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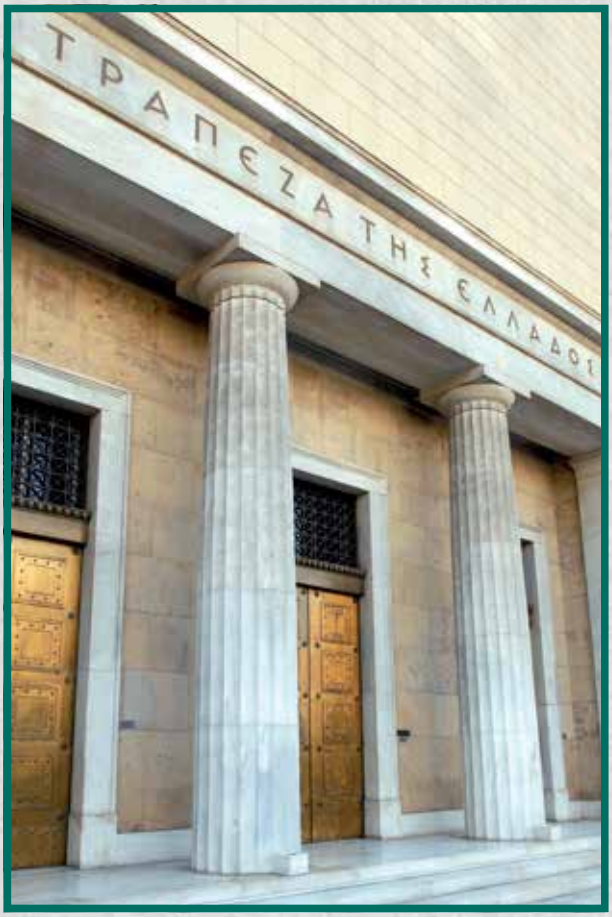

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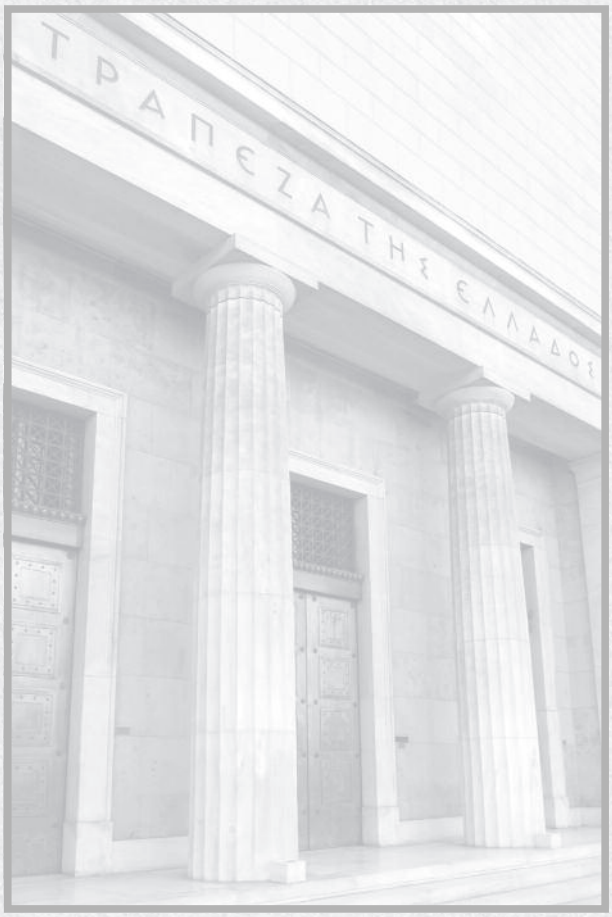

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BANK OF GREECE
21, E. Venizelos Avenue
GR-102 50 Athens

www.bankofgreece.gr

Economic Analysis and Research Department - Secretariat
Tel. +30 210 320 2393
Fax +30 210 323 3025

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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
Economic Analysis and Research Department

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.

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Nikos Vettas
Foundation for Economic and Industrial Research (IOBE), Athens University of Economics and Business, and Centre for Economic Policy Research, UK

Konstantinos Peppas
Foundation for Economic and Industrial Research (IOBE)

Sophia Stavraki
Foundation for Economic and Industrial Research (IOBE)

Michail Vasileiadis
Foundation for Economic and Industrial Research (IOBE)

ABSTRACT

The scope of the study is to examine the impact of various factors on the growth of Greek industrial firms, in order to identify those that can contribute to a gradual recovery of Industry in the coming years. In this context, we estimate a firm growth model with the Quantile Regression econometric method, using an unbalanced panel dataset of 18,143 companies that were active in Greek Industry over the period 2005-2018. The explanatory variables used are firm-, sector- and macroeconomic environment-specific. Further, we estimate the effects on firm growth from the structural reforms related to business environment and from the sector's participation in global value chains within or beyond the EU. The estimations highlight the positive effect on firm growth from exports and the reduction in the time and cost required to export, the availability of funding from the banking sector and the stock market, as well as from the reduction in the cost and procedures to start a business. Positive effects also stem from the participation of the faster-growing Greek industrial companies in value chains mainly outside the EU. By contrast, high corporate debt to banks, adverse macroeconomic conditions, energy costs and the participation of businesses other than the faster-growing ones in value chains in EU countries have a negative impact on firm growth. The latter effect is possibly due to the strong competition that these businesses face in the European markets. Some differences appear when estimates are made for the subsamples of high and low performance industrial sectors in terms of economic activity, financial efficiency, innovativeness and extroversion. The study includes policy recommendations based on the results of the estimations, to support growth in Industry. These concern the reduction of energy costs, the change in the depreciation method for investments in machinery and equipment, as well as the financing of the sector.

Keywords: firm growth; Quantile Regression; Fixed Effects panel data model; Global Value Chains; Vertical Specialisation

JEL classification: C22; C23; D22; L14

Η ΣΥΜΒΟΛΗ ΤΗΣ ΒΙΟΜΗΧΑΝΙΑΣ ΣΤΗΝ ΕΛΛΗΝΙΚΗ ΟΙΚΟΝΟΜΙΑ: ΔΕΔΟΜΕΝΑ ΚΑΙ ΠΡΟΟΠΤΙΚΕΣ

Νίκος Βέττας
Ίδρυμα Οικονομικών και Βιομηχανικών Ερευνών (ΙΟΒΕ),
Οικονομικό Πανεπιστήμιο Αθηνών
και Centre for Economic Policy Research, UK

Κωνσταντίνος Πέππας
Ίδρυμα Οικονομικών και Βιομηχανικών Ερευνών (ΙΟΒΕ)

Σοφία Σταυράκη
Ίδρυμα Οικονομικών και Βιομηχανικών Ερευνών (ΙΟΒΕ)

Μιχαήλ Βασιλειάδης
Ίδρυμα Οικονομικών και Βιομηχανικών Ερευνών (ΙΟΒΕ)

ΠΕΡΙΛΗΨΗ

Σκοπός της μελέτης είναι να εξετάσει την επίδραση διαφόρων παραγόντων στην ανάπτυξη των ελληνικών βιομηχανικών επιχειρήσεων, προκειμένου να αναδειχθούν αυτοί που μπορούν να συμβάλουν στη σταδιακή ανάκαμψη του τομέα της Βιομηχανίας συνολικά τα προσεχή έτη. Σε αυτό το πλαίσιο, εκτιμάται ένα υπόδειγμα ανάπτυξης επιχειρήσεων με τη μέθοδο της Παλινδρόμησης Ποσοστιαίων Σημείων (Quantile Regression) και τη χρήση διαστρωματικών και χρονολογικών σειρών (unbalanced panel data). Τα στοιχεία αφορούν 18.143 επιχειρήσεις που δραστηριοποιούνταν στην ελληνική Βιομηχανία την περίοδο 2005-2018. Οι ερμηνευτικές μεταβλητές αφορούν την ίδια την επιχείρηση, τον κλάδο όπου δραστηριοποιείται, τις μακροοικονομικές συνθήκες εντός των οποίων λειτουργεί, τις μεταρρυθμίσεις στο επιχειρηματικό περιβάλλον και τη συμμετοχή σε διεθνείς αλυσίδες αξίας είτε εντός είτε εκτός ΕΕ. Από τις εκτιμήσεις προκύπτει θετικός ρόλος στην ανάπτυξη των ελληνικών βιομηχανικών επιχειρήσεων από τις εξαγωγές και τη διευκόλυνση της πραγματοποίησής τους, από την παροχή χρηματοδότησης τόσο από τον τραπεζικό τομέα όσο και από τη χρηματιστηριακή αγορά, καθώς και από την απλοποίηση της διαδικασίας ίδρυσης επιχειρήσεων. Θετικές επιδράσεις προκύπτουν και από τη συμμετοχή των ταχύτερα αναπτυσσόμενων ελληνικών βιομηχανικών επιχειρήσεων σε αλυσίδες αξίας κυρίως εκτός ΕΕ. Από την άλλη πλευρά, αρνητική επίδραση στην ανάπτυξή τους ασκούν παράγοντες όπως η υψηλή δανειακή επιβάρυνση σε επίπεδο επιχείρησης, οι δυσμενείς μακροοικονομικές συνθήκες, το κόστος της ενέργειας, όπως και η συμμετοχή επιχειρήσεων εκτός των ταχύτερα αναπτυσσόμενων σε αλυσίδες αξίας με χώρες της ΕΕ, ενδεχομένως εξαιτίας του ισχυρού ανταγωνισμού που αντιμετωπίζουν. Ορισμένες διαφοροποιήσεις παρουσιάζονται στα αποτελέσματα όταν οι εκτιμήσεις περιορίζονται αποκλειστικά σε βιομηχανικούς κλάδους με υψηλές ή χαμηλές επιδόσεις σε δραστηριότητα, δείκτες χρηματοοικονομικής αποδοτικότητας, καινοτομία και εξωστρέφεια. Στα αποτελέσματα των εκτιμήσεων βασίζονται προτάσεις πολιτικής για τη στήριξη της ανάπτυξης της Βιομηχανίας, που αφορούν τη μείωση του ενεργειακού κόστους, τη μεταβολή του τρόπου αποσβέσεων των επενδύσεων σε μηχανήματα και εξοπλισμό και τη βελτίωση της χρηματοδότησης του τομέα.

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Nikos Vettas
Foundation for Economic and Industrial Research (IOBE), Athens University of Economics and Business, and Centre for Economic Policy Research, UK

Konstantinos Peppas
Foundation for Economic and Industrial Research (IOBE)

Sophia Stavraki
Foundation for Economic and Industrial Research (IOBE)

Michail Vasileiadis
Foundation for Economic and Industrial Research (IOBE)

1 INTRODUCTION

Following a period of diminishing importance and shares in the European economy, Industry has more recently become the focus of EU policies and initiatives.[1] To reinforce its position for Europe, the European Commission designed a renewed industrial policy strategy for the EU in 2017.[2] It was updated in early 2020, with a view to delivering on three key priorities: (i) maintaining European Industry's global competitiveness and a level playing field, at home and globally; (ii) making Europe climate-neutral by 2050; and (iii) shaping Europe's digital future.[3] Domestically, Industry is among the activities mostly affected by the recession of 2008-2013. Greek Industry recovered moderately in 2014-2019. Following these developments, its contribution to Greece's GDP fell to 11.6% in 2019, from 13.3% in 2007, when in the 1990s it averaged 17.8% of GDP.

Industry has been severely hit by the COVID-19 pandemic globally. This is compounded by the contraction of world trade volume, which according to recent estimates fell in 2020 to between 9.2% (WTO) and 10.4% (IMF).[4] In addition, the expected expansion of world trade in 2021 (IMF: +8.2%) is expected to partially offset the losses of 2020. However, the contraction of industrial production domestically during January-September 2020 has been 3.6%, i.e. considerably smaller compared with the euro area average (11.3%). This development is an indication of the resilience of Greek Industry. Looking ahead and with an eye towards attaining sustainable and high growth, it is of crucial importance that Industry plays a more important role in the Greek economy.

The scope of the present study is to examine empirically the effect of factors that determine the potential of industrial businesses to grow and evolve. In addition to those already identified in the relevant literature, we have added some new ones, such as participation in Global Value Chains, a variable that captures the dynamics of participation in the division of labour, at the global and regional level.

The remainder of the study is structured as follows: Section 2 presents the economic indicators selected for identifying the industrial sectors with the best or the worst performance in the period 2008-2018, in order to carry out estimations, besides those for the overall sample, about the factors affecting their growth. Among these indicators, the Vertical Specialisation indicator is calculated, separately for the EU countries and for the rest of the world. Section 3 provides a literature review on the

1 "Industry" refers to the grouping of sections B-E of NACE Rev. 2. Eurostat designates it as a domain of activity, alongside Trade, Constructions and Services. "Industrial sectors" refer to 2-digit NACE Rev. 2 activities under sections B-E.
2 European Commission (2017).
3 European Commission (2020).
4 Sources: Press release 862, WTO, 6.10.2020; and *World Economic Outlook*, IMF, October 2020.

main determinants of growth for Industry. Following that, the econometric model used in the estimations for Greek Industry is presented. The section concludes with the presentation of the estimation results. Based on these results, Section 4 presents policy recommendations to support growth in Industry in Greece in the coming years. Section 5 offers a summary of the findings in the study.

2 ASSESSMENT OF ECONOMIC ACTIVITY, EFFICIENCY, STRUCTRURAL CHARACTERISTICS AND EXPORT PERFORMANCE OF INDUSTRIAL SECTORS IN GREECE

The scope of this section is the assessment of 2-digit NACE Rev. 2 industrial sectors based on the trends of indicators and figures concerning economic activity, structural characteristics, financial efficiency and international competitiveness during the period 2008-2018, i.e. from the outbreak of the global financial crisis and the domestic recession to the most recent year for which data are available. The purpose of the exercise is to highlight the industrial sectors in Greece with the average best performance or the biggest improvement in the indicators considered under each category, as well as those sectors that performed poorly or have deteriorated the most. For these sectors, separate estimations of the econometric model capturing the growth determinants of businesses were carried out. These estimations provide further, useful insights into the basic model estimation, for the overall sample of businesses, about the factors that mostly affect growth in Industry. Another significant result of this section is the calculation, in the context of the sectoral assessment process, of the Vertical Specialisation index, separately for the EU countries and the rest of the world. Data for 23 2-digit industrial sectors or mergers of them, referring to sectors NACE Rev. 2 B-E, are available during the period under examination.

The figures and indicators concerning economic activity and the structural characteristics considered for the ranking of industrial sectors comprise:

1 Sector share in total Industry employment (average value): the ranking of a sector with respect to this indicator reflects its ability to create jobs, but also to improve its position in the domestic and global division of labour.

2 Ratio of gross fixed capital formation to gross value added – GFCF to GVA (cumulative change): the trend in this indicator indicates the efforts and the ability of an industrial sector to adapt to new conditions and challenges, thereby strengthening its growth prospects.

3 Firm size, measured by turnover per firm (average annual change): this indicator is considered as indicative of both growth performance and structural changes in a sector.

4 Ratio of R&D expenditures to turnover (average value): the intertemporal level of this indicator shows the efforts to adjust the production process to new and innovative products, in order to strengthen competitiveness in domestic and global markets.

The data for the economic and structural indicators described above were derived from the National Accounts and Structural Business Statistics data domains of Eurostat.

The figures and indicators concerning financial efficiency considered for the ranking of industrial sectors include:

1 Current liquidity ratio – CLR (average value): a constantly high value of this index indicates a sector's ability to cover its short-term liabilities with current assets. Therefore, the sector does not face liquidity problems, a characteristic which in times of intense credit crunch, as in some of the years during the period under review (e.g. 2012, 2015), was of great importance for the viability of businesses.

2 Leverage ratio – LR (debt to equity ratio, average value): the level of this indicator shows the exposure of a sector to credit risk.

3 Return on Assets – RoA (average value): the ranking of sectors indicates the degree of efficient asset management by their businesses, which can contribute to increasing profitability and firms' sustainability.

4 Gross margin ratio (gross profit to sales, average value): the value of this index shows the level of profitability over time and is closely related to the growth prospects of a sector.

The calculations of the financial indicators were based on data from the ICAP-Data.Prisma database.

The assessment of export performance of industrial sectors was based on the following indicators:

1 Openness to Trade index (cumulative change): calculated by the ratio of the sum of international trade inflows and outflows of a sector to its domestic output. A high value of the indicator most probably implies participation in Global Value Chains, which improves the growth potential of a sector.

2 Relative Trade Advantage indicator – RTA (cumulative change): a high value of the indicator is an indication of a competitive advantage of exports of an industrial sector against exports of the same sector from a certain economic region. In our study the examined region is the EU, excluding Greece. Usually, businesses from this area are among the most significant competitors for Greek businesses.

3 The participation of the Greek industrial sectors in Global Value Chains (GVCs) was also assessed in our study by means of the Vertical Specialisation (VS) indicator. What is more important in this study is that the VS indicator was decomposed into two components: one concerning participation in GVCs in the EU and another concerning participation in GVCs beyond the EU. To the best of our knowledge, this is the first time that a study about domestic sectors performs such calculations.

The data for the calculation of the first two indicators were drawn from the National Accounts and ComExt databases of Eurostat. The calculation of the VS indicator was based on data for inflows and outflows of goods and services from the World Input-Output Database. Data from this database reach up to 2014. Accordingly, the VS indicator was calculated for the period 2008-2014.

The presentation of the indicators highlights the various aspects of economic activity, structural characteristics, financial efficiency and exporting activity that were taken into account for the evaluation of the 2-digit industrial sectors.

Regarding the calculation of the VS indicator for each industrial sector and both country groups (EU, rest of the world), the methodology we followed was that of Wang et al. (2013). To the best of our knowledge, the first to apply this methodology to economic sectors in Greece to examine their participation in GVCs were Gibson et al. (2019). Vertical Specialisation at sector level concerns: (i) the part of the production process of the same sector based on inputs from other countries; and (ii) the usage of inputs from this sector in the production process in the rest of the world or in certain geographic regions. According to Wang et al. (2013), the assessment of participation of an industrial sector in GVCs is based on the decomposition of gross exports into four major components, included in domestic value added and foreign value added to domestic production. The first component of gross exports is the part of domestic value added absorbed abroad (DVA). That is, the domestically produced goods that are exported as either final or intermediate goods and do not return to the reporting economy. The second component of gross exports is the part of

domestic value added, which is initially exported and eventually returns to the domestic economy, but is not re-exported (RDV). The third component of gross exports is related to foreign value added to domestic production, for either final or intermediate goods, which after export do not return home (FVA). The fourth and last component of gross exports comprises international flows of intermediate goods through two channels: (i) imports of raw materials for exports of domestically produced intermediate goods, which return home and eventually are re-exported (foreign sources); and (ii) exports of raw materials for the production of intermediate goods abroad, which are then imported for the production of final goods that are re-exported (domestic sources). The fourth component of a sector's gross exports is called Pure Double Counting (PDC). The four components of gross exports can be further broken down into 10 sub-components (for details, see the figure in the Appendix). From the trends in the above components of gross exports, we can find evidence on whether the position of a sector in GVCs is upstream or downstream. The upstream position of a sector in GVCs refers to its participation mainly in the initial stages of a production process, while the downstream position of a sector in GVCs indicates when a sector moves up the production chain, towards the final stages of a production process.

According to the approach regarding participation in GVCs of Wang et al. (2013), the VS index is estimated with the following formula:

$$VS = FVA_{FIN} + FVA_{INT} + PDC$$

The terms FVA_{FIN} and FVA_{INT} refer to foreign value added of domestic final goods and of domestic intermediate goods, respectively. That is, the VS indicator is based on two of the four basic components of gross exports.

This formula has been calculated for each industrial sector based on inflows and outflows of goods and services with EU countries (excluding Greece), as well as on data about inflows and outflows with countries beyond the EU, for the period 2008-2014. The former calculations measured the participation of domestic industrial sectors in European value chains and the latter their involvement in value chains outside EU economies. Table A1 in the Appendix includes the estimates for the VS indicator in both country groups. A high value of the VS indicator denotes a high involvement in GVCs, either because a significant proportion of the domestic sector's gross exports relies on foreign value added, or due to high participation of a sector in different stages of the production process in other countries, or due to both factors. The VS indicator is calculated as a percentage of gross exports of a sector. The calculation of the VS indicator for both country groups aims at highlighting any possible differences in the intensity of participation of domestic industrial sectors in GVCs. Each industrial sector is involved in both value chains, but probably the degree of engagement in each one of them differs. The distinct estimations for the two country groups do not imply a separation between the two value chains. Actually, these are components at the global level, as evidenced by the fact that the Global Vertical Specialisation indicator is the weighted average of the VS indicator for both country groups.

The highest values of the VS indicator for the value chains in EU countries were recorded in the sectors of Basic metals (NACE Rev. 2 no 24; see Table A1 in the Appendix), Paper products (17) and Rubber and plastic products (22). By contrast, the lowest values were observed in Electricity, gas, steam and air conditioning supply (35), Water collection and supply (36) and Sewerage, waste collection and treatment (37-39). With regard to the VS indicator for the value chains beyond the EU, the highest values were recorded in Coke and refined petroleum products (19), Basic metals (24) and Electrical equipment (27). The lowest values of the VS indicator for this country group were observed in Water collection and supply (36), Sewerage, waste collection and treatment (37-39) and Repair and installation of machinery and

equipment (33). The differences in sector rankings in the two country groups are indicative of the differences in the intensity of participation of the domestic industrial sectors in GVCs inside and outside the EU, with the most striking example being the Coke and refined petroleum products sector. Further, even for sectors with high/low participation in GVCs in both country groups, the degree of involvement may differ significantly among them. For example, the value of the VS indicator for Basic metals is much higher among the non-EU partners.

From the examination of the components of the VS indicator for the EU countries emerges that the Fabricated metal products (25), Basic metals (24) and Rubber and plastic products (22) sectors are involved in the first stages of production process, i.e. they are upstream sectors, while the Food, beverages and tobacco products (10-12), Computers and electronic equipment (26) and Pharmaceutical products (21) sectors are involved in the final stages of production process. Respectively, in GVCs beyond the EU, Basic metals (24), Mining and quarrying (5-9) and Electrical equipment (27) are involved in the initial stages of production process, whereas Food, beverages and tobacco products (10-12), Computers and electronic equipment (26) and Pharmaceutical products (21) are involved in the final stages of production process.

As mentioned in the beginning of this section, the performance of each industrial sector in the VS indicator, as well as in the rest of the figures and indicators of economic activity, financial efficiency and exporting performance that were considered, defined those sectors for which separate estimations of the econometric model were carried out. The five 2-digit NACE Rev. 2 industrial sectors with the average best performance or the biggest improvement in the indicators considered were:

(i) Rubber and plastic products (22);

(ii) Other non-metallic mineral products (23);

(iii) Chemical products (20);

(iv) Fabricated metal products (25); and

(v) Electrical equipment (27).

Briefly, Rubber and plastic products (22) mainly recorded a significant improvement in the GFCF to GVA ratio, a high ranking in Gross margin ratio and high participation in GVCs in Europe. Other non-metallic mineral products (23) ranked low in LR, achieved a high involvement in GVCs beyond the EU and a high ranking in Gross margin ratio. Chemical products (20) ranked high in Gross margin ratio and RoA, while improving in the Openness to Trade index. Fabricated metal products (25) ranked high in the share in total Industry employment and showed a high participation in GVCs both in and beyond the EU. Electrical equipment (27) recorded a significant increase in firm size, a high ranking in Gross margin ratio and high participation in GVCs in the EU and beyond the EU[5].

On the other hand, the five industrial sectors that performed poorly or deteriorated the most are:

(i) Repair and installation of machinery (33);

(ii) Other transport equipment (30);

(iii) Motor vehicles and trailers (29);

(iv) Wood and products of wood (16); and

(v) Basic pharmaceutical products (21).

Repair and installation of machinery (33) mainly showed a low involvement in GVCs, both in and beyond the EU, and ranked high in LR and low in CLR. Other transport equip-

5 Those sectors performing better also achieved a high or average ranking in other indicators used. Also, the poorly performing sectors ranked low in some other criteria than those mentioned in the next paragraph. This does not exclude the probability of low/high performance, respectively, in some of the other applied criteria. As the average ranking derives from all the indicators, in some cases the average sector performance differs slightly between sectors.

ment (30) ranked low in CLR, Gross margin ratio and RoA. Motor vehicles and trailers (29) ranked low in the share in total Industry employment and Gross margin ratio, while having a high LR value. Wood and products of wood (16) recorded a low performance in Gross margin ratio and RoA, while deteriorating in the GFCF to GVA ratio. Finally, Basic pharmaceutical products (21) ranked high in LR and low in Gross margin ratio and RoA, while deteriorating in the GFCF to GVA ratio.

The following section of the study starts with a literature overview on the determinants of firm growth. Then, the selected econometric model to examine firm growth determinants in Industry in Greece is presented. The last part of the section comprises the results of the econometric estimations.

3 ECONOMETRIC ANALYSIS OF FIRM GROWTH DETERMINANTS IN INDUSTRY

The aim of this section is to examine the factors that affect the growth of industrial firms in Greece and quantify their impact. These factors are mainly classified as firm-, sector- and macroeconomic environment-specific. Also, we have included the effects of structural reforms related to business environment as well as the effect of vertical specialisation, i.e. participation in Global Value Chains. To the best of our knowledge, it is the first time that the latter estimation is carried out for Greek businesses. The data for all of the above factors were derived from an unbalanced dataset that covers the period 2005-2018 and comprises firms of all sizes and legal forms that are located in all regions of Greece. The structure of this section is as follows: the first subsection provides a brief literature review on the factors that affect firm growth in Industry. It is followed by a subsection which describes the econometric model and the variables used in the estimations. In the last subsection, the econometric estimations are presented and discussed.

3.1 LITERATURE REVIEW ON FIRM GROWTH DETERMINANTS

The factors that affect firm growth and survival have attracted the interest of scientific research in the field of Industrial Organisation. Initially, the literature examined the relationship between firm growth and size, i.e. the validity of Gibrat's Law (Gibrat 1931), according to which the growth of a firm in period t is independent of its size in period t-1. The empirical results on the validity of this law are mixed. For example, Hart and Prais (1956) and Hymer and Pashigian (1962) confirmed the validity of the law in the case of large manufacturing firms, but Elston (2002) and Fotopoulos and Louri (2004) did not confirm the validity of Gibrat's Law. This ambiguity has triggered the examination of other firm- and industry-specific factors probably affecting firm growth. Such studies used data for a large number of countries inside and outside Europe.

In the latter case, a number of studies analysed growth data for US manufacturing sectors. In this respect, White (1982), using data for 111 manufacturing sectors for the year 1972 and employing the OLS method, estimated that firms increased their market shares in case they were active in low capital intensive sectors with low vertical integration, as well as if they produced products for other sectors and were growing in the past. However, advertising intensity did not exert a statistically significant effect on growth. Evans (1987) estimated a growth model for a dataset of 42,339 industrial firms of all sizes that were active during the period 1976-1980. He estimated that the growth (in terms of employment) of new (up to six years old) and old firms declines as size and age increase, although a sharp rise in size and age (square of both variables) affects positively the growth of both groups. Moreover, in both categories of firms, the operation of more than one production unit exerted a positive effect on their growth, but a sharp increase in their number (square of the variable) affected positively only the growth of old firms. Acs and

Audretsch (1990), using a panel dataset of 237 small manufacturing firms for the period 1976-1982, estimated that firm growth (in terms of turnover) is negatively affected from high capital and advertising intensity, i.e. from entry barriers. In addition, sector innovation and the existence of high-skilled labour force affect firm growth positively, and the same effect was estimated in cases where small firms' productivity exceeded overall sector productivity. By contrast, the participation of employees in trade unions affected negatively firm growth, but Manufacturing sector growth does not affect firm growth. Lang, Ofek and Stulz (1996) examined the effects of leverage on the growth of 640 large (turnover above $1 billion) industrial firms for the period 1970-1989. They estimated a strong negative effect of leverage on firm growth, which was approached with three alternative measures (investments, employment, and capital expenditure). This negative effect remained unchanged when they took into account sectoral effects and when they separated their sample in firms with high and low Tobin's Q index and in firms with high and low Return on Assets (RoA) index.

As mentioned above, firm growth literature also examined cases in European countries. In this context, several studies have explored the factors affecting firm growth in Germany. Almus and Nerlinger (1999), using a bivariate Tobit Model and data for newly established firms in West Germany during period 1989-1996, examined the factors affecting growth (in employment terms) of low-, medium- and high-tech firms. Their estimations showed that small size affects negatively the growth of low- and medium-tech firms, whereas age affects positively the growth of high- and low-tech firms up to a certain threshold, beyond which its impact turns negative. In addition, synergies with other companies were found to have a positive effect on growth of low- and medium-tech firms, probably due to the spillovers of know-how and the easier access to capital markets and product distribution networks. Moreover, high-, medium- and low-tech firms with highly skilled owners (i.e. with studies in engineering) enjoy higher growth rates, and firms operating in medium- and high-tech sectors exhibit higher growth rates, compared with firms in the low-tech sectors.

Audretsch and Elston (2006) used a sample of German industrial and services companies, operating in the high-tech "New Market" during the period 1997-2000, and a sample of "traditional" industrial companies for the period 1970-1985 to assess the factors that affect their growth (in terms of employment). They estimated that in the case of traditional firms, growth is positively affected by current size, but is not affected by age and liquidity. After dividing this sample into high and low R&D intensity firms, they found that current size and age affect positively the growth of the former firms and that current size and liquidity affect positively the growth of the latter firms. The growth of firms operating in the "New Market" is affected negatively by size and positively by age, but liquidity does not exert a statistically significant effect on their growth. Dividing the sample of businesses operating in the "New Market" into small and large, they estimated that current size affects growth negatively, i.e. high-tech small enterprises grow faster compared with the older and larger ones.

The examination of the factors affecting firm growth was also carried out for other European countries such as the Netherlands, Spain, and Portugal. For the Netherlands, Bosma et al. (2004) used data from a field research in 1,100 small industrial firms that were founded during the period 1994-1997 to examine the growth factors (in employment terms) under a Tobit regression model. Their results showed that human capital investment, proxied by the past working experience of the firm's manager in the sector, either as an employee or as an entrepreneur, and investment in social capital, proxied by the development of network with other entrepreneurs, have a positive effect on firm growth. For Portugal, Barbosa and Eiriz (2011) estimated the impact of location on firm growth (in terms of total assets), using a sample of 6,468 companies from various sectors

and for the period 2000-2004. They estimated that firms located in areas with high production specialisation are growing more slowly than those operating in the same sector but located in areas with lower specialisation. Moreover, they found that the growth of firms operating in areas where there exist many startups is affected positively by them, implying that business skills spill over into all firms in such areas. Finally, they estimated that in areas where there exist both low-skilled and high-skilled employees, firm growth is affected positively by them. However, the intensity of local competition and innovation in a sector do not exert a statistically significant effect on firm growth.

In the case of Spain, Guarascio and Tamagni (2019) estimated the impact of innovation persistence on sales growth for 3,193 manufacturing companies, using the OLS method as well as a Quantile Regression model. The estimates, using the OLS method for four categories of innovative firms (companies with R&D activities, with patents, with new products, or with new production methods), showed that those characterised by sustainable innovation effort do not grow faster than other firms. This result remained unchanged when the initial sample was divided into two size categories, namely small-medium and large firms. They also estimated that the size and the R&D intensity of the previous period have a positive effect on firm growth, the productivity of the previous period has a negative impact, while age does not exert a statistically significant effect. Quantile Regression results showed that the growth of the faster-growing firms (60%-90%) which maintain their innovation effort is negatively affected, while the growth of the slower-growing firms which maintain their innovation effort is not affected. These results did not change across the different categories of innovation.

There are also studies examining the factors that affect firm growth in Greek Industry. In this respect, Droucopoulos and Thomadakis (1993) used a dataset of firms from different size classes (10-19, 20-29, 30-49 and 50-99 employees) operating in seven manufacturing sectors in 1983. In the case of the total sample, it was estimated that in capital intensive sectors, the growth of firms in three out of the four size classes (10-19, 30-49 and 50-99 employees) is negatively affected by this characteristic, and the same impact was found for two size categories (10-19 and 30-49 employees) in sectors that produce capital or intermediate goods. Advertising intensity in most cases did not exert a statistically significant effect on growth, but in cases where its effect was statistically significant, it was positive (20-29 and 50-49 employees in the total sample and 30-49 employees in the sectors that produce consumer goods). According to the authors, this result suggests that during this period product differentiation was not strong in Greek Industry and, as a result, advertising was not a serious barrier to entry. Sector growth has a negative effect on firm growth only in the cases of total sample and of firms with 20-29 and 30-49 employees, as well as in the case of firms with 30-49 employees that produce capital or intermediate goods. By contrast, the impact of relative efficiency was found to be positive in the total sample (firms with 10-19 and 50-99 employees), in the sample of firms that produce consumer goods (firms with 10-19 employees) and in the sample of firms that produce capital or intermediate goods (firms with 10-19, 20-29 and 30-49 employees). Finally, relative investment intensity was not estimated to have a statistically significant effect on firm growth. According to the authors, this was due to the fact that firms' investment during this period involved equipment replacement or the acquisition of land and buildings, rather than innovation investment, which stimulates growth.

In another study for Greece, Voulgaris, Asteriou and Agiomirgianakis (2003), using a sample of 143 small and medium-sized manufacturing enterprises for the period 1988-1996, explored for the first time the impact of financial factors on firm growth (measured in terms of sales), employing a Fixed Effects panel data

model. The estimates showed that firm size and liquidity exert a negative effect on growth. The first result was attributed to the fact that small firms need to grow in order to reach the Minimum Efficiency Scale. With regard to liquidity, small firms need financial support to grow. If such support is not provided by the banking system, only their liquidity can support their growth, which is usually small, and hence the growth rate drops sharply. Exporting activity has a positive effect on firm growth, especially for firms located in large urban areas, because large cities provide all the necessary infrastructure that facilitates export of goods. Labour productivity strengthens firm growth, and this effect was also estimated for profitability, as it allows small firms to finance their growth efforts. On the other hand, high customers' liabilities and low use of fixed capital have a negative effect on firm growth. The last two results indicate that small firms need the liquidity that comes from the recovery of their claims and that high growth rates can be achieved through high technology usage, which comes from investment in relevant fixed capital. Moreover, Fotopoulos and Louri (2004), using a sample of 2,640 Greek manufacturing firms operating in 1992 and 1997, estimated a growth model using the Quantile Regression method. Their estimations showed that firm size and age negatively affect growth, especially those that grow faster (quantiles of 75% and 90%). Foreign ownership has a positive effect on the growth of faster-growing firms (quantiles of 50% and 75%), while the same result was estimated for the effect of liquidity and sunk cost. Finally, leverage negatively affects the growth of slower-growing firms (quantiles of 10% and 25%).

Finally, Giotopoulos (2014) examined the growth pattern (in turnover terms) of businesses providing knowledge intensive services (kis) and those providing knowledge intensive business services (kibs) by implementing the Generalised Method of Moments in a sample of 29,348 Greek companies from the Services sector for the period 2004-2012. He estimated that past growth of kis and kibs firms enhances their growth in the subsequent years, due to their characteristics such as accumulated know-how, high specialisation and innovation. Conversely, firms that are not kis or kibs either do not achieve high growth dynamics or see their turnover decline. Regarding the impact of firm size, estimations showed that micro, small and medium-sized kibs firms continue to grow in the subsequent years, while for large firms no statistically significant effect was found. In addition, kis firms, regardless of their size, which grew in the past, continue growing in the future. Further, using the Quantile Regression method, estimations showed that kis and kibs firms in the higher quantiles of growth distribution continue to grow in the future, whereas kis and kibs firms in the lower quantiles fail to maintain their growth dynamics.

As mentioned above, firm growth also depends on a number of quality factors, such as innovation, education level of entrepreneurs and employees, foreign ownership, etc. One of the factors that may affect the growth of firms is their participation in Global Value Chains (GVCs). The main advantage of participation in GVCs is the fact that it reduces the dependence of firms on the domestic economy both in terms of suppliers and in terms of customers. The GVC literature has focused on many topics, such as the types of value chains (e.g. Borrus, Ernst and Haggard 2000; Raikes, Jensen and Ponte 2000), the management of value chains (e.g. Gereffi 1999; Lee and Chen 2000), and the development of methodologies for measuring the degree of participation in GVCs (e.g. Hummels, Ishii and Yi 2001; Daudin, Rifflart and Schweisguth 2009). In the last category of studies, Gibson et al. (2019) used data from the World Input-Output Database to investigate the degree of integration of Greek sectors into GVCs. Their study showed that domestic added value is high in Services, but much lower in Industry. At the same time, they found that there are sectors with upstreamness in GVCs (e.g. Crop and animal production, Wholesale-Retail trade), sectors with downstreamness (Accommodation and food serv-

ices), but also sectors which display the characteristics of both upstreamness and downstreamness (e.g. Manufacture of textiles, Wood and wood products, Petroleum and chemicals, etc.). In addition, both Manufacture of food products and Manufacture of Pharmaceuticals showed a rise in the importance of domestic value added in exports, a feature which, according to the authors, implies that the products are increasingly being made from start to finish, providing high levels of domestic value added in exports. Despite the above, to the best of our knowledge, there are no empirical studies that quantify the effects of participation in GVCs on firm growth. The current study includes such an estimation. There are, however, studies that investigate, on a theoretical base, the impact of participation in GVCs on the growth of economies (e.g. Kummritz and Quast 2016).

3.2 THE ECONOMETRIC MODEL FOR EXAMINING FIRM GROWTH DETERMINANTS

The literature review presented in the previous subsection shows that most studies examining the factors that affect firm growth used panel datasets (e.g. Evans 1987; Almus and Nerlinger 1999; Barbosa and Eiriz 2011; Guarascio and Tamagni 2019), whereas fewer studies used cross-sectional data (e.g. White 1982; Droucopoulos and Thomadakis 1993). Regarding the econometric method applied, initially, most studies used linear models, either for panel data (e.g. Evans 1987; Lang, Ofek and Stulz 1996) or for cross-sectional data (e.g. White 1982; Droucopoulos and Thomadakis 1993). Alternative econometric specifications were also applied, such as Tobit Model (Almus and Nerlinger 1999; Bosma et al. 2004) and the Generalised Method of Moments (GMM) (Giotopoulos 2014). More recent studies used the method of Quantile Regression (e.g. Fotopoulos and Louri 2004; Giotopoulos 2014; Guarascio and Tamagni 2019).

In the present study, taking into account the available dataset (panel data for the period 2005-2018) as well as the research question, we use the Quantile Regression method. According to Buchinsky (1998), the advantages of this method are the following: (i) different estimations at different quantiles (e.g. 25%, 50%, 75%, 90%) show the different response of the dependent variable to changes in the explanatory variables; (ii) in case of non-normal errors, this method may be more efficient than the Ordinary Least Squares method; and (iii) the objective function is a weighted sum of absolute deviations, which makes the estimated coefficient vector robust to outlier observations. Also, Fotopoulos and Louri (2004) emphasise that whereas the OLS method estimates the effects of the regressors on the conditional mean of the dependent variable, the Quantile Regression method estimates this effect at various quantiles of the conditional distribution of the dependent variable, thereby providing a more complete picture of the relationship between the dependent variable and the explanatory variables.

Taking into account the above properties, the algebraic form of the Quantile Regression Model used in the econometric estimations is the following:

$$y_i = x_i' \beta_\theta + u_{\theta i} \text{ with } i = 1, 2, \ldots, n, \text{ and } 0 < \theta < 1,$$

where y_i is the dependent variable, x_i is the vector of explanatory variables at the firm, sector and macroeconomic environment level, β_θ is the vector of the parameters to be estimated, $u_{\theta i}$ is the standard error, and θ is the θ-*th* quantile.

In order to obtain estimations of vector β_θ at the θ-*th* quantile, we solve the following problem:

$$\widehat{\beta_\theta} = \min_{\beta_\theta} \left(\sum_{i:y_i > x_i'\beta_\theta} \theta |y_i - x_i'\beta_\theta| + \sum_{i:y_i < x_i'\beta_\theta} (1-\theta) |y_i - x_i'\beta_\theta| \right)$$

We initially estimated the above econometric model with the use of pooled data for the period 2005-2018. However, in order to check for the robustness of the results we also estimated the Quantile Regression Model using

panel data for the above period, following the method of fixed effects. In this case, the model takes the following form:

$y_{it}=\alpha_{it}+x'_{it}\beta_{\theta}+u_{\theta it}$ with i=1, 2,..., n, t=1, 2,..., T, and $0<\theta<1$,

where y_{it} is the dependent variable, x_{it} is the vector of covariates, β_{θ} is the vector of the parameters to be estimated, $u_{\theta it}$ is the standard error, θ is the θ-*th* quantile, and α_{it} is the fixed effects parameter.

3.3 VARIABLES USED IN THE MODEL ESTIMATIONS

This subsection presents the dependent variable as well as the explanatory variables used in the different estimations of the econometric model. The choice of the variables is driven by the choice of the econometric model and the availability of data. As mentioned above, the data available cover the period 2005-2018 and were mainly retrieved from the ICAP-Data.Prisma database, which collects and publishes financial data of balance sheets of Greek firms of all legal forms.

The dependent variable of the econometric model is the growth rate of firms, which was proxied by the difference in the natural logarithm of sales between two consecutive years, an approach that is often used in the literature (e.g. White 1982; Acs and Audretsch 1990; Dimelis, Giotopoulos and Louri 2019; Guarascio and Tamagni 2019). The same change in employment (e.g. Evans 1987; Audretsch and Elston 2006) or in total assets could be used instead (e.g. Fotopoulos and Louri 2004; Barbosa and Eiriz 2011). However, we used sales as the dependent variable in our model, because the available employment data are relatively limited (only 51,631 observations in a total sample of 124,346 observations). As far as total assets are concerned, they may not reflect the actual size of a firm, because in many cases they include intangible assets (e.g. patents, trademarks) which are difficult to accurately appraise. Further, it is possible that total assets include trade receivables that are overdue and are considered impaired, and/or devaluated inventories, which both should reduce a firm's total assets. For these reasons, the dependent variable used for the estimated model is turnover, a variable that is also more frequently used in the literature.

It should be noted that, as the dependent variable of the model is the annual growth rate of sales, special attention was paid so that there are no gaps in the panel data. Also, when a firm does not appear in the dataset for two consecutive years, it is considered "dead".[6]

Continuing with the explanatory variables, they are firm-related (initial size, leverage, liquidity, profitability, age, legal form, location, export orientation, etc.), sector-related (degree of market concentration, bank financing) and macroeconomic environment-related (GDP growth rate, cost of energy). In addition, we estimate the effects of structural reforms related to business environment (time and cost to start a business, minimum capital to start a business, corporate tax burden, time and cost of processing imports and exports) and the impact of a sector's vertical specialisation in two country groups, which is a proxy of participation in GVCs, on the growth of Greek industrial firms.

We should note that we examined the impact of the above variables on all firms that were active for some time during the period 2005-2018, not just on firms that were active throughout the examined period. This also implies that the available dataset contains firms that were active before 2005 and firms that were established from 2005 onwards.

Taking into consideration the above, the explanatory variables of the econometric model are the following:[7]

6 The database used in this study does not provide any information on the reasons why a firm exits the market (failure, merger, acquisition).

7 The terms in parentheses indicate the labels of the explanatory variables in the estimation results tables contained in the Appendix.

- **initial size (initialsize):** natural logarithm of sales in period t-1.

- **leverage (leverage):** ratio of a firm's total liabilities to its total assets.

- **liquidity (liquidity):** ratio of a firm's current assets to its short-term liabilities.

- **profitability (profit):** ratio of a firm's earnings before taxes to its sales.

- **age (lnage):** natural logarithm of a firm's age.

- **degree of market concentration (herf):** the degree of market concentration is calculated using the Herfindahl-Hirschman Index (HHI). The HHI is defined as follows:

$$H = \sum_{i=1}^{n} \left(\frac{X_{ij}}{X_j}\right)^2$$

where x_{ij} is the market share (in sales terms) of firm i in a 2-digit NACE Rev. 2 sector j, and X_j is the sum of sales of all firms in this sector. The data to construct this variable were retrieved from the ICAP-Data.Prisma database.

- **bank loans (totalloans):** ratio of a firm's bank loans to its total liabilities.

- **rate of change of Gross Domestic Product-GDP (gdpd):** dummy variable that takes the value of 1 in the years of the period 2005-2018 during which the GDP of the Greek economy shrunk, and 0 otherwise.

- **rate of change of loans to Industry (fundingr):** average annual rate of change in the monthly outstanding amount of bank loans to industrial firms within a calendar year.

- **sector vertical specialisation index in European Union countries (vseu) and in the countries of the rest of the world (vsrow):** these two variables were constructed for the evaluation process of the extroversion and GVC participation of the industrial sectors of the Greek economy and are presented in detail in Section 2. The data to construct them for the econometric estimation were derived from the World Input-Output Database and cover the period 2005-2014.

- **legal form (ae, ike)**: dummy variables that take the value of 1 if a firm has the legal form of Société Anonyme **(ae)** or the legal form of Private Capital Company **(ike)**, and 0 otherwise. The legal form of Private Capital Company was established under Law 4072/2012. Thus, the ike dummy variable can take the value of 1 from 2012 onwards.

- **exporting activity (exp):** dummy variable that takes the value of 1 each year of the period 2005-2018 in which a firm exports, and 0 otherwise.

- **stock exchange (exchange):** dummy variable that takes the value of 1 if the firm is listed on the Stock Exchange, and 0 otherwise.

- **location (town):** dummy variable that takes the value of 1 if a firm is located within the prefectures of Attica and Thessaloniki, where the two largest cities of Greece are located, i.e. Athens and Thessaloniki, and 0 otherwise.

- **firm size (micro, small, medium, large):** dummy variables that take the value of 1 if firms are micro, small, medium-sized or large, respectively, based on their level of sales each year, and 0 otherwise. The classification of firms into size classes is based on the European Commission's relevant definition, which is the following:[8]

  - micro firms: €0≤Sales≤€2,000,000;

  - small firms: €2,000,000<Sales≤€10,000,000;

8 Recommendation No 2003/361/EC, OJ L 124, 20.5.2003, pp. 36-41. The European Commission also uses alternative measures to categorise firms according to their size, namely total assets and the number of persons employed, but these were not preferred for the same reasons that they were not selected to be the dependent variable of the econometric model.

- medium-sized firms: €10,000,000<Sales≤€50,000,000;
- large firms: Sales>€50,000,000.

- **time required to start a business (daysd):** dummy variable that takes the value of 1 if the time required to start a business is reduced on a yearly basis, and 0 otherwise.
- **cost required to start a business (coststartd):** dummy variable that takes the value of 1 if the cost (as a percentage of GDP per capita) required to start a business is reduced on a yearly basis, and 0 otherwise.
- **minimum capital required to start a business (mincapstartd):** dummy variable that takes the value of 1 if the minimum capital to start a business (as a percentage of GDP per capita) is reduced on a yearly basis, and 0 otherwise.
- **tax burden (taxrate):** annual corporate tax burden from income tax, consumption tax and employer contributions, as a percentage of profitability.
- **import/export time (timeimpd, timexpd):** dummy variables equal to 1 if the time (in days) to import **(timeimpd)** or export **(timexpd)** is reduced on a yearly basis, and 0 otherwise.
- **import/export cost (costimpd, costexpd):** dummy variable equal to 1 if the cost per container (in $) to import **(timeimpd)** or export **(timexpd)** is reduced on a yearly basis, and 0 otherwise. Both indices include the cost required to complete the necessary documents and procedures, but do not include the cost of duties.
- **energy costs (lnbrent):** the natural logarithm of the cost of Brent oil per barrel. In order to approach energy costs, we could use the cost of electricity and/or the cost of natural gas. However, given that the vast majority of Greek industrial companies uses oil as its main energy source, the cost of Brent oil was used as the explanatory variable representing energy costs in the estimations.

The variables leverage, liquidity, profitability, bank loans and vertical specialisation were lagged by one year in the econometric estimations to take into account potential endogeneity issues. Also, given that the cost of oil that a firm buys today affects its production costs in the future, the variable lnbrent was included in the estimations with one-year time lag.

The firm-level variables were constructed with data retrieved from the ICAP-Data.Prisma database (initial size, leverage, liquidity, profitability, age, market concentration, bank loans, legal form, exporting activity, stock exchange, location, firm size). The variables concerning the structural characteristics of the Greek economy were constructed with data retrieved from the World Bank's "Doing Business" database (cost, time and minimum capital to start a business, tax burden, time and cost to import/export goods). We also used data from the databases of the IMF (rate of change in GDP), the Bank of Greece (rate of change in the outstanding amount of loans to Industry), the US Energy Information Administration (Brent oil price) and the World Input-Output Database (VS index in the EU and in the countries of the rest of the world).

Before the presentation of the estimation results, we briefly present the dataset for industrial firms used in this study, retrieved from the ICAP-Data.Prisma database. The data cover the period 2005-2018 and were derived from the published annual financial statements of firms of all legal forms. The database also contains information about the sector, year of establishment and exporting activity of the firms listed. The sample used in the econometric estimations consists of 124,346 observations for 18,143 industrial firms that operated during the period 2005-2018 (unbalanced panel data).

Regarding some descriptive statistics for the sample of industrial firms, most of them are

micro firms (76.4% of firms, or 13,861 firms), i.e. firms with turnover of up to €2 million, have the legal form of Société Anonyme (62.8%, or 11,394 firms), are active in the Manufacture of food products sector (19.3%, or 3,507 firms), are located in one of the two prefectures with the largest cities of Greece (61.4%, or 11,135 firms) and do not have exporting activity (63.9%, or 11,598 firms).

3.4 ECONOMETRIC RESULTS

3.4.1 Estimations with the overall dataset

The basic econometric specification employed includes explanatory variables at the firm level that are typically used in the literature, i.e. initial size, leverage, liquidity, profitability and age, as well as sector concentration ratio. In each additional estimation, we included in the above set of variables one of the remaining variables mentioned in the previous subsection. We excluded all additional variables to avoid econometric problems (e.g. multicollinearity). Also, as mentioned above, some variables are lagged by one year to take into account potential endogeneity issues (variables labelled lag_). In each estimation we performed the Variance Inflator Factor test to check for possible multicollinearity problems, as well as an F-test to check if the results differ at a statistically significant level across the different quantiles. Thus, in this study we used four quantiles, namely 25%, 50%, 75% and 90%, an approach followed also in the literature (e.g. Fotopoulos and Louri 2004; Dimelis, Giotopoulos and Louri 2016 and 2019). In order to check for the robustness of the results, we performed additional estimations using time and sector dummies, as well as estimations with the Quantile Regression method adjusted for panel data. Moreover, we examined whether the determinants of growth differ between industrial sectors with high and low performance in economic activity, innovativeness, financial efficiency and extroversion, as defined in Section 2. However, due to space limitations, all these additional estimations are not presented here, but are available upon request. In any case, we report any observed differences in the results.

Proceeding with the analysis of the estimation results, we observe that the initial size (initialsize, see columns 1-4 of Table A2 in the Appendix)[9] has a positive effect on firm growth in the lower quantiles of growth distribution (25% and 50%), while this effect becomes negative in the upper quantiles (75% and 90%). This means that, as the initial size of less dynamic firms increases, these firms tend to grow faster. In the case of more dynamic firms instead, the smaller they are, the faster they tend to grow. This result can be partially explained by Gibrat's Law, according to which firm growth is independent of the initial firm size, since, on average, the different signs of coefficients between less and more dynamic firms may cancel out (Dimelis, Giotopoulos and Louri 2016 and 2019).

Leverage (lag_leverage, columns 1-4) affects negatively the growth of the slower-growing firms (quantile of 25%), but affects positively the growth of the faster-growing ones (quantiles of 75% and 90%). Slow-growing firms are negatively affected by the accumulation of liabilities, probably because their moderate growth rate is not sufficient to finance both the reduction of liabilities and their growth efforts. By contrast, fast-growing firms probably achieve higher profitability and are thus able to reduce their liabilities, finance their investment projects and grow. Fotopoulos and Louri (2004) have estimated a similar result.

The effect of liquidity (lag_liquidity, columns 1-4) on firm growth is estimated to be statistically insignificant. According to the relevant literature, liquidity affects positively firm growth (e.g. Fotopoulos and Louri 2004; Miroshnychenko, Bozzi and Barontini 2019), but a number of studies estimated a negative effect (Voulgaris, Asteriou and Agiomirgianakis 2003). The result of this study is in the same vein with that of Dimelis, Giotopoulos and Louri (2019), who estimated a statistically insignificant effect of liquidity on firm

9 The terms in parentheses indicate the labels of the explanatory variables in the estimation results tables contained in the Appendix.

growth. However, when we used a different definition of liquidity (current assets over total assets), we estimated a statistically significant negative effect on firm growth in all the quantiles and econometric specifications.

Similarly, we estimated a statistically insignificant effect of profitability on firm growth (lag_profit, columns 1-4). The relevant literature found positive (e.g. Voulgaris, Asteriou and Agiomirgianakis 2003) and statistically insignificant effects (e.g. Giotopoulos 2014). We performed additional estimations using different proxies of profitability (ratio of EBITDA to turnover, EBT to turnover), but we again obtained statistically insignificant results.

Firm age (lnage, columns 1-4) was found to negatively affect the growth of firms, regardless of their growth performance. In fact, the negative effect of age on growth increases as we move from the lowest (25%) to the highest quantile (90%). This result is considered an indication that as firms age, they become less adaptive to market changes and consequently their growth rate slows. Fotopoulos and Louri (2004) estimated the same effect, but Audretsch and Elston (2006) estimated a positive effect of age on firm growth for R&D intensive firms, probably because age is associated with additional experience, which is an important growth factor in highly competitive industries (e.g. pharmaceutical products).

High market concentration (herf, columns 1-4) affects positively firm growth, and this effect becomes stronger as we move from the lowest (25%) to the highest quantile (90%) of the growth distribution. This result indicates that a high market share enhances the growth prospects of firms, especially those with higher growth rates, as they usually have the resources needed to strengthen their market position (extensive customer network, better agreements with suppliers, acquisition of competitors, etc.).

Moving to the next econometric specifications, a high level of firm bank loans (lag_totalloans, see columns 5-8 of Table A2 in the Appendix) affects firm growth negatively, but this effect is less strong as we move from the lower to the higher quantiles of growth distribution. Accordingly, firms with slower growth rates face a higher difficulty in servicing their bank loans, which impedes their growth prospects. We should mention at this point that IOBE (2015) estimated a statistically insignificant effect of bank financing on the growth of firms operating in all sectors of the Greek economy.

Unfavourable macroeconomic conditions (gdp, columns 9-12) affect firm growth negatively. This negative effect is stronger for firms with slower growth performance (quantiles of 25% and 50%), as opposed to firms with higher growth performance (quantiles of 75% and 90%). This result implies that the former are more vulnerable than the latter during periods of harsh macroeconomic conditions, because their weak growth rates are not sufficient to cope with the difficulties arising from a persistent or very deep recession.

Moreover, increased funding to Industry (funding, columns 13-16) exerts positive effects on firm growth. Probably, increased bank funding allows firms to finance their investment projects, cover their liabilities to their suppliers and the Greek State, expand their customer network, etc., with positive effects on their growth. It is noted that during the period 2006-2011 bank finance to Industry increased at an average rate of 7.6%, whereas during the period 2012-2018 it declined at an average rate of 4.2%.

Regarding the effect of vertical specialisation relative to the other 26 EU countries (lag_vseu, columns 21-24), it was estimated to be negative. A stronger negative effect was estimated in the case of slower-growing firms, compared with faster-growing ones. This result is likely to reflect either the usage, by industrial firms, of raw materials produced outside the EU or domestically, or the very strong competition they face in the common market, resulting in a low participation in EU value chains and in low exports, or both. This

result did not change when we used the variable vseu (columns 17-20), i.e. the variable lag_vseu without a time lag. The effect of vertical specialisation in relation to the countries from the rest of the world (lag_vsrow, columns 29-32) is slightly different to that of the previous variable. The negative effect is limited to slow- or faster-growing firms (quantiles of 25%, 50% and 75%). In the case of firms with very high growth rates (quantile of 90%), the effect is positive. This result indicates that the activity of very fast-growing firms is underpinned by easier access to raw materials globally, which are probably of better quality and/or of lower cost, as well as by the bilateral trade with non-EU countries, which favours their exports. This result did not change when we used the variable vsrow (columns 25-28), instead of the variable ag_vsrow.

By inserting into the econometric model the legal form of the firm, it was found that the growth of Société Anonyme firms (ae, columns 33-36) is positively affected by it, but this effect is limited to the faster-growing firms. This result probably implies that the characteristics of Société Anonyme firms such as the separation of business management from shareholders, the amount of minimum capital required, the obligatory auditing of their financial statements, etc. are factors that foster the growth of faster-growing firms.

In the case of Private Capital Companies (ike, columns 37-40), it was estimated that their growth is positively affected by their legal form, regardless of their growth performance, but this effect is stronger for faster-growing firms. Probably their easier establishment, as opposed to other legal forms, both in terms of the procedures and the minimum capital required (which is very low), allows them to save valuable financial resources for important investment purposes (machinery, upgrading of existing equipment, R&D activities, recruitment of specialised staff, marketing, etc.). However, as this legal form was legislated in 2012, this result mainly concerns new firms, i.e. firms up to 5 years of age.

In addition, the estimates showed that exporting activity (exp, columns 41-44) has a positive impact on the growth of industrial firms, and this effect is stronger as we move from the lower to the upper quantiles. It seems that export orientation substantially expands firms' customer network, with positive effects on their turnover and consequently their growth.

The listing of industrial firms in the Stock Exchange (exchange, columns 45-48) positively affects their growth. One reason behind this result may be the fact that the availability of financing through the Stock Exchange is less costly and does not require any collateral, as opposed to bank finance, which eventually affects growth in a positive way. This positive effect is stronger in the case of the faster-growing firms (quantiles of 75% and of 90%).

The location of industrial firms within the prefectures of Attica and Thessaloniki (town, columns 49-52) affects negatively the growth of some of them, specifically those in the 50% and 75% quantiles, as this effect was insignificant in the remaining quantiles. On the one hand, large urban areas are characterised by greater concentration of highly skilled labour force and proximity to suppliers and customers, logistics services, national road networks, large ports, etc. (Krugman 1998). On the other hand, competition in large urban areas is more intense, due to the existence of many competitors. Moreover, large cities have features that increase production and operational costs, such as traffic congestion, higher level of wages and salaries, higher rents, higher real estate prices, etc. Thus, it seems that in the case of Greek industrial firms, the negative effects from location in large urban areas outweigh the positive ones.

Continuing, it was estimated that very small firm size (micro, columns 53-56) affects negatively business growth. The limitations that micro firms face in terms of human and physical capital, their limited access to bank financing, their governance structure, etc. are very likely to prevent them from growing. By con-

trast, in the rest of the size categories (small, medium, large, columns 57-68), size had a positive effect on firm growth, but the strongest impact was estimated for large firms (turnover over €50 million). Therefore, unlike micro firms, which account for the vast majority of firms in the sample (76.4%, or 13,861 enterprises), the largest firms can achieve high growth rates because they have more available human and physical capital, easier and less costly access to bank financing, more sources of raw materials, etc.

With respect to the econometric results regarding the relationship between business environment and growth, we observe that the reduction of the time required to start a business (daysd, columns 69-72) has a positive effect on firm growth only for firms that exhibit low growth rates. However, the reduction in the cost (coststartd, columns 73-76) and in the minimum capital required to start a business (mincapstart, columns 77-80) affects positively the growth of all firms, regardless of their growth rates. This result may be related to that of the legal form of IKE. It is quite likely that the resources saved due to the reduction of start-up costs and of the minimum capital are directed to investment purposes, with positive effects on the growth of an industrial firm.

As the above three dummy variables mainly affect new firms, we performed additional estimations for two different subsamples of new firms. The first one includes firms established during the period 2009-2013, which is a period marked by deep recession (-5.9% on average), the entry into the economic adjustment programmes and the implementation of numerous reforms. The second subsample includes firms that were established during the period 2014-2018, which is a period of relatively stable macroeconomic conditions after August 2015 and the launch of the third economic adjustment programme, with many reforms already in place, but also with capital controls in force (average growth rate of 0.7%). We chose two five-years periods because, according to Dunne, Roberts and Samuelson (1988), a significant share of new firms are driven to exit the market within the first five years of their operation. Also, we chose these two distinct time periods in order to estimate the impact of these variables on growth during two periods in which firms encountered many but also different difficulties.

During the first subperiod, the reduction of the days, cost and minimum capital required to start a business positively affected firm growth. For the latter two variables, this result holds only for the faster-growing firms (quantiles of 75% and 90%), as slower-growing firms do not benefit from such reductions. The results for the second subperiod indicate that the reduction of the days required to start a business negatively affects firm growth, but this result cannot be justified by the available information. The impact of the reduced cost to start a business remains the same as in the case of the first subsample. We cannot conclude on the effect of the minimum capital, because multicollinearity problems emerged.

As far as the reduction of firms' tax burden (taxrate, columns 81-84) is concerned, it positively affects their growth, especially of those in the lower quantiles of growth distribution (25% and 50%). Due to their slower growth rates, these firms have less resources available for their operating and growth expenditures and, therefore, they benefit from a tax reduction. However, the Variance Inflation Factor test score indicates possible multicollinearity problems (Mean VIF=16.5>10.0).

The analysis of the results continues with the effects of the import/export-related variables on firm growth. The results indicate that not only export orientation but also the reduction of the time (timexpd, columns 85-88) and of the cost required to export (costexpd, columns 89-92) facilitate firm growth. These positive effects are estimated for all quantiles of the growth distribution. Similarly, both the reduction of the time (columns 93-96) and the reduction of the cost required to import (columns 97-100) exert positive effects on firm growth.

The analysis of the results is concluded with the effect of the energy cost (lag_lnbrent, columns 101-104), which negatively affects firm growth. The increase of the energy cost should result in an increase of the production cost, which in turn reduces firms' profitability and the available resources to finance their growth. However, the Variance Inflation Factor test score indicates possible multicollinearity problems (Mean VIF=17.35>10.0).

3.4.2 Estimations with the overall dataset, using time and sector dummies and panel data

In order to assess the robustness of the above results, we repeated the above estimations with the use of time and sector dummies.[10] In the first case (time dummies), the overall conclusion is that the results do not change, although we observe some differences. For example, the reduction of tax burden (taxrate) does not exert a statistically significant effect on firm growth, while we could not conclude on the effect of an increase of funding to total Industry (fundingr) due to multicollinearity problems. The reduction of the time required to start a business (daysd) negatively affects firm growth, whereas the reduction of the time required to export goods (timexpd) positively affects the growth of firms, regardless of their growth path. Moreover, firms' high bank indebtedness (lag_totalloans) negatively affects the growth of faster-growing firms (90% quantile) and exerts a positive impact on the growth of slower-growing firms (25% quantile). Most probably, the latter result indicates that slower-growing firms need more funding for their everyday operation and investment, in order to reach the Minimum Efficient Scale of their sector. Also, the negative effect of vertical specialisation on firm growth, with respect to countries outside the EU (lag_vsrow), is limited only to slower-growing firms (25% quantile).

When estimations include sector dummies or both year and sector dummies, we do not observe any significant changes in the results. However, the use of a large number of dummies results in serious econometric problems (e.g. multicollinearity, non-convergence of the likelihood function).

When we used Quantile Regression adjusted for panel data, the results differed mainly in terms of statistical significance. For example, as opposed to the initial estimations, in this case the results for the lag-leverage, herf, lag_totalloans, small, and mincapstartd variables are statistically insignificant. In addition, initial size (initialsize) and vertical specialisation in relation to countries outside the EU (lag_vsrow) negatively affect firms' growth, regardless of their growth path. Also, the reduction of the time required to import goods (timeimpd) and of the cost to export goods (costexpd) affect only the growth of firms in the 50% quantile of the growth distribution for the former variable, and of the firms in the 75% quantile for the latter one. Further, in both cases this effect was estimated to be negative. Similarly, the reduction of the time required to export goods (timexpd) negatively affects the growth of firms in all quantiles but the 25% quantile. However, all the above statistically significant results with the use of panel data cannot be justified by the available information.

3.4.3 Estimations for high- and low-performance industrial sectors

Another interesting question in the context of our study is to examine whether the determinants of firm growth differ between industrial sectors with high and low performance in terms of economic activity, financial efficiency, innovativeness and extroversion during the period 2008-2018. In this respect, we performed additional estimations for five high-performance sectors defined in Section 2 herein, namely Chemicals and chemical products (20), Rubber and plastic products (22), Other non-metallic mineral products (23), Fabricated metal products (25) and Electrical equipment (27), as well as for five low-performance sectors, namely Wood and products of wood, except furniture

10 These estimation results are not tabulated, but are available upon request.

(16), Pharmaceutical products (21), Motor vehicles and trailers (29), Other transport equipment (30) and Repair and installation of machinery and equipment (33).[11]

In the case of high-performance sectors, as the initial size of less dynamic firms increases, these firms tend to grow faster, whereas in the case of more dynamic firms, the smaller they are, the faster they tend to grow. Again, liquidity and profitability do not exert a statistically significant effect, and age affects firm growth negatively. In addition, market concentration affects growth positively, but this effect now becomes weaker as we move from the lowest (25%) to the highest quantile (90%) of the growth distribution. Moreover, the effect of vertical specialisation in relation to countries outside the EU is again negative, which shows that even high-performance firms do not benefit from international trade flows with non-EU countries. Also, the reduction of the cost required to export/import goods, as well as the reduction of the time required to import goods again affect positively the growth of high-performance sectors in all quantiles but the 90% quantile. Finally, while leverage was found to negatively affect the growth of slower-growing firms, it affects positively the growth of faster-growing ones, which probably indicates that beyond a specific growth threshold, high-performance firms are in need of additional (indirect) funding, through their suppliers, to further expand their turnover. However, we cannot conclude on the effect of the remaining explanatory variables on high-performance firms' growth, either due to the fact that statistically significant results do not differ across different quantiles or due to multicollinearity problems in some estimations.

In the case of low-performance sectors, the statistically significant results differ from those in the overall sample only for the estimations which include the lag_vseu and lag_vsrow variables. In both cases, we estimated negative effects on growth for the first three quantiles (25%, 50%, 75%) of the growth distribution, but this negative effect weakens as we move from the lower to the upper quantile. However, these effects are stronger compared with those in the initial dataset, implying that low-performance firms are negatively affected to a larger extent by international trade flows with countries inside and outside the EU. As far as the rest of the explanatory variables in the basic model configuration are concerned, we do not observe any meaningful differences compared with the sample of high-performance sectors.

4 POLICY RECOMMENDATIONS TO SUPPORT THE GROWTH OF INDUSTRY IN GREECE

This section includes recommendations for policy actions to strengthen the growth prospects of Industry. The suggested policy actions relate to some of the explanatory variables used in the econometric estimations, which have a statistically significant effect on firm growth (tax burden, energy costs, bank lending).

The examined policy areas that concern a large part of industrial businesses in Greece are: (i) the cost of energy; (ii) the depreciation method used for investment in mechanical equipment; and (iii) sources of funding.

4.1 POLICY RECOMMENDATIONS ABOUT THE COST OF ENERGY

Regarding energy costs, although the energy intensity of production in Greek Manufacturing was limited in recent years, in 2017 it was 46% higher than the EU average, standing at 0.17 kTOE/€ millions of value added. In the Greek manufacturing sectors of high energy intensity, energy usage was 17% higher than the EU average, whereas in the rest of the manufacturing sectors domestic energy usage was 97% higher, compared with the EU average. Regarding the composition of the energy mix used, in Greece the fuels with the largest

11 These estimation results are also not tabulated, but are available upon request.

shares are electricity and oil, while in the EU these are electricity and gas.

Electricity cost comprises two parts: the competitive part and regulated charges. The first part includes the cost for the supply of electricity and the rest of the costs of the electricity provider (excise consumption duty, cost associated with CO_2 emissions, etc.). Regulated charges include charges for the transmission network, charges for the distribution network, the Special Duty for Greenhouse Gas Emissions Reduction (ETMEAP in Greek) and the cost for the Provision of Utilities (ΥΚΩ in Greek). The wholesale price of electricity baseload in Greece is over time 10%-40% higher than the EU average. In the second quarter of 2020, this difference was 33.5%, with the wholesale price of electricity baseload standing at €32.3/MWh, i.e. the second highest in the EU.[12]

The rising trend of electricity prices in Greece and Europe during the last three years is partly explained by the trend in the cost of CO_2 emission rights. During the period August 2017-August 2019 it increased fivefold, exceeding €27/tCO_2. Since then and until May 2020, the rise has moderated. However, this cost resurged afterwards (€25.4/tCO_2 in October 2020).

There are three other categories of factors that lead to differences in final electricity prices between EU countries: (i) different consumer exemptions in the final price components for certain consumers (e.g. of high energy intensity); (ii) different structure of these components; and (iii) different network charges and charges for supporting renewable energy sources. Hence, the final electricity prices for a specific industrial sector in different EU countries are not comparable.

Turning to the factors that shape the cost of gas, the final price for large industrial consumers is usually determined by bilateral futures contracts that are not published and include discounts and exemptions. However, the Weighted Average Gas Import Price is known. But this price does not include the wholesale profit and regulated charges. In general, gas prices in Greece follow the trends of the main markets in Europe, but cannot be compared with prices in other countries due to their different structure and lack of data, as is the case with electricity prices.

Despite the difficulty of directly comparing prices of both electricity and gas with those in other countries, there are clear indications of higher energy costs for Greek Industry relative to other EU countries, mainly in electricity. The most significant causes of this additional cost that need to be addressed are the following:

- Incomplete market opening: delay in the transition to a competitive energy market, as the implementation of the EU Target Model started on 1 November 2020, and in interconnection with neighbouring countries for market coupling (e.g. Italy, Bulgaria).

- Long delays in the operation of the Hellenic Energy Exchange, which started operating in March 2020.

- Inability to conclude bilateral futures contracts for energy, without participation in the pool network.

- Many and high additional charges and taxes that increase the competitive energy price.

- Lack of measures that are compatible with the EU regulatory framework to support Greek Industry in the field of energy and environmental issues.

4.2 POLICY RECOMMENDATIONS ABOUT THE DEPRECIATION OF INDUSTRIAL INVESTMENT

Investment in machinery is the focus of investment activity in Industry globally. In Greece, the current depreciation regime, which lies at

12 DG Energy (2020).

a fixed depreciation rate of 10% (straight line depreciation method), is one of the most unfavourable in Europe. In other European countries with low fixed depreciation rates for machinery, faster depreciation is also possible (e.g. in Belgium or France). In addition, in most EU countries an accelerating depreciation method is applied to this category of fixed capital.

Specifically, up until 2012 there was a more favourable depreciation regime for investment in machinery in Greece, according to which a company could determine whether the method of straight line (fixed) or accelerating depreciation would be applied and accordingly the depreciation period, which ranged between 4 and 10 years. The possibility to choose the depreciation method allowed for its adaptation to the "financial reality" of the investment, i.e. the time it takes to become profitable.

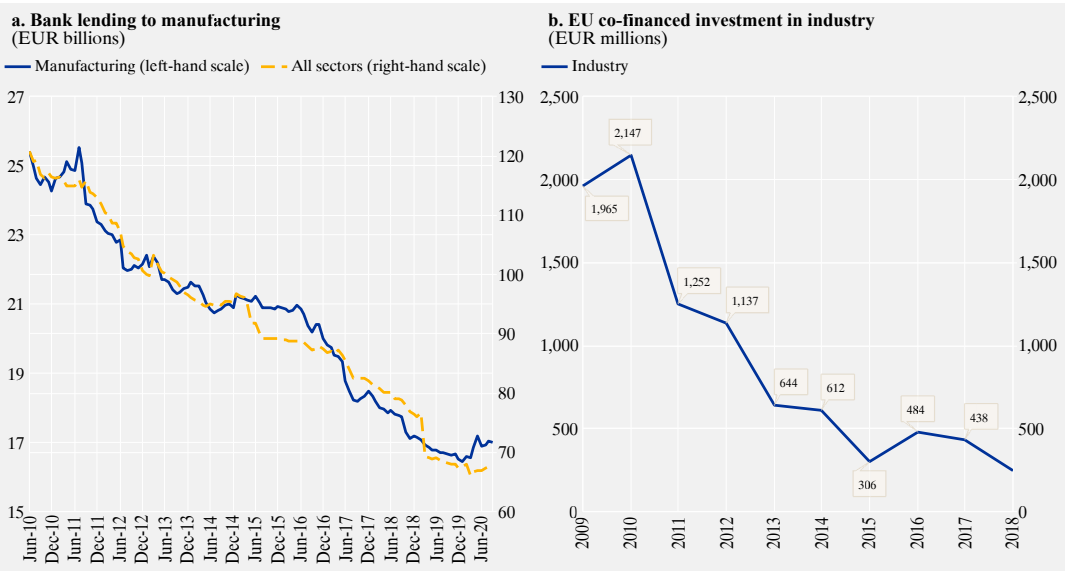
On the one hand, faster depreciation, e.g. with the accelerating depreciation method, enhances the liquidity of businesses in the period after an investment, during which earnings may be poor or moderate. This effect of accelerating depreciation can also lead to additional investment, provided that a firm decides to invest (part of) its higher liquidity. On the other hand, faster depreciation of fixed assets implies reduced tax revenues in the years of the initial operation of an investment. However, this reduction is temporary and is offset in the long run by the increase of the tax burden for the company, due to the faster depletion of the value of the investment for depreciation, compared with the straight line depreciation method. Therefore, accelerating depreciation is a fiscally neutral measure in the long run.

Given the above and in order to stimulate investment activity in Industry, an alternative to the existing depreciation method of investment in machinery has been proposed by IOBE (2018). It is a method of accelerating depreciation, at an annual rate of 48%. The calculation of its potential impact was based on data about industrial investment in machinery and mechanical equipment for 2017 and 2018 (Eurostat and ICAP databases). For this purpose, assumptions were made regarding the investment rate on additional liquidity from the application of the proposed depreciation method (75%) and the income tax rate (fixed at 20%). Taking all these into account, an additional liquidity of €675.7 million results within three years, from one year of regular investment in machinery and mechanical equipment, of which €506.8 million will be reinvested. Within a decade, accelerating depreciation, at this depreciation rate, is a fiscally neutral method, compared with the currently implemented straight line depreciation approach. Regarding the economic impact of the additional industrial investment, on the basis of assumptions about the type of its multiplying effects on economic activity and estimates using the input-output method (Leontief method), gains in GDP reach €280 million within three years. Also, in the same period 20.2 thousand man-years of employment are created and a total budget revenue of €222 million is generated. That is, eventually the accelerating depreciation method can also increase fiscal revenues.

4.3 POLICY RECOMMENDATIONS ABOUT THE FINANCING OF INDUSTRY

One of the strongest effects of the domestic sovereign debt crisis in 2010 was that on the Greek banking system. The Greek State's loss of access to capital markets extended to the banking system. Additional pressure on banks' liquidity was exerted by the multiannual deep recession, which reduced private sector saving and gradually made it negative. The recession also affected the ability of many households and businesses to service their liabilities vis-à-vis the banking system (loans, credit cards, etc.). This resulted in a significant increase in overdue liabilities. Subsequently, the ability of the banking system to provide finance was further limited. Other developments, such as public debt relief measures (PSI programme, government bonds buyback), the sharp escalation of uncertainty due to the elec-

Chart 1 Bank lending and EU co-financed investment in Industry



Sources: Chart a: Bank of Greece; Chart b: Greek Ministry of Finance, State Budget reports.

tion cycle in 2012 and 2015, etc., also had a negative effect on banks' available assets and their quality. These developments also affected funding to Industry, as bank lending to Manufacturing declined by 30.0% in the period June 2010-September 2018, amounting to €17.8 billion by the end of the period (see Chart 1a).

Besides the decline in bank lending to industrial enterprises from 2010 to 2018, there was a significant decrease in financing from the EU co-financed part of the Public Investment Programme. Specifically, it decreased between 2011 and 2015 from €2.15 billion to just €306 million (see Chart 1b). Up until 2018, EU co-financing of industrial investment remained close to this level. This decline in EU co-financed industrial investment in Industry does not reflect a reduction in total EU co-financed investment, but is due to the lower share of Industry (from 22.2% in 2009 to 4.8% in 2018).

Following the completion of the last economic adjustment programme (EAP), lending to industrial enterprises continued to decline until February 2020, i.e. before the outbreak of the COVID-19 pandemic (-€1.17 billion, or -6.6%). In addition, bank lending rates for non-financial corporations domestically remained well above their euro area average, but also at higher levels compared with other countries that have implemented an EAP (4.0%, against 1.6% and 2.6%, respectively). Therefore, the terms and conditions of bank lending to enterprises in Greece remained a competitive disadvantage relative to the euro area.

The COVID-19 pandemic has significantly changed the facts on the availability of financing for businesses in the EU, both from the banking system and the public sector. To offset the impact of public health protection measures on the affected businesses and their employees, emergency funding mechanisms have been set up. In addition, the criteria for financial aid from existing funding schemes have eased. Some of the emergency financial instruments have a medium-term horizon, aiming to contribute to Europe's exit from the pandemic crisis and its gradual recovery.

On the banking system side, the European Central Bank (ECB)'s most important emer-

gency financial instrument is the €1.35 trillion Pandemic Emergency Purchase Programme (PEPP), the budget of which is likely to expand. The PEPP is important for Greece, as for the first time the country was accepted by the ECB in an asset purchase programme. This was achieved with the exception of Greece (waiver) from the ECB's eligibility requirements for securities issued by the central governments of euro area countries. At the same time, the ECB created a new liquidity facility, which consists of non-targeted pandemic emergency longer-term refinancing operations (PELTROs). These were available in the period of May-December 2020 and will gradually mature between July and September 2021. Their interest rate will be 25 points lower than the average interest rate on main refinancing operations (MROs). In addition, a new series of targeted longer-term refinancing operations was carried out between March and June 2020 (TLTRO III), with an interest rate of -0.50% and an expansion of banks' lending capacity (50%, instead of 30% of the eligible loan stock). Accordingly, loans of Greek banks up to €46 billion could become accepted as collateral.

In the context of these financial possibilities offered by the ECB, the liquidity that Greek banks have raised from the Eurosystem, through long-term refinancing operations, reached €24.4 billion at the beginning of the period April-September 2020 and totalled €38.96 billion by its end. These amounts do not include the activity of banks under the PEPP. However, they are indicative of banks' ability to provide financing to businesses not only in the short run, but also in the medium term. These developments can also support the financing of Industry.

The continuous increase of private sector deposits (by households and non-financial corporations) in recent years, which peaked during the period of the spread of the new coronavirus, can also stimulate the provision of new loans by banks to industrial companies and beyond. Overall, between August 2015 (launch of the third EAP) and August 2020, private sector deposits increased by €37.9 billion, of which €21.4 billion came from households. From the beginning of the year to August 2020, private sector deposits expanded by €8.4 billion.

On the part of the European Commission, the NextGenerationEU funding instrument was created to deal with the effects of the pandemic, with a financial envelope of €750 billion. In combination with the 2021-2027 Multiannual Financial Framework, which will provide the regular EU co-financing for investment projects, both financing mechanisms constitute the European Commission's Recovery Plan for Europe.

Greece is expected to receive from NextGenerationEU support amounting to €32 billion, of which €19.3 billion will be in the form of grants and €12.7 billion will be loans. According to the planning of NextGenerationEU, more than 37% of its funds will be related to the Green Transition target and at least 20% to the Digital Strategy of the EU. These priorities are in line with those of the new European Union Industry Strategy of March 2020 (implementation of the European Green Deal and the Strategy on Shaping Europe's Digital Future).[13]

The resources that will be allocated to Greece under the 2021-2027 Multiannual Financial Framework (MFF) amount to €18.96 billion (2018 prices). According to the information available, the Greek 2021-2027 MFF will include seven sectoral Operational Programmes (OPs) and 13 regional OPs. The support of industrial enterprises will be possible mainly through the OPs "Competitiveness – Entrepreneurship", "Digital Transformation" and "Environment – Energy – Climate change". The first of these OPs will be a successor to the "Competitiveness, Entrepreneurship & Innovation" OP for the period 2014-2020, while its budget is expected to be

13 European Commission (2020).

approximately 50% higher than the budget of its predecessor (€10.9 billion). Therefore, there is potential for expansion of EU co-financed investment in Greek Industry in the coming years.

Industrial companies, not only the large ones, but also those of medium and small size, must explore the possibilities of financing through the Greek capital market. Especially for small and medium-sized enterprises, the most suitable financial instruments through the domestic capital market are the Alternative Market (EN.A. in Greek) and the listed private funds of the Athens Exchange. The most important difference of the Alternative Market from the ATHEX Main Market are the admission requirements, which are much easier to meet in the former market. Indicatively, for a company to enter the "EN.A. STEP" segment of the Alternative Market, there is no restriction in terms of equity and profitability. In the case of companies that have published financial statements, the statements for the most recent fiscal year must comply with IAS/IFRS standards and must have been audited by a Certified Auditor. If a company does not have at least two years of previous activity in the sector of economy and the area of business in which it will operate after admission of its shares in "EN.A. STEP", the main evaluation criterion is a business plan. The sector of activity can be either a technologically advanced sector or a more traditional sector of the Greek economy. There is no restriction on the level of raised funds.

In summary, there is significant potential for increased financing of Industry in the coming years. It can be provided by the banking system, but also by the EU Structural and Investment Funds as well as by the emergency Fund created to tackle the effects of the pandemic. The domestic capital market provides some new financing opportunities, concerning mainly the small and medium-sized businesses, such as the Alternative Market and listed private funds, which are easily accessible and are currently used to a very small extent by businesses and investors, probably due to lack of information about them.

5 SUMMARY OF FINDINGS

The significance of Industry for sustainable economic growth is rapidly gaining ground in the recent years. The European Commission designed a renewed industrial policy, aimed at the adaptation of European Industry in order to lead the EU's twin transitions (ecological and digital), as well as to drive its global competitiveness.[14] In Greece, the importance of Industry has been declining since the 1980s, in GDP terms. Though Industry has been severely hit by the COVID-19 pandemic globally, the decline in industrial production domestically was smaller compared with the euro area average.

In this context, we have examined the effects of factors that determine the potential of industrial businesses in Greece to grow and evolve, aiming to identify those which can help domestic Industry to gradually regain the role it had in previous decades and facilitate the economic recovery from the public health crisis.

First, the industrial sectors with the best and the worst performance during the period 2008-2018 in terms of economic activity, financial efficiency, innovativeness and global competitiveness were identified, on the basis of suitable evaluation criteria (trends in indicators and figures), in order to carry out econometric estimations besides those for the overall sample of industrial businesses. Such indicators also include the Vertical Specialisation indicator, a metric used for identifying the participation of a country or a sector in Global Value Chains. We calculated this indicator for all the industrial sectors and two different country groups, i.e. the EU countries and the rest of the world.

The factors whose impact on firm growth in Industry was examined were firm-, sector-, and

14 European Commission (2020).

macroeconomic environment-specific variables. The effects of structural reforms related to business environment and of vertical specialisation were also calculated. For the econometric estimations, the Quantile Regression method was preferred, for 25%, 50%, 75% and 90% quantiles of the growth distribution, due to its advantages (Buchinsky 1998; Fotopoulos and Louri 2004). The dataset used was unbalanced, consisting of 18,143 industrial firms that were active during the period 2005-2018.

The estimations with the overall dataset indicated that as the size of less dynamic firms increases, these firms tend to grow faster, whereas in the case of more dynamic firms, the smaller they are, the faster they tend to grow. Leverage affects negatively the growth of slower-growing firms, however it affects positively the growth of faster-growing ones. Also, as a firm ages, it becomes less adaptive to market changes and consequently has lower growth rates. Firms with lower growth rates face a higher difficulty to repay their bank loans and are more vulnerable, compared with firms with higher growth rates, during periods of harsh macroeconomic conditions. Moreover, the negative implications from establishment in large urban areas are stronger than the positive effects. Further, the effect of vertical specialisation with respect to the rest of EU countries was estimated to be negative, and it was stronger in the case of slower-growing firms. The negative effect of vertical specialisation in relation to the countries from the rest of the world is limited to slower-growing firms, as fast-growing firms are favoured by bilateral trade with countries outside the EU.

A high market share was found to enhance the growth prospects of firms, especially of those with higher growth rates. Positive effects were also estimated in the case of increased funding to industrial sectors. The growth of Société Anonyme firms is positively affected by their legal form only in the case of faster-growing firms. In the case of Private Capital Companies, the positive effect of this legal form is of the same magnitude for all firms, regardless of their growth performance. Exporting activity and the listing on the Stock Exchange have a positive impact on the growth of industrial firms, and this effect is stronger as we move from the lower to the upper quantiles of firm growth distribution. Moreover, the reduction of the time required to start a business has a positive effect on firm growth only for firms that exhibit low growth rates. However, the reduction of both the cost and the minimum capital required to start a business affects positively the growth of all firms, regardless of their growth speed. Finally, neither liquidity nor profitability exert a statistically significant effect on the growth of Greek industrial firms, whereas the reduction of both the time and the cost required to import/export facilitates firm growth.

By using time dummies in the estimations, we observed some differences in the results. However, these did not significantly change. For example, the reduction of tax burden does not exert a statistically significant effect on firm growth. The reduction of the time required to export goods affects positively the growth of firms, regardless of their growth path. Moreover, firms' high bank indebtedness affects negatively the growth of the fastest-growing firms and exerts a positive impact on the growth of slower-growing ones. Also, the negative effect of vertical specialisation among countries outside the EU on firm growth is limited only to slower-growing firms. However, when we included in the estimations sector dummies or both year and sector dummies, in many cases serious econometric problems occurred due to the use of a large number of dummies. Finally, when we used Quantile Regression adjusted for panel data, the results differed mainly in terms of statistical significance.

In the case of high-performance industrial sectors with respect to economic activity, financial efficiency, innovativeness and extroversion, the positive effect of market concentration weakened as we moved from the lowest to the highest quantile of the growth distribution. Also, high-performance firms do not

seem to benefit from participation in Global Value Chains with countries outside the EU, and the positive effects from the reduction in the cost required to export/import goods, as well as in the time required to import goods concern the first three quantiles of the growth distribution. Finally, while leverage affects negatively the growth of slower-growing firms, it affects positively the growth of faster-growing ones, which probably indicates that beyond a specific growth rate threshold, high-performance firms are in need of additional funding to further expand their turnover. In the case of low-performance sectors, we did not observe any meaningful differences in the effects, compared with the sample of high-performance sectors.

The study concludes with policy recommendations to strengthen the growth prospects of Greek Industry. The policy actions suggested relate to some of the explanatory variables used in the econometric estimations and concern the majority of industrial businesses. Specifically, these refer to the cost of energy, the depreciation method used for investment in machinery and mechanical equipment, and the sources of financing, taking also into account the emergency financing mechanisms for tackling the effects of the pandemic.

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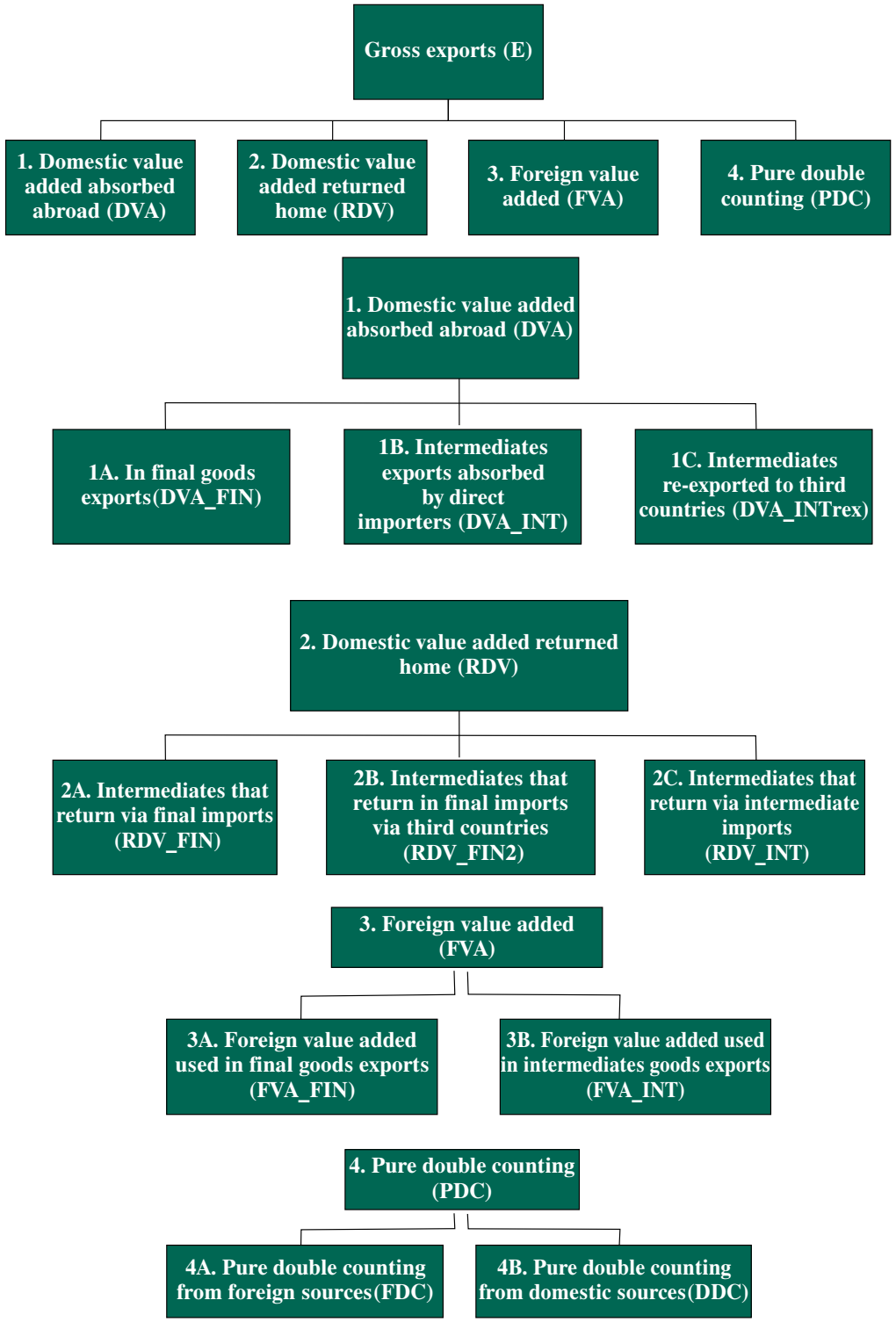
APPENDIX

Gross exports decomposition for calculating the Vertical Specialisation indicator



Source: Wang et al. (2013).

Table A1 Vertical Specialisation as % of gross exports (2008-2014 period average)

Nace Rev. 2 code	Industrial sector	EU-26*	Rest of the world
B5-9	Mining and quarrying	6.0	7.7
C10-C12	Food products, beverages and tobacco products	8.1	8.4
C13-C15	Textiles, wearing apparel and leather and related products	8.3	9.7
C16	Wood and of products of wood and cork	10.2	8.7
C17	Paper and paper products	17.3	10.0
C18	Printing and recording services	10.4	6.8
C19	Coke and refined petroleum products	6.2	61.7
C20	Chemicals and chemical products	13.1	14.7
C21	Basic pharmaceutical products and pharmaceutical preparations	9.3	10.4
C22	Rubber and plastic products	15.9	14.5
C23	Other non-metallic mineral products	6.5	14.8
C24	Basic metals	17.6	25.7
C25	Fabricated metal products	13.3	14.8
C26	Computer, electronic and optical products	10.1	7.4
C27	Electrical equipment	15.6	16.1
C28	Machinery and equipment n.e.c.	10.6	9.7
C29	Motor vehicles, trailers and semi-trailers	9.4	8.7
C30	Other transport equipment	9.7	11.5
C31-C32	Furniture and other manufactured goods	8.5	8.8
C33	Repair and installation of machinery and equipment	5.8	6.2
D35	Electricity, gas, steam and air conditioning supply	4.2	15.0
E36	Water collection, treatment and supply	4.8	5.6
E37-E39	Sewerage, waste collection, treatment and remediation activities	4.3	4.4
	Industry	**11.6**	**42.0**

Source: IOBE.
* Excluding Greece.

Table A2 Quantile regression results for the initial dataset

continue→

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0230***	0.0043***	-0.0232***	-0.0722***	0.0225***	0.0049***	-0.0222***	-0.0709***	0.0225***	0.0046***	-0.0227***	-0.0730***	0.0228***	0.0038***	-0.0235***	-0.0723***
	(0.0010)	(0.0006)	(0.0008)	(0.0020)	(0.0012)	(0.0006)	(0.0006)	(0.0015)	(0.0009)	(0.0007)	(0.0007)	(0.0016)	(0.0013)	(0.0008)	(0.0012)	(0.0022)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lag_leverage	-0.0556***	-0.0007	0.0335***	0.0785***					-0.0503***	-0.0030	0.0300***	0.0813***	-0.0556***	-0.0030	0.0299***	0.0765***
	(0.0074)	(0.0043)	(0.0060)	(0.0137)					(0.0050)	(0.0044)	(0.0084)	(0.0141)	(0.0067)	(0.0045)	(0.0075)	(0.0140)
	0.0000	0.8716	0.0000	0.0000					0.0000	0.4887	0.0004	0.0000	0.0000	0.5050	0.0001	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0001)	(0.0000)	(0.0000)	(0.0003)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0000)	(0.0000)	(0.0004)	(0.0000)	(0.0000)	(0.0001)	(0.0004)
	0.9856	0.9872	0.9216	0.9866	0.9752	0.9871	0.8859	0.9793	0.9893	0.9829	0.9400	0.9897	0.9754	0.9898	0.9809	0.9908
lag_profit	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0003	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004
	(0.0002)	(0.0002)	(0.0020)	(0.0037)	(0.0002)	(0.0015)	(0.0026)	(0.0041)	(0.0002)	(0.0008)	(0.0022)	(0.0038)	(0.0002)	(0.0002)	(0.0022)	(0.0036)
	0.9495	0.9538	0.9960	0.9216	0.9505	0.9941	0.9204	0.9282	0.9513	0.9891	0.9963	0.9229	0.9478	0.9530	0.9862	0.9185
lnage	-0.0287***	-0.0308***	-0.0577***	-0.1089***	-0.0231***	-0.0305***	-0.0600***	-0.1129***	-0.0257***	-0.0328***	-0.0573***	-0.1075***	-0.0283***	-0.0303***	-0.0560***	-0.1088***
	(0.0023)	(0.0010)	(0.0020)	(0.0034)	(0.0023)	(0.0015)	(0.0013)	(0.0035)	(0.0019)	(0.0015)	(0.0017)	(0.0034)	(0.0017)	(0.0013)	(0.0016)	(0.0035)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.1245***	0.0311***	0.0753***	0.3456***	0.1375***	0.0339***	0.0706***	0.3237***	0.0508***	0.0069	0.0429***	0.3312***	0.1263***	0.0482***	0.0860***	0.3517***
	(0.0131)	(0.0086)	(0.0096)	(0.0405)	(0.0125)	(0.0083)	(0.0102)	(0.0374)	(0.0100)	(0.0088)	(0.0124)	(0.0342)	(0.0134)	(0.0075)	(0.0098)	(0.0430)
	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4325	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000
lag_totalloa					-0.0369***	-0.0163***	-0.0149***	-0.0268***								
					(0.0044)	(0.0027)	(0.0045)	(0.0098)								
					0.0000	0.0000	0.0009	0.0064								
gdpd									-0.1480***	-0.0820***	-0.0720***	-0.0577***				
									(0.0024)	(0.0016)	(0.0019)	(0.0042)				
									0.0000	0.0000	0.0000	0.0000				
fundingr													0.0275	0.1248***	0.1574***	0.1245***
													(0.0203)	(0.0130)	(0.0154)	(0.0282)
													0.1763	0.0000	0.0000	0.0000
Constant	-0.3877***	0.0272***	0.6371***	1.6876***	-0.4170***	0.0225***	0.6536***	1.7391***	-0.2965***	0.0792***	0.6734***	1.7280***	-0.3862***	0.0328***	0.6359***	1.6876***
	(0.0140)	(0.0071)	(0.0138)	(0.0319)	(0.0166)	(0.0076)	(0.0097)	(0.0219)	(0.0122)	(0.0091)	(0.0086)	(0.0286)	(0.0169)	(0.0100)	(0.0166)	(0.0314)
	0.0000	0.0001	0.0000	0.0000	0.0000	0.0030	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF	6.19				6.07				5.86				5.53			
F(.)	96.79				30.08				194.59				67.35			
Prob > F	0.0000				0.0000				0.0000				0.0000			

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Quantile regression results for the initial dataset

continue→

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0233***	0.0052***	-0.0231***	-0.0720***	0.0233***	0.0054***	-0.0233***	-0.0721***	0.0246***	0.0054***	-0.0232***	-0.0726***	0.0241***	0.0056***	-0.0230***	-0.0725***
	(0.0009)	(0.0006)	(0.0007)	(0.0018)	(0.0007)	(0.0004)	(0.0008)	(0.0014)	(0.0011)	(0.0007)	(0.0010)	(0.0016)	(0.0008)	(0.0005)	(0.0007)	(0.0017)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lag_leverage	-0.0533***	-0.0002	0.0342***	0.0793***	-0.0494***	-0.0006	0.0350***	0.0794***	-0.0542***	-0.0010	0.0336***	0.0807***	-0.0517***	-0.0021	0.0329***	0.0794***
	(0.0070)	(0.0050)	(0.0089)	(0.0095)	(0.0063)	(0.0046)	(0.0076)	(0.0129)	(0.0087)	(0.0051)	(0.0058)	(0.0120)	(0.0049)	(0.0041)	(0.0079)	(0.0141)
	0.0000	0.9686	0.0001	0.0000	0.0000	0.9031	0.0000	0.0000	0.0000	0.8481	0.0000	0.0000	0.0000	0.6026	0.0000	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0004)	(0.0001)	(0.0000)	(0.0000)	(0.0004)	(0.0000)	(0.0000)	(0.0000)	(0.0003)	(0.0000)	(0.0000)	(0.0000)	(0.0004)
	0.9815	0.9878	0.9192	0.9890	0.9939	0.9870	0.8796	0.9897	0.9852	0.9847	0.8651	0.9854	0.9900	0.9803	0.9322	0.9885
lag_profit	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004
	(0.0002)	(0.0002)	(0.0012)	(0.0019)	(0.0009)	(0.0016)	(0.0031)	(0.0052)	(0.0013)	(0.0017)	(0.0029)	(0.0036)	(0.0002)	(0.0002)	(0.0021)	(0.0034)
	0.9473	0.9540	0.9936	0.8462	0.9891	0.9942	0.9974	0.9441	0.9922	0.9946	0.9973	0.9194	0.9515	0.9558	0.9962	0.9148
lnage	-0.0275***	-0.0306***	-0.0582***	-0.1100***	-0.0288***	-0.0301***	-0.0579***	-0.1088***	-0.0272***	-0.0311***	-0.0578***	-0.1076***	-0.0288***	-0.0309***	-0.0578***	-0.1082***
	(0.0020)	(0.0012)	(0.0017)	(0.0033)	(0.0026)	(0.0015)	(0.0018)	(0.0044)	(0.0018)	(0.0016)	(0.0020)	(0.0028)	(0.0021)	(0.0012)	(0.0018)	(0.0034)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.0854***	0.0187**	0.0736***	0.3309***	0.0759***	0.0069	0.0695***	0.3254***	0.1723***	0.0507***	0.0754***	0.3247***	0.1892***	0.0553***	0.0853***	0.3361***
	(0.0162)	(0.0074)	(0.0082)	(0.0369)	(0.0171)	(0.0104)	(0.0142)	(0.0369)	(0.0164)	(0.0101)	(0.0127)	(0.0391)	(0.0112)	(0.0078)	(0.0111)	(0.0380)
	0.0000	0.0120	0.0000	0.0000	0.0000	0.5083	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
vseu	-0.7755***	-0.2085***	-0.0858***	-0.2606***												
	(0.0272)	(0.0145)	(0.0165)	(0.0343)												
	0.0000	0.0000	0.0000	0.0000												
lag_vseu					-0.8967***	-0.2923***	-0.1936***	-0.3693***								
					(0.0204)	(0.0143)	(0.0271)	(0.0493)								
					0.0000	0.0000	0.0000	0.0000								
vsrow									-0.7921***	-0.1821***	-0.0011	0.1007***				
									(0.0201)	(0.0133)	(0.0176)	(0.0354)				
									0.0000	0.0000	0.9522	0.0044				
lag_vsrow													-0.8909***	-0.2487***	-0.0511***	0.0530**
													(0.0270)	(0.0109)	(0.0125)	(0.0263)
													0.0000	0.0000	0.0000	0.0441
Constant	-0.3428***	0.0274***	0.6429***	1.7064***	-0.3252***	0.0312***	0.6524***	1.7145***	-0.3598***	0.0233***	0.6373***	1.6822***	-0.3358***	0.0265***	0.6385***	1.6866***
	(0.0129)	(0.0062)	(0.0071)	(0.0220)	(0.0111)	(0.0033)	(0.0118)	(0.0183)	(0.0143)	(0.0071)	(0.0159)	(0.0257)	(0.0096)	(0.0050)	(0.0098)	(0.0273)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF	5.92				6.06				5.81				5.89			
F(.)	559.32				242.33				438.55				866.05			
Prob > F	0.0000				0.0000				0.0000				0.0000			

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Quantile regression results for the initial dataset

continue →

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0259***	0.0049***	-0.0241***	-0.0743***	0.0244***	0.0048***	-0.0221***	-0.0698***	0.0183***	-0.0005	-0.0280***	-0.0771***	0.0230***	0.0040***	-0.0243***	-0.0750***
	(0.0009)	(0.0006)	(0.0008)	(0.0016)	(0.0009)	(0.0004)	(0.0008)	(0.0012)	(0.0009)	(0.0006)	(0.0008)	(0.0022)	(0.0012)	(0.0006)	(0.0009)	(0.0020)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4085	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lag_leverage	-0.0657***	-0.0028	0.0375***	0.0872***	-0.0550***	-0.0022	0.0297***	0.0771***	-0.0528***	0.0004	0.0394***	0.0853***	-0.0558***	-0.0005	0.0341***	0.0847***
	(0.0060)	(0.0044)	(0.0076)	(0.0118)	(0.0061)	(0.0032)	(0.0046)	(0.0092)	(0.0065)	(0.0040)	(0.0080)	(0.0118)	(0.0086)	(0.0051)	(0.0086)	(0.0178)
	0.0000	0.5248	0.0000	0.0000	0.0000	0.4904	0.0000	0.0000	0.0000	0.9302	0.0000	0.0000	0.0000	0.9160	0.0001	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0001)	(0.0000)	(0.0001)	(0.0004)	(0.0000)	(0.0000)	(0.0000)	(0.0003)	(0.0001)	(0.0000)	(0.0000)	(0.0005)	(0.0001)	(0.0000)	(0.0000)	(0.0003)
	0.9853	0.9912	0.9736	0.9886	0.9662	0.9867	0.8610	0.9859	0.9837	0.9885	0.9645	0.9925	0.9852	0.9842	0.8323	0.9877
lag_profit	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0001	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004
	(0.0002)	(0.0002)	(0.0015)	(0.0026)	(0.0002)	(0.0016)	(0.0029)	(0.0040)	(0.0003)	(0.0012)	(0.0022)	(0.0032)	(0.0002)	(0.0007)	(0.0030)	(0.0044)
	0.9512	0.9548	0.9879	0.8889	0.9548	0.9943	0.9973	0.9292	0.9666	0.9927	0.9742	0.9081	0.9407	0.9866	0.9940	0.9333
lnage	-0.0253***	-0.0302***	-0.0583***	-0.1116***	-0.0252***	-0.0292***	-0.0554***	-0.1008***	-0.0315***	-0.0337***	-0.0599***	-0.1112***	-0.0287***	-0.0309***	-0.0583***	-0.1108***
	(0.0024)	(0.0015)	(0.0021)	(0.0037)	(0.0019)	(0.0011)	(0.0014)	(0.0029)	(0.0030)	(0.0011)	(0.0019)	(0.0035)	(0.0028)	(0.0015)	(0.0015)	(0.0034)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.1139***	0.0298***	0.0751***	0.3380***	0.1195***	0.0326***	0.0768***	0.3587***	0.1312***	0.0598***	0.0937***	0.3931***	0.1245***	0.0284***	0.0720***	0.3068***
	(0.0132)	(0.0103)	(0.0135)	(0.0462)	(0.0154)	(0.0098)	(0.0117)	(0.0340)	(0.0143)	(0.0088)	(0.0086)	(0.0342)	(0.0132)	(0.0108)	(0.0115)	(0.0391)
	0.0000	0.0037	0.0000	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0084	0.0000	0.0000
ae	-0.0515***	-0.0085***	0.0174***	0.0513***												
	(0.0034)	(0.0024)	(0.0036)	(0.0082)												
	0.0000	0.0004	0.0000	0.0000												
ike					0.1088***	0.0541***	0.1253***	0.3521***								
					(0.0061)	(0.0073)	(0.0173)	(0.0597)								
					0.0000	0.0000	0.0000	0.0000								
exp									0.0480***	0.0453***	0.0529***	0.0600***				
									(0.0038)	(0.0021)	(0.0027)	(0.0050)				
									0.0000	0.0000	0.0000	0.0000				
exchange													-0.0013	0.0193***	0.0622***	0.2000***
													(0.0123)	(0.0070)	(0.0068)	(0.0172)
													0.9135	0.0055	0.0000	0.0000
Constant	-0.3906***	0.0257***	0.6356***	1.6806***	-0.4210***	0.0149**	0.6140***	1.6221***	-0.3415***	0.0774***	0.6770***	1.7246***	-0.3883***	0.0322***	0.6543***	1.7306***
	(0.0133)	(0.0091)	(0.0123)	(0.0225)	(0.0104)	(0.0061)	(0.0136)	(0.0203)	(0.0180)	(0.0101)	(0.0155)	(0.0357)	(0.0180)	(0.0091)	(0.0153)	(0.0319)
	0.0000	0.0048	0.0000	0.0000	0.0000	0.0147	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF	6.58				5.54				5.83				5.45			
F(.)	122.29				88.52				181.35				175.51			
Prob > F	0.0000				0.0000				0.0000				0.0000			

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Quantile regression results for the initial dataset

continue→

	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0231***	0.0044***	-0.0230***	-0.0721***	-0.0378***	-0.0339***	-0.0737***	-0.1525***	0.0119***	-0.0003	-0.0241***	-0.0726***	0.0127***	-0.0020***	-0.0323***	-0.0808***
	(0.0012)	(0.0007)	(0.0010)	(0.0016)	(0.0018)	(0.0011)	(0.0023)	(0.0033)	(0.0009)	(0.0005)	(0.0007)	(0.0016)	(0.0009)	(0.0005)	(0.0012)	(0.0019)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4847	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
lag_leverage	-0.0557***	-0.0002	0.0344***	0.0802***	-0.0526***	0.0007	0.0310***	0.0560***	-0.0568***	-0.0016	0.0357***	0.0794***	-0.0571***	-0.0003	0.0299***	0.0749***
	(0.0060)	(0.0050)	(0.0076)	(0.0133)	(0.0057)	(0.0030)	(0.0063)	(0.0108)	(0.0074)	(0.0051)	(0.0070)	(0.0140)	(0.0088)	(0.0054)	(0.0073)	(0.0130)
	0.0000	0.9701	0.0000	0.0000	0.0000	0.8093	0.0000	0.0000	0.0000	0.7507	0.0000	0.0000	0.0000	0.9599	0.0000	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0004)	(0.0001)	(0.0000)	(0.0000)	(0.0004)	(0.0000)	(0.0000)	(0.0000)	(0.0004)	(0.0001)	(0.0000)	(0.0000)	(0.0003)
	0.9728	0.9873	0.9614	0.9900	0.9839	0.9947	0.9205	0.9897	0.9634	0.9861	0.9654	0.9893	0.9865	0.9849	0.8755	0.9871
lag_profit	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0001	-0.0003	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0002	-0.0004
	(0.0002)	(0.0012)	(0.0023)	(0.0035)	(0.0002)	(0.0002)	(0.0018)	(0.0032)	(0.0002)	(0.0002)	(0.0011)	(0.0028)	(0.0002)	(0.0002)	(0.0015)	(0.0033)
	0.9571	0.9927	0.9965	0.9160	0.9529	0.9578	0.9426	0.9175	0.9442	0.9509	0.9891	0.8964	0.9444	0.9504	0.9161	0.9120
lnage	-0.0291***	-0.0307***	-0.0580***	-0.1094***	-0.0246***	-0.0293***	-0.0536***	-0.1001***	-0.0264***	-0.0298***	-0.0565***	-0.1087***	-0.0290***	-0.0313***	-0.0588***	-0.1137***
	(0.0015)	(0.0010)	(0.0017)	(0.0034)	(0.0021)	(0.0015)	(0.0018)	(0.0034)	(0.0020)	(0.0016)	(0.0022)	(0.0045)	(0.0019)	(0.0013)	(0.0015)	(0.0029)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.1260***	0.0380***	0.0777***	0.3491***	0.1191***	0.0471***	0.0931***	0.4568***	0.1365***	0.0526***	0.0883***	0.3438***	0.1230***	0.0240**	0.0727***	0.4153***
	(0.0103)	(0.0086)	(0.0088)	(0.0406)	(0.0181)	(0.0099)	(0.0138)	(0.0452)	(0.0116)	(0.0109)	(0.0107)	(0.0277)	(0.0115)	(0.0102)	(0.0083)	(0.0350)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0192	0.0000	0.0000
town	-0.0026	-0.0082***	-0.0146***	-0.0064												
	(0.0035)	(0.0014)	(0.0028)	(0.0056)												
	0.4433	0.0000	0.0000	0.2535												
micro					-0.2626***	-0.1741***	-0.2288***	-0.4440***								
					(0.0055)	(0.0037)	(0.0065)	(0.0131)								
					0.0000	0.0000	0.0000	0.0000								
small									0.0956***	0.0538***	0.0356***	-0.0151***				
									(0.0036)	(0.0019)	(0.0021)	(0.0048)				
									0.0000	0.0000	0.0000	0.0015				
medium													0.1032***	0.0675***	0.0889***	0.1222***
													(0.0038)	(0.0025)	(0.0027)	(0.0062)
													0.0000	0.0000	0.0000	0.0000
Constant	-0.3858***	0.0299***	0.6437***	1.6898***	0.6095***	0.6613***	1.4739***	3.0606***	-0.2680***	0.0724***	0.6317***	1.6983***	-0.2495***	0.1109***	0.7643***	1.8056***
	(0.0153)	(0.0103)	(0.0156)	(0.0282)	(0.0280)	(0.0183)	(0.0368)	(0.0613)	(0.0130)	(0.0084)	(0.0133)	(0.0281)	(0.0120)	(0.0081)	(0.0158)	(0.0265)
	0.0000	0.0038	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF	5.79				5.68				5.71				5.56			
F(.)	52.66				50.56				43.67				95.94			
Prob > F	0.0000				0.0000				0.0000				0.0000			

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Quantile regression results for the initial dataset

continue→

	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0199***	0.0019***	-0.0325***	-0.1011***	0.0229***	0.0043***	-0.0232***	-0.0721***	0.0230***	0.0029***	-0.0232***	-0.0724***	0.0220***	0.0025***	-0.0232***	-0.0726***
	(0.0011)	(0.0005)	(0.0012)	(0.0022)	(0.0010)	(0.0005)	(0.0007)	(0.0018)	(0.0007)	(0.0005)	(0.0008)	(0.0018)	(0.0009)	(0.0005)	(0.0009)	(0.0021)
	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lag_leverage	-0.0548***	-0.0007	0.0317***	0.0798***	-0.0544***	-0.0014	0.0337***	0.0785***	-0.0522***	-0.0035	0.0297***	0.0799***	-0.0575***	-0.0062	0.0283***	0.0789***
	(0.0070)	(0.0044)	(0.0071)	(0.0150)	(0.0085)	(0.0049)	(0.0064)	(0.0121)	(0.0051)	(0.0041)	(0.0082)	(0.0119)	(0.0116)	(0.0055)	(0.0072)	(0.0109)
	0.0000	0.8721	0.0000	0.0000	0.0000	0.7737	0.0000	0.0000	0.0000	0.3898	0.0003	0.0000	0.0000	0.2636	0.0001	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0009)
	0.9860	0.9913	0.9526	0.9468	0.9728	0.9881	0.8486	0.9814	0.9894	0.9777	0.7377	0.7826	0.9693	0.9906	0.9212	0.9955
lag_profit	-0.0000	-0.0000	-0.0002	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0002	-0.0004
	(0.0002)	(0.0016)	(0.0026)	(0.0036)	(0.0002)	(0.0002)	(0.0022)	(0.0041)	(0.0013)	(0.0027)	(0.0040)	(0.0043)	(0.0002)	(0.0002)	(0.0012)	(0.0026)
	0.9576	0.9943	0.9466	0.9219	0.9489	0.9549	0.9963	0.9288	0.9923	0.9966	0.9980	0.9314	0.9420	0.9507	0.8889	0.8891
lnage	-0.0290***	-0.0307***	-0.0585***	-0.1015***	-0.0293***	-0.0307***	-0.0577***	-0.1093***	-0.0275***	-0.0319***	-0.0550***	-0.1083***	-0.0246***	-0.0293***	-0.0549***	-0.1067***
	(0.0022)	(0.0013)	(0.0019)	(0.0038)	(0.0026)	(0.0012)	(0.0015)	(0.0044)	(0.0018)	(0.0012)	(0.0025)		(0.0029)	(0.0013)	(0.0013)	(0.0038)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.1194***	0.0250**	0.0608***	0.2092***	0.1247***	0.0300***	0.0754***	0.3442***	0.1185***	0.0597***	0.0734***	0.3528***	0.1461***	0.0711***	0.0922***	0.3599***
	(0.0151)	(0.0102)	(0.0120)	(0.0278)	(0.0145)	(0.0092)	(0.0087)	(0.0373)	(0.0089)	(0.0108)	(0.0125)	(0.0415)	(0.0150)	(0.0077)	(0.0136)	(0.0341)
	0.0000	0.0143	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
large	0.0467***	0.0490***	0.1470***	0.3878***												
	(0.0063)	(0.0045)	(0.0059)	(0.0147)												
	0.0000	0.0000	0.0000	0.0000												
daysd					0.0205***	0.0093***	0.0002	0.0030								
					(0.0037)	(0.0020)	(0.0029)	(0.0059)								
					0.0000	0.0000	0.9491	0.6174								
coststartd									0.0788***	0.0584***	0.0638***	0.0538***				
									(0.0038)	(0.0010)	(0.0017)	(0.0048)				
									0.0000	0.0000	0.0000	0.0000				
mincapstartd													0.0914***	0.0704***	0.0699***	0.0591***
													(0.0027)	(0.0012)	(0.0023)	(0.0037)
													0.0000	0.0000	0.0000	0.0000
Constant	-0.3448***	0.0613***	0.7735***	2.0849***	-0.3918***	0.0252***	0.6370***	1.6863***	-0.4348***	0.0207***	0.5956***	1.6562***	-0.4149***	0.0270***	0.6070***	1.6638***
	(0.0188)	(0.0085)	(0.0161)	(0.0310)	(0.0146)	(0.0058)	(0.0082)	(0.0227)	(0.0124)	(0.0074)	(0.0138)	(0.0262)	(0.0090)	(0.0073)	(0.0156)	(0.0309)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0053	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF	5.51				5.55				5.76				5.62			
F(.)	253.47				53.13				53.90				72.80			
Prob > F	0.0000				0.0000				0.0000				0.0000			

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Quantile regression results for the initial dataset

continue→

	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0216***	0.0052***	-0.0232***	-0.0723***	0.0231***	0.0042***	-0.0227***	-0.0721***	0.0230***	0.0042***	-0.0229***	-0.0721***	0.0231***	0.0042***	-0.0228***	-0.0720***
	(0.0012)	(0.0005)	(0.0006)	(0.0014)	(0.0009)	(0.0005)	(0.0007)	(0.0021)	(0.0007)	(0.0004)	(0.0007)	(0.0012)	(0.0007)	(0.0004)	(0.0006)	(0.0013)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lag_leverage	-0.0550***	-0.0023	0.0322***	0.0781***	-0.0560***	-0.0017	0.0329***	0.0807***	-0.0549***	-0.0014	0.0325***	0.0805***	-0.0551***	-0.0020	0.0323***	0.0798***
	(0.0073)	(0.0037)	(0.0083)	(0.0140)	(0.0050)	(0.0032)	(0.0067)	(0.0109)	(0.0055)	(0.0041)	(0.0078)	(0.0123)	(0.0088)	(0.0054)	(0.0072)	(0.0128)
	0.0000	0.5255	0.0001	0.0000	0.0000	0.5960	0.0000	0.0000	0.0000	0.7375	0.0000	0.0000	0.0000	0.7165	0.0000	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0001)	(0.0000)	(0.0000)	(0.0002)	(0.0001)	(0.0000)	(0.0001)	(0.0003)	(0.0001)	(0.0000)	(0.0000)	(0.0004)	(0.0000)	(0.0000)	(0.0000)	(0.0003)
	0.9900	0.9863	0.9475	0.9795	0.9893	0.9878	0.9861	0.9874	0.9851	0.9901	0.8503	0.9902	0.9701	0.9897	0.9168	0.9872
lag_profit	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004
	(0.0002)	(0.0002)	(0.0010)	(0.0033)	(0.0002)	(0.0008)	(0.0024)	(0.0036)	(0.0002)	(0.0002)	(0.0022)	(0.0030)	(0.0002)	(0.0002)	(0.0016)	(0.0041)
	0.9467	0.9524	0.9922	0.9127	0.9532	0.9890	0.9967	0.9178	0.9484	0.9570	0.9871	0.9009	0.9453	0.9518	0.9761	0.9294
lnage	-0.0249***	-0.0294***	-0.0572***	-0.1090***	-0.0292***	-0.0308***	-0.0584***	-0.1083***	-0.0287***	-0.0307***	-0.0582***	-0.1089***	-0.0291***	-0.0311***	-0.0579***	-0.1088***
	(0.0018)	(0.0009)	(0.0017)	(0.0044)	(0.0027)	(0.0014)	(0.0025)	(0.0033)	(0.0024)	(0.0013)	(0.0019)	(0.0038)	(0.0025)	(0.0013)	(0.0022)	(0.0032)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.1421***	0.0312***	0.0792***	0.3540***	0.1257***	0.0307***	0.0675***	0.3426***	0.1196***	0.0313***	0.0749***	0.3434***	0.1166***	0.0300***	0.0682***	0.3382***
	(0.0120)	(0.0090)	(0.0109)	(0.0302)	(0.0169)	(0.0097)	(0.0128)	(0.0347)	(0.0153)	(0.0080)	(0.0099)	(0.0278)	(0.0127)	(0.0070)	(0.0128)	(0.0405)
	0.0000	0.0005	0.0000	0.0000	0.0000	0.0016	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
taxrate	1.5806***	0.9461***	0.7329***	0.6166***												
	(0.0221)	(0.0246)	(0.0252)	(0.0412)												
	0.0000	0.0000	0.0000	0.0000												
timexpd					0.0027	0.0092***	0.0145***	0.0141***								
					(0.0026)	(0.0018)	(0.0021)	(0.0048)								
					0.2894	0.0000	0.0000	0.0034								
costexpd									0.0140***	0.0088***	0.0092***	0.0109***				
									(0.0024)	(0.0017)	(0.0023)	(0.0042)				
									0.0000	0.0000	0.0001	0.0091				
timeimpd													0.0140***	0.0142***	0.0148***	0.0123**
													(0.0028)	(0.0018)	(0.0029)	(0.0058)
													0.0000	0.0000	0.0000	0.0352
Constant	-1.1581***	-0.4584***	0.2728***	1.3838***	-0.3887***	0.0268***	0.6271***	1.6774***	-0.3934***	0.0253***	0.6314***	1.6809***	-0.3915***	0.0264***	0.6282***	1.6800***
	(0.0179)	(0.0147)	(0.0151)	(0.0326)	(0.0113)	(0.0073)	(0.0140)	(0.0333)	(0.0131)	(0.0054)	(0.0126)	(0.0185)	(0.0111)	(0.0060)	(0.0107)	(0.0212)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF	16.50				5.59				5.59				5.55			
F(.)	45.41				101.72				77.24				90.44			
Prob > F	0.0000				0.0000				0.0000				0.0000			

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A2 Quantile regression results for the initial dataset

	97	98	99	100	101	102	103	104
	25%	50%	75%	90%	25%	50%	75%	90%
initialsize	0.0228***	0.0044***	-0.0231***	-0.0721***	0.0212***	0.0051***	-0.0234***	-0.0723***
	(0.0008)	(0.0005)	(0.0010)	(0.0022)	(0.0006)	(0.0006)	(0.0008)	(0.0018)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
lag_leverage	-0.0564***	-0.0015	0.0326***	0.0794***	-0.0506***	-0.0024	0.0317***	0.0750***
	(0.0077)	(0.0042)	(0.0059)	(0.0156)	(0.0053)	(0.0051)	(0.0073)	(0.0123)
	0.0000	0.7145	0.0000	0.0000	0.0000	0.6366	0.0000	0.0000
lag_liquidity	0.0000	-0.0000	-0.0000	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0001)	(0.0004)	(0.0001)	(0.0000)	(0.0000)	(0.0003)
	0.9774	0.9888	0.9663	0.9889	0.9927	0.9836	0.9292	0.9870
lag_profit	-0.0000	-0.0000	-0.0000	-0.0004	-0.0000	-0.0000	-0.0000	-0.0004
	(0.0002)	(0.0013)	(0.0030)	(0.0039)	(0.0002)	(0.0012)	(0.0026)	(0.0043)
	0.9529	0.9931	0.9973	0.9244	0.9561	0.9925	0.9970	0.9327
lnage	-0.0287***	-0.0306***	-0.0578***	-0.1092***	-0.0277***	-0.0302***	-0.0580***	-0.1087***
	(0.0019)	(0.0011)	(0.0017)	(0.0038)	(0.0023)	(0.0014)	(0.0018)	(0.0033)
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
herf	0.1124***	0.0311***	0.0745***	0.3425***	0.1571***	0.0302***	0.0815***	0.3473***
	(0.0119)	(0.0091)	(0.0094)	(0.0465)	(0.0121)	(0.0100)	(0.0108)	(0.0323)
	0.0000	0.0006	0.0000	0.0000	0.0000	0.0025	0.0000	0.0000
costimpd	0.0257***	0.0131***	0.0089***	0.0083*				
	(0.0037)	(0.0015)	(0.0020)	(0.0050)				
	0.0000	0.0000	0.0000	0.0983				
lag_lnbrent					-0.1970***	-0.0868***	-0.0674***	-0.0558***
					(0.0038)	(0.0027)	(0.0023)	(0.0070)
					0.0000	0.0000	0.0000	0.0000
Constant	-0.3925***	0.0220***	0.6326***	1.6853***	0.4762***	0.3858***	0.9305***	1.9305***
	(0.0109)	(0.0076)	(0.0160)	(0.0284)	(0.0134)	(0.0124)	(0.0147)	(0.0463)
	0.0000	0.0039	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	92,831	92,831	92,831	92,831	92,831	92,831	92,831	92,831
Mean VIF			5.55				17.35	
F(.)			66.07				126.88	
Prob > F			0.0000				0.0000	

Source: IOBE.
Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

WHAT DRIVES WAGE DIFFERENTIALS IN GREECE: WORKPLACES OR WORKERS?

Theodora Kosma
Economic Analysis and Research Department

Pavlos Petroulas
Economic Analysis and Research Department

Evangelia Vourvachaki
Economic Analysis and Research Department

ABSTRACT

Using a micro-aggregated dataset that contains gross wages as well as employer and employee characteristics, we investigate whether observed wage differentials in Greece reflect mostly the underlying variation in employer characteristics, i.e. the structure of the Greek production, or worker and job characteristics. Our results show that both employer and worker characteristics are important contributors to the observed wage dispersion of full-time private sector jobs in Greece. Occupation and workplace effects alone explain around 52% of the overall wage variation in Greece. An additional 11% is explained by controlling for the impact of workplace-occupation matching. Other observable characteristics of the workers such as age, gender and type of job contract add up to 23.5% more explanatory power. Finally, our results also show that both the observed gender and contract type wage gaps are more prevalent among high-skilled occupations, acting thus as a disincentive to the acquisition of skills.

Keywords: wage differentials; micro-aggregated data; wage gap

JEL classification: J31; C20

ΤΙ ΕΞΗΓΕΙ ΤΙΣ ΜΙΣΘΟΛΟΓΙΚΕΣ ΔΙΑΦΟΡΕΣ ΣΤΗΝ ΕΛΛΑΔΑ: ΤΑ ΧΑΡΑΚΤΗΡΙΣΤΙΚΑ ΤΩΝ ΕΡΓΟΔΟΤΩΝ Ή ΤΩΝ ΕΡΓΑΖΟΜΕΝΩΝ;

Θεοδώρα Κοσμά
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Παύλος Πέτρουλας
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Ευαγγελία Βουρβαχάκη
Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

ΠΕΡΙΛΗΨΗ

Χρησιμοποιώντας στοιχεία που προέρχονται από τη σύνθεση μικροδεδομένων για τους ακαθάριστους μισθούς και τα χαρακτηριστικά των εργοδοτών και των εργαζομένων, διερευνούμε κατά πόσον οι παρατηρούμενες μισθολογικές διαφορές στην Ελλάδα αντικατοπτρίζουν περισσότερο διαφορές στα χαρακτηριστικά των εργοδοτών, δηλαδή τη δομή της ελληνικής παραγωγικής διαδικασίας, ή διαφορές στα χαρακτηριστικά των εργαζομένων και των θέσεων εργασίας. Τα αποτελέσματα δείχνουν ότι τα χαρακτηριστικά τόσο των εργοδοτών όσο και των εργαζομένων αποτελούν σημαντικούς προσδιοριστικούς παράγοντες της παρατηρούμενης διασποράς των μισθών πλήρους απασχόλησης στον ιδιωτικό τομέα στην Ελλάδα. Μόνο το επάγγελμα των εργαζομένων και τα χαρακτηριστικά των εργοδοτών εξηγούν περίπου 52% της συνολικής διασποράς των μισθών στην Ελλάδα. Ένα επιπλέον 11% της διασποράς εξηγείται από τη συνδυαστική επίδραση (matching) επαγγελμάτων και εργοδοτών. Άλλα παρατηρήσιμα χαρακτηριστικά των εργαζομένων όπως η ηλικία, το φύλο και ο τύπος της σύμβασης εργασίας εξηγούν έως και επιπλέον 23,5% της διασποράς. Τέλος, τα ευρήματά μας δείχνουν επίσης ότι το μισθολογικό χάσμα (wage gap) που υπάρχει μεταξύ των δύο φύλων και μεταξύ διαφορετικών τύπων συμβάσεων (αορίστου ή ορισμένου χρόνου) είναι μεγαλύτερο μεταξύ επαγγελμάτων υψηλής εξειδίκευσης, γεγονός που λειτουργεί ως αντικίνητρο για την απόκτηση δεξιοτήτων υψηλής εξειδίκευσης.

WHAT DRIVES WAGE DIFFERENTIALS IN GREECE: WORKPLACES OR WORKERS?[1]

Theodora Kosma
Economic Analysis and Research Department

Pavlos Petroulas
Economic Analysis and Research Department

Evangelia Vourvachaki
Economic Analysis and Research Department

1 INTRODUCTION

There is an extensive empirical literature analysing the sources of wage dispersion. Apart from the importance of worker characteristics, one stream of the literature has also stressed the role of employer characteristics. Along this line of research, a lot of studies have focused on the drivers of inter-industry wage differentials and have noted the role of wage differentials at the level of the establishment. The availability of longitudinal matched employer-employee microdata has also allowed to control for unobserved worker and firm heterogeneity (see e.g. Abowd et al. 1999b) and delve deeper into the role of matching between employer and employee characteristics (see e.g. Woodcock 2008). The findings regarding the relative importance of different factors in driving wage differentials of seemingly homogeneous workers contribute to understanding wage setting practices and the sources of wage inequality.

This study aims to shed some light on the relative importance of these factors in explaining wage differentials for private sector full-time jobs in Greece over the period 2016-2019. For this purpose, we use detailed administrative data from the ERGANI information system. The advantage of these data is that they offer up-to-date information at a granular level for key attributes of employers and workers that are the focal point of this study.

During our sample period, headcount employment in Greece grew at robust rates, supported by strong net job creation in the private sector, while wage dynamics were rather muted.[2] At the same time, there was considerable wage dispersion among full-time jobs in the private sector. There was, on average, a threefold difference between the average wage at the 90th percentile, compared with the average wage at the 10th percentile in our sample.

Understanding the drivers of these wage differentials would contribute to a better understanding of the factors shaping wage dynamics in Greece during the recent period. The main question we aim to address in this study is the following: Do wage differentials mostly reflect the underlying variation in employer characteristics, i.e. the structure of the Greek production, or worker and job characteristics? Answering this question would provide insights into the drivers of wage dispersion, which may also prove useful for designing policies aimed at supporting labour income.

Our results show that both employer and worker characteristics are important contributors to the observed wage dispersion of full-time private sector jobs in Greece. Occupation and establishment effects alone explain around 52% of the overall wage variation in Greece. An additional 11% is explained by controlling for the impact of workplace-occu-

1 We would like to thank the Ministry of Labour and Social Affairs for providing detailed micro-aggregated employment and wages data from the ERGANI information system. We would also like to thank Heather Gibson and Hiona Balfoussia for their constructive comments and suggestions. The views expressed in this paper are of the authors and do not necessarily reflect those of the Bank of Greece.

2 According to LFS data, average annual employment growth stood at 2% and, according to ERGANI data, about 137 thousand jobs on average were created annually. The growth rate of economy-wide compensation per employee moved into positive territory in 2017 for the first time since the beginning of the economic crisis and increased moderately by 1.4%, on average, during 2017-2019 (National Accounts data).

pation matching. Other observable characteristics of the workers such as age, gender and type of job contract add up to 23.5% more explanatory power. We further show that there are significant gender wage differentials and a wage premium for older workers as well as for those working on contracts of indefinite length.

The remainder of the article is structured as follows: Section 2 provides a short literature review. Section 3 describes the data and the methodology used in our analysis of wage differentials, while Section 4 presents and discusses our empirical findings. The final section concludes.

2 LITERATURE REVIEW

The literature has long looked into the drivers of wage dispersion and the relative importance of worker, employer and job characteristics, as it was understood early on that observable worker characteristics alone, like education, age, gender, tenure, etc., cannot account for the existing wage differentials at the individual level.

A large body of theoretical literature highlighted the importance of employers in the wage determination process and thereby in wage differentials, offering explanations such as wage efficiency considerations (see e.g. Shapiro and Stiglitz 1984) or rent sharing, the role of labour market institutions (see e.g. Booth 1995), search frictions (see e.g. Mortensen 2003), as well as differences in the firm technology (see e.g. Rosen 1986).

Along this stream of research, a long list of empirical studies focused on the importance of inter-industry wage differentials in accounting for wage dispersion (see e.g. Krueger and Summers 1988; Katz and Summers 1989; Gibbons and Katz 1992; Du Caju et al. 2010). They show that inter-industry wage differentials cannot be fully explained by observable worker or firm characteristics. In this respect, these findings point to the relevance of unobserved employee or job characteristics, or support non-competitive explanations regarding wage determination such as efficiency wages or rent sharing.

The seminal article by Groshen (1991) used data for six US manufacturing industries to show that a considerable part of the intra-industry wage variation is due to establishment wage differentials (20%-70%). Her empirical approach involves analysing the sources of the wage variance using controls for worker occupation (at a fine level of detail), the establishment and the interaction of the two. Her results indicate that these factors taken together account for almost all the variation in wages. Her findings are consistent with the theory that firms tend to sort their workers (irrespective of occupation) according to their (unmeasured) labour quality. They are also consistent with explanations relating to differences across establishments as regards compensation practices, wage efficiency, rent sharing, or technology.

Following a similar empirical approach, Lane et al. (2007) use data that cover all sectors of the US economy and exploit a very granular classification of occupations. Their findings concur with the conclusions of Groshen (1991) that wage differences between establishments account for an important fraction of total wage variation. Also, within-establishment analysis shows that there is a positive correlation of occupational wages, which provides further support to the sorting theory or to hypotheses resting on establishment-specific labour compensation policies.

The availability of matched employer-employee data was key to studying the role of unobserved heterogeneity in driving wage differentials and obtaining unbiased estimates of the relative importance of worker and employer effects. In their seminal work using longitudinal data for France, Abowd et al. (1999b) show that unobserved heterogeneity, like worker labour quality or the productivity of the firm, could bias the estimates of the drivers of wage differentials to the extent that

observables correlate with these unobserved factors (i.e. due to omitted variables).[3] They find that the main driver of wage differentials is the worker (person) effects. Firm characteristics are also found to have a bearing on wage differentials (see also Abowd et al. 2002). Moreover, they show that firms whose workers enjoy a wage premium (i.e. above the wage explained by workers' observable characteristics) tend to be more productive and use a more capital and skill intensive technology. A more important role for firm effects is found in a companion paper with data for the United States (the Washington State in partiuclar – see Abowd et al. 1999a).

This more recent stream of studies has also been able to assess the role of unmeasured characteristics of the worker-employer match, reflecting for example the match-specific human capital, in driving wage differentials. Similarly to the case raised by Abowd et al. (1999b) for unobserved worker and firm effects, Woodcock (2008) shows that omitting match effects in a regression-based analysis leads to biased estimates of the importance of different factors, thereby potentially leading to wrong conclusions as regards the sorting of workers into firms. Furthermore, in his empirical application he finds that match effects also make a meaningful contribution to wage differentials.

As regards studies for Greece which look into the sources of wage dispersion, Papapetrou and Tsalaporta (2017) and Nicolitsas (2011) use the Structure of Earnings survey and focus on inter-industry wage differentials. Nicolitsas (2011) finds important inter-industry wage differentials even after controlling for employer and employee characteristics. Papapetrou and Tsalaporta (2017) reach a similar conclusion using matched employer-employee data and a methodology that allows them to control for unobserved worker heterogeneity. Their findings offer support to efficiency wage or rent-sharing explanations, as they find weak evidence in favour of unobserved heterogeneity due to worker quality.

3 DATA AND METHODOLOGY

3.1 DATA

Our analysis of wage differentials is based on gross monthly earnings of private sector employees for four years (2016-2019). The data are from the annual accounts of ERGANI, an administrative database, covering the whole population of employees working under private law contracts in Greece. ERGANI includes very detailed information on various employer, employee and job characteristics.[4] Due to the sensitivity of the data contained therein, only micro-aggregated data are currently available for research purposes, albeit at a very fine level as detailed below.[5]

More specifically, data on wages are available for the following worker, employer and job characteristics, respectively: (i) worker gender, age and occupation; (ii) region, main sector of establishment activity, firm size (in number of employees); (iii) type of job contract (open-ended or fixed-term) and type of employment (full-time, part-time or intermittent). This information is available at the level of 89 2-digit NACE sectors of activity, 7 age categories, 46 occupation categories, 12 firm size categories and 13 NUTS 2 regions (see Tables A1-A5 in Appendix A for details). Our analysis is limited to full-time jobs, which ensures comparability of wages. Thus, one observational row may refer to the average gross monthly wage of full-time employees in the occupational category "physical and engi-

3 For example, to the extent that high-quality workers are sorted into specific industries (a positive correlation with industry features), absent any controls for the quality of the workers, the estimate of the inter-industry wage differentials would be overstated.

4 This database includes the information submitted annually by all private-sector employers and serves as a detailed registry of the employment history of all private sector employees. Employees working in public sector entities, whose contracts are governed by private sector labour law, are also registered in this database. The information collected is at the job/worker level (see also Kosma et al. 2019).

5 Being census data, the ERGANI data may differ from other statistical sources such as ELSTAT, the data of which are sample-based. Moreover, the data used in the current analysis are not directly comparable to those published in the annual ERGANI reports, as they are different in nature. Specifically, our data are micro-aggregated and include wages corresponding to employment positions, rather than individuals.

neering science associate professionals", who belong to the age category 25-34, are male, work on a fixed-term contract, in firms in sector 31 (manufacture of furniture) that employ between 51-250 people and are located in the area of Central Macedonia. Overall, our final dataset includes a total of 575,495 observation cells (unbalanced over the years).[6]

These data show that there is significant wage dispersion across occupations (see Table A6 in Appendix A), firm sizes, sectors and regions (see Bank of Greece 2020). As such, it is necessary to account for all these factors in a unified analysis of wage determination in Greece as well as analyse their relative importance.

3.2 METHODOLOGY

The methodology in this section follows that of Lane et al. (2007) and Groshen (1991). The main aim of this approach is to obtain a simple and intuitive decomposition of the variation in wages into the shares attributed to occupational and workplace characteristics, as well as the joint impact of workplace and occupational characteristics.

However, our dataset does not contain an establishment identifier. As such, in order to isolate, to the greatest extent possible, the impact of workplace characteristics on wages —given the structure of our data— we introduce "workplace type" dummies that are defined by the unique combination of sector (2-digit NACE), size (12 size classes) and region (13 regions) of operation. Therefore, one workplace type may be the following: firms in sector 31 (manufacture of furniture) employing between 51-250 people in the region of Central Macedonia. By doing so, we essentially define homogeneous workplaces. Moreover, given the granularity of the dimensions of our data, for specific regions, size classes and sectors, the workplace dummies may on several occasions refer to one firm. This approach yields a total of 3,863 homogeneous workplace dummies. As is evident from this description, our workplace dummies are sufficiently detailed and they can provide a reasonable approximation of a virtual establishment operating in a specific sector, in a specific region in Greece.[7]

We exploit the various dimensions of our rich data, attempting to isolate the impact of other characteristics beyond that of the homogeneous workplace, to which wage data refer, and, as in Lane et al. (2007), we estimate the following regressions:

$$W_{xijt} = a + \beta' workplace_i + \varepsilon_{xijt} \quad (1)$$

$$W_{xijt} = a + \gamma' occup_j + \varepsilon_{xijt} \quad (2)$$

$$W_{xijt} = a + \beta' workplace_i + \gamma' occup_j + \varepsilon_{xijt} \quad (3)$$

$$W_{xijt} = a + \beta' workplace_i + \gamma' occup_j + \delta' (workplace_i * occup_j) + \varepsilon_{xijt} \quad (4)$$

W_{xijt} is the log average wage of workers with personal characteristics x in workplace i, in occupation j at time t;

$workplace_i$ is a vector of workplace type dummies;

$occup_j$ is the vector of occupational dummies;

$(workplace_i * occup_j)$ is a vector of dummy variables indicating a specific workplace and occupation match.[8]

In equations (1) and (2) the log average wage of workers with personal characteristics x working in workplace i and occupation j are regressed on the vector of workplace and occu-

6 The final dataset is trimmed at the 1% level for wages. Nine sectors of activity with a very small employment share (NACE Rev. 2 codes 2, 5, 9, 37, 39, 75, 97, 98, 99) and employees aged below 15 are also discarded from the analysis.

7 Of course, we could simply include individual dummies for each workplace characteristic, but this is not the aim of this exercise, i.e. to estimate the impact of size, sector and region separately, which has already been done in the literature. The objective of this exercise is to exploit the granularity of our data and identify representative firm types for Greece as defined by the sector, size and region of operation.

8 For instance, a specific workplace-occupation match could be the following: machine operators in firms, in sector 31 (manufacture of furniture) employing between 51-250 people in the region of Central Macedonia.

pational dummies, respectively. In equation (3) workplace and occupational dummies are simultaneously introduced into the regression, while in equation (4) workplace and occupational dummies as well as their interactions are simultaneously included. Let us denote equation (3), which includes the main effects, as the *main equation*, following the intuitive terminology of Lane et al. (2007), and equation (4) as the *cell regression*, as it also accounts for the impact of the job match.

Our analysis focuses on the comparisons of R^2 from the above regressions in order to decompose the impact of the various characteristics on wages. Let R^2_{work} be the R^2 of equation (1), R^2_{occ} that of equation (2), R^2_{main} that of equation (3) and R^2_{cell} that of equation (4), which includes workplace and occupational dummies as well as the interaction of the two.

In this context, therefore, the marginal contribution of workplace characteristics on wages can be calculated as follows: $R^2_{main} - R^2_{occ}$. The marginal contribution of occupational characteristics can be similarly obtained by calculating the following difference: $R^2_{main} - R^2_{work}$.

It is not necessarily expected that the explanatory power of occupational and workplace characteristics in equation (3) is equal to the summation of the explanatory power of each characteristic from equations (1) and (2). The following difference $R^2_{work}+R^2_{occ}-R^2_{main}$, referred to as the *"joint"* explanatory power of occupation and workplace (see Lane et al. 2007), can be used to evaluate the importance of positive or negative sorting of occupations across establishments.[9] In particular, positive sorting implies a clustering of high-wage occupations in high-wage firms, while negative sorting refers to a clustering of high-wage occupations in low-wage workplaces.[10]

Finally, the difference $R^2_{cell} - R^2_{main}$ refers to the wage premium paid to a particular occupation in a particular workplace, above the premium predicted by the occupation and workplace characteristics alone. It basically captures the premium of a specific workplace-occupation match. It may involve the skill requirements of production process, on-the-job training or differences in occupational tenure across workplaces, basically workplace-specific wage policies.

The remaining unexplained component $1-R^2_{cell}$ refers to the unexplained part not captured by workplace and occupational indicators. This may be related to other personal and job characteristics not captured by variation of workplace and occupational characteristics, such as gender, contract type, tenure/work experience, and ability.

4 RESULTS

4.1 WAGE VARIANCE DECOMPOSITION RESULTS

Table 1 presents the main results of our empirical exercise. Our sample consists of 575,495 observations. The first panel of Table 1 presents the R^2s from the relevant equations described in the previous section. Our results show that there are significant occupational as well as workplace wage differentials in Greece. One can see that occupational and workplace characteristics along with their interaction explain 63% of wage variation. Therefore, occupational and workplace characteristics, as well as their interaction, explain most of the observed variation in wages. The lower panel provides information on the marginal contribution of workplace and occupation characteristics. In particular, almost 15% of the wage

9 More specifically, the explanatory power of workplace dummies will be overstated, if the wage equation is estimated using controls for workplace characteristics only, as it will also capture the "crowding" of certain occupations in certain types of workplaces. The same holds for the explanatory power of occupational dummies. Therefore, $R^2_{work}+R^2_{occ}$ will be higher than R^2_{main}, which accounts for both occupational and workplace differentials. As Hamermesh (2008) argues, if one has a lot of information on workers, it will look as if worker characteristics matter more and if one has a lot of information on firms, it will look as if firms matter more. The difference thus measures the "joint" (collinear) explanatory power of occupation and workplace characteristics (see Groshen 1991).

10 The correlation between occupation and workplace effects can also be used as an additional test of positive or negative sorting (see Gruetter and Lalive 2009). While the idea of positive sorting is easy to understand, the same is not true for negative sorting. For instance, as Gruetter and Lalive (2009) argue, negative sorting may refer to a situation where high-wage workers may "purchase" safer jobs.

Table 1 Wage variance decomposition

R^2_{work}	0.374
R^2_{occ}	0.281
R^2_{main}	0.520
R^2_{cell}	0.630
Marginal contribution of characteristics	
Occupation	0.146
Workplace	0.239
Joint contribution	0.135
Job cell	0.110
Unexplained	0.370

Source: ERGANI and authors' estimations.
Note: The estimation sample consists of 575,495 observations. The dependent variable is log (wage).

variation is unambiguously related to the impact of the occupation, i.e. occupational wage differentials, 24% to the impact of the workplace, i.e. workplace wage differentials, and 11% to the impact of the workplace-occupation cell, i.e. the wage premium of a specific occupation-workplace match. The joint contribution of occupation and workplace is positive at 14%, which, along with a correlation of 16% between occupation and workplace effects, point to a positive sorting in our data, i.e. a clustering of high-wage occupations in high-wage workplaces. Our results are in line with those of Lane et al. (2007), who provide similar evidence for the United States.[11]

A decomposition analysis at the sectoral level provides some very insightful results regarding the relative contribution of occupational and workplace characteristics in explaining the wage variation within broader sectors, i.e. intra-industry wage differentials. Table B1 in Appendix B provides similar information as Table 1 above at the level of broad NACE sectors. For expositional purposes, in the lower panel, where the marginal contributions are presented, the sectors with the highest value for each component are highlighted. Looking across sectors, we can see that occupational characteristics contribute relatively more in sectors like agriculture and accommodation and food services. These occupational wage differentials could potentially reflect a more distinct divide in the production process of these sectors across occupations. For example, an irrigation specialist will get a significantly higher wage than an unskilled worker in the agricultural sector. Similarly, a hotel manager in the accommodation and food services sector will get a wage premium compared with a waiter at a restaurant.

By contrast, the contribution of workplace characteristics seems to be higher within a specialised production process such as financial and insurance services and information and communications, where the production of the final output requires a specific bundle of occupations in order for the product to be produced.[12] For instance, in order to repair a computer or to produce a specific computer programme, specific skills are required. In such instances, it is the workplace rather than the occupation that contributes more to the wage variation within these sectors. Our results thus imply that an IT specialist will get a different —most probably a higher premium— if she works in a high-tech company like Nokia, rather than a regional store repairing home PCs. Also, an economist will get a higher wage premium if she works for a systemic bank rather than a small regional cooperative bank or a small insurance company.[13]

When it comes to the wage premium attributable to a specific occupation-workplace

11 There is plenty of evidence on the sorting of certain types of workers across certain types of firms. However, results depend on the dimension on which one focuses. For example, using Austrian data, Gruetter and Levine (2009) provide evidence of a positive sorting of workers across industries, but of negative sorting across firms. Woodcock (2008), using data for the United States, finds that there are indications of positive sorting of workers across industries. Woodcock (2008) also finds that there is sorting of women into lower-paying industries and lower-paying firms within industries, resulting in a gender wage gap in the United States.

12 Workplace characteristics also have high explanatory power in the transportation and storage sector, reflecting the relative importance of the subsectors of shipping, air and energy transport in the transportation and communications sector in Greece.

13 While the sectoral agreement of the banking sector union would tend to equalise wages among banking sector employees, we expect to see differences across workplaces in the banking sector, as firm/bank-level agreements, especially in systemic banks, are also prevalent in the sector. In our analysis these differences will be captured by the detailed nature of the size and regional variables.

match, the contribution appears to be higher in sectors with less standardised production processes such as agriculture, mining, administrative services, etc. Therefore, an irrigation specialist in the agricultural sector will get a higher premium in a big farm operating in a region from which a high share of fresh fruit are collected/packaged and exported.

Interestingly, the manufacturing sector, a goods producing sector with standardised production processes in terms of capital and labour requirements, does not seem to be an outlier in terms of the contribution of occupation or workplace characteristics, i.e. occupational and workplace differentials exist, but are not above average.

Table B2 in the Appendix B performs the same exercise by size categories for the 12 major firm size categories. Interestingly, the unexplained share of the wage seems to be higher at the two extremes, for very small firms and for very large firms in Greece. At the same time, matching between occupation and workplace characteristics plays a greater role for small firms. This result is similar to that found by Lane et al. (2007) and may reflect a more idiosyncratic production process (technology) and less standardised pay-setting practices in small firms.[14]

4.2 THE ROLE OF INDIVIDUAL CHARACTERISTICS

As can be seen from our results even after controlling for workplace, occupational and matching effects, there is a non-negligible unexplained variation in wages (37% – see Table 1). As such, we progress our analysis further by investigating the effects on wage determination of workers' individual characteristics, such as age, gender and type of contract (permanent or fixed-term).

Specifically, we take the "net" wage, after the impacts of workplace and occupation characteristics as well as the interactions of the two have been conditioned out, and examine the relative importance of various employee characteristics such age, gender and job characteristics, namely contract type (whether the job is of definite or indefinite length). Thus, we let ε_{xijt} from equation (4) be equal to $Wnet_{xt}$ and estimate the following equation:[15]

$$Wnet_{xt} = a + \beta_x' \, personal\ characteristics_{xt} + \varepsilon_{xt} \quad (5)$$

$Wnet_{xt}$: wage net of workplace, occupational and matching effects;

$personal\ characteristics_{xt}$: referring to controls for age (age categories: 15-24, 25-34, 35-44, 45-54, 55-64, 65+), gender (male, female) and contract type (fixed-term or open-ended).

Thus, equation (5) captures the effect of personal characteristics on wages.

In the first column of Table 2 (equation 5) we can note that including age alone accounts for an additional 20% of the variation in wages compared with equation (4).[16]

The wage increase due to age is somewhat moderate for the age group 25-34 compared with our reference category, which is the age group 15-24, and stands at about 14%. However, the age premium increases rapidly thereafter, up to 48% for the age categories 55-64 and above. This result may point in two directions. On the one hand, the return on employees' labour market experience or firm-specific human capital is very large. On the other hand, we see that there is clear positive wage discrimination due to age (or a negative discrimination towards younger workers). This may also partly reflect the institutionalised wage discrimination against younger employees, such as the introduction of sub-minimum

14 This result is also in line with the findings of Haltiwanger et al. (2007), who show that new firms (which tend to be smaller) exhibit greater earnings heterogeneity.

15 "Conditioning out" the impact of certain worker and firm characteristics and focusing on the impact of other factors of interest on the net or "clean" wage is something customarily done in the literature (see for example Christopoulou et al. (2010) and references therein).

16 It should be noted that this regression refers to the net wage, i.e. the one from which we have already conditioned out the effects stemming from occupation, establishment and occupation-establishment matching effects. Thus, 20% is the proportion of variation explained in addition to what has already been explained by equation (4).

Table 2 Impact of personal and job characteristics - OLS results

(dependent variable: log wage; net of workplace; occupational and matching effects)

	Equation (5): Age only	Equation (5): Contract type only	Equation (5): Gender only	Equation (5): All personal characteristics
Age 25-34	0.131*** (0.00127)			0.127*** (0.00124)
Age 35-44	0.271*** (0.00124)			0.261*** (0.00122)
Age 45-54	0.351*** (0.00127)			0.336*** (0.00124)
Age 55-64	0.389*** (0.00136)			0.370*** (0.00133)
Age 65+	0.390*** (0.00230)			0.368*** (0.00226)
Fixed-term contract		-0.138*** (0.000794)		-0.106*** (0.000718)
Female			-0.0477*** (0.000719)	-0.0333*** (0.000633)
Observations	575,476	575,476	575,476	575,476
R-squared	0.201	0.050	0.008	0.235

Source: ERGANI and authors' estimations.
Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

wages for younger workers in the period 2016-2018,[17] but also the fact that in several sectors/occupations, wages and promotions are tenure-related (instead of skill-related). For example, it is very difficult for a better-skilled younger person to become promoted and thereby receive a higher wage (say to obtain a lower/middle managerial position such as a head of section), as the position itself may be tenure-related and not available to anybody who does not have at least 15 years of related work experience.

In the second and third columns we see that a fixed-term contract is associated with a lower average wage of about 14%, while being female is associated with a lower average wage of about 5%.[18] Both these personal characteristics add explanatory power to our wage equations, albeit to a significantly lower degree than age. Finally, in the last column of Table 2 we add all personal characteristics at the same time and see that they retain their magnitude in terms of point estimates, but also that their total additional explanatory power for wages is about 23.5%. Thus, occupation, workplace, matching and personal characteristics are able to explain a total of 86.5% of the overall wage variation in our data.

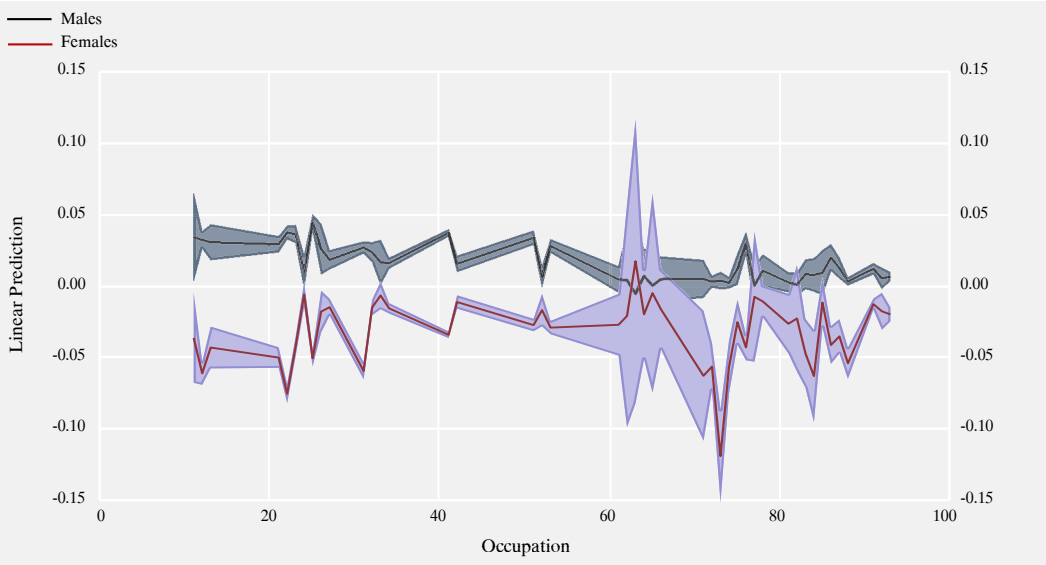
Delving further into wage discrimination emanating from gender and from working on fixed-term contracts, we interact these two variables with our occupational and age dummies. This will allow us to estimate our gender and contract wage gaps for each occupation and age category and obtain the respective marginal effects of each interaction. Specifically, we investigate how the main effects of gender and contract (-5% and -14%, respectively) obtained in Table 2 are distributed across occupations and age categories. Thus, we estimate and obtain the marginal effects of our variables of interest from the following regressions:

17 For example, younger workers would in principle not be eligible to any tenure-related benefits, as these were abolished in the early years of the economic adjustment programme and were retained only for older cohorts.

18 Negative effects on wages stemming from fixed-term contracts have long been documented in the literature, see e.g. Jimeno and Toharia (1993). The evidence on the gender pay gap is also extensive (see e.g. Papapetrou 2004; Albrecht et al. 2003; Blau and Kahn 1996).

Chart 1 Gender wage gap by occupation, marginal effects

(predicted gender effects by occupation with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

$$Wnet_{xt} = a + \theta' personal\ characteristics_{xt} + \mu'_{jx}(occup_j * personal\ characteristics_{xt}) + \varepsilon_{xt} \quad (6a)$$

and

$$Wnet_{xt} = a + \theta' personal\ characteristics_{xt} + \mu'_{kx}(age_k * personal\ characteristics_{xt}) + \varepsilon_{xt} \quad (6b)$$

The results are presented in Charts 1-4 and are in terms of marginal effects for our interaction variables.

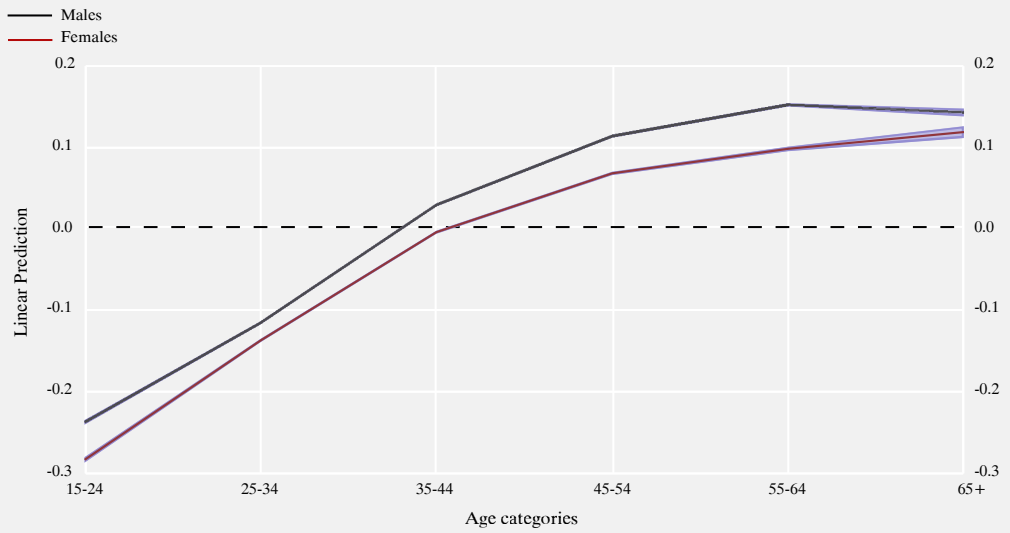
The gender wage gap, i.e. the difference between the estimated male and female effects, by occupation is shown in Chart 1. The wage gap can be understood as the difference between the black line – which is the estimated wage effect of being male in each occupation – and the red line – which is the estimated wage effect of being female in each occupation. Thus, if the estimate for males in one occupation is 0.035 and for females -0.04, it implies that the wage gap is about 7.5%. The results indicate that the wage gap between males and females tends to be larger, on average, for occupations in the range 11 to 34 rather than for occupations 41 to 93 (see Appendix A, Table A5), or rather the gender wage gap tends to be larger for high-skilled occupations and smaller for low-skilled occupations. These results are broadly in line with the so-called "glass ceiling" hypothesis. "Glass ceiling" refers to fact that women do quite well in the labour market up to a point beyond which there is an effective limit on their labour market prospects (Albrecht et al. 2003).[19]

In a similar fashion, Chart 2 shows that the gender wage gap tends to be smaller for younger individuals and increase for prime age individuals. In particular, the wage gap tends to widen from the age of 35 up to 64 and becomes narrower again after that. This may be connected with the child rearing age for females, when females tend to opt for career profiles

19 Albrecht et al. (2003) provide evidence of a "glass ceiling" in Sweden on the basis of quantile regressions. In particular, they find that the gender wage gap in Sweden increases throughout the wage distribution and accelerates in the upper tail. Since the wages of higher-skilled workers are expected to be at the upper tail of the wage distribution, our results can be considered as being broadly in line with the results of this literature.

Chart 2 Gender wage gap by age category, marginal effects

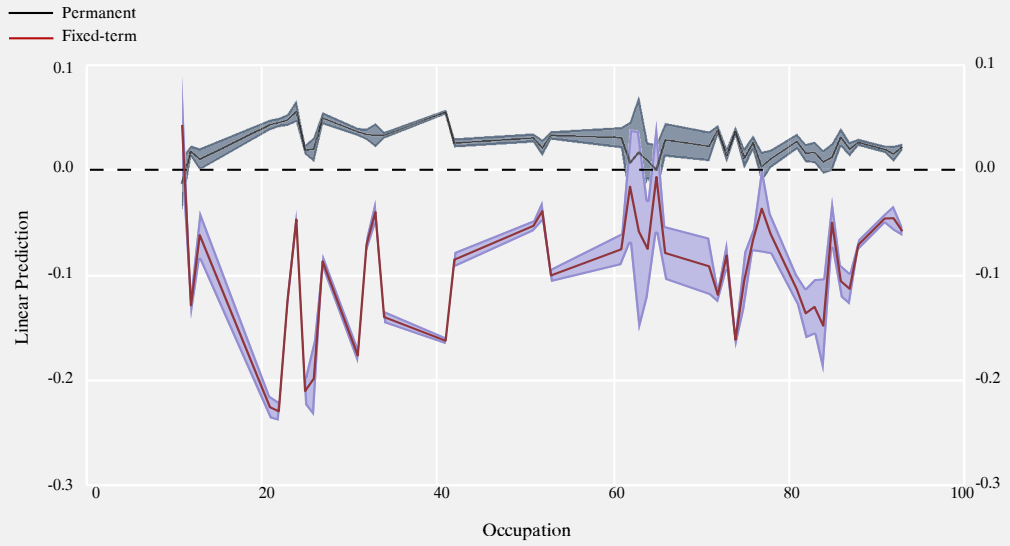
(predicted gender effects by age category with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

Chart 3 Contract wage gap by occupation, marginal effects

(predicted contract effects by occupation with 95% CIs)

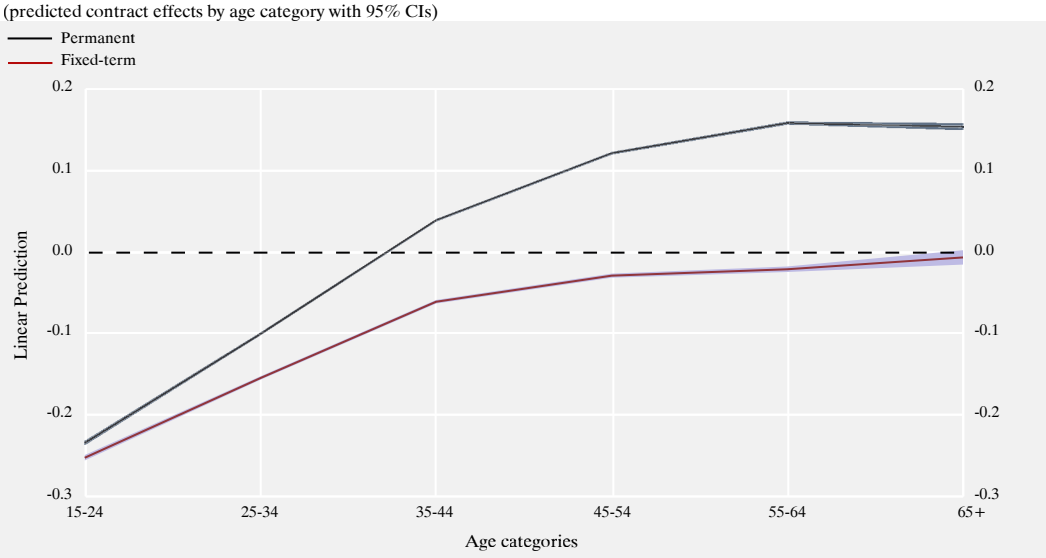


Note: The chart is based on post-estimation of marginal effects for our interaction variables.

that are more compatible with their responsibilities as the main providers of child care. Hospido et al. (2019), using personnel data for the European Central Bank (ECB) during the period 2003-2017, find that a wage gap between males and females in the ECB emerges a few years after their hiring despite their similar entry salaries and characteristics. One important driver of this result is the presence of children. They also find that the presence of children also influences the probability of applying for a promotion in the case of women. There-

Chart 4 Contract wage gap by age category, marginal effects

(predicted contract effects by age category with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

fore, all these career choices are likely to affect the career-salary profiles of women.

Turning to the wage gap due to contract type, we perform a similar exercise. In Chart 3 we see that working under a fixed-term contract implies a negative wage effect across almost all occupations. Similarly to the gender occupational effects, the effects of being on a fixed-term contract are, on average, stronger for high-skilled occupations and weaker for low-skilled occupations.[20]

Finally, in Chart 4 we see that the negative effects of being on a fixed-term contract increase with age. This is a plausible result, as tenure-related premia such as promotions are less likely to occur for employees on fixed-term contracts. In addition, wage floors (such as minimum wages) may be more binding for younger workers, thus compressing the negative wage effects of being on a fixed-term contract.[21]

5 CONCLUSIONS

By using a micro-aggregated dataset on full-time private sector employees, we analyse the importance of employer, employee and job characteristics in determining wages. Overall, we are able to explain about 86.5% of the observed wage variation in our data. Our results show that both employer and employee characteristics are important in determining wages. Furthermore, a good matching between employers and employees is also necessary for obtaining a higher wage.

While our results imply that one way for a worker to increase her wage is to change employer, they also imply that there is room for active policies to play an important role in increasing wages.

On the one hand, development policies can be important. Specifically, policies that allow firms to grow (such as lowering the administrative costs) will increase wages as —in general— large firms pay better than small ones. Also, policies that promote the development of

20 The results are in line with Paul et al. (2014) and Da Silva and Turrini (2015), who find that a considerable negative wage effect exists for the high-skilled. As such, their findings suggest that apart from a negative wage gap, there are also lower incentives to accumulate skills.

21 The findings of gender and contract wage gap by occupation and age category tend to be stronger in a population-weighted regression setting, see Appendix B, Charts B1-B4.

high value added sectors will have an impact on wages.[22] On the other hand, active labour market policies may also play an important role for increasing wages. Specifically, life-long learning, which enhances workers' mobility across occupations or allows them to obtain new skills in order to be promoted, will also have a significant impact on their wages.

Moreover, our results suggest that there is considerable negative wage discrimination towards younger people. In particular, to the extent that promotions (which will allow for occupational status changes) are tenure-related, they negatively affect the wages of younger people (up to the age of 44). As such, the phasing out of such policies and their replacement with skill-related promotions may have a strong impact on wages for younger people and also on the incentive to acquire skills.

There seems to be significant female wage discrimination, even after occupational differences are accounted for. This discrimination also seems to be larger for females in high-skilled occupations and prime age women. Thus, policies that will actively promote higher female wages, such as active mentoring for promotions or female quotas in leading positions, as well as policies that will allow a better family career balance of female employees, such as increased state funded pre- and primary school child care, increased flexibility in terms of working hours and/or teleworking possibilities, seem to have an important role to play in wage developments.[23]

Finally, there also seems to be wage discrimination in terms of contract type. Employees on fixed-term contracts seem to earn significantly less than ones in permanent positions. Moreover, this negative effect seems to be larger for high-skilled occupations and increasing with age. To the extent that this reflects initial screening costs of an individual in order to fill a permanent position, it is understandable. However, if fixed-term contracts are not used primarily in this manner, it will create lower incentives to accumulate skills and affect the productivity of the workforce. This aspect of the Greek labour market needs further research based on individual microdata, where individuals can be followed over time, in order to evaluate the probabilities of fixed-term contracts being converted into permanent positions.

22 See for example Bank of Greece (2020).
23 Hospido et al. (2019) show that decisive measures to reduce gender discrimination can be very effective in this regard.

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APPENDIX A

DATA DESCRIPTION

Table A1 Age categories

<15
15-24
25-34
35-44
45-54
55-64
65+

Table A2 Firm size categories

(number of employees)
0-10
11-50
51-250
251-500
501-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
3501-4000
> 4000

Table A3 NUTS 2 regions

01	Eastern Macedonia and Thrace
02	Central Macedonia
03	Western Macedonia
04	Epirus
05	Thessaly
06	Ionian islands
07	Western Greece
08	Central Greece
09	Attica
10	Peloponnese
11	North Aegean
12	South Aegean
13	Crete

Table A4 Two-digit NACE Rev. 2 sectors of activity

01	Crop and animal production, hunting and related service activities
02	Forestry and logging
03	Fishing and aquaculture
05	Mining of coal and lignite
06	Extraction of crude petroleum and natural gas
07	Mining of metal ores
08	Other mining and quarrying
09	Mining support service activities
10	Manuf. of food products
11	Manuf. of beverages
12	Manuf. of tobacco products
13	Manuf. of textiles
14	Manuf. of wearing apparel
15	Manuf. of leather and related products
16	Manuf. of wood and of products of wood and cork, ex. furniture; Manuf. of articles of straw and plaiting materials
17	Manuf. of paper and paper products
18	Printing and reproduction of recorded media
19	Manuf. of coke and refined petroleum products
20	Manuf. of chemicals and chemical products
21	Manuf. of basic pharmaceutical products and pharmaceutical preparations
22	Manuf. of rubber and plastic products
23	Manuf. of other non-metallic mineral products
24	Manuf. of basic metals
25	Manuf. of fabricated metal products, except machinery and equipment
26	Manuf. of computer, electronic and optical products
27	Manuf. of electrical equipment
28	Manuf. of machinery and equipment n.e.c.
29	Manuf. of motor vehicles, trailers and semi-trailers
30	Manuf. of other transport equipment
31	Manuf. of furniture
32	Other manufacturing
33	Repair and installation of machinery and equipment
35	Electricity, gas, steam and air conditioning supply
36	Water collection, treatment and supply
37	Sewerage
38	Waste collection, treatment and disposal activities; materials recovery
39	Remediation activities and other waste management services
41	Construction of buildings
42	Civil engineering
43	Specialised construction activities
45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	Wholesale trade, except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles
49	Land transport and transport via pipelines
50	Water transport
51	Air transport
52	Warehousing and support activities for transportation
53	Postal and courier activities
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video and television programme production, sound recording and music publishing activities
60	Programming and broadcasting activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance and pension funding, except compulsory social security
66	Activities auxiliary to financial services and insurance activities
68	Real estate activities
69	Legal and accounting activities
70	Activities of head offices; management consultancy activities
71	Architectural and engineering activities; technical testing and analysis
72	Scientific research and development
73	Advertising and market research
74	Other professional, scientific and technical activities
75	Veterinary activities
77	Rental and leasing activities
78	Employment activities
79	Travel agency, tour operator and other reservation service and related activities
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
84	Public administration and defence; compulsory social security
85	Education
86	Human health activities
87	Residential care activities
88	Social work activities without accommodation
90	Creative, arts and entertainment activities
91	Libraries, archives, museums and other cultural activities
92	Gambling and betting activities
93	Sports activities and amusement and recreation activities
94	Activities of membership organisations
95	Repair of computers and personal and household goods
96	Other personal service activities
97	Activities of households as employers of domestic personnel
98	Undifferentiated goods- and services-producing activities of private households for own use
99	Activities of extraterritorial organisations and bodies

Table A5 Two-digit (or lower) ISCO-88 occupations

11 (11)	Legislators and senior officials
12 (12)	Corporate managers
13 (13)	Managers of small enterprises
21X (21)	Physicists, mathematicians and related professions
21X (22)	Architects, engineers and related professionals
22 (23)	Life science and health professionals
23 (24)	Teaching professionals
24X (25)	Business professionals
24X (26)	Legal professionals
24X (27)	Other scientific, art and related professionals
31 (31)	Physical and engineering science associate professionals
32 (32)	Life science and health associate professionals
33 (33)	Teaching associate professionals
34 (34)	Other associate professionals
41 (41)	Office clerks
42 (42)	Customer services clerks
51X (51)	Personal services workers
51X (52)	Protective services workers
52 (53)	Models, salespersons and demonstrators
61X (61)	Field crop and vegetable growers
61X (62)	Tree and shrub crop growers
61X (63)	Mixed-crop growers
61X (64)	Market-oriented animal producers and related workers
61X (65)	Forestry and related workers
61X (66)	Fishery workers
61X (67)	Hunters and trappers
71X (71)	Extraction workers
71X (72)	Building trades workers
72X (73)	Metal workers
72X (74)	Machinery workers
73 (75)	Precision, handicraft, craft printing and related trades workers
74X (76)	Food processing and related trades workers
74X (77)	Wood treaters, cabinet-makers and related trades workers
74X (78)	Textile, garment and related trades workers
81 (81)	Stationary plant and related operators
82X (82)	Metal- and mineral-products machine operators
82X (83)	Chemical-, rubber- and plastic-products machine operators
82X (84)	Wood- and paper-products machine operators
82X (85)	Textile-, fur- and leather-products machine operators
82X (86)	Food and related products machine operators
82X (87)	Assemblers, other machine operators n.e.c.
83 (88)	Drivers and mobile plant operators
91 (91)	Sales and services elementary occupations
92 (92)	Agricultural, fishery and related labourers
93 (93)	Labourers in mining, construction, manufacturing and transport

Notes: Codes in the parentheses give the original classification codes that are based on ELSTAT's "ΣΤΕΠ-92" classification system. Correspondence to ISCO-88 by ELSTAT.

Table A6 Average occupational wages (logarithms)

Occupation – Two-digit (or lower) ISCO-88	
Legislators and senior officials	7.7
Corporate managers	7.6
Managers of small enterprises	7
Physicists, mathematicians and related professions	7.3
Architects, engineers and related professionals	7.5
Life science and health professionals	7.2
Teaching professionals	7
Business professionals	7.5
Legal professionals	7.7
Other scientific, art and related professionals	7.1
Physical and engineering science associate professionals	7.1
Life science and health associate professionals	6.9
Teaching associate professionals	6.9
Other associate professionals	7
Office clerks	6.9
Customer services clerks	6.8
Personal services workers	6.8
Protective services workers	6.7
Models, salespersons and demonstrators	6.7
Field crop and vegetable growers	6.8
Tree and shrub crop growers	6.7
Mixed-crop growers	6.8
Market-oriented animal producers and related workers	6.8
Forestry and related workers	6.7
Fishery workers	6.7
Extraction workers	7
Building trades workers	7
Metal workers	7
Machinery workers	7
Precision, handicraft, craft printing and related trades workers	6.9
Food processing and related trades workers	6.7
Wood treaters, cabinet-makers and related trades workers	6.8
Textile, garment and related trades workers	6.8
Stationary plant and related operators	7
Metal- and mineral-products machine operators	7
Chemical-, rubber- and plastic-products machine operators	6.9
Wood- and paper-products machine operators	6.9
Textile-, fur- and leather-products machine operators	6.8
Food and related products machine operators	6.8
Assemblers, other machine operators n.e.c.	6.9
Drivers and mobile plant operators	6.9
Sales and services elementary occupations	6.8
Agricultural, fishery and related labourers	6.7
Labourers in mining, construction, manufacturing and transport	6.7
Average	**7.0**
Standard deviation	**0.27**

Source: ERGANI and authors' calculations.

APPENDIX B

ADDITIONAL REGRESSION RESULTS

Table B1 Wage variance decomposition - Sectoral analysis

	Agricult-ure etc.	Mining etc.	Manu-facturing	Electricity	Water supply	Contruct-ion	Wholesale and retail trade	Trans-portation and storage	Accomo-dation and food services	Inform-ation and communic ations
R^2_{work}	0.195	0.278	0.303	0.219	0.314	0.252	0.242	0.330	0.264	0.352
R^2_{occ}	0.347	0.308	0.291	0.275	0.397	0.231	0.243	0.307	0.315	0.227
R^2_{main}	0.467	0.477	0.490	0.423	0.578	0.414	0.436	0.507	0.490	0.497
R^2_{cell}	0.638	0.639	0.624	0.556	0.686	0.569	0.577	0.640	0.587	0.608
Marginal contribution of characterisitics										
Occupation	**0.272**	0.199	0.187	0.204	**0.264**	0.162	0.194	0.177	**0.226**	0.145
Workplace	0.12	0.169	0.199	0.148	0.181	0.183	0.193	0.200	0.175	**0.27**
Joint contribution	0.075	0.109	0.104	0.071	**0.133**	0.069	0.049	**0.130**	0.089	0.082
Job cell	**0.171**	**0.162**	0.134	0.133	0.108	**0.155**	0.141	0.133	0.097	0.111
Unexplained	0.362	0.361	0.376	0.444	0.314	0.432	0.423	0.360	0.413	0.392
Observations	14,209	5,056	141,125	9,177	13,060	28,609	76,899	30,566	37,715	22,006

	Financial and insurance services	Real estate activities	Professional, scientific and technical activities	Administr-ative and support services	Public administr-ation, defence, etc.	Education	Human health and social work activities	Arts, entertain-ment and recreation	Other service activities
R^2_{work}	0.408	0.224	0.315	0.243	0.133	0.255	0.184	0.390	0.419
R^2_{occ}	0.265	0.335	0.264	0.325	0.281	0.177	0.236	0.216	0.302
R^2_{main}	0.557	0.482	0.490	0.447	0.385	0.400	0.391	0.505	0.550
R^2_{cell}	0.686	0.608	0.617	0.600	0.517	0.527	0.525	0.650	0.687
Marginal contribution of characterisitics									
Occupation	0.149	**0.258**	0.175	0.204	**0.252**	0.145	0.207	0.115	0.131
Workplace	**0.292**	0.147	**0.226**	0.122	0.104	0.223	0.155	**0.289**	**0.248**
Joint contribution	**0.116**	0.077	0.089	**0.121**	0.029	0.032	0.029	0.101	**0.171**
Job cell	0.129	0.126	0.127	**0.153**	0.132	0.127	0.134	**0.145**	0.137
Unexplained	0.314	0.392	0.383	0.400	0.483	0.473	0.475	0.350	0.313
Observations	11,496	5,099	34,785	31,191	23,875	15,123	38,683	16,983	19,838

Source: ERGANI and authors' estimations.
Notes: The table reports wage variance decomposition for major sectors of activity. The cells in bold font mark by characteristic the five highest marginal contributions across sectors. Results are based on estimating equations (1)-(4) by broad NACE sector.

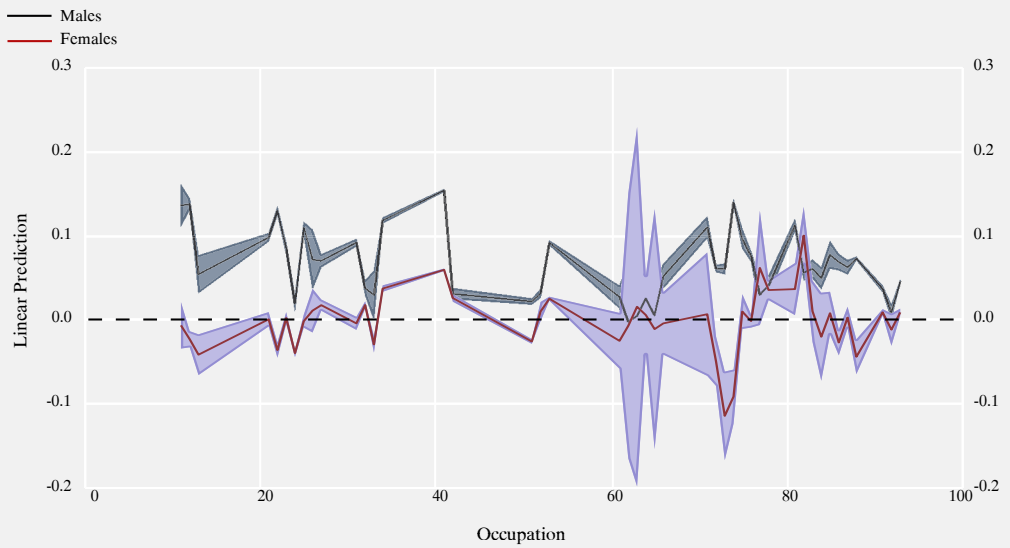
Table B2 Wage variance decomposition - Analysis by firm size

	1-10	11-50	51-250	251-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	>4000
R^2_{work}	0.190	0.203	0.203	0.248	0.253	0.290	0.362	0.541	0.265	0.233	0.082	0.205
R^2_{occ}	0.179	0.263	0.317	0.320	0.303	0.362	0.279	0.292	0.308	0.346	0.562	0.281
R^2_{main}	0.318	0.399	0.449	0.475	0.462	0.516	0.514	0.626	0.454	0.450	0.579	0.404
R^2_{cell}	0.511	0.556	0.567	0.601	0.610	0.652	0.647	0.744	0.588	0.614	0.645	0.504
Marginal contribution of characterisitics												
Occupation	0.128	0.196	**0.246**	**0.227**	0.209	**0.226**	0.152	0.085	0.189	**0.217**	**0.497**	0.199
Workplace	0.139	0.136	0.132	**0.155**	**0.159**	**0.154**	**0.235**	**0.334**	0.146	0.104	0.017	0.123
Joint contribution	0.051	0.067	0.071	0.093	0.094	**0.136**	**0.127**	**0.207**	**0.119**	**0.129**	0.065	0.082
Job cell	**0.193**	**0.157**	0.118	0.126	**0.148**	**0.136**	0.133	0.118	0.134	**0.164**	0.066	0.100
Unexplained	**0.489**	**0.444**	**0.433**	0.399	0.390	0.348	0.353	0.256	**0.412**	0.386	0.355	**0.496**
Observations	151,990	155,690	128,971	50,758	38,300	18,326	7,823	5,995	3,743	1,344	1,447	11,108

Source: ERGANI and authors' estimations.
Notes: The cells in bold font mark by characteristic the five highest marginal contributions across firm size category. Results are based on estimating equations (1)-(4) by firm size category.

Chart B1 Gender wage gap by occupation, population-weighted, marginal effects

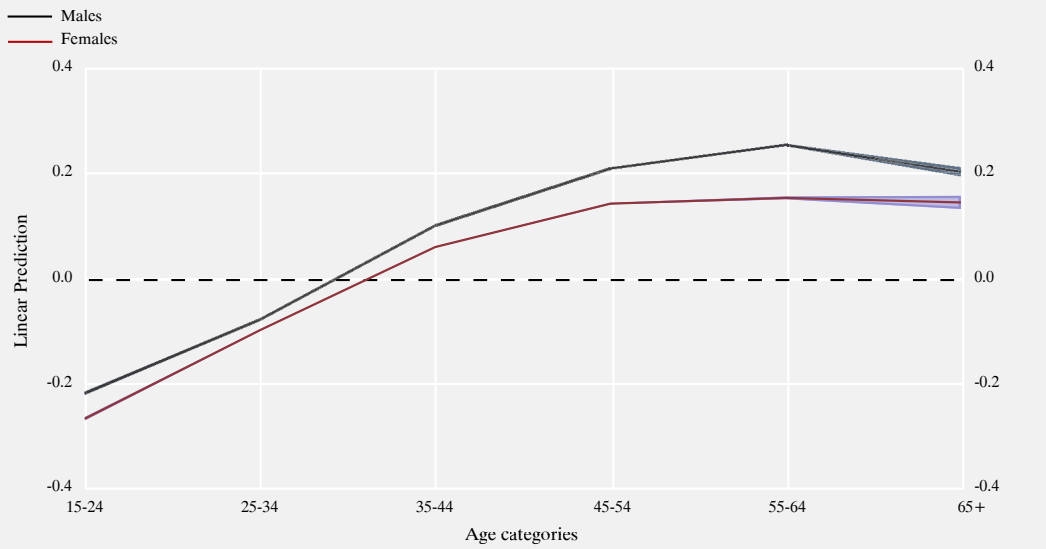
(predicted gender effects by occupation, population-weighted, with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

Chart B2 Gender wage gap by age category, population-weighted, marginal effects

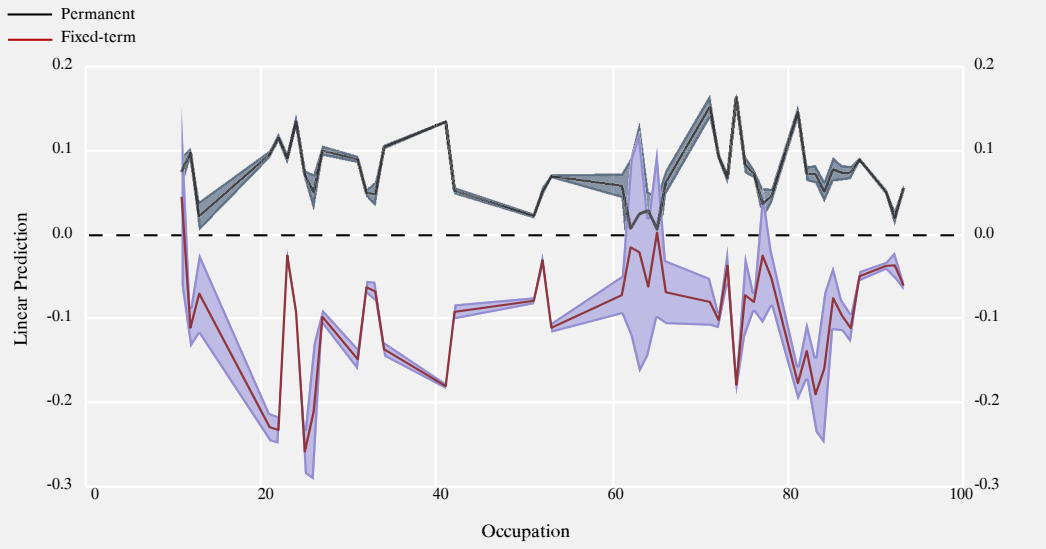
(predicted gender effects by age category, population-weighted, with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

Chart B3 Contract wage gap by occupation, population-weighted, marginal effects

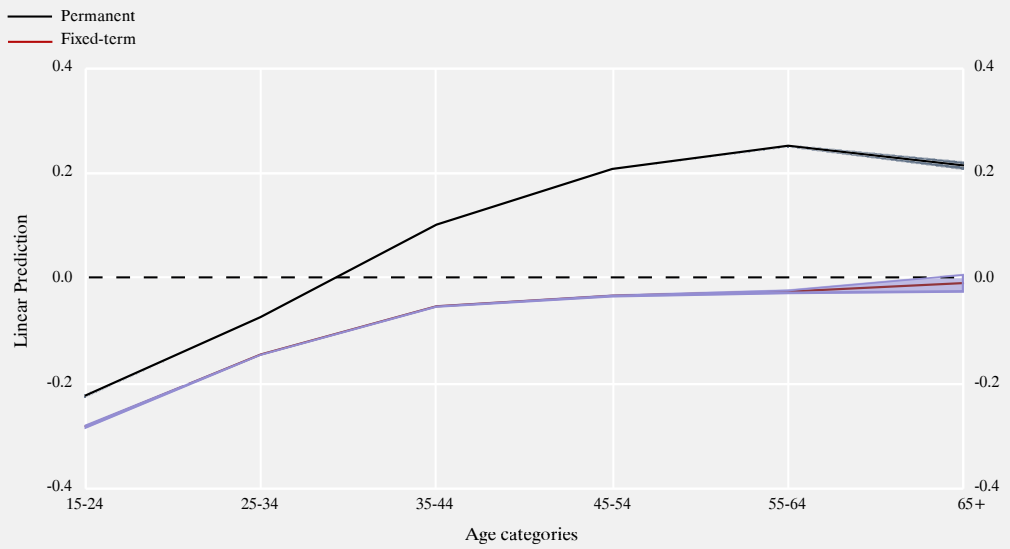
(predicted contract effects by occupation, population-weighted, with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

Chart B4 Contract wage gap by age category, population-weighted, marginal effects

(predicted contract effects by age category, population-weighted, with 95% CIs)



Note: The chart is based on post-estimation of marginal effects for our interaction variables.

DOES EARNINGS QUALITY MATTER? EVIDENCE FROM THE ATHENS EXCHANGE

Ioannis Asimakopoulos
Bank of Greece, Economic Analysis and Research Department

Athanasios P. Fassas
University of Thessaly, Department of Accounting and Finance

Dimitris Malliaropulos
Bank of Greece, Economic Analysis and Research Department,
and University of Piraeus, Department of Banking and Financial Management

ABSTRACT

The relation between accounting earnings and firm valuation has long been a topic of interest to academics and stock market participants. The study analyses the relationship between earnings quality and firm value using a sample of non-financial firms with shares listed on the Athens Exchange over the period 2004-2019. The empirical findings indicate that investors value earnings quality, and this is reflected in a better valuation for firms having earnings of higher quality. The results are robust to different methodologies and controls for firm-specific factors. The evidence is of particular importance for Greek firms seeking to expand their sources of financing beyond the Greek banking system. Such a development requires constant monitoring and strengthening of the corporate governance framework, with the aim of improving the quality of information conveyed by the firms to investors. In this respect, the provisions of Law 4706/2020 regarding the Greek corporate governance framework and the operation of the Hellenic Capital Market Commission seem to be in the right direction.

Keywords: earnings quality; firm value; Tobin's Q

JEL classification: G15; G32; M41; C33

ΕΙΝΑΙ ΣΗΜΑΝΤΙΚΗ Η ΠΟΙΟΤΗΤΑ ΤΩΝ ΕΤΑΙΡΙΚΩΝ ΚΕΡΔΩΝ; ΕΥΡΗΜΑΤΑ ΑΠΟ ΤΟ ΧΡΗΜΑΤΙΣΤΗΡΙΟ ΑΘΗΝΩΝ

Ιωάννης Ασημακόπουλος
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών

Αθανάσιος Π. Φάσσας
Πανεπιστήμιο Θεσσαλίας, Τμήμα Λογιστικής και Χρηματοοικονομικής

Δημήτρης Μαλλιαρόπουλος
Τράπεζα της Ελλάδος, Διεύθυνση Οικονομικής Ανάλυσης και Μελετών,
και Πανεπιστήμιο Πειραιώς, Τμήμα Χρηματοοικονομικής και Τραπεζικής Διοικητικής

ΠΕΡΙΛΗΨΗ

Η σχέση λογιστικών κερδών και αποτίμησης των επιχειρήσεων αποτελεί για χρόνια θέμα ενδιαφέροντος τόσο για τους ακαδημαϊκούς όσο και για τους επενδυτές. Η μελέτη αναλύει τη σχέση της ποιότητας των κερδών και της αξίας των επιχειρήσεων με βάση ένα δείγμα από επιχειρήσεις του μη χρηματοπιστωτικού τομέα με μετοχές εισηγμένες στο Χρηματιστήριο Αθηνών κατά την περίοδο 2004-2019. Τα εμπειρικά ευρήματα δείχνουν ότι οι επενδυτές αξιολογούν θετικά την ποιότητα των κερδών και αυτό αντανακλάται σε καλύτερη αποτίμηση για τις επιχειρήσεις των οποίων τα κέρδη αξιολογούνται ως υψηλότερης ποιότητας. Τα αποτελέσματα της μελέτης εξακολουθούν να ισχύουν και μετά την εφαρμογή εναλλακτικών μεθοδολογιών αλλά και μετά το συνυπολογισμό συγκεκριμένων χαρακτηριστικών των επιχειρήσεων. Τα ευρήματα έχουν ιδιαίτερη σημασία για τις ελληνικές επιχειρήσεις που επιδιώκουν να επεκτείνουν τις πηγές χρηματοδότησής τους πέρα από τον τραπεζικό δανεισμό. Για να γίνει αυτό εφικτό, απαιτείται συνεχής παρακολούθηση και ενίσχυση του πλαισίου εταιρικής διακυβέρνησης ώστε να βελτιωθεί η ποιότητα των πληροφοριών που δημοσιοποιούν οι επιχειρήσεις στο επενδυτικό κοινό. Από αυτή την άποψη, οι διατάξεις του ν. 4706/2020 σχετικά με το πλαίσιο εταιρικής διακυβέρνησης στην Ελλάδα και τη λειτουργία της Επιτροπής Κεφαλαιαγοράς φαίνεται να είναι προς τη σωστή κατεύθυνση.

DOES EARNINGS QUALITY MATTER? EVIDENCE FROM THE ATHENS EXCHANGE[1]

Ioannis Asimakopoulos
Bank of Greece, Economic Analysis and Research Department

Athanasios P. Fassas
University of Thessaly, Department of Accounting and Finance

Dimitris Malliaropulos
Bank of Greece, Economic Analysis and Research Department, and University of Piraeus, Department of Banking and Financial Management

1 INTRODUCTION

The quality of financial information is of great importance for both firms and investors. For example, firms can influence their cost of capital by affecting the precision and quantity of information available to investors through adopted accounting standards and corporate disclosure policies. More importantly, on the basis of both theoretical and empirical work (e.g. Easley and O'Hara 2004; Leuz and Verrecchia 2004; Francis et al. 2005), information risk (defined as the uncertainty of the quality of information used or desired by investors to price securities) is a non-diversifiable risk factor for which investors require a higher risk premium. The quality of information is also important for the economy as a whole, given that, often in the past, accounting fraud cases had shaken investors' confidence and, through spillover effects, had negative repercussions on stock markets and on the economies.

Focusing on the bottom line of a company's financial information, i.e. reported earnings, investors are aware that the numbers are affected by deliberate choices between various accounting treatments and business options. There is extensive evidence (anecdotal and empirical) that firms manage reported earnings to avoid earnings decreases or losses (e.g. Burgstahler and Dichev 1997; Dechow and Schrand 2004; Campa 2019), or sacrifice long-term economic value to hit a target or to smooth short-term earnings (e.g. Graham et al. 2005). In the accounting jargon, terms like "big bath" charges or "cookie jar" reserves are often met and they occur for a number of reasons such as to influence stock market perceptions, to increase management's compensation or to avoid regulatory interventions. For instance, in a survey of CFOs conducted by Dichev et al. (2013), the respondents estimated that about 20% of firms manage earnings to misrepresent economic performance, with 93.5% of the answers attributing this misrepresentation to the desire to influence stock price. Also interesting is the finding that 60.1% of executives feel that managers manage earnings because they believe such misrepresentation will go undetected. Therefore, in order to assess the earnings power, analysts must make some determination of the quality of earnings.[2]

Although reported earnings have been the holy grail of firms' performance for centuries, and the importance of their quality is acknowledged in the literature as early as the mid-1930s (Graham and Dodd 1934), the empirical emphasis on the importance of their quality came much later. For example, Lev (1989) stated that "no serious attempt is being made to question the quality of the reported earnings numbers prior to correlating them with returns". Following this, researchers started paying more attention to the importance of "quality" using various measures as proxies of "earnings quality". Following Lev's

1 We would like to thank Seraina Anagnostopoulou, Hiona Balfoussia and Heather Gibson for useful comments on earlier drafts. 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.

2 Although it is generally agreed in the literature that accounting quality is a concept much broader than earnings management and therefore the notion of earnings quality does not completely coincide with that of earnings management, herein we refer to the concepts of earnings management and earnings quality interchangeably, under the assumption that managed earnings cannot be considered as financial information of high quality.

study, extensive research is performed with the studies of Jones (1991), Dechow and Dichev (2002), Dechow et al. (1996), Ohlson (1995), Sloan (1996), Basu (1997), Raonic et al. (2004), Francis et al. (2004), Kothari et al. (2005) to name a few, focusing on the role of accruals, earnings persistence, earnings smoothness, timeliness, investor responsiveness, etc. as proxies of earnings quality.

Despite this extensive research, there is no consensus among both practitioners and academics on how to define and measure earnings quality. There is an agreement, however, that the term "earnings quality" is contextual, meaning different things to different users,[3] and that earnings do not perfectly measure performance. For example, Dechow at el. (2010), in reviewing the voluminous literature on the quality of earnings, starting with the assumption that reported earnings are a function of a company's financial performance during a reporting period, note that an accounting system that measures an unobservable construct (performance) inherently involves estimations and judgment. Thus, it has the potential for unintentional errors and intentional bias (i.e. earnings management). Also, since companies choose among a set of pre-determined accounting standards to measure performance, no single standard will perfectly measure performance for any given company.[4]

Taking stock of the literature, the majority of the relevant studies utilises data from a few large economies, predominantly the US, and therefore there is scarce evidence for smaller economies (Balios, Sdrolias and Thanos 2020), while most studies examine the economic consequences of one attribute of earnings in isolation (Gaio and Raposo 2011). More importantly, not only the literature calls for more in-depth single country studies, but also Greece offers an interesting setting because of its distinctive financial reporting regime, culture and socio-economic context, weak enforcement of accounting regulation, and evidence of creative accounting (see for example Tsalavoutas et al. 2012; Ferentinou and Anagnostopoulou 2016).

Based on the above, and motivated by some recent cases of accounting irregularities involving firms listed on the Athens Exchange and by the explicit reference on the importance of earnings quality in the recent "Growth Plan of the Greek Economy" (prepared by a High Level Working Group chaired by Professor Pissarides), the present study attempts to shed light on the importance of accuracy and reliability of corporate disclosures, focusing on the importance of earnings quality. In particular, using data from non-financial firms with shares listed on the Athens Exchange (Athex) for the period 2004-2019, we analyse the relationship between earnings quality (EQ), as measured by the (composite) StarMine earnings quality index, and firm value, proxied by Tobin's Q. We find that firms with earnings of higher quality are compensated with higher valuations. The results are robust to different model specifications and controls for firm-specific factors. The evidence is of particular importance as the increasing financing needs of Greek firms, following nearly a decade of subdued investment due to the Greek crisis, call for the development of more market-based solutions that would complement the banking system. Such a development would require, among other policy measures, increased efforts by the firms, the auditors, the State and the relevant supervisory authorities to improve the quality of information conveyed to investors.

The rest of the paper is organised as follows: the next section briefly reviews the relevant literature, putting emphasis on evidence from

3 For example, Dechow and Schrand (2004) comment that the press refers to an earnings quality problem when earnings contain unusual items even if the disclosures are in accordance with the accounting principles, a perception not accepted by regulators and auditors that see earnings of high quality when they conform to the spirit of the rules. For creditors, the quality of earnings is related to how easily these can be converted to cash flows, while compensation committees usually see earnings of high quality when they reflect managers' performance and are not influenced by events beyond management control.

4 As an example, Dechow et al. (2010) use the concept of cost of goods sold (COGS), which represents the reportable measure of a firm's unobservable inventory production performance during a given period. Although accounting standards define the costs to be included in COGS and the timing of the recognition of the costs, the resulting "standardised" measure of COGS will not be an equally good measure of decision-relevant performance across all companies (e.g. retail chains versus oil producing companies), and it will not be a perfect representation of performance.

Greece. Section 3 presents the proxies used to measure earnings quality and firm value, while Section 4 discusses the data and methodology employed in this analysis. Section 5 presents the relevant empirical results and, finally, Section 6 concludes.

2 LITERATURE REVIEW

The relation between accounting earnings and stock prices has long been a topic of interest to academics and stock market participants. Starting with the seminal papers by Beaver (1968) and Ball and Brown (1968), considerable empirical evidence suggests a relation between capital markets and financial statements and, particularly relevant for the present study, that accounting earnings are associated with stock returns. Kothari (2001) provides a comprehensive review of the main methodological issues and messages derived from the capital market research in accounting. Among other findings in the related literature, we note the low explanatory power of applied models and the small earnings response coefficients. This motivated researchers to expand their analysis, decomposing earnings into several attributes (i.e. persistence, smoothness, timeliness) in an attempt to gain a better understanding of the association between earnings and stock valuations. The study of these attributes drove researchers to pay increased attention to the concept of earnings management practices and thus to the value relevance of the quality of earnings. As stated by Lo (2008), among the research topics in accounting and finance, the most provocative is earnings management because it explicitly involves potential wrongdoing, mischief, conflict, cloak and dagger, and a sense of mystery.

Extensive research in the field based on the models of Jones (1991), Dechow and Dichev (2002), Ohlson (1995) and their modified versions suggests that investors price securities in a manner that reflects their awareness of accruals quality,[5] with lower-quality accruals being associated with higher costs of debt, lower price, earnings multiples, and larger equity betas (e.g. Francis et al. 2005). Extended discussion on the concept of earnings management, as well as related critical reviews of studies on the relation between earnings quality and firms' valuation are offered in a number of papers (e.g. Healy and Wahlen 1999; Dechow and Skinner 2000; Dechow et al. 2010; Dichev et al. 2013).

In some selected evidence, DeAngelo et al. (1996), Barth et al. (1999) and Beatty et al. (2002) argue that firms with successive and consistent earnings increases are valued higher, but when the earnings increasing pattern is interrupted, the stock price falls substantially. Rountree et al. (2008) find that cash-flow volatility is negatively related to firm value, meaning that firms with smooth cash flows are valued with a premium, while Bao and Bao (2004) suggest that lower variability of earnings does not guarantee income smoothers' higher firm values. Instead, smoothers' earnings should be more value-relevant if they are of high quality. Chaney and Lewis (1995) argue that firms with smoother earnings have greater informativeness of their earnings and achieve higher earnings response coefficients, while Hunt et al. (2000) find that companies with smoother earnings enjoy higher market value and that the discretionary part of earnings smoothing has a stronger effect on this relationship. Dechow et al. (1996) report that, when earnings management is revealed, the share price will be negatively affected. However, Wang (2019), studying "reverse mergers"[6], finds no reflection of earnings management in the firm's value. Gaio and Raposo (2011), using a cross-country sample, find a strong and positive relation between earnings quality and firms' value, while Yu et al. (2019) document a negative relationship between earnings quality and IPO underpric-

5 The interest in accruals quality stems from the fact that although accruals are an essential part of income, they are not recognised in the cash flows statement and are not easily detected (e.g. Peasnell et al. 2005). For an overview discussion on accruals, see Ohlson (2014).

6 A reverse merger occurs where a private company acquires a public company, mostly for the purpose of bypassing the complex process of going public.

ing. In another strand of the literature, Leuz et al. (2003) find less earnings management for countries with developed stock markets, dispersed ownership, strong investor rights and strong legal enforcement, with the negative association between investor protection and earnings management being supported by Haw et al. (2004), Lang et al. (2006), Burgstahler et al. (2006) and Francis and Wang (2008). Overall, there is no consensus in the literature on how significant earnings quality is for firms' valuation, with results often depending on the choice of the earnings quality proxy and the type of country investigated.

The introduction of International Financial Reporting Standards (IFRS) since 2005 in the EU motivated a number of studies, which aimed to examine whether IFRS led to a decrease in earnings management practices, improving the quality of corporate disclosures (e.g. Ball 2006; Barth et al. 2008; Chen et al. 2010; Ahmed et al. 2013; Christensen et al. 2013; Doukakis 2014; Ipino and Parbonetti 2017). The literature provides reasons for both the arguments that mandatory adoption of IFRS may improve or reduce accounting quality, and this may be explained by the fact that the quality of accounting numbers is affected by multiple factors, with accounting standards being only one of them. More interesting, the literature also suggests that the regulatory efforts to increase earnings quality might have had unintended consequences, with firms substituting one form of earnings management with another (for example accrual-based earnings management with real earnings management). Finally, the literature has also examined the effect that economic crises may have on earnings management, with unclear findings. For example, Filip and Raffournier (2014) provide the conflicting views in the literature on earnings management in troubled periods, while after analysing the earnings management behaviour of European listed companies (from 16 countries) during the 2008-2009 financial crisis and the years before, they report a significant decline in income smoothing and an improvement of accruals quality during the crisis period. They also show that country-specific characteristics, such as law enforcement, corporate governance quality and importance of financial markets, partially explain cross-country differences in income smoothing, but have no impact on measures of accruals quality.

Regarding the evidence from Greece, Baralexis (2004) reports that creative accounting was practised in Greece frequently, with large companies overstating profit, the overriding motive being demand for external financing, while small companies understated profit in order to reduce income taxes. Koumanakos et al. (2005) investigated mergers and acquisitions cases during the period 2001–2003 involving Athex-listed firms and, by focusing on discretionary accruals as a measure of managers' earnings manipulation, found weak evidence of biased accruals reported by managers in the year preceding the announcement and the completion of the deal.[7] However, using a broader sample, Koumanakos et al. (2008) documented that several major Greek companies in financial distress with qualified audit opinions do appear to have manipulated their reported earnings by exploiting the weaknesses of Greek accounting principles. Gasteratos et al. (2016) examined the phenomenon of earnings management in the Greek construction industry and found that discretionary accruals (showing lower profits) increase in periods of higher corporate tax rates, with large companies resorting to earnings management more frequently than small ones. On the other hand, Balios, Sdrolias and Thanos (2020), by examining whether and to what extent Greek state-owned firms engage in earnings management techniques, found no evidence of any earnings management techniques during the period 2012-2016.

Dimitropoulos and Asteriou (2008), using a sample of non-financial firms with shares listed

7 Speaking of earnings management and merger activity, a nice summary of the international evidence together with the finding of downward earnings management in firms seeking to be acquired can be found in Anagnostopoulou and Tsekrekos (2015).

on the Athens Exchange during the period 1995-2004, found weak evidence of earnings timeliness. Nevertheless, they found that disclosure improves earnings informativeness for firms with low conservatism, but not in the case of firms with high timeliness. Overall, their findings suggest that there are cases where better disclosure may not result in more informative stock prices. For the same period, using a similar sample, Dimitropoulos and Asteriou (2009) analysed the relevance of financial reporting and concluded that investors price accruals, with non-discretionary accruals being more important compared to the discretionary ones in explaining stock return movements. Iatridis and Alexakis (2012) provide evidence that the provision of voluntary accounting disclosures is negatively associated with earnings management.

In another strand of the literature, the quality of earnings is linked to corporate governance practices. For example, Bekiris and Doukakis (2011) examined the association between corporate governance and accruals earnings management in a sample of firms listed on the Athens, Milan and Madrid stock exchanges, and found an inverse relationship between corporate governance and earnings management, especially for large and middle capitalisation firms. Tasios and Bekiaris (2012), using a survey method to investigate auditors' perceptions of the quality of financial reports of Greek firms, concluded that the quality of financial reports of Greek companies is perceived to be moderate, while the main factors which auditors believe that lead to poor quality in financial reporting are earnings management, deviation from accounting principles, insufficient supervision/audit from public authorities, family ownership, and poor corporate governance. Smaraidos et al. (2018) investigated the impact of corporate governance on decisions that may manipulate earnings in Greek listed firms and concluded that firms with a strong and independent board of directors combined with an active audit committee, together with financial soundness and the presence of a large audit firm, are deterred from practices related to earnings management.

Regarding the relationship between auditor activity and earnings management, Caramanis and Lennox (2008), by focusing on the association between audit effort (measured by audit hours) and earnings management, find that managers are reporting aggressively high earnings when audit effort is low as, based on their results, firms are more likely to report income-increasing abnormal accruals than income-decreasing abnormal accruals when audit hours are lower, while the magnitude of income-increasing abnormal accruals is negatively related to audit hours. Also, firms are more likely to manage earnings upwards to just meet or beat the zero earnings benchmark, when auditors work fewer hours. Tsipouridou and Spathis (2012, 2014), by examining the relationship between earnings management and auditor reporting (opinion), found that audit opinions are not related to earnings management. Also, the size of the audit firm does not affect the level of earnings management, and the audit opinion qualification is not issued in response to management's opportunistic behaviour. However, they also commented that the interpretation of the results is conditional on the Greek context, where the economic bonding of auditors with their clients is strong, investor protection is low, enforcement mechanisms are weak and there is low litigation and reputation loss, even in the post-IFRS period.

The quality of information reported by Greek firms improved after the adoption of IFRS.[8] Indicatively, Iatridis and Rouvolis (2010) investigated the effects of the transition from Greek GAAP to IFRS, examining, among other issues, the degree of earnings management under IFRS and the value relevance of IFRS-based accounting numbers. They concluded that the quality of firms' financial measures improved significantly following the transition

8 It should be noted that similar evidence, i.e. that IFRS adoption reduces the scope for earnings management, is related to timelier loss recognition and leads to more value relevant accounting measures, is also found internationally (e.g. Iatridis 2010).

period and therefore IFRS adoption led to more value relevant accounting measures. Dimitropoulos et al. (2013) also found convincing evidence that the implementation of IFRS contributed to less earnings management, timelier loss recognition and greater value relevance of accounting figures, compared to the Greek accounting standards. Chimonaki and Vergos (2019) examined whether IFRS adoption resulted in decreased accounting manipulation and found evidence that IFRS adoption has increased transparency and lowered information costs.

On the other hand, Tsalavoutas et al. (2012), by examining the combined value relevance of book value of equity and net income before and after the mandatory transition to IFRS in Greece, found that the expected higher accounting quality after the adoption of IFRS, as expressed by higher combined value relevance of book value and net income, was not identified in the case of Greek companies. However, they documented an increase in the valuation weight put on the book value of equity and a decrease in the valuation weight on net income, consistent with IFRS being more focused on the balance sheet and introducing more volatility and less persistence in net income. In addition, they found that reconciliation statements, due to the introduction of IFRS, were incrementally value relevant and therefore conveyed useful information to investors. Ferentinou and Anagnostopoulou (2016) examined the use of Accrual-based Earnings Management (AEM) and Real Earnings Management (REM) before and after the mandatory adoption of IFRS in 2005 and found a statistically significant shift from AEM to REM after the adoption of IFRS, indicating the replacement of one form of earnings management with the other.

Regarding the effect of the global financial crisis on earnings quality, Iatridis and Dimitras (2013), using a sample of Portuguese, Irish, Italian, Greek and Spanish listed companies, concluded that firms in Portugal, Italy and Greece tend to engage more in earnings management in their effort to improve their lower profitability and liquidity and to accommodate their higher debt. In addition, the reported financial numbers of Portuguese and Greek firms that are audited by the Big 4 auditors were found to be of higher quality before the crisis. In a later study for the same countries, Dimitras et al. (2015) provided evidence that financially distressed companies that are audited by one of the Big 4 auditors exhibit lower discretionary accruals, and the results revealed that Greek and Spanish companies reduced earnings management manipulation during the recession. Finally, Kousenidis et al. (2013), for a sample of EU countries including Greece, indicate that, on average, earnings quality has improved in the crisis period; however, in the presence of incentives for earnings management, earnings quality deteriorates, while Persakis and Iatridis (2015, 2016), for a sample of publicly listed firms in advanced countries, including Greece, found that during the financial crisis, earnings quality decreased, with the effect being more severe in countries characterised by medium and weak shareholder protection, and that higher audit quality implied higher earnings quality.[9]

3 MEASURING EARNINGS QUALITY AND FIRM VALUE

3.1 EARNINGS QUALITY PROXY

Although the respective literature is vast, there is no consensus regarding the most appropriate measure of earnings quality (e.g. Dechow et al. 2010). A general classification is between accounting-based and market-based measures (Francis et al. 2004). Accounting-based measures use only accounting data and refer to the effectiveness of cash flow allocation, while market-based measures use both accounting and market data and focus on the relationship between earnings and stock returns. Sepa-

9 Another interesting strand of the literature on earnings management, although less relevant to the present study, links tax auditing mechanisms, forensic accounting and tax evasion to earnings management (e.g. Balios et al. 2020).

rately, Dechow et al. (2010) recognise three broad proxies for earnings quality: statistical properties of earnings; investors' responsiveness to earnings; and external indicators of financial reporting quality.

The measure of accruals quality is one of the most widely used measures in the literature. It is based on the idea that the stronger the correlation of earnings with cash flows, the higher earnings quality is. Earnings with higher level of discretionary accruals are considered to be of lower quality. The importance of earnings persistence and cash flow predictability is also emphasised in the equity valuation models, especially those relying on the discounted cash flow (Dechow et al. 2010). Due to the complexity of the earnings quality concept, in the present study we chose to use a composite indicator in measuring the quality of earnings.

Specifically, we use the StarMine Earnings Quality (EQ) score, which is included in the Refinitiv Eikon database and represents a quantitative measure of the reliability and persistence of earnings as a proxy of earning quality. It is a percentile ranking from 0 to 100 (with 100 denoting the highest quality) and is calculated on the basis of financial statements data. It identifies companies that are likely to have earnings with high or low sustainability over a period of one year, based on decomposing past earnings into sustainable and non-sustainable components, in line with the methodology developed by StarMine.[10] The quantitative multi-factor econometric model follows the empirical evidence from the literature, based on which accounting quality is a broad concept, can take a number of forms and can be manifested in a number of ways (e.g. earnings persistence, discretionary accruals, etc.). It favours earnings backed by cash flows, while it disfavours earnings driven by accruals and other non-sustainable sources. In practice, it identifies companies with high operating efficiency, strong cash flow and a proven record of earnings meeting the earlier projections. Higher values of persistence and predictability indicate higher earnings quality. Therefore, earnings with higher score are a more precise indicator of future performance, accurately capture the current and past performance and are a reliable measure of firm valuation. Companies with a high EQ score possess strong fundamentals and are more likely to outperform their benchmark, while companies with a low EQ score are not necessarily involved in earnings management, since it could also reflect declining performance compared with the past. The EQ score consists of four components: accruals (four-quarter changes in current and non-current operating assets and liabilities scaled by the company' average assets); cash flows (annualised free cash flow scaled by the company's average assets); operating efficiency, measured by operating profit margin and net operating asset turnover; and exclusions,[11] measured by the recent quarterly value of the special items and other exclusions, scaled by average assets.

3.2 FIRM VALUE PROXY

Tobin's Q ratio is a widely used measure to proxy companies' value (e.g. Lang and Stulz, 1994; Bitner and Dolan 1996; La Porta et al. 2002; Kapopoulos and Lazaretou 2007; Rountree et al. 2008; Toudas 2009; Gaio and Raposo 2011; Davidson et al. 2013; Pagratis et al. 2014; Dybvig and Warachka 2015). The literature suggests that Tobin's Q is a good proxy of firm value and it provides continuous, long-term valuation of a company, indicating market participants' expectations regarding the company's future performance and economic returns.[12] A Tobin's Q ratio of one suggests that the company is fairly valued. Values higher than one imply that the company generates economic rents by using its assets efficiently. In line with the literature (e.g. Wang 2019; Gaio and Raposo 2011), we measure Tobin's Q as follows:

10 For details regarding the StarMine econometric model, see for instance Gaumer at el. (2009) and http://www.premiacap.com/QWAFAFEW/atas_20051020.pdf.

11 It should be noted that the component of exclusion refers to North America only and is not taken into consideration for companies located in other countries.

12 Note that, among other assumptions, Tobins' Q assumes that financial markets are efficient and thus the market value can be seen as an unbiased estimate of the present value of a firm's future income streams and that the book-to-value is a good proxy for the replacement cost of the firm's capital.

$$Q_{i,t} = (BVA_{i,t} + MVE_{i,t} - BVE_{i,t})/BVA_{i,t} \qquad (1)$$

where $Q_{i,t}$ is the Tobin's Q of firm i in fiscal year t; $BVA_{i,t}$ is the book value of total assets of firm i in fiscal year t;[13] $MVE_{i,t}$ is the market value of common equity of firm i (computed as stock price times the number of common shares outstanding) in fiscal year t[14]; and $BVE_{i,t}$ is the book value of equity of firm i in fiscal year t.

4 DATA AND METHODOLOGY

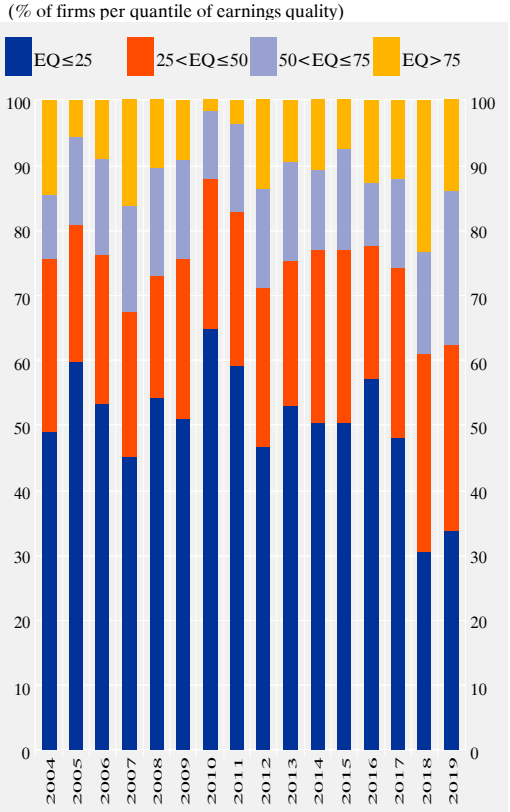
In order to empirically test the relationship between earnings quality and firm value, we run the following panel regression:

$$Q_{i,t} = \alpha + \beta_1 EQ_{i,t} + \beta_2 SIZE_{i,t} + \beta_3 ROA_{i,t} + \beta_4 \Delta(SALES_{i,t}) + \beta_5 DEBT_{i,t} + \varepsilon_{i,t} \qquad (2)$$

where EQ is the earnings quality score (StarMine EQ score). In addition, based on empirical evidence (e.g. Durnev and Kim 2005; Dechow et al. 2010) which supports that the choice of accounting methods is associated with firm characteristics, such as size, performance, leverage, growth opportunities, etc., we control for firm characteristics. In particular, we include company size ($SIZE$), measured as the log of total assets, return on assets (ROA), the logarithmic change in annual sales ($\Delta SALES$), and leverage ($DEBT$), proxied by the total-debt-to-total-assets ratio. Both fixed effects (FE) and random effects (RE) models with and without time-effects are applied. Our dataset includes an unbalanced panel of 1,953 observations, covering the period from 2004 to 2019. Balance sheet information, stock price data and the StarMine EQ score were drawn from the Refinitiv Eikon database.

Panel A of Table 1 includes selected descriptive statistics of the variables under examination.[15] The average Tobin's Q of the sample is 1.10, while the median value is 0.94, indicating that the market's long-term valuation of the average Greek firm reflects its reported fundamentals. Regarding EQ, there is significant variability in the sample, with the average value of 33 indicating moderate quality of earnings, although there seems to be a tendency of improvement over time, especially in the last two years (see Chart 1). Panel B of Table 1 shows the Pearson correlations among the variables. The correlation coefficients between Tobin's Q and the other variables are positive, albeit rather low, while the respective correlations between EQ and the other variables are slightly higher.

Chart 1 Distribution of firms per quantile of earnings quality (EQ) per year



Source: Authors' own estimations.
Note: The chart plots the distribution of firms per quantile of earnings quality score. Indicatively, the blue bar reports the percentage of firms in the sample belonging to the bottom 25% quantile with respect to earnings quality.

13 The book value of assets is used as a proxy for the replacement cost.
14 Following a common practice in the accounting literature, we used the stock price three months after the end of the fiscal year.
15 It should be noted that outliers were not removed from the sample, as their exclusion did not alter the key findings and inferences of the applied models.

Table 1 Descriptive statistics and correlation matrix

Panel A: Descriptive statistics

	Q	EQ	SIZE	SALES	ROA	DEBT
Mean	1.10	33.24	18.43	0.0293	0.1323	0.3606
Median	0.94	25.00	18.15	0.0188	0.5690	0.3260
Maximum	10.91	100.00	23.58	3.6633	56.7268	6.6937
Minimum	0.30	1.00	13.66	-6.8998	-116.7328	0.0000
Std. Dev.	0.70	26.79	1.65	0.3508	9.2212	0.3127
Skewness	6.6	0.8	0.6	-5.2	-2.3	6.2
Kurtosis	81.2	2.6	3.4	108.5	36.6	98.1
Observations	1,953	1,953	1,953	1,953	1,953	1,953

Panel B: Correlation matrix

	Q	EQ	SIZE	SALES	ROA	DEBT
Q	1					
EQ	0.22	1				
SIZE	0.01	0.16	1			
SALES	0.04	0.14	0.08	1		
ROA	0.09	0.32	0.25	0.24	1	
DEBT	0.15	-0.10	0.02	-0.06	-0.48	1

Source: Authors' own estimations.
Notes: The table includes descriptive statistics (Panel A) and the correlation matrix (Panel B) of Tobin's Q, earnings quality (EQ), the logarithm of total assets (SIZE), annual sales logarithmic changes (SALES), return on assets (ROA) and the total-debt-to-total-assets ratio (DEBT) for our sample over the period 2004-2019.

5 EMPIRICAL RESULTS

In order to proceed with the panel estimation, we first check for stationarity. The panel unit root tests are reported in Table 2. The null hypothesis that a unit root is present is rejected in all cases (assuming both common and individual unit roots), suggesting that Tobin's Q, earnings quality, return on assets, the logarithm of total assets, the log change in annual sales and the total-debt-to-total-assets ratio are stationary.

The panel estimation results of equation (2) are presented in Table 3. Our empirical findings (based on a fixed effects model) show that the firm value, as proxied by Tobin's Q, is significantly and positively related to EQ. Note that the Hausman test is used in order to test the appropriateness of the FE model relative to the RE model. As shown in Table 3, there is evidence in favour of fixed effects in all cases. The advantage of the FE specification is that it controls for unobserved heterogeneity and allows for arbitrary correlations between the firm-specific fixed effects and the independent variables (Wooldridge 2010). Nevertheless, for robustness purposes, Table 1 also reports results for both FE and RE estimates, as well as pooled OLS estimates. Overall, the positive relation between Tobin's Q and EQ is statistically robust regardless of the estimation technique. More importantly, the information content of EQ remains significant

Table 2 Panel unit root tests

	Q	EQ	SIZE	SALES	ROA	DEBT
Null: Unit root (assumes common unit root process)						
Levin, Lin and Chu t-stat	-23.30***	-10.55***	-6.60***	-5.43***	-12.65***	-3.42***
Null: Unit root (assumes individual unit root process)						
Pesaran and Shin W-stat	-6.86***	-8.71***	-3.63***	1.41	-9.44***	0.055
ADF-Fisher Chi-square	448.7***	513.2***	347.8***	276.4	516.8***	339.8***
PP-Fisher Chi-square	355.2***	934.7***	541.0***	323.0**	870.4***	412.5***

Source: Authors' own estimations.
Notes: The table includes panel unit root tests for Tobin's Q, earnings quality (EQ), the logarithm of total assets (SIZE), annual sales logarithmic changes (SALES), return on assets (ROA) and the total-debt-to-total-assets ratio (DEBT). H_0: unit root is present. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

even after controlling for firm characteristics, i.e. size, return on assets, sales growth, and leverage.[16]

Moreover, in order to correct for any correlation within panels, we use a Prais-Winsten specification of the model with panel-corrected standard errors. We estimate the model using both a common autoregressive term and panel-specific autoregressive terms. In both cases, we use an AR(1) specification of the autoregressive term. The respective results are reported in Table 4. Our findings remain robust to within-panel correlation, suggesting that firms with higher earnings quality are valued more highly in the Greek stock market.

In order to further investigate the robustness of our findings, we estimate equation (2) using two alternative estimation methods. First, in order to address the concern that the relation between firm valuation and earnings quality may be endogenous, we estimate equation (2) using a two-stage least squares (2SLS) method. Earnings quality (EQ) is instrumented with its lagged value, return on assets, the log of the company's total assets, the logarithmic change in annual sales and the total-debt-to-total-assets ratio. The results are reported in Table 5 and clearly show that earnings quality positively impacts firm valuation, as proxied by Tobin's Q, even when we account for the possible endogeneity of EQ.

Finally, in order to address potential measurement error concerns (see Gompers et al. (2010) and Gaio and Raposo (2011) for a comprehensive discussion), we also use a quantile regression that can capture how the median or the 10th or 90th percentiles of Tobin's Q are affected by earnings quality. In general, the qth quantile regression has the following form:

$$Q(Q_{i,t}) = \alpha_i^{(q)} + \beta_i^{(q)} EQ_{i,t} + \gamma_i^{(q)} SIZE_{i,t} + \delta_i^{(q)} ROA_{i,t} + \zeta_i^{(q)} \Delta(SALES_{i,t}) + \eta_i^{(q)} DEBT_{i,t} + \varepsilon_{i,t} \quad (3)$$

This quantile specification allows the effect of earnings quality to be estimated in each of the 10 quantiles (0.1, 0.2, ... 0.9) of Tobin's Q distribution. We employ a bootstrap methodology with 2,000 replications to estimate standard errors of the quantile regression coefficients.

16 The results from the control variables indicate that the valuation of earnings quality seems to be relatively more important for smaller firms, as suggested by the negative coefficient in the size variable. A puzzling result may be the positive sign of the debt coefficient, as higher corporate indebtedness is expected to negatively affect valuations. One possible explanation, based on the relatively low average levels of leverage reported in Table 1, is that firms were below optimal capital structure and therefore an increase in their leverage improves their valuation because of the interest tax shield. In addition, in conjunction with the negative sign of size, higher indebtedness, especially of smaller firms, may reflect the fact that these firms have to resort to borrowing to pursue profitable investment opportunities, as their internal profitability was not sufficient to finance new investments. This explanation is in line with previous evidence that only a small fraction of firms with shares listed on the Athens Exchange were in a position to finance their growth exclusively with internal resources (e.g. Athanasoglou, Asimakopoulos and Siriopoulos 2006).

Table 3 Panel data estimations

	Pooled regression	FE model	FE model (with time-effects)	RE model	RE model (with time-effects)
EQ	0.0044*** (0.0007)	0.0021*** (0.0005)	0.0021*** (0.0006)	0.0027*** (0.0007)	0.0026*** (0.0007)
ROA	0.0222*** (0.0067)	0.0156** (0.0071)	0.0095 (0.0067)	0.0162** (0.0079)	0.0101 (0.0076)
SIZE	-0.0243*** (0.0088)	-0.5231*** 0.1040)	-0.4639*** (0.1005)	-0.1682*** (0.0339)	-0.1415*** (0.0311)
SALES	-0.0010 (0.0058)	-0.0005 (0.0572)	-0.0009 (0.0026)	-0.0008 (0.0029)	-0.0013 (0.0027)
DEBT	0.6527*** (0.1300)	0.4904*** (0.1573)	0.5519*** (0.1925)	0.5987*** (0.1885)	0.6344*** (0.2168)
Constant	1.1559*** (0.1641)	10.4723*** (1.6109)	9.6292*** (1.8711)	3.8890*** (0.6309)	3.7060*** (0.6146)
R-squared	0.09	0.24	0.34	0.20	0.30
F-statistic	13.93	7.27	12.34	33.52	229.64
Durbin-Watson stat	0.38	0.76	0.71	0.63	0.61
Specification tests					
F-test (pooled OLS vs. FE)		17.90***	17.89***		
Hausman test (FE vs. RE)				71.38***	87.04***

Source: Authors' own estimations.
Notes: The table reports estimates of the following panel regression for the years 2004 to 2019: $Q_{i,t}=\alpha+\beta_1 EQ_{i,t}+\beta_2 SIZE_{i,t}+\beta_3 ROA_{i,t}+\beta_4 SALES_{i,t}+\beta_5 DEBT_{i,t}+\varepsilon_i$ where Q is Tobin's Q, EQ is the earnings quality score (StarMine EQ score), ROA is return on assets, $SIZE$ is the log of the company's total assets, $SALES$ is the logarithmic change in annual sales and $DEBT$ is the total-debt-to-total-assets ratio. We estimate a pooled regression model, a fixed effect (FE) model without and with time-effects and a random effect (RE) model again without and with time-effects. Robust standard errors are in parentheses. An F-test is used to determine whether the fixed effects (FE) model outperforms the pooled OLS, and Hausman's test examines the appropriateness of the FE model relative to the RE model. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

Table 4 Panel data estimations with autoregressive term

	Pooled regression	Prais-Winsten with PCSEs model with AR(1)	Prais-Winsten with PCSEs model with panel-specific AR(1)
EQ	0.0044*** (0.0007)	0.0022*** (0.0004)	0.0025*** (0.0004)
ROA	0.0222*** (0.0051)	0.0038* (0.0021)	0.0071*** (0.0025)
SIZE	-0.0243* (0.0144)	-0.0383 (0.0287)	-0.0406** (0.0173)
SALES	-0.0010 (0.1103)	-0.0018 (0.0028)	-0.0013 (0.0438)
DEBT	0.6527*** (0.0661)	0.4843*** (0.0604)	0.5827*** (0.0711)
Constant	1.1559*** (0.2535)	1.5814*** (0.4955)	1.6268*** (0.3041)
Common AR(1)		0.6883*** (0.0411)	
R-squared	0.09	0.24	0.46
Wald x^2	198.73	61.08	67.29

Source: Authors' own estimations.
Notes: The table reports estimates of the panel regression using a Prais-Winsten specification with a common autoregressive term and with panel-specific autoregressive terms for the years 2004 to 2019: $Q_{i,t}=\alpha+\beta_1 EQ_{i,t}+\beta_2 SIZE_{i,t}+\beta_3 ROA_{i,t}+\beta_4 SALES_{i,t}+\beta_5 DEBT_{i,t}+\varepsilon_i$ where Q is Tobin's Q, EQ is the earnings quality score (StarMine EQ score), ROA is return on assets, $SIZE$ is the log of the company's total assets, $SALES$ is the logarithmic change in annual sales and $DEBT$ is the total-debt-to-total-assets ratio. Panel-corrected standard errors are in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

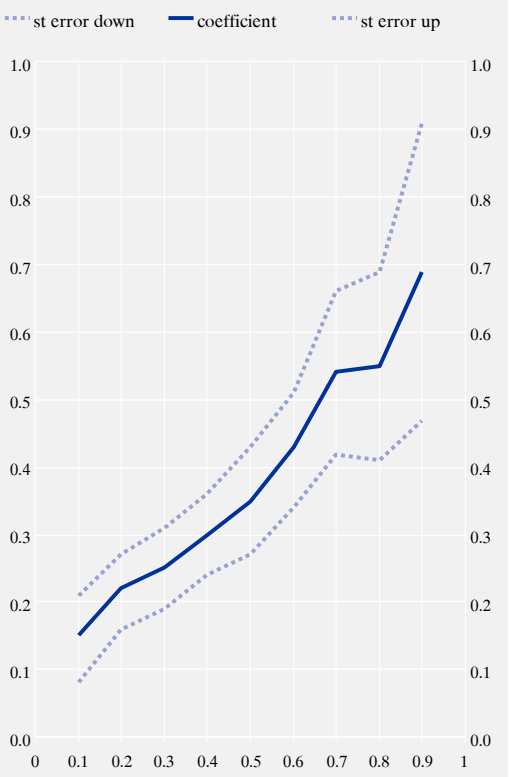
Table 5 Two-stage least squares (2SLS) regression estimates

	First stage EQ	Second stage Q
EQ		0.0124*** (0.0022)
ROA	0.5327*** (0.1193)	0.0112* (0.0061)
SIZE	1.1330*** (0.3967)	-0.0334*** (0.0103)
SALES	0.2649 (0.2220)	-0.0058 (0.0060)
DEBT	2.7046 (2.1494)	0.6160*** (0.1381)
EQ_(lag 1)	0.2976*** (0.0313)	
C	2.3132 (7.2431)	1.0477*** (0.1823)

Source: Authors' own estimations.
Notes: The table reports parameter estimates of the two-stage least squares (2SLS) regression system of equations of earnings quality (EQ) and Tobin's Q (Q) at the firm level. EQ is instrumented with return on assets (ROA), the log of the company's total assets (SIZE), the logarithmic change in annual sales (SALES), the total-debt-to-total-assets ratio (DEBT) and its lagged value (EQ_lag 1). Robust standard errors are in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

Chart 2 Quantile regression plot for earnings quality

(coefficients, x100)



Source: Authors' own estimations.
Note: The chart plots estimates of the quantile regression coefficients of earnings quality with their associated 95% confidence interval in each of the 9 quantiles of Tobin's Q distribution.

Table 6 reports parameter estimates for selected quantiles, ranging from 0.10 to 0.90 for equation (3), while the quantile regression plot for earnings quality with the associated (95%)

Table 6 Quantile regression estimates

Quantile	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
EQ	0.0014*** (0.0004)	0.0022*** (0.0003)	0.0024*** (0.0003)	0.0028*** (0.0003)	0.0034*** (0.0004)	0.0043*** (0.0004)	0.0051*** (0.0007)	0.0058*** (0.0006)	0.0064*** (0.0011)
ROA	0.0099** (0.0039)	0.0106*** (0.0031)	0.0116*** (0.0027)	0.0130*** (0.0022)	0.0139*** (0.0018)	0.0139*** (0.0021)	0.0168*** (0.0034)	0.0177*** (0.0029)	0.0225*** (0.0042)
SIZE	0.0239*** (0.0044)	0.0193*** (0.0040)	0.0143*** (0.0039)	0.0084** (0.0041)	0.0033 (0.0048)	-0.0091* (0.0055)	-0.0313*** (0.0074)	-0.0547*** (0.0093)	-0.1041*** (0.0099)
SALES	0.0115 (0.0108)	0.0238* (0.0127)	0.0331*** (0.0120)	0.0416*** (0.0126)	0.0295 (0.0352)	0.0223 (0.0358)	0.0207 (0.0385)	0.0277 (0.0298)	-0.0456 (0.0380)
DEBT	0.5586*** (0.0491)	0.5686*** (0.0445)	0.5504*** (0.0439)	0.5690*** (0.0483)	0.6069*** (0.0574)	0.6363*** (0.0643)	0.6217*** (0.0910)	0.6631*** (0.1272)	0.6305*** (0.1043)
C	0.0064*** (0.0762)	0.1290*** (0.0712)	0.2742*** (0.0714)	0.4171*** (0.0753)	0.5357*** (0.0877)	0.8006*** (0.1052)	1.3182*** (0.1524)	1.8711*** (0.1764)	3.1002*** (0.1972)

Source: Authors' own estimations.
Notes: This table includes the parameter estimates for selected quantiles ranging from 0.10 to 0.90 of the following quantile regression model: $Q(Q_{i,t})=\alpha_i^{(q)}+\beta_1^{(q)}EQ_{i,t}+\gamma_i^{(q)}\,SIZE_{i,t}+\delta_i^{(q)}\,ROA_{i,t}+\zeta_i^{(q)}\,SALES_{i,t}+\eta_i^{(q)}\,DEBT_{i,t}+\varepsilon_{i,t}$ where Q is the Tobin's Q, EQ is the earnings quality score (StarMine EQ score), ROA measures return on assets, $SIZE$ is the log of the company's total assets, $SALES$ denotes the logarithmic change in annual sales and $DEBT$ is the total-debt-to-total-assets ratio. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

confidence interval is presented in Chart 2. Our estimates suggest that earnings quality is statistically significant across all quantiles. Interestingly, the EQ coefficient monotonically increases as we move from the lowest to the highest quantile of Tobin's Q distributions, suggesting that earnings quality plays an even more significant role for the highly valued companies.

6 CONCLUSION

Earnings management practices, earnings quality and their effect on investors' perception of the value of firms have attracted the interest of researchers for decades. High-quality earnings should clearly reflect the actual operating performance of firms, leading to a better reflection of their intrinsic value (e.g. Dechow and Schrand 2004). However, the empirical evidence remains inconclusive, depends on the choice of the earnings quality proxy and is mostly related to large economies.

Considering that accounting irregularities observed in some firms over the past few years have raised concerns about the quality of the reported earnings of firms with shares listed on the Athens Exchange, the present study attempts to shed light on the significance of earnings quality. Using financial and stock price data from non-financial Athex-listed firms for the period 2004-2019, a composite index of earnings quality, consisting of three components (accruals, cash flows, and operating efficiency), and Tobin's Q as a proxy for firms' value, we find that firms with better earnings quality are valued higher by investors. The results remain robust across different model specifications and controls for firm-specific characteristics.

Our findings are of particular interest to market participants and supervisory authorities and indicate that firms, through the quality of their earnings, can achieve higher valuations and, therefore, better terms of financing, especially when they need to gain access to international capital markets. The importance of earnings quality in raising capital is well-documented in the literature, which supports the view that firms with the best earnings quality enjoy significant discounts in their cost of capital (e.g. Francis et al. 2002, 2005; Persakis and Iatridis 2015; Eliwa et al. 2016). This is also corroborated by recent evidence from the corporate bond market where Greek firms with strong fundamentals and high level of earnings quality find financing in international markets at a lower cost, compared with bank loans.[17]

Increasing the number of firms that are able to successfully raise capital from international markets at a lower cost requires, in addition to strong fundamentals, well-enforced outsider rights, which would limit insiders' acquisition of private control benefits and, consequently, mitigate insiders' incentives to manage accounting earnings because they have little to conceal from outsiders (Leuz et al. 2003). It is also well-documented in the literature that the valuation of firms is higher (and the required premium lower) in countries with better protection of minority shareholders (La Porta et al. 2002), as well as that strong investor protection is associated with effective corporate governance (La Porta et al. 2000). In this respect, the provisions of Law 4706/2020 regarding the Greek corporate governance framework and the operation of the Hellenic Capital Market Commission seem to be in the right direction. However, because of the dynamic nature of financial markets, continuous efforts are needed towards monitoring the effectiveness of corporate governance mechanisms, audit function, oversight and supervisory actions, with a view to ensuring the integrity of the financial reporting process.

17 The importance of strong fundamentals and developments in the cost of financing for non-financial firms through bond issues are continuously discussed in several reports published by the Bank of Greece. Indicatively, see *Governor's Annual Report* for the years 2015 (Box IX.1, pp. 208-212) and 2019 (pp. 251-252) and *Monetary Policy Report*, July 2019 (pp. 142-143). Also, a detailed analysis of Greek non-financial firms' financing through international bond markets, as well as details on the Bank of Greece corporate bond index (which is available in Bloomberg) can be found in Migiakis (2014).

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WORKING PAPERS
(AUGUST – DECEMBER 2020)

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The economic impact of pandemics: real and financial transmission channels

Working Paper No. 283
Hiona Balfoussia, Heather D. Gibson, Dimitris Malliaropulos and Dimitris Papageorgiou

The authors explore the economic impact of the pandemic and the importance of real and financial sector linkages in this context. They explicitly model the financial sector and trace its role in propagating the pandemic shocks. The authors find that the pandemic-induced adverse labour supply shock can have sizeable effects on the real economy, which are further propagated through the banking sector. Moreover, the contemporaneous pandemic-induced financial shock has financial, but also real effects, including high and protracted firm bankruptcies as well as a more fragile banking sector, thus hindering the financing of the real economy. The duration of the pandemic matters for its impact on the macroeconomy, as both business investment and bank balance sheets take disproportionately longer to recover. The findings underline the need for well-targeted policy measures to support the real economy and, secondarily, the financial sector during the pandemic and provide justification for several of the policy initiatives recently taken by governments, central banks and regulatory institutions around the world.

The Single Supervisory Mechanism and its implications for the profitability of European banks

Working Paper No. 284
Ioanna Avgeri, Yiannis Dendramis and Helen Louri

The scope of this paper is to examine whether and how the establishment of the Single Supervisory Mechanism (SSM) influenced the profitability of European banks. To do so, the authors employ the returns on assets and equity as alternative indicators for profitability. Using data for 344 European banks in 2011-2017, they apply the difference-in-differences methodology combined with matching techniques. The main findings indicate a statistically significant and positive effect on profitability for the directly supervised banks, especially those located in the periphery of the euro area, implying that institutional improvements introduced by the SSM were beneficial not only for strengthening stability and increasing credibility, but also for improving performance and enhancing integration.

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