this type of supply shocks as pure price-push shocks with no effect on quantities (see, for instance Oosterhaven, 1996 or Dietzenbacher, 1997). This interpretation is based on a partial equilibrium approach that must rely on the assumption of perfectly price inelastic demand. In contrast, in the model described in this section, quantities do react to changes in prices in a general equilibrium setting, and thus, downstream propagation of supply shocks also implies real effects (see Proposition 1 in Acemoglu et al. 2016).

$$d \ln y = \sum_{j=1}^{n} \lambda_j dz_j \tag{6}$$

where $d \ln y$ refers to aggregate GDP, and $\lambda_j = \frac{p_j y_j}{GDP}$ is the so-called Domar weight (Domar (1961)), which is a proxy of the size of industry j. Note that if all sectors experience a unitary shock ($dz_j = 1 \forall j$), the aggregate impact may be larger than one because the sum of Domar weights is greater than or equal to one as the sum of output across all industries is larger than or equal to the sum of value added of all industries (GDP). Intuitively, the shock to industry j (dz_j) also implies and increase in intermediate deliveries to other sectors and thus their output.

Table A.1 in the Appendix shows Domar weights for all industries in Spain, Germany, France, Italy and the United Kingdom based on the National Input-Output Tables (NIOTs) database described in Section 4. Construction and real estate industries present in most countries the largest Domar weights in the vicinity of 0.13. In the case of Spain, two industries are worth highlighting with Domar weights significantly larger than those of other countries: *Manufacture of food products* and *Accommodation and food service activities*, which they are both related to tourism services. Their Domar weights are 0.14 and 0.12, much larger than the average weights of 0.07 and 0.05 in the other four countries.

The result in equation (6) is the well-known Hulten's Theorem, which states that a sector-specific shock has an aggregate impact equal to its Domar weight regardless of the I-O structure of the economy. Indeed, this result holds much more generally as shown in Hulten (1978). In a recent paper, Baqaee and Farhi (2019) show that Hulten's Theorem only provides a first order approximation and prove that Domar weights change in response to industry-specific shocks when second order approximations are considered. Typical Cobb-Douglas models used in the production-networks literature imply constant I-O matrices and Domar weights so that the first order approximation is exact. However, these implications do not hold in any other setting with a more flexible production technology in which the I-O structure and Domar weights react to shocks.

Imagine for example the effect of shutting down the whole electricity or the retail trade sectors. Despite they both have similar Domar weights, it is easy to think that the impact of shutting down electricity is much more disruptive than that of retail trade. Along these lines, Summers[6] made the point that "... electricity was only 4% of the economy, and so if you lost 80% of electricity, you couldn't possibly have lost more than 3% of the economy [...] we would understand that somehow, even if we didn't exactly understand it in the model, that when there wasn't any electricity, there wasn't really going to be much economy."

In order to assess the relevance of the different industries within each domestic economy, we describe in the next section the output multipliers that take into account the I-O importance of the different sectors beyond its size (Domar weight). We acknowledge that these multipliers are far from the first-best approach in which a fully-fledged model along the lines in Baqaee and Farhi (2019) is

[6]See "Crises yesterday and today." Speech at 14th Jacques Pollack Annual IMF Research Conference in Honor of Stanley Fischer. http://larrysummers.com/imf-fourteenthannual-research-conference-in-honor-of-stanley-fischer

calibrated to the Spanish economy. Anyhow, we interpret our multipliers-based exercise as a first step in the general endeavor of better understanding the most systemic industries of the Spanish economy in comparison with other European countries.

3 I-O multipliers: The nuts and bolts

An I-O multiplier summarizes the aggregate impact that can be expected from a one-Euro increase in the output of a given sector. For example, in response to the global financial crisis many governments reacted with sector-specific programs such as the $3 billion Car Allowance Rebate System in the United States with the hope that the car industry offers large spillovers to the rest of the economy. Multipliers measure the economic impact per Euro spent in these programs. As discussed in the previous section, tracing the propagation of industry-specific shocks through I-O linkages in order to compute multipliers crucially relies in the so-called Leontief matrix that we next describe.

3.1 The Leontief matrix

- The direct requirement matrix A has entries $a_{ij} = \frac{p_j x_{ij}}{p_i y_i}$.
- a_{ij}s measure the Euros required by industry i from industry j ($p_j x_{ij}$) for producing one Euro of output ($p_i y_i$).
- 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 requires inputs from industry j.
- These indirect requirements are captures by the Leontief matrix (H) defined as:

$$H \equiv (I - A)^{-1} = \sum_{k=0}^{\infty} A^k \tag{7}$$

- h_{ij} element of the Leontief matrix H measures the importance of industry j as a direct and indirect input-supplier to industry i in the economy.
- Note also that given the properties of the I-O matrix A, we can re-write $h_{ij} = a_{ij} + \sum_{r=1}^{n} a_{ir} a_{rj} + ...$ for $i \neq j$.

3.2 Computing multipliers

Making use of the Leontief matrix described above we can compute different multipliers depending on the outcome (output, employment and value added) and two different multipliers depending on the propagation (downstream and upstream). In practice, the differences between downstream and upstream multipliers depend on whether we consider columns or rows of the Leontief matrix, while the differences between output, employment and value added multipliers depend on the weights used to sum the appropriate elements of the Leontief matrix.

To be more concrete, for each industry j, we compute four different multipliers:

$$\text{Output Multiplier}_j^{DO} = \sum_{i=1}^{n} h_{ij} \quad (8)$$

$$\text{Output Multiplier}_j^{UP} = \sum_{i=1}^{n} h_{ji} \quad (9)$$

$$\text{Employment Multiplier}_j^{DO} = \sum_{i=1}^{n} \omega_i h_{ij} \quad (10)$$

$$\text{Employment Multiplier}_j^{UP} = \sum_{i=1}^{n} \omega_i h_{ji} \quad (11)$$

where DO refers to downstream (from supplier to customers), UP refers to upstream (from customer to suppliers), and n corresponds to the total number of industries. Turning to the two different elements of the Leontief matrix H considered, h_{ij} measures the direct and indirect importance of sector j as a supplier of industry i (downstream propagation from supplier j to its different i customers) while h_{ji} measures the relevance of industry j as a customer of industry i (upstream propagation from customer j to its different i suppliers). Note that the summation in equation (8) refers to the sum over the rows of column j of the Leontief matrix, and the summation in (9) to the sum over the columns or row j. Turning to employment multipliers, $\omega_i = \frac{E_i}{Y_i}$ is the ratio of employment in number of employees (E) over gross output in Euros (Y). For the sake of completeness, we also consider value added multipliers by simply considering as weights θ_i instead of ω_i, being $\theta_i = \frac{VA_i}{Y_i}$ the ratio of value added (VA) over gross output (Y) of industry i.

Output multipliers estimate the aggregate increase in gross output measured in Euros per Euro of additional output in industry j. Employment multipliers in (10) and (11) show the aggregate impact on employment (measured in persons) per 1 million additional output in industry j. Finally, value added multipliers estimate the aggregate increase in value added (GDP) measured in Euros per Euro of additional output in industry j. Note that employment and value added multipliers are relevant not only because the employment and value added effects are interesting per se, but also because they alleviate the double-counting problem in output multipliers (see section 3.4 for details).

We still consider output multipliers as the baseline because they are the ones capturing propagation per se, our main interest in the paper. In contrast, value added and employment multipliers are also driven by other factors independent of the I-O structure and propagation patterns. In particular, a shock to a given sector may have a large impact on GDP and thus a large value added multiplier if the VA-output ratio of this sector is very large, and/or it may present a large impact on aggregate employment if the sector is very intensive in the use of employment per unit of output. In both cases, these large multipliers are not driven by propagation through the I-O network, while output multipliers are only determined by this propagation.

3.3 A two industry example

In order to provide some intuition, let us consider a simple example with two industries, electricity and manufacture (of motor vehicles). The direct requirement matrix of this 2-industry economy would be:

	Manufacture	Electricity
Manufacture	a_{11}=0.06	a_{12}=0.03
Electricity	a_{21}=0.01	a_{22}=0.30

The numbers in the first row of this A matrix indicates that the manufacture (of motor vehicles) sector requires/spends 6 cents on purchases from manufacture and 3 cents on purchases of electricity per euro of output. Similarly, looking at the second row, the electricity industry spends 1 cent per euro of output on purchases from manufacture and 30 cents per euro on purchases from electricity. These are the a_{ij} elements discussed above. Again, note that the typical I-O table is presented as the transpose of this example as explained in section 4.

Moreover, from this I-O matrix (A) one can compute the Leontief inverse ($H \equiv (I-A)^{-1}$) represented in the following table:

	Manufacture	Electricity	Multiplier$_{UP}$
Manufacture	h_{11}=1.064	h_{12}=0.045	1.079
Electricity	h_{21}=0.015	h_{22}=1.429	1.474
Multiplier$_{DO}$	1.109	1.444	

The numbers in the 2×2 central quadrant of this table refer to the h_{ij} elements of the Leontief matrix. Recall that these elements can be approximated by $h_{ij} = a_{ij} + \sum_{r=1}^{n} a_{ir}a_{rj} + ...$ for $i \neq j$ and $h_{ij} = 1 + a_{ij} + \sum_{r=1}^{n} a_{ir}a_{rj} + ...$for $i = j$. Take for example the elements $h_{11} = 1.064$ and $h_{12} = 0.045$, which can be approximated by:

$$h_{11} \approx 1 + a_{11} + a_{11}a_{11} + a_{12}a_{21} = 1 + 0.06 + 0.06 \cdot 0.06 + 0.03 \cdot 0.01 = 1.0639$$
$$h_{12} \approx a_{12} + a_{11}a_{12} + a_{12}a_{22} = 0.03 + 0.06 \cdot 0.03 + 0.03 \cdot 0.30 = 0.041$$

These approximations illustrate the essence of the Leontief matrix. For instance, the importance of electricity (industry 2) as a direct and indirect supplier of manufacture (industry 1) is captured by the element h_{12}, which is the sum of the direct requirements of manufacture of cars from electricity (a_{12}) plus two indirect requirements: (i) in order to produce cars, the manufacture industry also makes purchases from the own car industry and this extra production requires at the same time some electricity as captured by the term $a_{11}a_{12}$; (ii) also, the electricity required for producing cars requires at the same time some extra electricity as captured by the term $a_{12}a_{22}$.

Turning to h_{11}, one euro of sales by manufacture ultimately results in 1.064 euros in output for manufacture — the original euro plus 6.4 cents in multiple type impacts because in order to satisfy the additional euro of sales, manufacture requires additional inputs from its own industry and from electricity.

Moreover, this table shows the process of computing downstream and upstream multipliers by summing the h_{ij} elements across rows and columns. These multipliers are reported in the third column (e.g. manufacture multiplier$_{UP}$ = 1.064+0.015 = 1.079) and the third row (e.g. electricity multiplier$_{DO}$ = 0.015+1.429=1.444).

As discussed in Section 2, the upstream multiplier of 1.079 can be rationalized by a demand shock: imagine an exogenous increase in the demand of Spanish cars from China of 1 million euros. The manufacture of motor vehicles industry increases production in order to satisfy this demand shock and thus requires additional inputs not only from electricity but also from its own industry of motor vehicles, either directly or indirectly through the car requirements from the electricity sector. The upstream propagation would result in a final increase of 1.079 million euros of total output in the Spanish economy according to the simple I-O structure above.

3.4 Caveats

In order to clearly acknowledge the limitations of our approach, this section highlights a number of drawbacks inherent in the use of I-O multipliers for policy analysis. These limitations are all associated with a number of restrictive assumptions of our conceptual framework in section 2.

To be more concrete, section 2 rationalizes the validity of our multipliers in a static environment in which industries produce under Cobb-Douglas technologies and constant returns to scale. Under Cobb-Douglas production functions, elasticity of substitution among inputs is one, which means that a 1 per cent reduction in the price of a given input gives rise to an increase of 1 percent in its demand so that the share spent in this good remains constant. Therefore, industries cannot substitute one input by others in response to price changes. On the other hand, the assumption of constant returns to scale implies the absence of economies of scale, which means that the proportion of inputs used in the production process are insensitive to the level of production. Intuitively, if 100 cars require 10 tons of steel, 200 cars will require 20 tons of steel. The fact the the model is static implies that multipliers are computed only for an initial equilibrium with given I-O relationships but it may well be that these relationships react in response to the shocks. In other words, we abstract from the dynamic adjustment process.

In our analysis, it is also implicitly assumed that the economy operates with spare capacity and that there always exists underutilized resources and labour force in the sectors hit by the shocks. For instance, if demand for Spanish cars from China in a given year increases say by 10 per cent, it is possible to meet the extra demand by the present production capacity. However, if many resources are close to full-utilization, the multiplier effects will ignore or mask (negative) displacement effects (i.e. employees need to move from one industry to another industry if final demand is increased). Therefore, high positive multiplier effects can include hidden opportunity costs and substitution effects.[7]

A final drawback that we acknowledge is double-counting in output multipliers. Imagine for the sake of illustration a hypothetical economy with two sectors whose outputs are 100 and 300 million euros and total output of 400 million. If their output multipliers are respectively, 1.3 and 1.1, then their respective output contributions are 130 and 330 million with a total contribution of 460 million, which is more than the actual output in the economy. While this adding-up problem is inherent in all studies using output I-O multipliers (see Leones et al. (1994)), we also compute employment and value added multipliers that alleviate this concern. Note however that we still consider these multipliers because the potential spillovers and propagation patterns from industry-specific shocks are better proxied when considering output multipliers that do not depend on employment intensities or value added ratios of the affected industries. For instance, the highest employment multipliers and the highest value added multipliers in our data correspond to industries with the highest employment intensity and the highest value added to output ratio regardless of the position in the I-O structure, which refers more to productivity and size than to propagation per se.

All in all, while these caveats indicate that our multipliers should be interpreted with a grain of salt, we argue that the across-countries differences are informative in relative terms. Anyhow, we leave for further research relaxing these assumptions and re-computing our multipliers under more realistic settings.

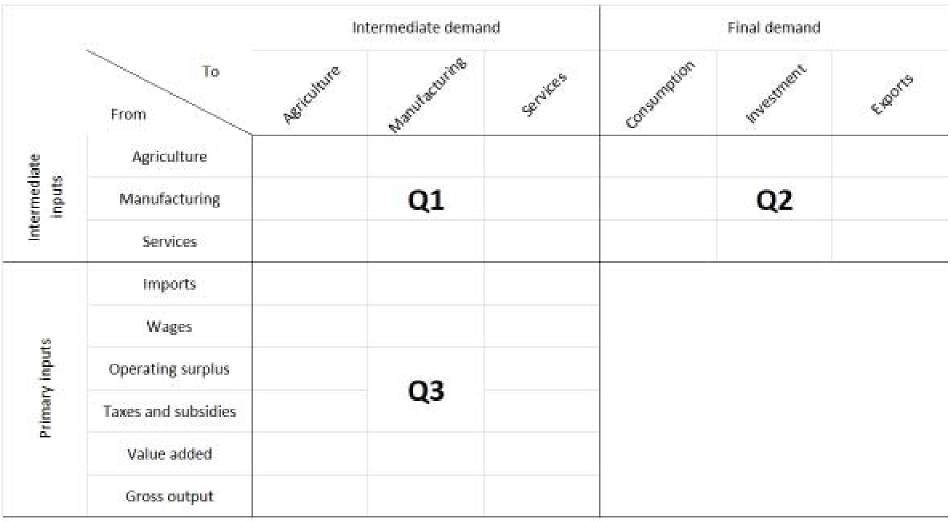
4 Data

In this section, we describe the main features of an Input-Output table as well as the main database used in the paper, the so-called national Input-Output tables (NIOTs). In an I-O table, the structure of an economy can be represented by the transaction flows across various sectors. We can distinguish three quadrants in an I-O table as it is shown in Figure 1. For the sake of illustration imagine there are only three sectors: agriculture, manufacturing and services. The heart of the I-O table is the intermediate consumption quadrant **Q1**. The entries in each row of this quadrant account for the quantities of output that a particular industry sells as intermediate inputs to the same or other industries in the different columns.

All these intermediate transactions included in the quadrant **Q1** provide the information on the sectoral linkages within an economy, for instance, the euros that manufacturing purchases from services. It is worth noting at this point that our multipliers are based on the domestic input requirements, which means that we only consider the input requirements from national industries to

[7] Our theoretical framework implicitly assumes that the economy responds exactly in the same way in a boom phase as it does in a recession ignoring the potential importance of major asymmetries that exist over the business cycle. Needless to say, this assumption is immaterial to our results since we focus on a single year 2014.

Figure 1: Stylized representation of an Input-Output table.



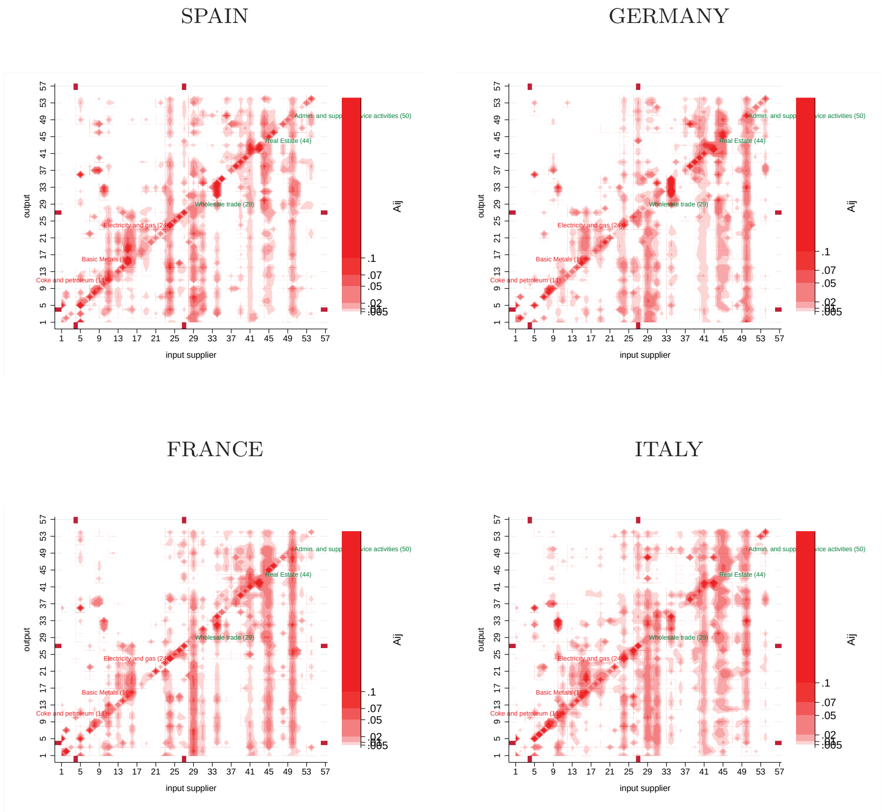
produce one unit of output while we ignore those sourced from abroad. This is so because we aim to identify the most systemic industries within the different domestic economies in order to illustrate how the propagation through I-O linkages of the same shock may differ across countries depending on their domestic production networks. Needless to say, extending the analysis to take into account the role of imported inputs and international trade in general is an interesting issue that we leave for further research.[8]

An I-O table is generally closed by adding two other quadrants: (1) the final demand quadrant **Q2**, which represents the distribution of sectoral output across consumption (household and government), investment, and exports; (2) the primary inputs quadrant **Q3** capturing employment (wages), gross operating surplus, taxes and subsidies, value added, and gross output. Note that in our example in Figure 1 the intermediate inputs from **Q1** refer only to domestic requirements so that we also include in quadrant **Q3** the row measuring total inputs from abroad (imports) for each industry.

Turning to the datasource, we use the National Input-Output Tables (NIOTs) which are the I-O tables at the country level from the *World Input-Output Database* (WIOD) database. In particular, all the figures in this paper refer to the year 2014. Since Timmer et al. (2016) provide a detailed description of this database, we simply comment its main characteristics here. The main advantage of using the NIOTs is that they are fully homogenized across countries, which allows us to compute and compare country-specific I-O multiplies. In particular, NIOTs are constructed from a time-series of national supply and use tables (SUTs) for each country, taking as inputs national accounts data and benchmark supply and use tables (see Dietzenbacher et al. (2013) and Timmer et al. (2016) for more details). The dataset contains the I-O tables for 43 countries covering more than 85 per cent of world GDP over the period 2000-2014. As regards the industry breakdown, it provides information of 56 industries classified according to ISIC rev. 4 nomenclature. Transaction flows in NIOTs are

[8]By making use of the world requirement matrix, instead of the domestic block of the I-O matrix, we can take into account international feedback effects into account and thus providing a more complete picture of the propagation of shocks as discussed for instance in Frohm and Gunnella (2017).

Figure 2: Input-output matrices in advanced economies in 2014



Notes: These graphs depict the technical coefficients, that is, the direct requirement of inputs by industry i. Element i,j represents the amount of dollars spent by industry i in goods from industry j as a fraction of gross output in industry i. It can be observed that the main source is usually from the same as the producer sector. A contour plot method is used, showing only those shares greater than 1, 2, 5 and 10 percent. Source: NIOTs 2016 release.

expressed in millions of current US dollars and measured in basic prices reflecting all costs borne by the producer.

Finally, note that we also make use of the Socio Economic Accounts (SEA) to obtain the number of employees data at country-industry level to compute labor intensities, i.e., number of employees per unit of gross output. For EU28 countries the source of this data is Eurostat.

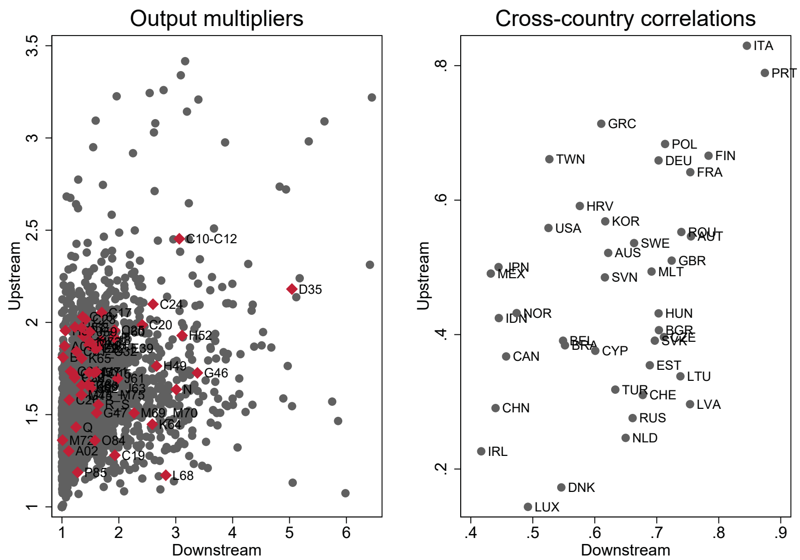
Figure 2 plots the graphical representation of the direct requirement matrices (**A**) computed from NIOT data for Spain, Germany, France and Italy. White denotes that there is no significant connection between two sectors. While darker nodes point to a higher requirement from that sector to produce one unit of output. By comparing these matrices it can be observed the that the input-output network is more intense in some manufacturing sectors and some service industries (such as wholesale trade, real Estate and administrative support services) but with not visual clear differences across countries.

5 Results

5.1 Industry-specific multipliers in Spain and other countries

The left panel of Figure 3 shows all the computed output multipliers for a total of 2,268 (54 × 42) country-industry pairs.[9] The estimated upstream multipliers vary from a minimum of 1 to a maximum of 3.42 (Manufacture of motor vehicles in China) while the variation in downstream multipliers is larger, from 1 to 6.45 (Manufacture of chemicals in China). Indeed, China presents the largest domestic multipliers in general, especially upstream multipliers with all the top 20 multipliers from Chinese industries.

Figure 3: Output multipliers across countries.



Notes. In the left panel, each dot refers to an output multiplier corresponding to country-industry pairs. Red dots with labels refer to Spanish industries. In the right panel, each dot refers to a cross-country correlation of the industry-specific output multipliers, which summarizes the similarities across national I-O structures.

While the average multiplier is 1.60 both downstream and upstream, the median is 1.58 for upstream propagation but 1.37 for downstream. The distribution of downstream multipliers is skewed to the left with many industries featuring small multipliers together with a few very large multipliers. In contrast, upstream multipliers are centered around 1.60 with a somehow symmetric distribution (see the histograms in Figure A.1 of the Appendix).

The right panel of Figure 3 plots the bi-variate correlations of Spanish multipliers across industries (both downstream and upstream) with the remaining 41 countries. The average cross-country correlation between Spain and other countries is 0.62 for downstream and 0.46 for upstream mul-

[9]Note that 2 out of 56 industries in NIOTs, Activities of households and Activities of extraterritorial organizations and bodies, have zero requirements from other sector in most countries so that they are excluded from the analysis.

tipliers, which suggests that Spanish I-O structure presents certain similarities with that of other countries. Interestingly enough, we can identify four different groups of countries in terms of the strength of these similarities from the right panel of Figure 3. A first group of two countries, Italy and Portugal, with a very similar structure as indicated by correlations around 0.8 for upstream and 0.9 for downstream. A second group formed by other european countries (Germany, France, Greece, Poland, and Finland) presenting correlations around 0.7 and 0.8 for upstream and downstream, respectively. A third group of more heterogeneous countries such as United Kingdom, United States, Korea, or Sweden with correlations in the vicinity of 0.5-0.6 for upstream and 0.7 for downstream. The last group we identify includes all the other countries with correlations generally below 0.5 for upstream and 0.7 for downstream. It is worth highlighting that these correlations refer to domestic multipliers in order to investigate the propagation of sector-specific shocks within each country, our main interest in this paper.

Table 1: Output multipliers for Spain.

PANEL A: Top 6 industry multipliers					
		Downstream			Upstream
Electricity, gas, steam and air con	D35	5.04	Manufacture of food products, bever	C10-C12	2.45
Wholesale trade, except of motor ve	G46	3.38	Electricity, gas, steam and air con	D35	2.18
Warehousing and support activities	H52	3.11	Manufacture of basic metals	C24	2.10
Manufacture of food products, bever	C10-C12	3.06	Manufacture of paper and paper prod	C17	2.05
Administrative and support service	N	3.01	Manufacture of wood and of products	C16	2.03
Real estate activities	L68	2.83	Manufacture of other non-metallic m	C23	2.02
PANEL B: Bottom 6 industry multipliers					
Manufacture of computer, electronic	C26	1.13	Scientific research and development	M72	1.36
Forestry and logging	A02	1.12	Public administration and defence;	O84	1.36
Water transport	H50	1.06	Forestry and logging	A02	1.30
Fishing and aquaculture	A03	1.05	Manufacture of coke and refined pet	C19	1.28
Mining and quarrying	B	1.02	Education	P85	1.19
Scientific research and development	M72	1.01	Real estate activities	L68	1.17

Notes. This table reports output multipliers that show the economy-wide increase in gross output (measured in Euros) per Euro of additional output in a given industry.

Turning to Spanish multipliers, Table 1 shows the top 6 and bottom 6 industry-specific multipliers. Panel A refers to the highest 6 multipliers identifying the most systemic industries in terms of downstream (from suppliers to customers) and upstream (from customers to suppliers) propagation. The highest downstream multiplier corresponds to electricity (5.04) because electricity represents an important input for most activities, especially those related to manufacturing. Other industries with very high downstream multipliers are wholesale trade, warehousing, manufacture of food products, administrative and support activities, and real estate activities, which are all intensively used by many industries.

In the case of upstream propagation, the highest multipliers correspond to manufacture of food products, electricity, manufacture of basic metals, manufacture of paper, manufacture of wood and manufacture of other non-metallic minerals. The strong upstream propagation of demand shocks to these industries can be explained by two facts related to electricity: (i) these manufacturing activities are very dependent on electricity: for instance, for each euro produced by the industry of manufacture of paper, 0.2 euros are purchased from the electricity industry; (ii) the direct requirement of electricity from electricity is also very high: for producing and additional euro of electricity, 0.38 euros from the electricity sector are required.

With respect to the bottom multipliers in Panel B of Table 1, we observe that the bottom 6 industries in terms of downstream multipliers are those related to the primary sector (forestry and logging A02, fishing and aquaculture A03, mining and quarrying B), water transport (H50), and manufacture of computer and electronic products (C26) because those are industries not used intensively by others. Interestingly enough, the lowest multiplier of 1.01 corresponds to scientific research and development (M72), suggesting that Spanish industries invest very little in R&D activities.

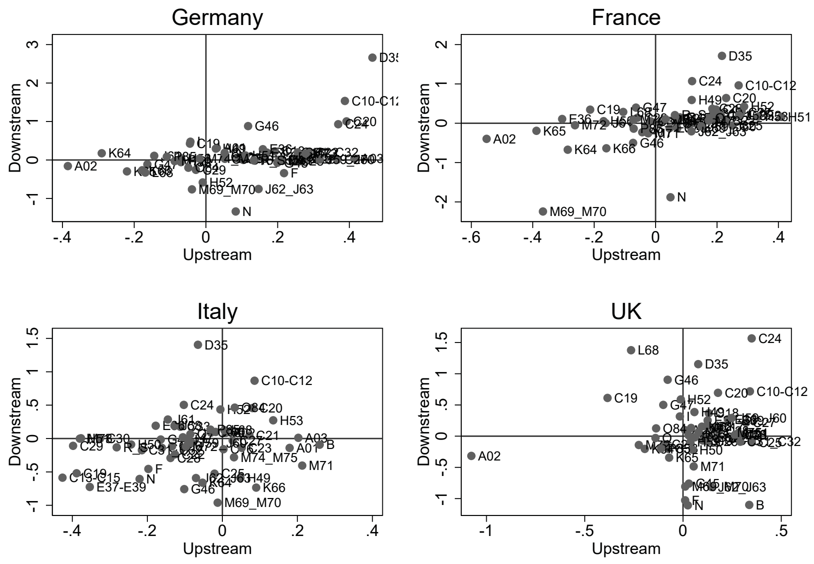
Turning to the lowest upstream multipliers, those correspond to scientific research and development (M72), education (P85), public administration and defence (O84), forestry and logging (A02), manufacture of petroleum products (C19), and real estate activities (L68). Low upstream multipliers in the case of industries closely related to public services and forestry are intuitive given those are not generally very dependent on intermediate inputs from other industries. The case of manufacture of petroleum products can be explained because Spain is a net importer of petroleum products so that inputs related to this industry are not necessarily produced in Spain and thus are not included in the domestic multiplier. It is worth stressing the case of real estate activities as an illustration of the importance of the distinction between downstream and upstream propagation: while the upstream multiplier of this industry is the lowest (1.17), its downstream multiplier is among the highest (2.83).

We now look at the differences between Spanish multipliers and those of other European countries (Germany, France, Italy, United Kingdom) reported in Figure 4. Each dot in the four plots refers to the difference between the Spanish multiplier in a given industry and the corresponding multiplier in the same industry for other countries.

Three findings are worth highlighting from Figure 4. First, manufacturing industries heavily dependent on electricity such as manufacture of basic metals or manufacture of chemicals and of course electricity per se present much larger multipliers in Spain than in other European countries (both upstream and downstream). These are basically the dots far away from the origin (0,0) located in the upper right quadrant of the four plots. This result suggests that either electricity in Spain is more expensive than in other countries or Spanish industries are more inefficient in terms of electrical energy consumption than their European counterparts. Second, Spanish industries related to agriculture (A02) and finance and insurance activities (K64, K65) present lower upstream multipliers than those of other European countries, especially Germany and France. Third, downstream multipliers of activities related to professional services such as administrative and support (N) and legal and accounting (M69-M70) are lower in Spain than in other European countries, which suggests that Spanish industry rely little on this type of services.

Tables A.2, A.3, A.4, A.5, and A.6 in the Appendix provide the full list of computed output multipliers for Spain, Germany, France, Italy, and United Kingdom, respectively.

Figure 4: Differences in output multipliers — Spain versus other countries.



Notes. Each dot refers to an industry. In particular, it reports the difference between the Spanish output multiplier and the corresponding multiplier in the other countries. Industries (dots) in the upper-right quadrant of each plot have higher downstream and upstream output multipliers in Spain.

5.1.1 Employment multipliers

In this section, we present the calculated employment multipliers in order to determine the leading employment generating sectors in Spain and other countries. These multipliers are useful when assessing the economy-wide impact of sector-specific shocks because they alleviate the double-counting issue inherent to output multipliers (see section 3.4 for details). Moreover, they might shed some light on sectoral potentials in relation to the creation of jobs in the economy.

Table 2 presents the top 6 and bottom 6 Spanish industries in terms of employment (downstream and upstream) multipliers. To be more concrete, these multipliers show the aggregate impact on employment (measured in persons) per 1 million additional output in each industry.

Panel A refers to the highest 6 multipliers identifying the industries with larger employment generation capacity in terms of downstream (from suppliers to customers) and upstream (from customers to suppliers) propagation. Administrative and support service activities (N) is the industry with the highest downstream and upstream employment multipliers. In particular, a 1 million increase in its output gives rise to 27.90 additional jobs if the increase is driven by a supply shock (downstream propagation) and 20.70 if the driver is a demand shock (upstream propagation). Other industries with high employment multipliers are Postal and courier activities (H53), Retail trade, except of motor vehicles and motorcycles (G47), Education (P85) and Public administration and defence (O84).

In contrast to output multipliers, the ranking of industries in terms of employment multipliers is very similar for both downstream (supply shock) and upstream (demand shock) propagation.

Table 2: Employment multipliers for Spain.

PANEL A: Top 6 industry multipliers					
		Downstream			Upstream
Administrative and support service	N	27.90	Administrative and support service	N	20.75
Wholesale trade, except of motor ve	G46	19.68	Postal and courier activities	H53	19.56
Postal and courier activities	H53	18.20	Retail trade, except of motor vehic	G47	16.28
Electricity, gas, steam and air con	D35	17.80	Education	P85	14.95
Retail trade, except of motor vehic	G47	17.50	Forestry and logging	A02	14.78
Education	P85	15.51	Public administration and defence;	O84	14.45
PANEL B: Bottom 6 industry multipliers					
Air transport	H51	3.75	Manufacture of motor vehicles, trai	C29	5.21
Manufacture of coke and refined pet	C19	3.50	Manufacture of chemicals and chemic	C20	5.10
Manufacture of other transport equi	C30	3.41	Telecommunications	J61	5.04
Water transport	H50	3.15	Electricity, gas, steam and air con	D35	3.75
Manufacture of motor vehicles, trai	C29	3.11	Real estate activities	L68	1.69
Manufacture of basic pharmaceutical	C21	2.95	Manufacture of coke and refined pet	C19	1.12

Notes. This table reports employment multipliers that show the aggregate impact on employment (measured in persons) per 1 million additional output in each industry.

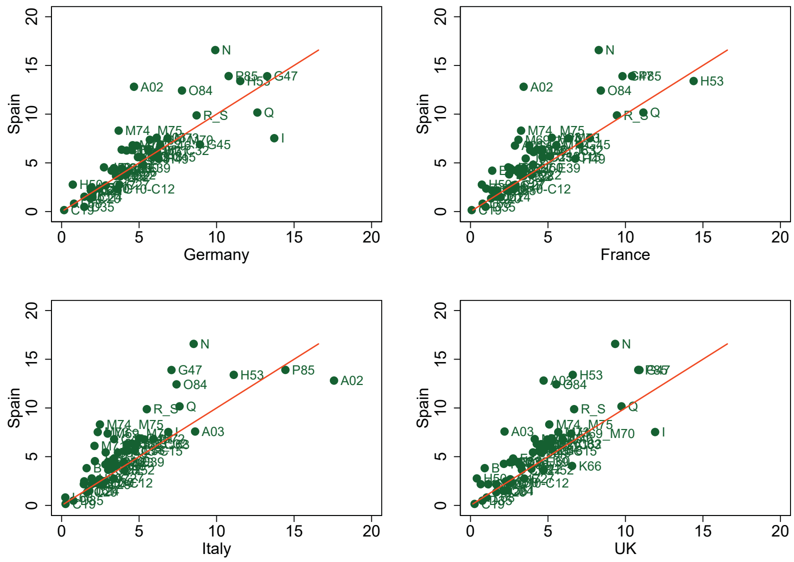
This is so because employment intensity weights are the main driver of the employment multipliers (note that the main diagonal of the Leontief matrix has elements above 1 that are multiplied by the employment intensity of the own industry, while all the other terms are generally close to 0). Therefore, the ranking of top employment multipliers is very similar to the ranking of employment intensities, which are indeed very close to the multipliers per se. For instance, employment intensity of industry Postal and courier activities (H53) is 13.4 and its employment multipliers are 18.2 and 19.5. Figure 5 reports these employment intensities for all industries in Spain and other countries.

It is worth highlighting two exceptions to this pattern in Table 2. Electricity (D35) and Wholesale trade, except of motor vehicles and motorcycles (G46) present high downstream employment multipliers despite their employment intensities are low: 0.5 for electricity and 6.8 for wholesale trade. These are industries with very strong downstream propagation due to their importance as inputs for many other sectors as captured by their high output multipliers in Table 1.

Turning to bottom employment multipliers in Panel B, we observe again that industries with the lowest employment multipliers are basically those with the lowest employment intensities. For instance, the only three industries with employment intensities below 1 are Manufacture of coke and refined petroleum products (C19), electricity (D35) and Real estate activities (L68). However, other industries such as Telecommunications (J61), Manufacture of chemicals (C20), and Manufacture of motor vehicles (C29) present intensities between 1.5 and 2.1 job per million output, which are among the bottom 10.

Figure 5 shows these employment intensities for all Spanish industries vis-a-vis other European countries. As expected, all industries among the top employment multipliers in Panel A of Table 2 are those with the highest intensities above 10 jobs per million output. In general, most industries present higher intensities in Spain than in other countries, as expected from the well-known lower labor

Figure 5: Number of employments per million output.



Notes. These plots show employment intensities (employments per million output) across countries. Dots above the 45-degree line refer to industries with higher employment intensities in Spain than in the other countries.

productivity levels that characterize the Spanish economy. Also, it is worth highlighting the only two industries with employment intensities clearly lower in Spain than in other countries: Accommodation and food service activities (I) and Human health and social work activities (Q). These are industries related to tourism and care of the elderly activities in which Spain has comparative advantage.

All in all, industries with high potential in relation to the creation of jobs are basically those with higher employment intensities, i.e., those that require more jobs per million of output produced. This finding poses a trade-off: industries with lower productivity are those with greater employment generation capacity per unit of output produced while high-productivity industries are those with lower potential of jobs creation.

In terms of comparison of Spanish employment multipliers with other countries, two findings are worth highlighting: (i) the correlations between Spanish multipliers and those of other countries are high and strong similarities arise with France, Germany and Italy (see Figure A.2 in the Appendix);[10] (ii) still, when comparing with these European countries, employment multipliers are larger for most industries in Spain because of the higher employment intensities in Spanish industries (see Figure A.3 in the Appendix) as a clear indication of their lower labor productivities.

Finally, it is worth highlighting that Tables A.2, A.3, A.4, A.5, and A.6 in the Appendix report the list of computed employment multipliers for all industries in Spain, Germany, France, Italy, and United Kingdom, respectively.

[10]Note that the sample is smaller than that of output multipliers in Figure 3 due to lack of employment data for some countries.

5.1.2 Value added multipliers

Multipliers in terms of value added quantify the impact of a 1 million output increase in a given sector on value added of downstream and/or upstream industries. Intuitively, we substract from the output multipliers the part of gross output increases in each sector that is devoted to purchase intermediate inputs from other industries. Since aggregate GDP is the sum of industry-specific value added (i.e. gross output net of intermediates), these multipliers provide a measure of the aggregate impact of industry shocks in terms of GDP.

Table 3 reports the top 6 and bottom 6 industries in terms of value added multipliers. Top industries in terms of downstream propagation in Panel A are very similar to those of output in Table 1. Sectors such as real estate (L68), electricity (D35) and wholesale trade (G46) appear as very systemic industries with the highest downstream multipliers because they are industries used intensively as inputs by many others. However, note that these value added multipliers are much lower than output multipliers. Take the example of electricity that presents a (downstream) value added multiplier of 1.74 in Table 3 but an output multiplier of 5.04 in Table 1. This indicates that much of the gross output directly and indirectly generated by a supply shock to the electricity industry is devoted to purchase intermediate inputs. For instance, the manufacture of basic metals expands production when electricity is cheaper after a supply shock, but part of this increase is devoted to pay for the additional electricity required. Anyhow, the multipliers are still large and suggest that supply/productivity shocks to industries such as electricity and real estate may have large economy-wide effects.

In terms of upstream propagation of demand shocks, the highest value added multipliers correspond to those industries with the largest shares of value added to gross output since the list of Top 6 industries is different to that of output multipliers. For instance, Real estate activities (L68) is the industry with the highest value added multiplier and the lowest output multiplier. This is so

Table 3: Value added multipliers for Spain.

PANEL A: Top 6 industry multipliers					
		Downstream			Upstream
Real estate activities	L68	1.74	Real estate activities	L68	0.98
Electricity, gas, steam and air con	D35	1.74	Education	P85	0.95
Wholesale trade, except of motor ve	G46	1.52	Forestry and logging	A02	0.95
Administrative and support service	N	1.45	Retail trade, except of motor vehic	G47	0.94
Financial service activities, excep	K64	1.41	Legal and accounting activities; ac	M69-M70	0.93
Warehousing and support activities	H52	1.27	Public administration and defence;	O84	0.91
PANEL B: Bottom 6 industry multipliers					
Manufacture of electrical equipment	C27	0.42	Manufacture of textiles, wearing ap	C13-C15	0.62
Manufacture of textiles, wearing ap	C13-C15	0.38	Manufacture of electrical equipment	C27	0.62
Air transport	H51	0.38	Manufacture of chemicals and chemic	C20	0.56
Manufacture of coke and refined pet	C19	0.34	Manufacture of basic metals	C24	0.52
Water transport	H50	0.33	Manufacture of motor vehicles, trai	C29	0.43
Manufacture of motor vehicles, trai	C29	0.25	Manufacture of coke and refined pet	C19	0.12

Notes. This table reports value added multipliers that show the aggregate impact on aggregate value added (measured in euros) per 1 million additional euro in each industry.

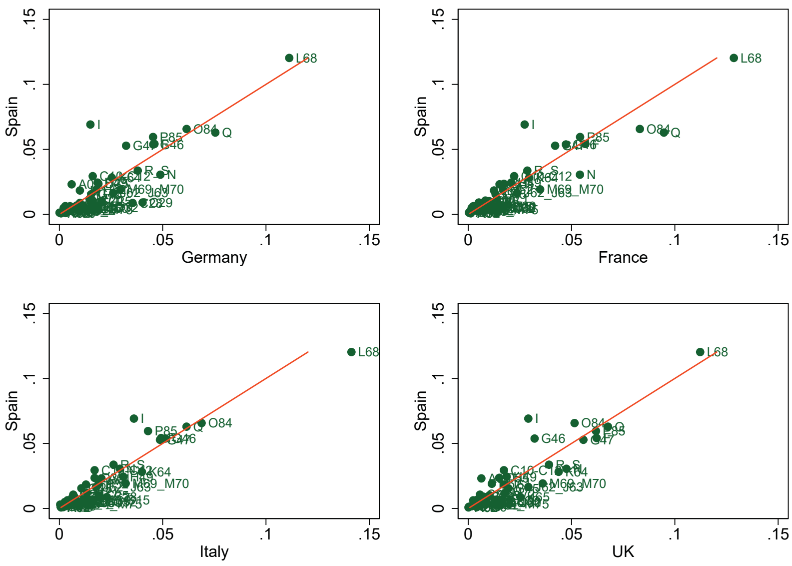
because it present the highest value added to output ratio (12%) as shown in Figure 6 in spite of requiring relatively little input from other industries. Note that the differences between value added and output multipliers can only be explained by the value added to output ratios used when adding up 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.

This observation serves to illustrate our interest in output multipliers when assessing the magnitude of the propagation of industry-specific shocks, which resembles the so-called Hulten's theorem stating that under certain assumptions the aggregate impact of a given industry shock is equal to the share of this industry in the economy regardless of the I-O structure and its position in the production network (see Baqaee and Farhi (2019)). The bottom line is: despite a demand shock to real estate activities may have a large impact on GDP due to its large weight in aggregate GDP as suggested by the value added multipliers in Table 3, it is important to emphasize that this is an industry requiring little inputs from other industries and thus presents a relative weak upstream propagation as indicated by output multipliers in Table 1.

Turning to the lowest 6 value added multipliers, they generally correspond to industries with the lowest value added to output ratios. Indeed, the lowest upstream multiplier corresponds to Manufacture of coke and refined petroleum (C19), which is the industry with the lowest value added to output ratio below 0.1%. The remaining bottom multipliers also correspond to sectors with value added to output ratios generally below 1% such as Manufacture of textiles (C13-C15) or Manufacture of motor vehicles (C29), which indicate that are industries with a large share of their gross output devoted to purchases of intermediate goods.

Figure 6 shows the value added to output ratios for the different industries and European countries. Three observations are worth highlighting: (i) the industry with the largest ratio is Real estate

Figure 6: Ratio of value added to output.



activities (L68) in all the five countries; (ii) other industries with large ratios are Public administration and defence (O84), Education (P85), Retail trade (G47) and Human health and social work activities (Q), which are activities that require few intermediate inputs for production; (iii) Accommodation and food service activities (I), related to tourism services, has a much larger value added to output ratio in Spain than in the other countries.

Finally, Figure A.4 in the Appendix show the differences in value added multipliers between Spain and other countries. Electricity (D35) clearly presents a much larger downstream VA multiplier in Spain than in other countries, which was also the case of output multipliers. In contrast, Manufacture of motor vehicles (C29) presents in Spain a lower downstream and upstream value added multiplier than in other European countries, which suggest that the GDP impact of a shock to this industry may be lower in Spain as we next analyze in more detail.

5.2 Automobile industry shock in 2018 and its propagation

The euro area economy was characterized by a slowdown in the second half of 2018. In particular, seasonally adjusted GDP rose by 0.4% in the euro area (EA19) between June and December 2018, well below the 1.4% growth over the same period in 2017. This slowdown was more pronounced in Germany than in Spain: German GDP growth between June and December went from 1.1% in 2017 to -0.2% in 2018, while the corresponding Spanish figures were 1.3% and 1.1% in 2017 and 2018, respectively. Despite several factors can be at the root of these differences (see Banco de España (2019)), we focus here on the potential role of the domestic propagation of the supply shock hitting the European automobile industry in the second half of 2018.

A new EU legislation on pollutant emissions in the context of the Worldwide Harmonised Light Vehicle Test Procedure (WLTP) came into force in September 2018. We interpret this WLTP shock as a negative supply shock to the European car manufacturing industry. In particular, under the new EU regulation (EU) 2017/1151, the application of a new protocol for the measurement of automobile pollutant emissions is mandatory and all new vehicle registrations must comply with a more stringent protocol for the measurement of fuel consumption and emissions. Although this regulatory change has different effects on the car industry, the most immediate impact is related to the need for car manufacturers to adapt their production systems to ensure that vehicles comply with the new legal requirements and thus it can be interpreted as a negative technology shock for this sector. In order to quantify the impact of the new regulation in the production of new cars, we look at production data.[11] Compared to the level of production registered in June, Spanish car production was 5.6% below in December 2018. Similarly, German car production finalized 2018 at a level 5.3% below June 2018. Using EUROSTAT production data in euros, these figures would imply a loss in production between December and June of 3,675.9 million euros in Spain and 19,293 millions in Germany.

[11]Note however that automobile production figures were distorted around the dates of entry into force of the regulation. In Spain, for instance, the auto component of the Industrial Production Index (IPI) was growing at 2.2% before the summer (June) but significantly decreased, in year-on-year terms from September to December 2018.

Based on Hulten's theorem discussed in Section 2.2, a first option to quantify the aggregate impact of these shocks could be to look at Domar weights for Germany and Spain in Table A.1. The ratio of gross output over GDP (Domar weight) is larger in Germany (0.128) than in Spain (0.052) so that the aggregate impact of a similar drop in production attributed to the WLTP shock (-5.3% and -5.6% in Germany and Spain) is -0.67 percentage points in Germany (-0.053×0.128) and -0.29 pp. in Spain (-0.056×0.052). Note that the main driver of these differences is basically the fact that the automobile industry accounts for more than 20% of Germany's manufacturing production (around 7% of the economy's total output) but it only accounts for 11% of total manufacturing output in Spain (around 3% of total output). We next look at downstream output multipliers in Tables A.2 and A.3 to assess the relevance of differences across the I-O matrices in Spain and Germany. In the case of the car manufacturing industry, the downstream multiplier is computed at 1.22 for Spain while it is higher for Germany, 1.48. Multiplying these multipliers by the fall in car production in terms of Euros for both countries, we obtain an impact on aggregate economic activity of -0.84 pp. in Germany and -0.37 pp. in Spain once we take into account the propagation of the WLTP shock to the rest of the economy. Finally, according to the employment multipliers in Tables A.2 and A.3, the fall in aggregate employment attributable to the WLTP shock would be 76,000 jobs in Germany and 11,000 in Spain.

Interestingly enough, if we interpret the fall in production due to the WLTP shock as a demand-driven shock (e.g. caused by a fall in demand from China), its aggregate impact would be much larger since upstream multipliers are larger than downstream multipliers in the case of the automobile industry. In particular, a negative demand shock of the same magnitude of the WLTP supply shock would have an overall effect on economic activity of -0.99 pp. of GDP in Germany and -0.52 pp. in Spain, as well as a cost in terms of employment losses of around 100,000 and 19,000 jobs in Germany and Spain, respectively.

Needless to say, the figures in this exercise must be interpreted with a grain of salt. The aggregate figures inferred from our back-of-the-envelope calculations do not aim to provide a proper quantification of the WLTP shock but rather to illustrate that differences in country-specific production networks might lead to significant differences in the macroeconomic consequences of similar industry-specific shocks.

6 Concluding remarks

The paper reports industry-specific multipliers for 56 sectors in five European countries with special emphasis on the Spanish economy. These downstream and upstream multipliers can be used to quantify the aggregate impact of sector-specific shocks depending on their origin, either supply- or demand-driven. Moreover, the multipliers serve to assess the differences and similarities across country-specific input-output domestic networks.

Furthermore, we highlight four main findings from our analysis: (i) the Spanish domestic I-O structure is similar to that of Italy and Portugal; (ii) the most systemic industry in Spain is the electricity sector; (iii) the electricity multipliers for the Spanish economy are much larger than those of other European countries; (iv) the introduction of the WLTP emissions testing procedure in September 2018 can account for a non-negligible fraction of the stronger slowdown in Germany than in Spain because automobile industry is more systemic within the German economy.

To conclude, we leave for further research two issues that are worth exploring in the case of the Spanish economy. First, a better understanding on how relaxing the assumptions discussed in section 3.4 might affect the reported sector-specific multipliers, as well as how these multipliers change over time. Second, explore the role of the I-O structure in forecasting given the recent paper by Carvalho and Reischer (2019) in which they show that information on the structure of the production network of an economy can help to produce better forecasts of both sector-level and aggregate growth rates.

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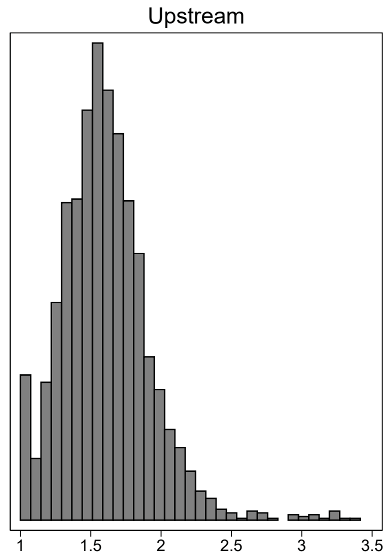
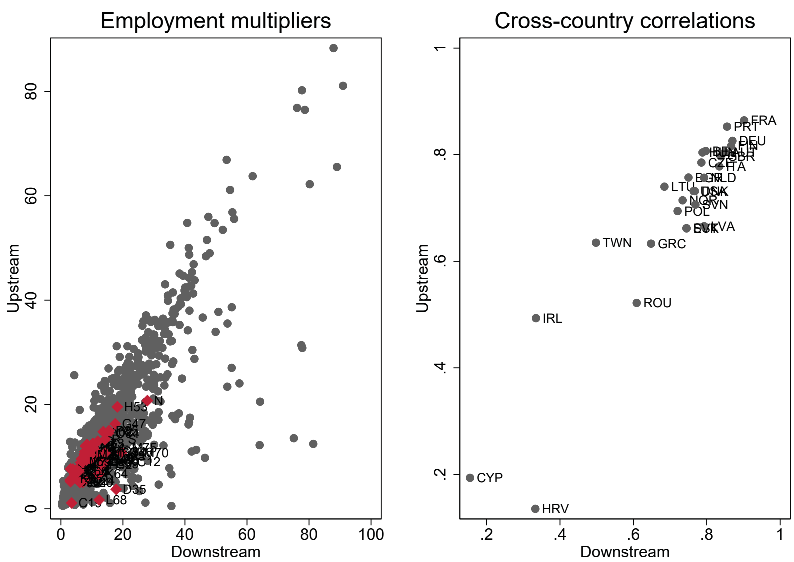
A Additional Tables and Figures

Figure A.1: Histograms of output multipliers across countries.



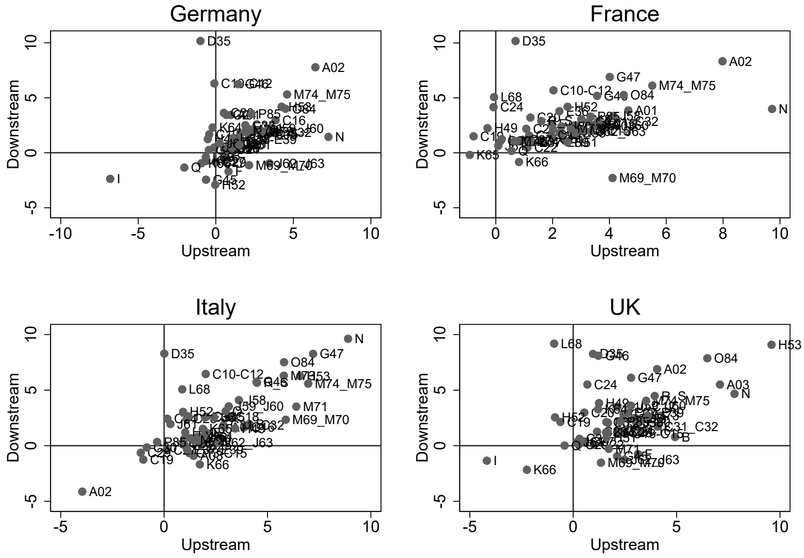
Notes. This plot shows the histogram of the computed multipliers corresponding to 2,268 country-industry pairs.

Figure A.2: Employment multipliers across countries.



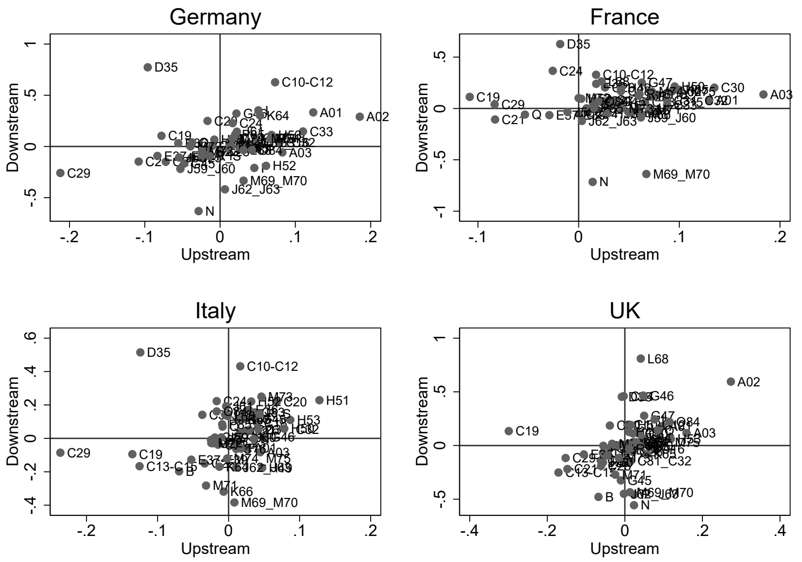
Notes. In the left panel, each dot refers to an employment multiplier corresponding to country-industry pairs. Red dots with labels refer to Spanish industries. In the right panel, each dot refers to a cross-country correlation of the industry-specific employment multipliers, which summarizes the similarities across national I-O structures.

Figure A.3: Differences in employment multipliers — Spain versus other countries.



Notes. Each dot refers to an industry. In particular, it reports the difference between the Spanish employment multiplier and the corresponding multiplier in the other countries. For instance, industries (dots) in the upper-right quadrant of each plot have higher downstream and upstream employment multipliers in Spain.

Figure A.4: Differences in value added multipliers — Spain versus other countries.



Notes. Each dot refers to an industry. In particular, it reports the difference between the Spanish value added multiplier and the corresponding multiplier in the other countries. For instance, industries (dots) in the upper-right quadrant of each plot have higher downstream and upstream value added multipliers in Spain.

Table A.1: Domar weights across countries

Industry	ISIC code	Spain	Germany	France	Italy	UK
Crop and animal production, hunting	A01	0.044	0.018	0.041	0.037	0.016
Forestry and logging	A02	0.001	0.002	0.003	0.001	0.001
Fishing and aquaculture	A03	0.003	0.000	0.001	0.001	0.001
Mining and quarrying	B	0.006	0.004	0.003	0.007	0.027
Manufacture of food products, bever	C10-C12	0.141	0.071	0.081	0.088	0.056
Manufacture of textiles, wearing ap	C13-C15	0.021	0.009	0.009	0.055	0.007
Manufacture of wood and of products	C16	0.006	0.009	0.005	0.010	0.004
Manufacture of paper and paper prod	C17	0.013	0.015	0.009	0.015	0.008
Printing and reproduction of record	C18	0.008	0.008	0.005	0.008	0.007
Manufacture of coke and refined pet	C19	0.048	0.030	0.025	0.036	0.017
Manufacture of chemicals and chemic	C20	0.052	0.053	0.035	0.035	0.022
Manufacture of basic pharmaceutical	C21	0.015	0.018	0.013	0.017	0.014
Manufacture of rubber and plastic p	C22	0.019	0.029	0.016	0.027	0.015
Manufacture of other non-metallic m	C23	0.016	0.017	0.013	0.021	0.010
Manufacture of basic metals	C24	0.042	0.038	0.017	0.038	0.012
Manufacture of fabricated metal pro	C25	0.029	0.048	0.026	0.055	0.022
Manufacture of computer, electronic	C26	0.007	0.028	0.012	0.015	0.015
Manufacture of electrical equipment	C27	0.016	0.039	0.011	0.024	0.008
Manufacture of machinery and equipm	C28	0.025	0.091	0.020	0.076	0.021
Manufacture of motor vehicles, trai	C29	0.052	0.128	0.028	0.033	0.031
Manufacture of other transport equi	C30	0.017	0.015	0.031	0.015	0.019
Manufacture of furniture; other man	C31-C32	0.013	0.019	0.009	0.026	0.011
Repair and installation of machiner	C33	0.011	0.015	0.027	0.013	0.009
Electricity, gas, steam and air con	D35	0.096	0.049	0.056	0.058	0.064
Water collection, treatment and sup	E36	0.010	0.003	0.005	0.006	0.005
Sewerage; waste collection, treatme	E37-E39	0.017	0.018	0.015	0.027	0.017
Construction	F	0.130	0.105	0.144	0.141	0.156
Wholesale and retail trade and repa	G45	0.029	0.023	0.024	0.024	0.034
Wholesale trade, except of motor ve	G46	0.100	0.078	0.108	0.112	0.069
Retail trade, except of motor vehic	G47	0.080	0.061	0.071	0.082	0.094
Land transport and transport via pi	H49	0.052	0.037	0.043	0.063	0.039
Water transport	H50	0.003	0.010	0.008	0.009	0.011
Air transport	H51	0.011	0.010	0.010	0.008	0.013
Warehousing and support activities	H52	0.043	0.047	0.030	0.044	0.027
Postal and courier activities	H53	0.005	0.011	0.006	0.005	0.014
Accommodation and food service acti	I	0.118	0.032	0.050	0.070	0.058
Publishing activities	J58	0.008	0.012	0.013	0.006	0.012
Motion picture, video and televisio	J59-J60	0.012	0.012	0.014	0.010	0.017
Telecommunications	J61	0.036	0.024	0.031	0.027	0.033
Computer programming, consultancy a	J62-J63	0.029	0.043	0.038	0.034	0.046
Financial service activities, excep	K64	0.043	0.056	0.061	0.062	0.085
Insurance, reinsurance and pension	K65	0.020	0.028	0.030	0.016	0.064
Activities auxiliary to financial s	K66	0.008	0.013	0.020	0.021	0.022
Real estate activities	L68	0.136	0.146	0.159	0.159	0.155
Legal and accounting activities; ac	M69-M70	0.030	0.051	0.080	0.049	0.056
Architectural and engineering activ	M71	0.023	0.024	0.032	0.021	0.033
Scientific research and development	M72	0.007	0.012	0.031	0.009	0.010
Advertising and market research	M73	0.009	0.009	0.010	0.010	0.012
Other professional, scientific and	M74-M75	0.006	0.009	0.007	0.015	0.014
Administrative and support service	N	0.053	0.080	0.093	0.064	0.087
Public administration and defence;	O84	0.089	0.094	0.113	0.089	0.095
Education	P85	0.069	0.059	0.066	0.051	0.082
Human health and social work activi	Q	0.098	0.110	0.122	0.103	0.139
Other service activities	R-S	0.055	0.056	0.048	0.057	0.063

Table A.2: Multipliers for Spain — Full list

Industry	ISIC code	Output Down	Output Up	Employment Down	Employment Up	Value added Down	Value added Up
Crop and animal production, hunting	A01	1.65	1.88	9.93	10.62	0.77	0.85
Forestry and logging	A02	1.12	1.30	13.67	14.78	0.84	0.95
Fishing and aquaculture	A03	1.05	1.87	7.88	12.04	0.47	0.82
Mining and quarrying	B	1.02	1.81	3.88	7.62	0.44	0.76
Manufacture of food products, bever	C10-C12	3.06	2.45	13.43	9.05	1.05	0.77
Manufacture of textiles, wearing ap	C13-C15	1.20	1.72	6.68	9.56	0.38	0.62
Manufacture of wood and of products	C16	1.36	2.03	8.41	12.36	0.44	0.76
Manufacture of paper and paper prod	C17	1.70	2.05	5.97	7.12	0.51	0.66
Printing and reproduction of record	C18	1.68	1.90	9.54	10.96	0.70	0.81
Manufacture of coke and refined pet	C19	1.93	1.28	3.50	1.12	0.34	0.12
Manufacture of chemicals and chemic	C20	2.41	1.99	7.09	5.10	0.71	0.56
Manufacture of basic pharmaceutical	C21	1.15	1.73	2.95	5.53	0.43	0.67
Manufacture of rubber and plastic p	C22	1.58	1.86	6.23	7.42	0.52	0.64
Manufacture of other non-metallic m	C23	1.42	2.02	6.36	8.88	0.47	0.71
Manufacture of basic metals	C24	2.60	2.10	7.75	5.52	0.67	0.52
Manufacture of fabricated metal pro	C25	1.92	1.96	9.64	9.50	0.69	0.69
Manufacture of computer, electronic	C26	1.13	1.58	5.09	7.52	0.51	0.70
Manufacture of electrical equipment	C27	1.37	1.93	4.42	6.54	0.42	0.62
Manufacture of machinery and equipm	C28	1.47	1.88	5.96	7.43	0.54	0.68
Manufacture of motor vehicles, trai	C29	1.22	1.70	3.11	5.21	0.25	0.43
Manufacture of other transport equi	C30	1.22	1.70	3.41	5.62	0.47	0.66
Manufacture of furniture; other man	C31-C32	1.26	1.84	7.76	11.00	0.52	0.79
Repair and installation of machiner	C33	1.48	1.67	8.66	9.63	0.72	0.81
Electricity, gas, steam and air con	D35	5.04	2.18	17.80	3.75	1.74	0.64
Water collection, treatment and sup	E36	1.35	1.66	5.91	7.59	0.66	0.79
Sewerage; waste collection, treatme	E37-E39	1.62	1.86	6.92	8.61	0.58	0.73
Construction	F	1.92	1.92	9.64	9.57	0.83	0.83
Wholesale and retail trade and repa	G45	1.34	1.61	8.87	10.13	0.69	0.84
Wholesale trade, except of motor ve	G46	3.38	1.73	19.68	10.83	1.52	0.90
Retail trade, except of motor vehic	G47	1.61	1.51	17.50	16.28	0.92	0.94
Land transport and transport via pi	H49	2.66	1.76	13.80	9.42	1.13	0.83
Water transport	H50	1.06	1.96	3.15	7.63	0.33	0.75
Air transport	H51	1.23	1.97	3.75	7.28	0.38	0.68
Warehousing and support activities	H52	3.11	1.93	13.25	8.43	1.27	0.88
Postal and courier activities	H53	1.48	1.73	18.20	19.56	0.78	0.91
Accommodation and food service acti	I	1.56	1.73	11.76	10.74	0.86	0.89
Publishing activities	J58	1.35	1.97	7.51	10.49	0.53	0.81
Motion picture, video and televisio	J59-J60	1.49	1.95	7.23	9.09	0.60	0.85
Telecommunications	J61	1.98	1.70	6.17	5.04	0.96	0.87
Computer programming, consultancy a	J62-J63	1.51	1.64	9.25	10.13	0.81	0.90
Financial service activities, excep	K64	2.59	1.45	12.17	6.68	1.41	0.90
Insurance, reinsurance and pension	K65	1.35	1.80	4.03	5.89	0.61	0.89
Activities auxiliary to financial s	K66	1.48	1.65	5.74	7.19	0.76	0.89
Real estate activities	L68	2.83	1.17	12.30	1.69	1.74	0.98
Legal and accounting activities; ac	M69-M70	2.27	1.51	14.26	10.70	1.22	0.93
Architectural and engineering activ	M71	1.60	1.73	9.44	10.34	0.78	0.87
Scientific research and development	M72	1.01	1.36	6.88	9.02	0.67	0.85
Advertising and market research	M73	1.49	1.90	10.35	12.53	0.66	0.88
Other professional, scientific and	M74-M75	1.34	1.61	10.41	11.66	0.76	0.90
Administrative and support service	N	3.01	1.64	27.90	20.75	1.45	0.89
Public administration and defence;	O84	1.58	1.36	15.37	14.45	0.98	0.91
Education	P85	1.28	1.19	15.51	14.95	0.99	0.95
Human health and social work activi	Q	1.25	1.43	11.87	12.93	0.77	0.85
Other service activities	R-S	1.64	1.55	14.21	13.32	0.92	0.90

Table A.3: Multipliers for Germany — Full list

Industry	ISIC code	Output		Employment		Value added	
		Down	Up	Down	Up	Down	Up
Crop and animal production, hunting	A01	1.34	1.85	6.49	9.64	0.43	0.73
Forestry and logging	A02	1.28	1.69	5.90	8.36	0.55	0.76
Fishing and aquaculture	A03	1.01	1.46	6.22	8.68	0.52	0.74
Mining and quarrying	B	1.04	1.60	4.16	7.01	0.43	0.71
Manufacture of food products, bever	C10-C12	1.53	2.07	7.13	9.14	0.43	0.69
Manufacture of textiles, wearing ap	C13-C15	1.01	1.55	4.98	7.98	0.34	0.61
Manufacture of wood and of products	C16	1.36	1.93	5.44	8.50	0.40	0.69
Manufacture of paper and paper prod	C17	1.55	1.79	5.25	6.26	0.48	0.62
Printing and reproduction of record	C18	1.46	1.71	8.34	9.39	0.61	0.73
Manufacture of coke and refined pet	C19	1.51	1.32	1.83	1.54	0.23	0.20
Manufacture of chemicals and chemic	C20	1.41	1.59	3.47	4.58	0.46	0.57
Manufacture of basic pharmaceutical	C21	1.13	1.52	2.64	4.64	0.58	0.77
Manufacture of rubber and plastic p	C22	1.38	1.57	5.86	6.89	0.52	0.63
Manufacture of other non-metallic m	C23	1.38	1.75	5.54	7.58	0.52	0.73
Manufacture of basic metals	C24	1.67	1.73	4.30	4.84	0.45	0.51
Manufacture of fabricated metal pro	C25	1.90	1.68	8.93	8.31	0.80	0.73
Manufacture of computer, electronic	C26	1.08	1.49	3.73	6.10	0.50	0.71
Manufacture of electrical equipment	C27	1.36	1.56	5.22	6.55	0.57	0.69
Manufacture of machinery and equipm	C28	1.51	1.63	5.56	6.54	0.59	0.68
Manufacture of motor vehicles, trai	C29	1.48	1.73	3.97	5.19	0.51	0.64
Manufacture of other transport equi	C30	1.15	1.65	2.93	5.72	0.39	0.64
Manufacture of furniture; other man	C31-C32	1.06	1.59	5.89	8.74	0.48	0.74
Repair and installation of machiner	C33	1.45	1.61	6.16	7.73	0.57	0.70
Electricity, gas, steam and air con	D35	2.38	1.72	7.64	4.73	0.97	0.73
Water collection, treatment and sup	E36	1.07	1.50	3.55	5.63	0.63	0.84
Sewerage; waste collection, treatme	E37-E39	1.54	1.70	5.69	7.03	0.67	0.81
Construction	F	2.26	1.70	11.34	8.75	1.04	0.78
Wholesale and retail trade and repa	G45	1.42	1.41	11.32	10.76	0.86	0.89
Wholesale trade, except of motor ve	G46	2.50	1.61	13.44	9.38	1.19	0.88
Retail trade, except of motor vehic	G47	1.72	1.67	17.25	16.73	0.84	0.89
Land transport and transport via pi	H49	2.37	1.74	12.56	9.94	1.06	0.84
Water transport	H50	1.12	2.02	1.03	5.28	0.34	0.74
Air transport	H51	1.11	1.86	2.43	6.16	0.30	0.62
Warehousing and support activities	H52	3.70	1.94	16.16	8.46	1.45	0.82
Postal and courier activities	H53	1.43	1.80	14.02	15.31	0.67	0.84
Accommodation and food service acti	I	1.09	1.77	14.13	17.55	0.51	0.84
Publishing activities	J58	1.34	1.77	7.08	9.43	0.64	0.87
Motion picture, video and televisio	J59-J60	1.48	1.63	5.00	5.68	0.82	0.91
Telecommunications	J61	1.87	1.84	5.32	4.79	0.81	0.84
Computer programming, consultancy a	J62-J63	2.26	1.50	10.21	6.67	1.23	0.89
Financial service activities, excep	K64	2.41	1.74	9.88	6.89	1.10	0.85
Insurance, reinsurance and pension	K65	1.65	2.03	4.79	6.52	0.63	0.86
Activities auxiliary to financial s	K66	1.74	1.83	6.70	8.11	0.75	0.87
Real estate activities	L68	3.15	1.34	12.70	2.33	1.78	0.94
Legal and accounting activities; ac	M69-M70	3.03	1.55	15.39	8.55	1.55	0.90
Architectural and engineering activ	M71	1.62	1.52	8.74	8.81	0.87	0.90
Scientific research and development	M72	1.04	1.45	4.78	7.06	0.67	0.89
Advertising and market research	M73	1.32	1.62	8.42	9.56	0.71	0.90
Other professional, scientific and	M74-M75	1.30	1.63	5.12	7.07	0.68	0.88
Administrative and support service	N	4.35	1.55	26.45	13.48	2.08	0.92
Public administration and defence;	O84	1.78	1.41	11.37	9.96	1.01	0.87
Education	P85	1.19	1.30	11.99	12.65	0.88	0.93
Human health and social work activi	Q	1.06	1.38	13.21	14.96	0.73	0.89
Other service activities	R-S	1.65	1.42	12.35	11.33	1.01	0.91

Table A.4: Multipliers for France — Full list

Industry	ISIC code	Output Down	Output Up	Employment Down	Employment Up	Value added Down	Value added Up
Crop and animal production, hunting	A01	1.88	1.92	6.07	5.95	0.69	0.72
Forestry and logging	A02	1.52	1.85	5.34	6.80	0.68	0.86
Fishing and aquaculture	A03	1.04	1.77	5.45	8.17	0.33	0.64
Mining and quarrying	B	1.07	1.70	2.63	5.25	0.44	0.74
Manufacture of food products, bever	C10-C12	2.10	2.18	7.74	7.02	0.73	0.75
Manufacture of textiles, wearing ap	C13-C15	1.00	1.54	4.67	6.87	0.32	0.56
Manufacture of wood and of products	C16	1.36	2.02	5.77	8.48	0.41	0.73
Manufacture of paper and paper prod	C17	1.44	1.87	4.41	5.95	0.43	0.63
Printing and reproduction of record	C18	1.33	1.71	6.48	7.95	0.57	0.73
Manufacture of coke and refined pet	C19	1.59	1.49	2.00	1.90	0.22	0.23
Manufacture of chemicals and chemic	C20	1.77	1.76	3.88	3.88	0.50	0.53
Manufacture of basic pharmaceutical	C21	1.07	1.54	1.64	3.53	0.54	0.75
Manufacture of rubber and plastic p	C22	1.51	1.63	5.75	6.31	0.56	0.63
Manufacture of other non-metallic m	C23	1.41	1.89	4.55	6.62	0.47	0.71
Manufacture of basic metals	C24	1.53	1.98	3.59	5.60	0.31	0.55
Manufacture of fabricated metal pro	C25	1.98	1.71	7.99	7.56	0.74	0.69
Manufacture of computer, electronic	C26	1.00	1.51	2.57	4.72	0.46	0.69
Manufacture of electrical equipment	C27	1.10	1.65	3.23	5.60	0.35	0.59
Manufacture of machinery and equipm	C28	1.11	1.69	3.78	6.36	0.37	0.64
Manufacture of motor vehicles, trai	C29	1.08	1.76	2.02	5.04	0.21	0.51
Manufacture of other transport equi	C30	1.17	1.72	1.26	3.61	0.27	0.52
Manufacture of furniture; other man	C31-C32	1.05	1.63	4.91	7.41	0.44	0.70
Repair and installation of machiner	C33	1.61	1.60	5.85	6.37	0.68	0.72
Electricity, gas, steam and air con	D35	3.33	1.96	7.62	3.05	1.11	0.65
Water collection, treatment and sup	E36	1.24	1.96	2.13	5.35	0.42	0.77
Sewerage; waste collection, treatme	E37-E39	1.74	1.81	5.96	7.32	0.64	0.76
Construction	F	1.77	1.84	7.01	7.59	0.71	0.76
Wholesale and retail trade and repa	G45	1.20	1.53	7.82	9.37	0.63	0.81
Wholesale trade, except of motor ve	G46	3.88	1.80	14.50	7.26	1.53	0.84
Retail trade, except of motor vehic	G47	1.21	1.57	10.60	12.27	0.67	0.87
Land transport and transport via pi	H49	2.07	1.65	11.55	9.71	0.93	0.79
Water transport	H50	1.01	2.12	0.75	5.32	0.12	0.65
Air transport	H51	1.07	1.57	2.81	4.75	0.42	0.63
Warehousing and support activities	H52	2.69	1.64	9.06	5.90	1.17	0.88
Postal and courier activities	H53	1.31	1.39	16.40	16.75	0.83	0.88
Accommodation and food service acti	I	1.66	1.76	10.51	10.53	0.82	0.86
Publishing activities	J58	1.14	1.70	4.15	6.35	0.57	0.83
Motion picture, video and televisio	J59-J60	1.57	1.80	4.76	5.64	0.69	0.79
Telecommunications	J61	1.97	1.86	5.53	4.95	0.83	0.81
Computer programming, consultancy a	J62-J63	1.71	1.53	7.30	6.79	0.94	0.90
Financial service activities, excep	K64	3.26	1.73	11.12	5.49	1.45	0.85
Insurance, reinsurance and pension	K65	1.54	2.19	4.23	6.80	0.43	0.79
Activities auxiliary to financial s	K66	2.11	1.81	6.58	6.37	0.82	0.82
Real estate activities	L68	2.54	1.28	7.23	1.75	1.48	0.95
Legal and accounting activities; ac	M69-M70	4.51	1.88	16.55	6.59	1.86	0.86
Architectural and engineering activ	M71	1.86	1.76	7.40	7.27	0.79	0.80
Scientific research and development	M72	1.06	1.62	5.82	8.36	0.57	0.85
Advertising and market research	M73	1.43	1.72	8.15	9.89	0.66	0.84
Other professional, scientific and	M74-M75	1.25	1.68	4.30	6.16	0.60	0.83
Administrative and support service	N	4.89	1.59	23.91	11.02	2.16	0.88
Public administration and defence;	O84	1.47	1.33	10.10	9.95	0.92	0.89
Education	P85	1.41	1.26	12.21	11.62	0.99	0.94
Human health and social work activi	Q	1.11	1.26	11.69	12.38	0.83	0.90
Other service activities	R-S	1.43	1.49	11.32	11.71	0.78	0.84

Table A.5: Multipliers for Italy — Full list

Industry	ISIC code	Output Down	Output Up	Employment Down	Employment Up	Value added Down	Value added Up
Crop and animal production, hunting	A01	1.79	1.70	8.27	7.69	0.82	0.83
Forestry and logging	A02	1.03	1.29	17.81	18.74	0.81	0.93
Fishing and aquaculture	A03	1.04	1.67	8.80	10.61	0.55	0.77
Mining and quarrying	B	1.11	1.55	1.94	3.50	0.63	0.83
Manufacture of food products, bever	C10-C12	2.20	2.37	6.98	7.03	0.62	0.75
Manufacture of textiles, wearing ap	C13-C15	1.79	2.15	7.35	8.34	0.55	0.75
Manufacture of wood and of products	C16	1.52	2.03	6.73	8.46	0.50	0.75
Manufacture of paper and paper prod	C17	1.84	2.21	5.35	6.15	0.51	0.68
Printing and reproduction of record	C18	1.59	1.93	6.91	7.82	0.61	0.77
Manufacture of coke and refined pet	C19	2.45	1.67	4.75	2.12	0.43	0.26
Manufacture of chemicals and chemic	C20	1.95	1.91	4.66	4.01	0.49	0.49
Manufacture of basic pharmaceutical	C21	1.11	1.66	2.28	4.24	0.39	0.64
Manufacture of rubber and plastic p	C22	1.82	1.99	6.21	6.40	0.56	0.66
Manufacture of other non-metallic m	C23	1.56	1.97	5.98	7.25	0.50	0.70
Manufacture of basic metals	C24	2.10	2.20	5.32	5.36	0.45	0.54
Manufacture of fabricated metal pro	C25	2.45	1.98	9.58	7.69	0.84	0.73
Manufacture of computer, electronic	C26	1.24	1.71	4.31	5.93	0.46	0.67
Manufacture of electrical equipment	C27	1.40	1.90	4.81	6.41	0.43	0.64
Manufacture of machinery and equipm	C28	1.77	2.02	5.73	6.57	0.57	0.71
Manufacture of motor vehicles, trai	C29	1.33	2.10	3.75	6.34	0.34	0.67
Manufacture of other transport equi	C30	1.23	2.03	3.56	6.46	0.33	0.69
Manufacture of furniture; other man	C31-C32	1.43	2.06	5.93	8.13	0.47	0.75
Repair and installation of machiner	C33	1.30	1.78	6.06	7.60	0.56	0.77
Electricity, gas, steam and air con	D35	3.64	2.25	9.52	3.74	1.23	0.76
Water collection, treatment and sup	E36	1.16	1.84	3.36	5.61	0.49	0.76
Sewerage; waste collection, treatme	E37-E39	2.34	2.21	7.28	7.50	0.70	0.78
Construction	F	2.37	2.12	8.48	7.52	0.89	0.81
Wholesale and retail trade and repa	G45	1.36	1.77	6.31	7.71	0.58	0.80
Wholesale trade, except of motor ve	G46	4.14	1.83	13.94	6.36	1.51	0.85
Retail trade, except of motor vehic	G47	1.59	1.61	9.24	9.08	0.81	0.92
Land transport and transport via pi	H49	3.25	1.72	12.25	5.99	1.31	0.79
Water transport	H50	1.15	2.20	2.54	5.85	0.27	0.67
Air transport	H51	1.23	2.35	2.55	6.26	0.15	0.55
Warehousing and support activities	H52	2.68	1.93	10.21	7.51	1.05	0.85
Postal and courier activities	H53	1.20	1.59	11.93	12.98	0.67	0.83
Accommodation and food service acti	I	1.57	1.82	9.12	9.57	0.74	0.87
Publishing activities	J58	1.15	2.10	3.41	6.87	0.39	0.82
Motion picture, video and televisio	J59-J60	1.55	2.03	3.69	5.96	0.60	0.86
Telecommunications	J61	1.69	1.84	4.23	4.73	0.76	0.87
Computer programming, consultancy a	J62-J63	2.10	1.71	8.97	7.52	0.99	0.89
Financial service activities, excep	K64	3.25	1.50	11.35	4.78	1.58	0.92
Insurance, reinsurance and pension	K65	1.25	1.82	2.52	4.01	0.50	0.87
Activities auxiliary to financial s	K66	2.21	1.56	7.42	5.46	1.08	0.89
Real estate activities	L68	2.70	1.17	7.23	0.81	1.61	0.98
Legal and accounting activities; ac	M69-M70	3.23	1.52	11.92	4.82	1.60	0.92
Architectural and engineering activ	M71	2.01	1.52	5.93	3.95	1.06	0.90
Scientific research and development	M72	1.13	1.46	6.38	7.59	0.69	0.87
Advertising and market research	M73	1.49	2.27	4.05	6.73	0.41	0.83
Other professional, scientific and	M74-M75	1.62	1.58	4.84	4.69	0.88	0.90
Administrative and support service	N	3.62	1.86	18.28	11.85	1.45	0.86
Public administration and defence;	O84	1.12	1.33	7.86	8.65	0.82	0.93
Education	P85	1.14	1.22	15.17	15.29	0.91	0.96
Human health and social work activi	Q	1.18	1.52	8.76	9.95	0.70	0.86
Other service activities	R-S	1.77	1.84	8.54	8.82	0.77	0.85

Table A.6: Multipliers for United Kingdom — Full list

Industry	ISIC code	Output		Employment		Value added	
		Down	Up	Down	Up	Down	Up
Crop and animal production, hunting	A01	1.55	1.87	7.50	8.20	0.59	0.75
Forestry and logging	A02	1.44	2.38	6.79	10.72	0.25	0.68
Fishing and aquaculture	A03	1.07	1.83	2.39	4.94	0.35	0.66
Mining and quarrying	B	2.12	1.47	3.11	2.70	0.91	0.83
Manufacture of food products, bever	C10-C12	2.34	2.11	9.91	6.91	0.86	0.76
Manufacture of textiles, wearing ap	C13-C15	1.27	1.62	5.61	7.02	0.63	0.79
Manufacture of wood and of products	C16	1.40	1.91	7.07	9.09	0.47	0.69
Manufacture of paper and paper prod	C17	1.56	1.90	4.77	5.53	0.58	0.71
Printing and reproduction of record	C18	1.32	1.77	6.72	8.52	0.59	0.78
Manufacture of coke and refined pet	C19	1.32	1.66	1.36	1.74	0.20	0.42
Manufacture of chemicals and chemic	C20	1.72	1.81	4.11	4.56	0.52	0.60
Manufacture of basic pharmaceutical	C21	1.13	1.45	1.68	3.06	0.65	0.81
Manufacture of rubber and plastic p	C22	1.60	1.68	6.14	6.42	0.66	0.70
Manufacture of other non-metallic m	C23	1.40	1.99	3.91	5.82	0.44	0.69
Manufacture of basic metals	C24	1.03	1.75	2.24	4.83	0.21	0.52
Manufacture of fabricated metal pro	C25	2.02	1.61	8.34	7.30	0.88	0.75
Manufacture of computer, electronic	C26	1.21	1.45	3.90	5.16	0.57	0.68
Manufacture of electrical equipment	C27	1.16	1.61	4.04	6.00	0.45	0.65
Manufacture of machinery and equipm	C28	1.39	1.70	4.70	6.28	0.53	0.69
Manufacture of motor vehicles, trai	C29	1.36	1.79	3.02	4.95	0.37	0.58
Manufacture of other transport equi	C30	1.09	1.66	2.79	5.32	0.36	0.62
Manufacture of furniture; other man	C31-C32	1.34	1.55	6.04	6.92	0.67	0.77
Repair and installation of machiner	C33	1.68	1.74	6.54	8.03	0.69	0.78
Electricity, gas, steam and air con	D35	3.89	2.10	9.55	2.79	1.29	0.64
Water collection, treatment and sup	E36	1.08	1.43	3.47	4.65	0.74	0.90
Sewerage; waste collection, treatme	E37-E39	1.36	1.73	3.96	5.98	0.58	0.78
Construction	F	2.95	1.91	10.39	6.43	1.29	0.81
Wholesale and retail trade and repa	G45	2.10	1.58	9.81	8.01	1.02	0.85
Wholesale trade, except of motor ve	G46	2.48	1.80	11.59	9.61	1.05	0.85
Retail trade, except of motor vehic	G47	1.11	1.61	11.39	13.48	0.64	0.89
Land transport and transport via pi	H49	2.28	1.71	9.97	8.17	1.00	0.82
Water transport	H50	1.28	1.91	0.96	4.39	0.49	0.80
Air transport	H51	1.18	1.69	3.01	5.66	0.47	0.73
Warehousing and support activities	H52	2.52	1.94	10.70	9.31	1.07	0.87
Postal and courier activities	H53	1.57	1.69	9.12	9.97	0.72	0.79
Accommodation and food service acti	I	1.25	1.74	13.11	14.92	0.62	0.82
Publishing activities	J58	1.32	1.68	5.42	7.45	0.69	0.87
Motion picture, video and televisio	J59-J60	1.20	1.70	3.62	6.29	0.60	0.87
Telecommunications	J61	1.82	1.58	5.85	4.87	0.93	0.82
Computer programming, consultancy a	J62-J63	2.32	1.50	10.51	7.65	1.26	0.90
Financial service activities, excep	K64	2.79	1.64	8.90	5.48	1.33	0.86
Insurance, reinsurance and pension	K65	1.69	1.88	2.81	4.22	0.69	0.83
Activities auxiliary to financial s	K66	1.32	1.56	7.91	9.43	0.74	0.88
Real estate activities	L68	1.45	1.44	3.12	2.62	0.93	0.93
Legal and accounting activities; ac	M69-M70	3.07	1.50	15.79	9.36	1.66	0.92
Architectural and engineering activ	M71	2.09	1.68	9.73	8.62	1.05	0.90
Scientific research and development	M72	1.15	1.59	4.81	7.33	0.65	0.88
Advertising and market research	M73	1.47	1.63	7.66	8.92	0.77	0.90
Other professional, scientific and	M74-M75	1.28	1.53	6.37	8.14	0.73	0.87
Administrative and support service	N	4.12	1.61	23.23	12.94	2.00	0.87
Public administration and defence;	O84	1.45	1.50	7.50	7.97	0.76	0.80
Education	P85	1.48	1.30	13.35	12.67	1.00	0.91
Human health and social work activi	Q	1.28	1.57	11.85	13.35	0.62	0.77
Other service activities	R-S	1.66	1.49	9.73	9.37	0.95	0.89

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