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MULTIPLIER EFFECTS BY SECTOR: AN INPUT-OUTPUT ANALYSIS OF THE GREEK ECONOMY

Constantina Backinezos
Economic Analysis and Research Department

Stelios Panagiotou
Economic Analysis and Research Department

Evangelia Vourvachaki
Economic Analysis and Research Department

ABSTRACT

This study presents sectoral output, gross value added and employment multipliers for the Greek economy based on the most recent Input-Output tables of 2015, which were compiled according to the European System of Accounts (ESA) 2010. Our analysis utilises the Leontief model, in both the "open" and "closed" variations with respect to households' consumption, which allows to assess, at a disaggregated sectoral level, the direct and indirect production effects, as well as the induced consumption effects caused by exogenous changes in the final demand of each sector. The multipliers offer an up-to-date and systematic ranking of sectors according to their economy-wide potential impact owing to their technological features and inter-sectoral linkages.

Keywords: input-output analysis; Leontief multipliers; output multipliers; GVA multipliers; employment multipliers; Greek economy

JEL classification: C67; D57; F40; E32

ΚΛΑΔΙΚΕΣ ΠΟΛΛΑΠΛΑΣΙΑΣΤΙΚΕΣ ΕΠΙΔΡΑΣΕΙΣ: ΜΙΑ ΑΝΑΛΥΣΗ ΕΙΣΡΟΩΝ-ΕΚΡΟΩΝ ΤΗΣ ΕΛΛΗΝΙΚΗΣ ΟΙΚΟΝΟΜΙΑΣ

Κωνσταντίνα Μπακινέζου
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Στέλιος Παναγιώτου
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Ευαγγελία Βουρβαχάκη
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

ΠΕΡΙΛΗΨΗ

Η μελέτη παρουσιάζει τους πολλαπλασιαστές προϊόντος, ακαθάριστης προστιθέμενης αξίας και απασχόλησης για την ελληνική οικονομία ανά κλάδο, με βάση τους πιο πρόσφατους πίνακες εισροών-εκροών, του 2015, οι οποίοι έχουν καταρτιστεί σύμφωνα με το Ευρωπαϊκό Σύστημα Εθνικών και Περιφερειακών Λογαριασμών (ESA) 2010. Η ανάλυση χρησιμοποιεί το υπόδειγμα Leontief στις δύο εκδοχές του, δηλ. την "ανοικτή" και την "κλειστή" ως προς την κατανάλωση των νοικοκυριών, το οποίο μας επιτρέπει να εκτιμήσουμε, σε αναλυτικό κλαδικό επίπεδο, τις άμεσες και έμμεσες επιδράσεις παραγωγής, καθώς και τις προκαλούμενες έμμεσες επιδράσεις κατανάλωσης που οφείλονται σε εξωγενείς μεταβολές της τελικής ζήτησης κάθε κλάδου. Οι πολλαπλασιαστές προσφέρουν μια επικαιροποιημένη και συστηματική κατάταξη των κλάδων ανάλογα με το δυνητικό αντίκτυπό τους στο σύνολο της οικονομίας λόγω των τεχνολογικών τους χαρακτηριστικών και των διακλαδικών τους διασυνδέσεων.

MULTIPLIER EFFECTS BY SECTOR: AN INPUT-OUTPUT ANALYSIS OF THE GREEK ECONOMY[1]

Constantina Backinezos
Economic Analysis and Research Department

Stelios Panagiotou
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Evangelia Vourvachaki
Economic Analysis and Research Department

1 INTRODUCTION

Input-output analysis provides a representation of the structure of production of an economic system, which may be as large as the world economy or as small as a metropolitan area or even a single enterprise (see Leontief 1986), offering a useful methodological approach for the quantification of the interdependencies among individual sectors and the assessment of their potential for output and employment growth.

The input-output table is the core of input-output analysis and provides a consistent and systematic way of presenting sectoral statistics and summarising transactions within the framework of the basic economic activities of a modern open economy: production; consumption; investment; and trade with the rest of the world. One of the major uses of the information from the input-output tables is to assess the extent to which the impact of changes in one or more exogenous factors generated by unforeseen events or policy action propagates through the supply and use of intermediate goods and services, thus affecting overall economic activity.

From the input-output tables, a set of summary measures can be derived, known as the input-output multipliers that express total output, value added and employment generated in all sectors of the economy and at all stages of production by one monetary unit of final demand for the output of each sector, taking into account all inter-sectoral relations. They incorporate not only the direct effects of the production of one unit of output, caused by the use of inputs that are supplied by other sectors operating domestically, but also the indirect effects caused by the production of intermediate inputs and the consumption of labour income in the economy.

An important advantage of the input-output multipliers is that they offer an ordering of sectors in terms of their overall production and consumption effects on the economic outcome of interest, on the basis of the underlying cross-sectoral variation in technology and production structure (supply chains, import dependency, etc.). Being independent of the size of the sectors, they contribute meaningfully to the analysis of the aggregate impact of sectoral-level developments.

This paper presents the output, gross value added (GVA) and employment multipliers of the Greek economy at a disaggregated level, using the latest available input-output tables for 2015. The different sectors are ranked by the size of the computed multipliers that reflect the size of their linkages with other sectors and their ability to influence the rest of the economy. Our analysis uses the Leontief demand-driven static input-output model, in both its "open" and "closed" variations (with respect to households' consumption).

This paper is organised as follows: In Section 2 we present the methodology and data employed. The results of the analysis are discussed in Sec-

1 The authors would like to thank C. Papazoglou and seminar participants of the Bank of Greece for their useful comments and invaluable insights into the issues discussed in this article. The views expressed are of the authors and do not necessarily reflect those of the Bank of Greece. The authors are responsible for any errors or omissions.

tion 3. Finally, the concluding remarks of the analysis are presented in Section 4.

2 METHODOLOGY AND DATA

2.1 THE STATIC INPUT-OUTPUT MODEL

An input-output table describes the flow of goods and services between sectors of the economy, as the products of one process are used as inputs in other processes. It shows, from the demand perspective, the distribution of a sector's output across all intermediate and final uses and, from the supply perspective, the structure of the costs of each sector in terms of the value of the intermediate and primary inputs used. Overall, the value of a sector's output equals the value of its inputs.

The following analysis is based on the *demand perspective* of the production process.[2] The balance between total output and its uses, intermediate and final, is described by the basic equality between supply and demand written as follows:

$$x = Ax + x_d \qquad (1)$$

where $x=[x_1, \ldots, x_n]'$ is the vector of output, n denotes the number of sectors, $x_d=[x_{1d}, \ldots, x_{nd}]'$ is the vector of final demand and $A=[\alpha_{ij}]$ is the nxn matrix of *technical coefficients*.[3] The technical coefficients measure the inputs directly required from one sector i to produce one unit of output of the sector j. They are calculated as $\alpha_{ij}=x_{ij}/x_j$, where x_{ij} is the output of sector i used as input by sector j. One of the most important assumptions in the input-output analysis is that all inputs are used in fixed proportions in relation to the output of each sector, given by the technical coefficients.

Solving the above equation for the output vector x results in

$$x = (I-A)^{-1} x_d \qquad (2)$$

where I is the identity matrix.

Equation (2) allows the transformation of the final demand vector (x_d) into an output vector (x) by multiplying the former with the inverse Leontief matrix $(I-A)^{-1}$. Each element (l_{ij}) of the inverse Leontief matrix shows how much output is generated in sector i to satisfy one unit of final demand of sector j and it reflects total (direct and indirect) input requirements.

In the process described above, a number of summary measures can be derived, known as the input-output multipliers.

2.2 SIMPLE OUTPUT MULTIPLIERS

The most frequently used types of multipliers are those that estimate the effects of exogenous changes on the outputs of the economy, the *output multipliers*. The output multiplier for sector j is defined as the total value of production in all sectors of the economy at all stages of production that is necessary in order to satisfy one currency unit of final demand for sector j's output. It can be shown from equation (2) that the sum of the elements of the j^{th} column of the inverse Leontief is the output multiplier for sector j. This is known as the *simple multiplier*.[4]

The simple multiplier incorporates the *direct and indirect effects* of one unit of final demand on output. The direct effect contains an *initial output effect*, which is by definition equal to one, since an additional unit of output from any sector requires an initial one unit worth of output from that sector. It also includes any immediate additional output supplied by other sectors used as input by sector j, measured by the technical coefficients in matrix A. The indirect effect of one unit of final demand is the difference between the direct effect and the simple multiplier effect and reflects the additional value created in the production process, i.e. the additional subsequent outputs required for the

2 The methodology of derivation of the multipliers is explained in detail in Miller and Blair (2009) and Ten Raa (2017).
3 i refers to the sector of the i^{th} row and j refers to the sector of the j^{th} column.
4 The inverse Leontief matrix is a sector-to-sector multiplier, while the simple multiplier is a sector-to-economy multiplier.

production of the direct inputs needed in the production of the additional unit.[5]

The simple multiplier is the same as the *backward linkage* of each sector and measures the degree up to which a sector is beneficial to the economy by stimulating additional activity as a purchaser of inputs from other sectors. One of the main factors determining the size of the simple multipliers relates to the relative share of leakages from the domestic inter-sectoral system through the use of imports and primary inputs as a share of the total input requirements for each industry. The size of the multiplier would be smaller, the higher the import content of the production process of a sector and the higher the share of primary inputs in total output.

2.3 TOTAL OUTPUT MULTIPLIERS

The model presented so far does not take into account the effects induced by household consumption, since it is assumed that households' spending takes place outside the system and there is no feedback between the household sector and other sectors. This model is said to be *open with respect to households*. However, households earn incomes in payments for their labour services, which they spend on purchasing goods and services. A change in the production of one sector will lead to a change in the amounts earned and spent by households. If the feedback from this household activity is accounted for, then the model is said to be *closed with respect to households*.

In the closed model, households are treated as an additional sector of the economy and an augmented (n+1)x(n+1) matrix B of technical coefficients is obtained with one additional row at the bottom and one additional column to the right,[6] the bottom row containing the share of employees' compensation in the corresponding sectors' output and the rightmost column containing the share of the household consumption of each sector in total.

Then output multipliers can be calculated on the basis of the column sums of the augmented inverse matrix $(I-B)^{-1}$, known as the *total multipliers*. The difference between the simple multiplier and the total multiplier reflects the *household induced consumption effects* of one currency unit of final demand.

It is clear that the simple multipliers underestimate economic impacts, given that they omit household incomes and expenditure. An important factor determining the size of the total multipliers relates to the consumption pattern of households. The larger the share of household income consumed rather than being leaked out of the system via e.g. savings or taxation, the larger the induced consumption effects would be.

2.4 VALUE ADDED AND EMPLOYMENT MULTIPLIERS

The input-output model can be extended to calculate the *value added multipliers*, which relate to the value added created by the initial shock on final demand. Value added captures the value that the sector adds to the economy through the use of primary inputs (labour, capital and land) and it is measured by the difference between the sector's output and the cost of its intermediate inputs. Value added is often considered to be a better measure of the contribution of this sector to the economy, since it is closer to GDP.

The additional information needed to compute value added multipliers is the set of sectoral *value added coefficients*, which measure the share of the value added of each sector in the sector's output and they can be obtained from the input-output table.

If v is a row vector of value added coefficients, the value added simple multipliers according to the open model are:

5 An alternative approach to understanding the initial, direct, and indirect effects is to consider the power series approximation for the inverse $(I-A)^{-1}=I+A+A^2+A^3+...$, and associate the initial effect with the unit matrix I, the direct effect with the matrix of technical coefficients A and the indirect effect with the rest of the terms of the expansion.

6 The element in the bottom right corner of matrix B is zero.

$$V=v(I-A)^{-1} \quad (3)$$

The same approach is used to calculate employment multipliers. The major difference is that instead of the value added coefficients, we need the sectoral *employment coefficients* vector e that measures employment in physical terms (persons) per unit of output. Then the employment multipliers are

$$E=e(I-A)^{-1} \quad (4)$$

and they can be used to estimate the impact of each sector on employment.

Total value added and employment multipliers can be calculated from the closed model replacing matrix A in (3) and (4), respectively, by the augmented matrix B discussed above. As in the case of the output multipliers, the difference between the simple and the total multiplier of value added and employment reflects the household induced consumption effects of one currency unit of final demand.

The size of the value added and employment multipliers depends not only on the technical coefficients, as in the case of output multipliers, but also on the size of value added and employment coefficients, respectively. The higher the share of the value of primary inputs and employment in total output, the higher the value added and employment multipliers, respectively.

2.5 UNDERLYING ASSUMPTIONS AND INTERPRETATION OF THE INPUT-OUTPUT MULTIPLIERS

The interpretation of the results derived from the application of the input-output analysis must consider certain key underlying assumptions that include the following (see McLennan 1997):

(a) a fixed input structure in each sector described by fixed technical coefficients;[7]

(b) each sector produces a homogeneous product or if there are more than one products, they are produced in fixed proportions to each other;

(c) production in each sector exhibits constant returns to scale;

(d) there is unlimited supply of labour and capital at fixed prices; and

(e) there are no constraints, such as the external balance, nor government actions on the response of each industry to a stimulus.

The multipliers therefore do not take into account economies of scale, unused capacity or technological change. In addition, input-output analysis relies on the interdependence that stems from the sales and purchase links of intermediates between industries. Other interdependencies, such as collective competition for factors of production, changes in commodity prices which induce producers and consumers to alter the mix of their purchases and other constraints which operate on the economy as a whole, as well as pre-existing conditions are not generally taken into account.

The combination of the assumptions embedded in the input-output analysis and the excluded interdependencies suggests that input-output multipliers may overestimate the effects of exogenous changes in final demand. According to Oosterhaven et al. (1986), the values of the simple and the total multipliers can be deemed as the lower and the upper limits of the effect following an increase in final demand. This is particularly the case in the short run, when capacity and other constraints are more relevant. However, they provide a consistent measure of the interdependence between one sector and the rest of the economy, which is easy to compute and appropriate for comparisons across sectors.

2.6 DATA

The Symmetric Input-Output Tables (SIOT) for the year 2015 at basic prices compiled according to the ESA 2010 were used, available

7 Assumption (a) is supported by empirical evidence from comparisons of input-output tables for Greece and other countries over time.

from Eurostat and the Hellenic Statistical Authority (ELSTAT 2019). Employment data by sector were available for the year 2015 from ELSTAT.[8]

Although the SIOT is provided on a *product-by-product* basis, in our analysis we refer to sectors, as: (a) the vast majority of the industries produce almost exclusively the corresponding product (according to the Supply Table) and (b) the *product-by-product* SIOT is effectively a *product-by-product adjusted-industries* input-output table (Box 12.1, United Nations 2018). It is noted that the structure of CPA (European Classification of Products by Activity) corresponds to that of NACE Rev. 2 (European Classification of Economic Activities); *the coding of the first four digits is identical with that used in NACE Rev. 2, with very few exceptions* (Eurostat 2008b).

In order to focus on the multiplier effects of exogenous changes in final demand on the domestic economy, we use the domestic input-output tables that exclude imported intermediate inputs from the cross-sectoral transactions. In the same manner, the final demand components in the domestic input-output tables include the domestic and foreign demand of domestically produced products (i.e. abstracts from imported final goods). Given that the sectoral gross output is the sum of the value of the primary and intermediate (domestically produced or imported) inputs, it follows that our calculation of the technical coefficients *(αij)* implicitly treats the use of imported intermediates as a leakage from the domestic production system.

3 RESULTS

Tables 1 to 3 present the output, gross value added and employment multipliers, respectively, by sector of activity.[9] In all tables, the rank of each sector is included. The total multiplier reflects both direct and indirect production effects, as well as the induced consumption effects caused by an increase in the respective industry's final demand by €1 million. The (simple) mean multiplier values across all sectors are also reported.

Overall, the reported multipliers in Tables 1 to 3 underline the considerable heterogeneity across sectors in terms of their production technology features, market structure and degree of linkages with other sectors through the flows of goods and services intermediates.[10]

Table 1 presents **output multipliers** by sector of activity. There are 54 sectors that exhibit a total multiplier higher than 2, meaning that an increase of €1 million in final demand would cause a more than double increase in domestic output (i.e. of more than €2 million). On average, an increase of €1 million in final demand would lead to an increase of €2.372 million in domestic output. This increase incorporates the initial increase in the output of the average sector in the economy in order to meet the increase in demand (€1 million), the follow-up increase in the production of its direct suppliers of intermediates (€0.359 million), the indirect production effects (€0.171 million) and the induced consumption effects when endogenising households (€0.842 million).

The magnitude of the simple multiplier reflects the importance of primary inputs in the production of a sector and thereby the extent to which the sector is linked to other activities in the production process. The higher the use of imported intermediates though, the higher the leakages from the domestic production system and thus the lower the simple multiplier. In this

8 On 16 October 2020 ELSTAT published revised Annual National Accounts data that also included a change of the base year (2015=100). At the time of the publication of this study, there were no revised supply, use and input-output tables available. For consistency reasons, the data on employment used for the derivation of the employment multipliers are the National Accounts data at the 64 NACE Rev. 2 level of detail before the revision. We note though that there are no major revisions involved in the revised data.

9 Multipliers for "Services of households as employers" (CPA/NACE Rev. 2 97-98) and "Services of extraterritorial organisations" (CPA/NACE Rev. 2 99) are not presented.

10 There is a positive, though not so strong correlation between the rank (on the basis of the Spearman rank correlation) of the various total multipliers (Output, GVA and Employment). Specifically, the correlation amounts to 0.40 (for GVA-Employment), 0.51 (for Output-GVA) and 0.54 (for Output-Employment).

Table 1 Output multipliers

Nace Rev. 2 code	Industry	Direct	Rank	Simple	Rank	Total	Rank
01	Crop and animal production etc.	1.351	38	1.533	30	1.889	58
02	Forestry and logging	1.235	53	1.340	52	1.935	57
03	Fishing and aquaculture	1.241	52	1.344	51	1.736	59
05-09	Mining and quarrying	1.357	36	1.518	34	2.513	21
10-12	Manuf. of food, beverages and tobacco	1.523	6	1.813	4	2.389	30
13-15	Manuf. of textiles, wearing apparel etc.	1.414	20	1.627	18	2.584	17
16	Manuf. of wood and related products	1.582	2	1.998	2	2.783	10
17	Manuf. of paper and paper products	1.525	5	1.871	3	2.629	13
18	Printing and reproduction of recorded media	1.363	35	1.590	24	2.593	15
19	Manuf. of coke and refined petroleum products	1.180	58	1.258	58	1.437	61
20	Manuf. of chemicals	1.306	44	1.447	43	2.046	53
21	Manuf. of basic pharmaceutical products	1.479	10	1.714	10	2.629	14
22	Manuf. of rubber and plastic products	1.411	21	1.616	19	2.240	40
23	Manuf. of other non-metallic mineral products	1.445	14	1.678	13	2.438	28
24	Manuf. of basic metals	1.428	17	1.660	15	2.166	44
25	Manuf. of fabricated metal products	1.389	25	1.600	22	2.257	39
26	Manuf. of computer, electronic products etc.	1.320	42	1.479	40	2.088	49
27	Manuf. of electrical equipment	1.438	15	1.693	11	2.351	34
28	Manuf. of machinery and equipment n.e.c.	1.366	33	1.561	29	2.391	29
29	Manuf. of motor vehicles etc.	1.337	40	1.513	36	2.281	38
30	Manuf. of other transport equip.	1.289	45	1.438	45	2.129	47
31-32	Manuf. of furniture other manuf.	1.448	13	1.726	7	2.456	27
33	Repair, installation of machinery and equip.	1.269	47	1.400	47	1.994	55
35	Electricity, gas, steam	1.340	39	1.478	42	2.080	50
36	Water collection, treatment and supply	1.417	19	1.607	21	2.674	12
37-39	Sewerage, waste management	1.252	51	1.371	49	2.059	52
41-43	Construction	1.485	9	1.768	6	2.457	26
45	Trade and repair of motor vehicles	1.373	31	1.481	39	2.212	41
46	Wholesale trade, except of motor vehicles	1.385	26	1.525	33	2.366	31
47	Retail trade, except of motor vehicles	1.406	22	1.526	32	2.495	22
49	Land transport and transport via pipelines	1.380	27	1.588	25	2.315	35
50	Water transport	1.402	23	1.611	20	2.070	51
51	Air transport	1.522	7	1.779	5	2.363	32
52	Warehousing etc.	1.366	34	1.508	38	2.295	37
53	Postal and courier activities	1.324	41	1.479	41	2.779	11
55-56	Accommodation and food svcs	1.373	30	1.593	23	2.148	45
58	Publishing	1.465	12	1.688	12	3.082	3
59-60	Motion picture, broadcasting etc.	1.375	29	1.570	28	2.856	7
61	Telecommunications	1.419	18	1.527	31	2.015	54
62-63	Computer programming, information svcs	1.369	32	1.511	37	2.494	23
64	Financial svcs	1.260	49	1.366	50	2.463	25
65	Insurance and pensions	1.437	16	1.627	17	2.357	33
66	Auxiliary financial and insurance activities	1.311	43	1.439	44	2.131	46
68A	Real estate services excluding imputed rents	1.083	61	1.117	61	1.297	62
69-70	Legal and accounting activities	1.256	50	1.326	54	2.093	48
71	Architectural and engineering activities etc.	1.498	8	1.650	16	2.207	43
72	Scientific research and development	1.228	54	1.334	53	2.571	18
73	Advertising and market research	1.573	3	1.725	9	2.489	24
74-75	Other professional etc. activities	1.539	4	1.665	14	2.554	20
77	Rental and leasing activities	1.398	24	1.583	27	2.210	42
78	Employment activities	1.112	60	1.158	60	2.584	16
79	Travel agency, tour operators etc.	1.674	1	2.051	1	2.853	8
80-82	Security and investigation etc. activities	1.352	37	1.518	35	2.798	9
84	Public administration and defence	1.192	55	1.282	56	2.892	6
85	Education	1.053	62	1.077	62	2.944	5
86	Human health activities	1.191	56	1.292	55	2.306	36
87-88	Residential care and social work activities	1.261	48	1.379	48	3.251	1
90-92	Creative, arts and entertainment activities etc.	1.288	46	1.421	46	1.985	56
93	Sports activities and recreation activities	1.479	11	1.726	8	3.050	4
94	Activities of membership organisations	1.377	28	1.585	26	3.223	2
95	Repair of computers etc.	1.167	59	1.226	59	1.545	60
96	Other personal service activities	1.186	57	1.268	57	2.556	19
	Average	**1.359**		**1.530**		**2.372**	

Source: 2015 Symmetric Input-Output Tables, ELSTAT/Eurostat, and authors' calculations.
Note: Multipliers for each sector show the increase in gross output (in € millions) caused by an increase of €1 million in the final demand of that sector.
Colour index: 1st quantile (top), 2nd quantile, 3rd quantile, 4th quantile (bottom).

regard, more upstream sectors and sectors with more complex technology in terms of primary input diversification are expected to feature higher simple (and direct) multipliers. Meanwhile, the size of the total multiplier is determined by the share of output that is allocated as compensation of the labour input, which indirectly reflects the labour intensity of a sector. Moreover, total multipliers depend on the home bias in households' consumption, i.e. the extent to which households consume domestically produced goods and services. To some extent, however, strong induced consumption effects go against strong production effects, since a higher output share for labour indirectly suggests a lower share for primary inputs. All in all, more downstream and labour intensive sectors are expected to feature higher total multipliers.

Table 1 shows that high in the ranking in terms of their total output multiplier are services industries on account of their strong induced consumption effects. These notably include services that are largely produced by the public sector, such as *Residential care and social work, Education,* and *Public administration and defence*. While these sectors have a limited use of intermediates and thus feature low production effects (*Education* features the lowest direct and simple multipliers across all sectors), they have high labour intensity (due to technology and market structure) so that a large fraction of their output is returned to the domestic production system through labour income.

As regards important tourism-related activities, it is worth noting that *Travel agency and related services* feature among the top ten sectors in terms of their total multiplier. This outcome is driven by the particularly strong production effects of this sector given its strong inter-sectoral linkages. While *Accommodation and food services* also feature an above average simple multiplier, their total multiplier is below the average multiplier in the economy.

Manufacturing sectors feature by and large lower in the ranking in terms of their total multipliers, given their relatively high primary input and capital intensity. Manufacturing of *Coke and refined petroleum products* and *Chemicals* are among the ten sectors with the lowest total multiplier, which for the former reflects largely its high use of imported intermediates. The same holds for the primary sector activities. Other important manufacturing sectors for the Greek economy in terms of their exporting activity, such as the manufacturing of *Basic pharmaceutical products* and *Textiles* feature above average total multipliers and strong induced consumption effects. The same holds for the manufacturing of *Food, beverages and tobacco*, even though the high total multiplier in this case reflects mostly strong production effects. This is because the manufacturing of *Food, beverages and tobacco* is closely dependent on domestic activities for the supply of its primary inputs.

Table 2 presents the **gross value added multipliers** by sector of activity. An increase of €1 million in final demand would on average cause an increase of €0.8 million in gross value added (i.e. GDP) when accounting for the direct and indirect production effects. The multiplier is less than one unit because the use of intermediates in the production (whether domestically produced or imported) is treated as a leakage from the process of final good production (value added generation). Accounting for the induced consumption effects raises the value of the average multiplier to 1.058, which means that €0.258 million further worth of value added is generated if all of the additional labour income is used for consumption purposes (i.e. in the absence of further leakages of value).

A high simple gross value added multiplier value is directly related to a high share of gross value added in the overall production of a sector. Accordingly, if a higher share of this value added is allocated as compensation for labour, then the total gross value multiplier is also high. *Education, Public administration and defence,* and *Residential care and social work* stand on top of the ranking of sectors in terms of their

Table 2 Gross value added multipliers

Nace Rev. 2 code	Industry	Simple	Rank	Total	Rank
01	Crop and animal production etc.	0.782	40	0.891	52
02	Forestry and logging	0.860	21	1.042	32
03	Fishing and aquaculture	0.835	30	0.955	47
05-09	Mining and quarrying	0.854	24	1.158	20
10-12	Manuf. of food, beverages and tobacco	0.775	41	0.951	48
13-15	Manuf. of textiles, wearing apparel etc.	0.688	52	0.981	44
16	Manuf. of wood and related products	0.571	59	0.811	59
17	Manuf. of paper and paper products	0.518	61	0.751	60
18	Printing and reproduction of recorded media	0.682	54	0.989	42
19	Manuf. of coke and refined petroleum products	0.209	62	0.264	62
20	Manuf. of chemicals	0.686	53	0.869	53
21	Manuf. of basic pharmaceutical products	0.769	43	1.048	30
22	Manuf. of rubber and plastic products	0.519	60	0.711	61
23	Manuf. of other non-metallic mineral products	0.770	42	1.002	40
24	Manuf. of basic metals	0.698	50	0.853	55
25	Manuf. of fabricated metal products	0.712	49	0.914	50
26	Manuf. of computer, electronic products etc.	0.665	56	0.851	56
27	Manuf. of electrical equipment	0.623	58	0.825	58
28	Manuf. of machinery and equipment n.e.c.	0.730	47	0.984	43
29	Manuf. of motor vehicles etc.	0.696	51	0.931	49
30	Manuf. of other transport equip.	0.799	39	1.011	37
31-32	Manuf. of furniture other manuf.	0.679	55	0.902	51
33	Repair, installation of machinery and equip.	0.828	31	1.010	39
35	Electricity, gas, steam	0.816	34	1.000	41
36	Water collection, treatment and supply	0.855	23	1.181	14
37-39	Sewerage, waste management	0.883	16	1.093	25
41-43	Construction	0.751	46	0.962	46
45	Trade and repair of motor vehicles	0.900	15	1.123	23
46	Wholesale trade, except of motor vehicles	0.816	33	1.074	27
47	Retail trade, except of motor vehicles	0.873	20	1.170	17
49	Land transport and transport via pipelines	0.800	38	1.022	34
50	Water transport	0.728	48	0.869	54
51	Air transport	0.654	57	0.833	57
52	Warehousing etc.	0.811	36	1.052	29
53	Postal and courier activities	0.768	44	1.165	18
55-56	Accommodation and food svcs	0.802	37	0.972	45
58	Publishing	0.816	35	1.242	10
59-60	Motion picture, broadcasting etc.	0.841	29	1.235	11
61	Telecommunications	0.905	13	1.055	28
62-63	Computer programming, information svcs	0.878	18	1.179	15
64	Financial svcs	0.929	7	1.265	9
65	Insurance and pensions	0.929	8	1.152	21
66	Auxiliary financial and insurance activities	0.924	10	1.136	22
68A	Real estate services excluding imputed rents	0.966	3	1.021	35
69-70	Legal and accounting activities	0.937	4	1.171	16
71	Architectural and engineering activities etc.	0.845	28	1.016	36
72	Scientific research and development	0.909	12	1.288	7
73	Advertising and market research	0.878	19	1.112	24
74-75	Other professional etc. activities	0.913	11	1.185	13
77	Rental and leasing activities	0.855	22	1.047	31
78	Employment activities	0.968	2	1.404	4
79	Travel agency, tour operators etc.	0.766	45	1.011	38
80-82	Security and investigation etc. activities	0.882	17	1.274	8
84	Public administration and defence	0.933	6	1.426	2
85	Education	0.979	1	1.550	1
86	Human health activities	0.852	26	1.162	19
87-88	Residential care and social work activities	0.852	25	1.426	3
90-92	Creative, arts and entertainment activities etc.	0.902	14	1.075	26
93	Sports activities and recreation activities	0.816	32	1.222	12
94	Activities of membership organisations	0.852	27	1.353	5
95	Repair of computers etc.	0.935	5	1.033	33
96	Other personal service activities	0.929	9	1.323	6
	Average	**0.800**		**1.058**	

Source: 2015 Symmetric Input-Output Tables, ELSTAT/Eurostat, and authors' calculations.
Note: Multipliers for each sector show the increase in GVA (in € millions) caused by an increase of €1 million in the final demand of that sector.
Colour index: 1st quantile (top), 2nd quantile, 3rd quantile, 4th quantile (bottom).

total multiplier. As already discussed, this outcome reflects the low use of intermediates in these sectors in conjunction with their labour intensive technology and market structure (mostly produced by the public sector). As a result, a high share (above average) of their production regards new value added and is used for the compensation of labour. In turn, a higher proportion of their output, compared with the average sector, triggers further output increases in the economy due to the induced consumption effects.[11] Thus, any exogenous boost in the final demand of these activities would have an important multiplier effect on GDP.

As anticipated by the discussion above, downstream services with a high share of gross value added in their production and high labour intensity feature overall stronger total gross value added multiplier effects. Instead, upstream manufacturing activities with relatively low shares of gross value added in total output and low labour intensity feature lower multipliers, regardless of incorporating the induced consumption effects. Manufacturing of *Coke and refined petroleum products* has particularly low gross value added multiplier, reflecting its high dependence on intermediates in its production coupled with its high capital intensity. Primary sector activities also feature relatively low total gross value added multipliers, mostly on account of the low share of labour compensation in their production.[12] Finally, tourism-related services broadly feature gross value added multipliers that are close to (but somewhat below) the average multiplier effects in the economy.

It is worth noting at this point that sectors featuring relatively high gross value added multipliers are not necessarily those with relatively large shares in gross value added. By way of illustration, among the top ten sectors in terms of total gross value added multipliers, *Public administration and defence*, *Education* and *Financial services* also feature among the top ten sectors in terms of their 2019 gross value added shares.[13] On the contrary, *Employment* and *Residential care and social work activities* feature at the bottom quantile of the distribution of gross value added shares (0.09% and 0.16% in 2019, respectively). Such configurations are possible because the multipliers are meant to capture the degree of inter-sectoral linkages for each sector and, as such, their calculation is independent of the relative size of each sector.

Table 3 presents **employment multipliers** by sector, which are expressed in terms of the increase in the number of persons employed caused by an increase of €1 million in the final demand of the respective sector. The average employment multiplier suggests that an increase of €1 million in final demand causes an increase of 25 persons in employment (new employment positions) when only the direct and indirect production effects are considered. The increase in production due to the induced consumption effects brings about a further increase in employment of 6 more persons.

Sectors with a high ratio of employment to total output (high labour intensity) tend to feature higher employment multipliers, given that the multiplier effects on employment are mostly driven by the direct and indirect production effects. The stronger the linkages of a sector through the supply and use of domestic intermediate inputs, the higher these production effects on employment are. *Residential care and social work activities* feature the highest employment multipliers, despite its very small share in aggregate employment. *Crop and animal production* and the *Retail trade* sectors though combine a high share in aggregate employment with also very high employment multipliers. Lastly, apart from very high output multipliers, *Education* also features at the top of the distribution of employment multipliers due to its high labour intensity.

11 The same rationale holds for *Scientific research and development* and *Human health activities*. The former also features among the top ten sectors in terms of its gross value added multiplier.
12 This result relates to the high share of self-employed persons in the sector, so that compensation of employees (and accordingly the share of labour income in output) appears relatively low.
13 For the gross value added and employment (headcount) shares by sector in 2019 using the revised National Accounts Statistics (published on 16.10.2020), see Appendix 2.

Table 3 Employment multipliers

Nace Rev. 2 code	Industry	Simple	Rank	Total	Rank
01	Crop and animal production etc.	57	3	60	3
02	Forestry and logging	37	9	42	12
03	Fishing and aquaculture	25	26	28	32
05-09	Mining and quarrying	18	39	25	37
10-12	Manuf. of food, beverages and tobacco	25	27	29	29
13-15	Manuf. of textiles, wearing apparel etc.	34	11	41	14
16	Manuf. of wood and related products	49	5	55	5
17	Manuf. of paper and paper products	17	43	22	41
18	Printing and reproduction of recorded media	29	18	36	19
19	Manuf. of coke and refined petroleum products	4	61	5	61
20	Manuf. of chemicals	12	54	16	55
21	Manuf. of basic pharmaceutical products	20	34	27	33
22	Manuf. of rubber and plastic products	16	45	21	47
23	Manuf. of other non-metallic mineral products	17	41	23	40
24	Manuf. of basic metals	10	56	14	58
25	Manuf. of fabricated metal products	17	40	22	42
26	Manuf. of computer, electronic products etc.	17	42	22	43
27	Manuf. of electrical equipment	14	50	19	51
28	Manuf. of machinery and equipment n.e.c.	20	33	26	34
29	Manuf. of motor vehicles etc.	16	46	22	44
30	Manuf. of other transport equip.	31	14	37	17
31-32	Manuf. of furniture other manuf.	34	10	40	15
33	Repair, installation of machinery and equip.	12	53	16	54
35	Electricity, gas, steam	7	59	12	59
36	Water collection, treatment and supply	15	47	23	39
37-39	Sewerage, waste management	10	57	15	56
41-43	Construction	31	15	36	20
45	Trade and repair of motor vehicles	28	19	34	22
46	Wholesale trade, except of motor vehicles	20	35	26	36
47	Retail trade, except of motor vehicles	51	4	58	4
49	Land transport and transport via pipelines	27	22	32	25
50	Water transport	11	55	14	57
51	Air transport	14	49	19	52
52	Warehousing etc.	14	51	20	50
53	Postal and courier activities	27	23	36	18
55-56	Accommodation and food svcs	27	21	31	28
58	Publishing	27	20	38	16
59-60	Motion picture, broadcasting etc.	32	13	42	11
61	Telecommunications	7	60	11	60
62-63	Computer programming, information svcs	19	37	26	35
64	Financial svcs	12	52	20	48
65	Insurance and pensions	14	48	20	49
66	Auxiliary financial and insurance activities	26	25	31	27
68A	Real estate services excluding imputed rents	2	62	3	62
69-70	Legal and accounting activities	26	24	32	24
71	Architectural and engineering activities etc.	46	6	50	6
72	Scientific research and development	8	58	17	53
73	Advertising and market research	18	38	24	38
74-75	Other professional etc. activities	25	29	31	26
77	Rental and leasing activities	24	30	29	30
78	Employment activities	30	17	41	13
79	Travel agency, tour operators etc.	23	32	29	31
80-82	Security and investigation etc. activities	38	7	48	7
84	Public administration and defence	23	31	35	21
85	Education	33	12	47	9
86	Human health activities	25	28	32	23
87-88	Residential care and social work activities	77	1	91	1
90-92	Creative, arts and entertainment activities etc.	16	44	21	46
93	Sports activities and recreation activities	38	8	48	8
94	Activities of membership organisations	30	16	43	10
95	Repair of computers etc.	19	36	22	45
96	Other personal service activities	72	2	82	2
	Average	**25**		**31**	

Source: 2015 Symmetric Input-Output Tables, ELSTAT/Eurostat, and authors' calculations.
Note: Multipliers for each sector show the increase in the number of employed persons caused by an increase of €1 million in the final demand of that sector (rounded figures).
Colour index: 1st quantile (top), 2nd quantile, 3rd quantile, 4th quantile (bottom).

Moreover, manufacturing activities tend to feature relatively lower employment multipliers, primarily reflecting their low labour intensity. This is particularly the case for the manufacturing of *Coke and refined petroleum products*. Similarly to the discussion of the gross value added multiplier of this sector, the low value of the employment effects relates to its high use of imported intermediates and low labour intensity. It is worth noting at this point though that a low (high) value of employment multiplier may also mask high (low) efficiency in using labour in the technology embedded in the production, i.e. may well mask high (low) labour productivity. The relatively higher ranking of the *Textiles* manufacturing, which is largely characterised by smaller firms and low economies of scale, points to the relevance of both factors for shaping sectoral employment multipliers.

Furthermore, in line with the results in terms of output multipliers, employment multipliers in tourism-related activities are broadly close to the average multiplier effects across the economy, even though they have a relatively high share in aggregate employment (*Accommodation and food services* alone had the highest share in aggregate employment in 2019 among these sectors). Thus, a change in the final demand of these sectors would not have above average ripple effects on the entire production system of the Greek economy.

3.2 COMPARISON WITH PREVIOUS STUDIES

For the Greek economy, the existing studies using the input-output analysis framework can be broadly classified in three streams.[14] The first one attempts to identify the inter-sectoral relations and discusses the various multipliers of the Greek economy's sectors (either nationwide or regionally).[15] The second one focuses on the effects of a specific sector or industry on the Greek economy.[16] Finally, there is a third stream that attempts to identify the ratio of factors of production to output and the corresponding intensity of these factors.[17] Our research can be classified in the first stream, as it presents the inter-sectoral relations in the Greek economy.

As our analysis uses the latest available input-output tables (year 2015) based on ESA 2010, our results may not be directly comparable with previous studies. It should be noted that any intertemporal comparison must be evaluated with caution, as variations in the ranking of sectors could stem from a variety of reasons such as:

- Statistical authorities may change data sources and data compilation methods over time. In our case in particular, there is a change in methodology due to the adoption of the ESA 2010.[18] In addition, the aggregation of sectors may be different as well.

- Input-output tables are expressed in current, rather than constant, prices. Therefore, any changes in the inter-sectoral relations may stem from changes in prices over time, rather than from actual changes in quantities.

Against this background and departing from the absolute levels of multipliers, we can identify some characteristic facts when comparing the results of the present study with those of the Academy of Athens (2007) for 2005 and of Athanassiou et al. (2014) for 2010.[19] The latter study —as in our case— analysed 64 sectors of the 2010 Input-Output tables based on ESA 1995. According to the ranking of the output total multipliers, ten of the sectors that were ranked in the first quantile (i.e. top-15) in our analysis are also present in the top quantile in Athanassiou et al. (2014).[20] It is worth mentioning that the top quantile is dominated by

14 There is also another approach that initiates from the Supply and Use tables rather than directly from the Input-Output tables. Such studies estimate the Sraffian multipliers for the Greek economy. See for instance Mariolis and Soklis (2018).
15 See for instance Academy of Athens (2007) and Athanassiou et al. (2014).
16 See for instance IOBE (2012).
17 See for instance Skountzos and Stromplos (2011).
18 It is noted that in GVA terms, the transition from ESA 1995 to ESA 2010 impacted negatively industry groups B-E (mining; manufacturing; electricity etc.; water supply; sewerage etc.) and J (information and communication) and positively F (construction) and L (real estate activities) (Eurostat 2015).
19 Both studies do not present value added multipliers.
20 The five sectors that are present in our top quantile but not in Athanassiou et al. (2014) are: *Manufacture of wood, Publishing, Printing, Manufacture of paper* and *Manufacture of pharmaceutical products.*

service activities, *Education* and *Public administration and defence* are among the higher-ranked sectors, while *Social care activities* is the top-ranked sector in both studies. On the other hand, only seven sectors appear in the bottom quantile (i.e. bottom-15) such as *Real estate activities, Manufacture of coke* and *Fishing*. The *Manufacture of pharmaceutical products* sector, which was in the bottom quantile in Athanassiou et al. (2014), has climbed to the top quantile in our analysis.

In the case of the employment total multipliers, ten sectors are common in the top quantile including *Crop and animal production* and *Education*, while *Social care activities* is the top-ranked sector.[21] *Public administration and defence*, which was the 10th sector in Athanassiou et al. (2014), is ranked 21st in our analysis. In addition, *Manufacture of textiles* and *Manufacture of furniture*, which are ranked 14th and 15th in our analysis, were placed in the bottom half of sectors (positions 45 and 36, respectively) in Athanassiou et al. (2014). Turning to the bottom quantile, nine sectors are present in both studies, with *Real estate activities* positioned at the bottom. In addition, *Financial services*, which was ranked almost in the middle (29th position) in Athanassiou et al. (2014), is ranked among the lowest 15 sectors in our analysis. It is worth mentioning that *Accommodation and food services* is ranked in the third quantile (around position 40) on the basis of the total output multiplier and in the second quantile (around position 28) with respect to the total output employment multiplier in both studies.

The Academy of Athens (2007) study used the 2005 input-output tables, which were based on ESA 1995, included 26 sectors compared with the 64 sectors used in our study and calculated only the simple multipliers (i.e. direct and indirect effect). The key finding is that the top quantile (i.e. six sectors) of the Academy of Athens (2007) is dominated by manufacturing sectors, with *Financial intermediation* ranking 6th. The top quantile in our analysis (15 sectors) is almost equally split between manufacturing and services sectors. The sectors that are present in the top quantile of both studies are *Manufacturing of food and beverages* and *Manufacturing of basic metals*. In addition, the *Manufacturing of coke and refined petroleum products* sector was in the top quantile in the Academy of Athens (2007) study, but in our analysis ranks in the bottom quantile. The same is also true for *Financial intermediation/services*. As far as the bottom quantile is concerned, there is a surprising resemblance in both studies, with *Real estate services*, *Education* and *Health* ranked at the bottom positions.

Turning to the simple employment multipliers, the sectors in the top quantile in both studies are similar (including *Education*) except for *Manufacturing of food and beverages*, which is ranked almost in the middle in our analysis. As in the case of the simple output multipliers, the sectors in the bottom quantile are similar, including *Manufacturing of coke and refined petroleum products* and *Real estate services*. It is worth mentioning that the *Accommodation and food services* sector is ranked around the middle position in both studies for both output and employment multipliers.

4 CONCLUSIONS

This analysis has used the most recent Input-Output tables of 2015 for the Greek economy, which were compiled according to the European System of Accounts (ESA) 2010, to estimate, at a disaggregated level, sectoral output, gross value added and employment multipliers. In particular, for each sector estimates of the direct and indirect production effects caused by an exogenous final demand shift (simple multipliers) were presented, as well as the induced consumption effects generated when household consumption is endogenised in the Leontief model (total multipliers). Then the

21 The remaining five sectors that are present in our top quantile but not in Athanassiou et al. (2014) are: *Security and investigation activities, Architectural activities, Motion picture, Manufacture of furniture* and *Manufacture of textiles*.

different sectors of the Greek economy were ranked in terms of their ability to produce economy-wide outcomes on the basis of their technological features and extent of inter-sectoral linkages.

Our analysis shows that services sectors, including services provided largely by the public sector, are ranked high with respect to all three total multipliers on the back of their strong induced consumption effects. On the other hand, manufacturing activities tend to feature overall lower total multipliers, primarily due to their low labour intensity. We further show that a sector may exhibit strong output and employment multiplier effects, despite its small size (and vice versa). Interestingly, *Accommodation and food services*, which is a key tourism-related activity and has a high share in both gross value added and employment, features total multipliers that are close to the average multiplier across sectors. Our main findings are broadly consistent with the results and insights of earlier studies that used different vintages of the input-output tables, suggesting that the underlying structure of the Greek production (and home bias in consumption) has remained relatively unchanged over time. A common finding in the relevant literature focusing on the Greek economy is the strong multiplier effects of the non-market services that are largely provided by the public sector, which underscores the importance of public spending in supporting domestic activity.

Finally, it should be borne in mind that the input-output multipliers provide information which is useful for evaluating the performance of different sectors of the economy in terms of their ability to enhance economic activity by generating output and employment in other sectors, depending on the existing technology, regardless of the sector's share in the domestic economy or its position in international markets. This information can be helpful in evaluating performance even if the initial issue of interest is not the multiplier effects. For instance, while export performance and competitiveness in international markets are often associated with the growth of the manufacturing sectors, most of the relevant sectors are characterised by lower multipliers due to their high import content, reflecting increased participation in global value chains.

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APPENDIX I

Summary of output, GVA and employment total multipliers

Nace Rev. 2 code	Industry	Gross output	Rank	GVA	Rank	Employ-ment	Rank
01	Crop and animal production etc.	1.889	58	0.891	52	60	3
02	Forestry and logging	1.935	57	1.042	32	42	12
03	Fishing and aquaculture	1.736	59	0.955	47	28	32
05-09	Mining and quarrying	2.513	21	1.158	20	25	37
10-12	Manuf. of food, beverages and tobacco	2.389	30	0.951	48	29	29
13-15	Manuf. of textiles, wearing apparel etc.	2.584	17	0.981	44	41	14
16	Manuf. of wood and related products	2.783	10	0.811	59	55	5
17	Manuf. of paper and paper products	2.629	13	0.751	60	22	41
18	Printing and reproduction of recorded media	2.593	15	0.989	42	36	19
19	Manuf. of coke and refined petroleum products	1.437	61	0.264	62	5	61
20	Manuf. of chemicals	2.046	53	0.869	53	16	55
21	Manuf. of basic pharmaceutical products	2.629	14	1.048	30	27	33
22	Manuf. of rubber and plastic products	2.240	40	0.711	61	21	47
23	Manuf. of other non-metallic mineral products	2.438	28	1.002	40	23	40
24	Manuf. of basic metals	2.166	44	0.853	55	14	58
25	Manuf. of fabricated metal products	2.257	39	0.914	50	22	42
26	Manuf. of computer, electronic products etc.	2.088	49	0.851	56	22	43
27	Manuf. of electrical equipment	2.351	34	0.825	58	19	51
28	Manuf. of machinery and equipment n.e.c.	2.391	29	0.984	43	26	34
29	Manuf. of motor vehicles etc.	2.281	38	0.931	49	22	44
30	Manuf. of other transport equip.	2.129	47	1.011	37	37	17
31-32	Manuf. of furniture other manuf.	2.456	27	0.902	51	40	15
33	Repair, installation of machinery and equip.	1.994	55	1.010	39	16	54
35	Electricity, gas, steam	2.080	50	1.000	41	12	59
36	Water collection, treatment and supply	2.674	12	1.181	14	23	39
37-39	Sewerage, waste management	2.059	52	1.093	25	15	56
41-43	Construction	2.457	26	0.962	46	36	20
45	Trade and repair of motor vehicles	2.212	41	1.123	23	34	22
46	Wholesale trade, except of motor vehicles	2.366	31	1.074	27	26	36
47	Retail trade, except of motor vehicles	2.495	22	1.170	17	58	4
49	Land transport and transport via pipelines	2.315	35	1.022	34	32	25
50	Water transport	2.070	51	0.869	54	14	57
51	Air transport	2.363	32	0.833	57	19	52
52	Warehousing etc.	2.295	37	1.052	29	20	50
53	Postal and courier activities	2.779	11	1.165	18	36	18
55-56	Accommodation and food svcs	2.148	45	0.972	45	31	28
58	Publishing	3.082	3	1.242	10	38	16
59-60	Motion picture, broadcasting etc.	2.856	7	1.235	11	42	11
61	Telecommunications	2.015	54	1.055	28	11	60
62-63	Computer programming, information svcs	2.494	23	1.179	15	26	35
64	Financial svcs	2.463	25	1.265	9	20	48
65	Insurance and pensions	2.357	33	1.152	21	20	49
66	Auxiliary financial and insurance activities	2.131	46	1.136	22	31	27
68A	Real estate services excluding imputed rents	1.297	62	1.021	35	3	62
69-70	Legal and accounting activities	2.093	48	1.171	16	32	24
71	Architectural and engineering activities etc.	2.207	43	1.016	36	50	6
72	Scientific research and development	2.571	18	1.288	7	17	53
73	Advertising and market research	2.489	24	1.112	24	24	38
74-75	Other professional etc. activities	2.554	20	1.185	13	31	26
77	Rental and leasing activities	2.210	42	1.047	31	29	30
78	Employment activities	2.584	16	1.404	4	41	13
79	Travel agency, tour operators etc.	2.853	8	1.011	38	29	31
80-82	Security and investigation etc. activities	2.798	9	1.274	8	48	7
84	Public administration and defence	2.892	6	1.426	2	35	21
85	Education	2.944	5	1.550	1	47	9
86	Human health activities	2.306	36	1.162	19	32	23
87-88	Residential care and social work activities	3.251	1	1.426	3	91	1
90-92	Creative, arts and entertainment activities etc.	1.985	56	1.075	26	21	46
93	Sports activities and recreation activities	3.050	4	1.222	12	48	8
94	Activities of membership organisations	3.223	2	1.353	5	43	10
95	Repair of computers etc.	1.545	60	1.033	33	22	45
96	Other personal service activities	2.556	19	1.323	6	82	2
	Average	2.372		1.058		31	

Source: 2015 Symmetric Input-Output Tables, ELSTAT/Eurostat, and authors' calculations.
Note: Multipliers for each sector show the increase in gross output and GVA (in € millions) and in the number of employed persons (rounded) caused by an increase of €1 million in the final demand of that sector.

APPENDIX 2

Gross value added and employment shares by sector (2019)

(%)

Nace Rev. 2 code	Industry	GVA	Rank	Employment	Rank
01	Crop and animal production etc.	3.95	9	10.22	3
02	Forestry and logging	0.04	61	0.20	53
03	Fishing and aquaculture	0.37	38	0.46	30
05-09	Mining and quarrying	0.33	40	0.22	52
10-12	Manuf. of food, beverages and tobacco	3.14	10	2.66	10
13-15	Manuf. of textiles, wearing apparel etc.	0.30	42	0.64	26
16	Manuf. of wood and related products	0.06	60	0.17	57
17	Manuf. of paper and paper products	0.20	52	0.19	55
18	Printing and reproduction of recorded media	0.19	56	0.23	50
19	Manuf. of coke and refined petroleum products	0.29	43	0.08	61
20	Manuf. of chemicals	0.65	25	0.26	45
21	Manuf. of basic pharmaceutical products	0.58	29	0.23	51
22	Manuf. of rubber and plastic products	0.40	36	0.28	44
23	Manuf. of other non-metallic mineral products	0.45	34	0.36	39
24	Manuf. of basic metals	0.63	27	0.25	47
25	Manuf. of fabricated metal products	0.64	26	0.74	23
26	Manuf. of computer, electronic products etc.	0.19	57	0.08	60
27	Manuf. of electrical equipment	0.26	47	0.19	54
28	Manuf. of machinery and equipment n.e.c.	0.23	49	0.23	48
29	Manuf. of motor vehicles etc.	0.03	62	0.04	62
30	Manuf. of other transport equip.	0.17	58	0.10	58
31-32	Manuf. of furniture other manuf.	0.19	55	0.49	29
33	Repair, installation of machinery and equip.	0.26	45	0.36	38
35	Electricity, gas, steam	3.02	11	0.65	24
36	Water collection, treatment and supply	0.45	33	0.23	49
37-39	Sewerage, waste management	0.79	21	0.43	31
41-43	Construction	1.40	17	4.21	8
45	Trade and repair of motor vehicles	1.29	19	1.59	14
46	Wholesale trade, except of motor vehicles	6.33	4	5.05	7
47	Retail trade, except of motor vehicles	4.59	6	10.61	2
49	Land transport and transport via pipelines	1.72	16	2.52	11
50	Water transport	2.93	12	1.38	16
51	Air transport	0.51	31	0.08	59
52	Warehousing etc.	2.04	13	1.12	17
53	Postal and courier activities	0.33	41	0.36	40
55-56	Accommodation and food svcs	7.84	2	12.54	1
58	Publishing	0.20	51	0.29	43
59-60	Motion picture, broadcasting etc.	0.27	44	0.38	36
61	Telecommunications	1.98	14	0.65	25
62-63	Computer programming, information svcs	0.86	20	0.78	21
64	Financial svcs	4.52	7	1.02	18
65	Insurance and pensions	0.51	32	0.18	56
66	Auxiliary financial and insurance activities	0.21	50	0.52	28
68A	Real estate services excluding imputed rents	7.31	3	0.41	34
69-70	Legal and accounting activities	1.79	15	3.10	9
71	Architectural and engineering activities etc.	0.69	23	1.55	15
72	Scientific research and development	0.42	35	0.36	37
73	Advertising and market research	0.26	46	0.35	41
74-75	Other professional etc. activities	0.12	59	0.42	33
77	Rental and leasing activities	0.38	37	0.34	42
78	Employment activities	0.20	54	0.39	35
79	Travel agency, tour operators etc.	0.51	30	0.43	32
80-82	Security and investigation etc. activities	0.71	22	1.86	12
84	Public administration and defence	10.00	1	8.71	4
85	Education	5.51	5	7.98	5
86	Human health activities	4.01	8	5.05	6
87-88	Residential care and social work activities	0.37	39	0.79	20
90-92	Creative, arts and entertainment activities etc.	1.39	18	1.01	19
93	Sports activities and recreation activities	0.23	48	0.59	27
94	Activities of membership organisations	0.59	28	0.76	22
95	Repair of computers etc.	0.20	53	0.25	46
96	Other personal service activities	0.68	24	1.67	13

Source: National Accounts, ELSTAT/Eurostat, and authors' calculations.
Note: The sum does not add up to 100% as two sectors (*Imputed rents* and *Activities of households as employers*) amounting to 9.29% in GVA (mainly due to imputed rents) and to 0.68% in employment are not included.

APPENDIX 3

INPUT-OUTPUT TABLES

The production structure of a simple economy with three production sectors (primary, manufacturing and services) and no external sector is presented in the following table. The columns of the table represent the categories of total demand in the economy: use of intermediate inputs by the three sectors mentioned above and final demand for consumption and investment. The rows of the table represent the inputs of the economy: intermediate inputs produced by the three production sectors and value added by the primary inputs of labour, capital and land (expressed by the compensation of employees and the operating surplus).

Example of an input-output table (in currency terms)

		Intermediate use			Final demand		Output
		Agriculture	Manufacturing	Services	Consumption	Investment	
		QUADRANT I			QUADRANT II		
Intermediate inputs	Agriculture	20	34	10	30	6	100
	Manufacturing	20	152	40	88	100	400
	Services	10	72	20	90	8	200
		QUADRANT III			QUADRANT IV		
Primary inputs	Compensation of employees	30	100	90			220
	Operating surplus	20	42	40			102
	Input	100	400	200	208	114	

Source: Eurostat (2008a).

The table consists of four quadrants:

- *Quadrant I* contains the intermediate input requirements, namely the goods and services produced by each sector and used as input by the same and other sectors.
- *Quadrant II* includes the final use of goods and services produced.
- *Quadrant III* reports the cost of primary inputs used by each sector, which is actually the value added of this sector.
- *Quadrant IV*: usually no transactions are reported there.

The *columns* of an input-output table reflect the *cost structure* of a sector, as it purchases intermediate and primary inputs used in the relevant production process. The *rows* of the table reflect the *composition of the revenues* of each sector, as it sells its products for intermediate and final use.

The sum of each column in the table equals the respective row sum and expresses the total value of production of each sector.

The static input-output model

The balance between total inputs and outputs in this example is described by a set of linear equations:

$$x_1 = x_{11} + x_{12} + x_{13} + x_{1d} \quad (1)$$
$$x_2 = x_{21} + x_{22} + x_{23} + x_{2d} \quad (2)$$
$$x_3 = x_{31} + x_{32} + x_{33} + x_{3d} \quad (3)$$

where

x_j = output of sector j

x_{ij} = output of sector i used as input by sector j

x_{id} = final demand for the output of sector i

Assuming that all inputs are used in fixed proportions in relation to the output of a particular sector, the technical coefficients are defined as $a_{ij} = x_{ij}/x_j$. Then the intermediate input requirements of sector j can be written as $x_{ij} = a_{ij}/x_j$ and equations (1)-(3) can be transformed into the following Leontief equations system:

$$(1-a_{11})x_1 \quad -a_{12}x_2 \quad -a_{13}x_3 = x_{1d} \quad (4)$$
$$-a_{21}x_1 \quad +(1-a_{22})x_2 \quad -a_{23}x_3 = x_{2d} \quad (5)$$
$$-a_{31}x_1 \quad -a_{32}x_2 \quad +(1-a_{33})x_3 = x_{3d} \quad (6)$$

The above system of equations allows the determination of the output of the different sectors in the economy, given the technical coefficients and the final demand, which is isolated on the right-hand side of each equation.

If we express the above system of equations in matrix form, we can write:

$$Ax + x_d = x \quad \text{or} \quad (\text{I-A})\,x = x_d \quad (7)$$

The solution to the above equation system for output is given by

$$x = (I-A)^{-1}x_d \quad (8)$$

Matrix A is the technology matrix with the technical coefficients as elements (a_{ij}). The technical (I-A) is the Leontief matrix. Its diagonal (1-a_{ij}) elements identify, with a positive sign, the net (excluding intrasectoral consumption) output of the relevant sector (i), while the rest of the matrix elements, with a negative sign, identify the input requirements (costs).

Derivation of the output multipliers

It can be shown that the j^{th} column sum of the Leontief inverse is the output multiplier for sector j and it is known as the *simple multiplier*.

If the final demand of a given sector *j* increases by one currency unit, then the right-hand side vector in equation (8) will have 1 for sector *j* and 0 for the rest. Using the example of the table and allowing for a change of one unit in the primary sector, we get:

$$\Delta x = \begin{bmatrix} 0.07 & 0.02 & -0.07 \\ 0.00 & 0.13 & -0.25 \\ -0.03 & -0.46 & 0.98 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.07 \\ 0.00 \\ -0.03 \end{bmatrix} \quad (9)$$

The result is the same as the first column of the inverse and it records the changes in the outputs of all sectors caused by the initial change of one in the primary sector, taking into account the interlinkages between all sectors.