KEPE, *Greek Economic Outlook,* issue 39, 2019, pp. 62-79

Multidimensional analysis of the productivity of the Greek economy

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Abstract

The enhancement of productivity constitutes a crucial component for the sustainable development of a country and is closely related to more and better jobs and improved living standards. Hence, there are strong requirements for monitoring and interpreting the trends and main determinants of productivity, in conjunction with the design and evaluation of policies for promoting productivity at the national, sectoral and regional levels. This article first examines the national and sectoral dimensions of productivity in Greece. Given the increased and persistent regional inequalities in the country, it further analyses labour productivity and total factor productivity as well as the interregional productivity gap over time. The level and evolution of labour productivity are also investigated by sector of economic activity in each region. The findings provide useful insights into the formulation of policies for boosting the sustainable and inclusive growth, productivity and competitiveness of the country through identifying needs and opportunities for reforms and investments.

JEL codes: *D24, O47, R12.*

Keywords: *Labour productivity, multifactor productivity, sectoral and regional analysis, productivity gap.*

1. Introduction

Productivity improvements have a persistent effect and greatly determine the living standards and the sustainable growth, efficiency and stability of the economy of a country in the long run. The strengthening of productivity constitutes a major priority for the Greek government in both its national strategic growth plan (Hellenic Republic, 2018) and the national reform programme (Hellenic Republic, 2019). In contrast with horizontal measures of economic policy, whose effectiveness are contested, emphasis is given to the implementation of (more) targeted measures at the levels of regions and sectors of economic activity, in order to boost employment and regional development.

Specifically, the issue of the analysis of labour productivity, typically expressed in terms of the ratio of GDP to total working hours, can be regarded as multidimensional since it is affected by several driving factors which are present and interplay at the global, European, national, sectoral and regional/local levels. Particularly, the treatment of the productivity slowdown and the increasing inequalities among firms, industries and regions are considered as policy priorities for the European Union (Rincon-Aznar et al., 2014; Juncker et al., 2015; Van Ark and Jäger, 2017). For these purposes, fiscal policies and structural reforms are suggested and implemented in specific sectors, such as education, research and development (R&D) and the labour market, especially in high value-added and technology-intensive activities, and in the influence of the digital transformation of the economy. In this context, the contribution of ICT (tangible and intangible) capital and skills to output growth becomes increasingly important. However, it is stressed that, in Greece, the contribution of the ICT capital and quality of labour to output growth are relatively limited, compared to the corresponding contribution of the non-ICT capital and quantity of labour (Tsekeris, 2018).

At the sectoral level by region, some changes in labour productivity can be associated with effects that are common in the EU, while others can be attributed to

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– Opinions or value judgments expressed in this article are the author's own and do not necessarily reflect those of the Centre of Planning and Economic Research.

endogenous characteristics of regional economies, including the level of regional specialisation and the sectoral concentration of economic activity. For instance, the processes of globalisation and the international fragmentation of labour and value-added production are considered as having intensified the sectoral concentration and the single (vs. multiple) specialisation of regions, or geographically dispersed specialisation patterns, in order for local (and more vulnerable) industries to retain their productivity levels and be protected from the exposure to globalised market competition. Compared with the concentration of new and higher-technology sectors in the core regions of Europe, traditional and lower-technology sectors tend to concentrate in the periphery. As a result, regions in the EU periphery are likely to increase their dependence on lower-technology sectors and reduce their competitiveness, with regard to the ability to innovate and produce higher value-added goods (IGEAT–ULB, 2008; Vegeulers, 2017).

Among others, the labour productivity of an industry can vary with the market structure, competition conditions, age and size of firms, adoption and use of ICT, and the ability to achieve economies of scope and scale in the same and other regions. On the one side, regions with more mature and technologically advanced economies, whose products pertain to higher complexity, have arguably improved performance in innovation, knowledge diffusion and productive efficiency, compared to regions with lower or medium technology and less mature economies (Siegel et al., 1995; Aiginger and Davies, 2004; Van der Panne, 2004; Frenken et al., 2007; Prager and Thisse, 2012). On the other side, regions encompassing more traditional markets, with lower technology and knowledge intensity, which are less exposed to (international) competition, can possibly have higher profit margins and productivity growth rates compared to regions with more extroverted and differentiated markets (Holmes and Stevens, 2002; Lee et al., 2010; Petrakos et al., 2012; Papaioannou et al., 2017).

This article investigates the variations in labour productivity among the regions and sectors of the Greek economy, the heterogeneity of labour productivity by sector in each regional economy, and the changes that occurred during the period of deep and persistent economic crisis in the country. Specifically, Section 2 examines developments in labour productivity in Greece and differences between the national level of labour productivity and total factor productivity (TFP) and the corresponding international frontier. It is noted here that TFP, or multifactor productivity, is closely related to and often represents the efficiency of a national or regional economy. It denotes how efficiently physical capital and labour inputs (and, possibly, other inputs, like energy and land, given the availability and exploitability of data) are used in the production process. In other words, a change in TFP corresponds to that change of GDP which cannot be explained by changes in physical capital and labour (or other production) inputs. Section 3 provides an analysis of labour productivity and TFP by NUTS-II region,[1] giving emphasis on the gap between the core region (Attiki, where the capital city of Athens is located) and peripheral regions as well as the best-performing region in the EU-28. Section 4 analyses, in more detail, labour productivity by sector of economic activity in each region. Section 5 summarises and concludes, suggesting policies for strengthening productivity and reducing inequalities at the national, sectoral and regional levels.

2. National and sectoral dimensions of productivity

In this section, labour productivity is examined at both the national and the sectoral level, in order to identify possible structural problems in the Greek economy. According to the OECD, during the decade 2008-2017, labour productivity in the country decreased by -9.6%. This drop was smaller during the last 5-year period 2013-2017 (-1.4%), compared to that during the period 2008-2012 (-7.6%), namely, the first years of the economic crisis (Figure 1). To the contrary, during the same period (2008-2017), the average labour productivity in the EU-28 increased by 9%, while the increase in average labour productivity in the countries of the euro area and the OECD (about 8.4% in both cases) was slightly smaller. Nonetheless, there was a slowdown of labour productivity in all cases, particularly in the euro area (from 3.9% during 2008-2012 to 3.2% during 2013-2017).

Based on Papaioannou et al. (2017), the gap $P_{GAP,c,t}$ in labour productivity $P_{c,t}$ (expressed as the ratio of GDP to the total working hours) of a country c, with respect to the best-performing country f (with the maximum

1. This corresponds to the second-level classification of the Nomenclature of Territorial Units for Statistics (NUTS) for the sub-national division of EU regions.

labour productivity), in a sample of countries under examination, in time period (year) *t*, can be given as follows:

$$P_{GAPc,t} = \ln\left(\frac{P_{f,t}}{P_{c,t}}\right) \quad (1)$$

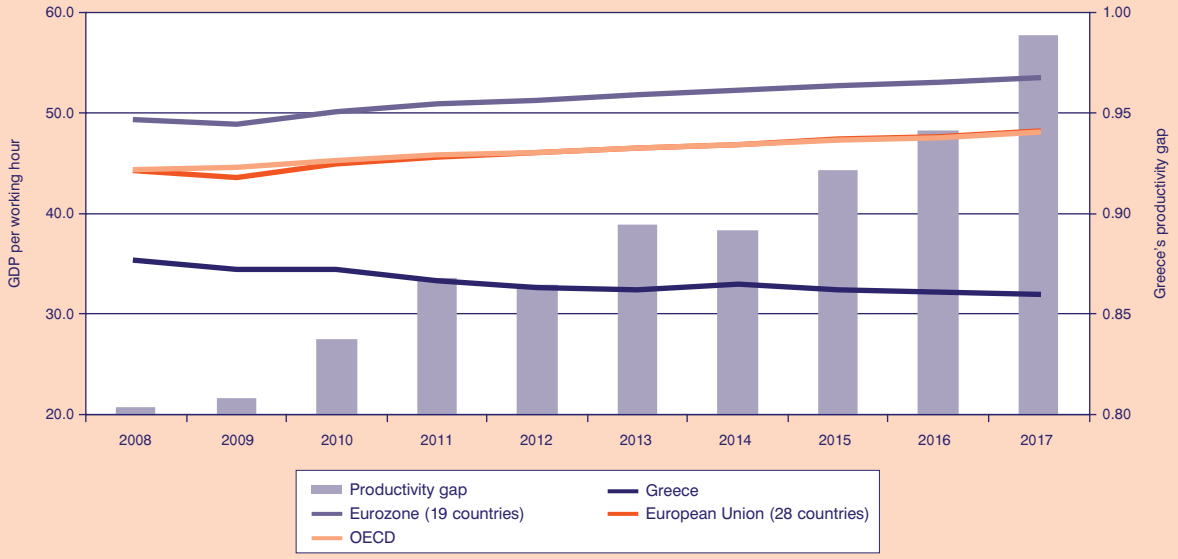
During 2008-2017, Greece notably increased (by 23%) its distance from the best-performing country in the euro area (and the OECD) (Figure 1). This increase was magnified during 2013-2017 (10.5%), compared to the period 2008-2012 (7.5%), suggesting a decline in the competitiveness of the country (as expressed by the distance from the production frontier[2]).

In addition to labour productivity, the TFP is also considered here, as it mirrors a range of productivity-influencing factors, such as agglomeration economies, networking effects, knowledge diffusion and other externalities, technological progress and organisational changes. Assuming the existence of constant elasticity of substitution between labour and capital, and constant returns to scale, a Cobb Douglas production function can be specified of the following form:[3]

$$Y_{i,t} = A_{i,t}(K_{i,t})^{\alpha}(L_{i,t})^{(1-\alpha)}, \quad (2)$$

where $Y_{i,t}$ represents the gross output and $K_{i,t}$ and $L_{i,t}$ the physical capital stock[4] and labour input (typically defined in terms of total working hours), respectively, in a country (or region) *i* in time period (year) *t*, while $A_{i,t}$ refers to a technological parameter that is neutral of capital and labour inputs, which here represents the

FIGURE 1
Labour productivity (GDP per working hour, in USD, constant prices, 2010 PPP[1]) in Greece, the Euro area, the EU-28 and OECD countries, and the productivity gap in Greece,[2] 2008-2017



Source: Own processing of data from the OECD.

Notes: 1. Prices are adjusted for Purchasing Power Parity (PPP).
2. The best-performing country during 2008-2014 was Luxemburg, and during 2015-2017 was Ireland.

2. It corresponds to the reference country for benchmarking (i.e., whose labour productivity defines the frontier) among the OECD countries. This country may differ across the time period of the study.

3. See Papaioannou et al. (2017) for further information and explanation about the theoretical background and specification of the Cobb Douglas production function and its application to the Greek regional economy. It is noted that the Cobb Douglas production function can be alternatively specified by assuming different returns to scale and types of technical progress, and it constitutes the most widely adopted production function in the literature (Acemoglu, 2008).

4. The variable of physical capital stock is estimated with the use of the perpetual inventory method for each region and year of the study period (Derbyshire et al., 2013).

TFP (Papaioannou et al., 2017). The parameter α denotes the capital share of income. In turn, TFP can be calculated as follows:[5]

$$TFP_{i,t} = \frac{Y_{i,t}}{\left(K_{i,t}\right)^{\alpha}\left(L_{i,t}\right)^{(1-\alpha)}} \quad . \qquad (3)$$

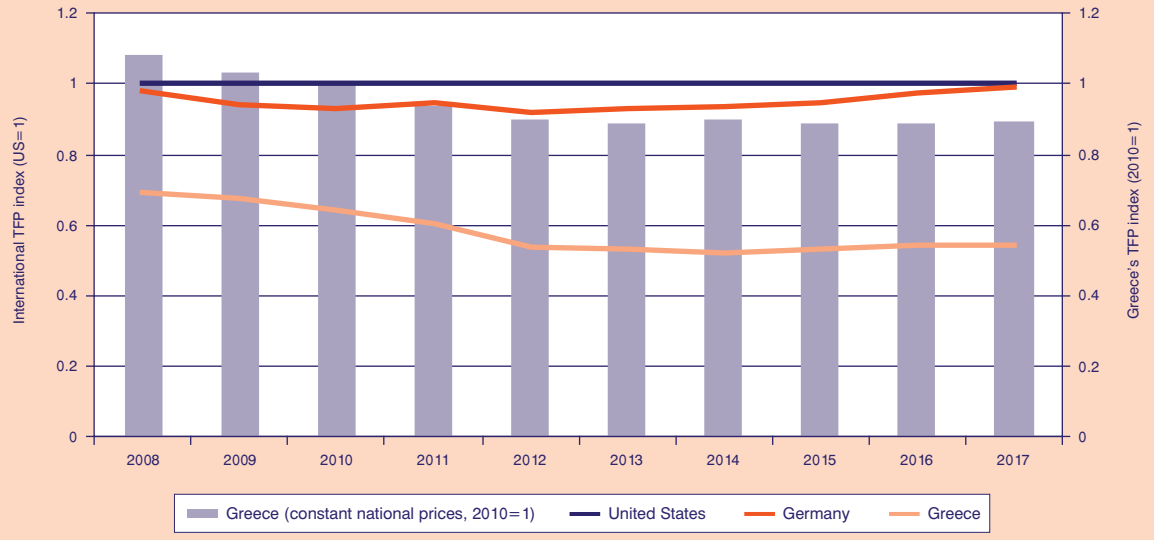
For the comparative analysis of TFP among countries and its intertemporal evolution in Greece, this measure is expressed as an index, in relation to the US=1 and in constant national prices over time (2010=1) (Figure 2). The TFP of the Greek economy presents a pronounced and increased deviation from the TFP of both the US and Germany, declining at about 54% of the TFP of those two countries in 2017. Especially, the TFP of the Greek economy (at constant national prices) was reduced by 17% during the period 2008-2012, and basically remained the same afterwards.

With regard to the sectoral dimension of labour productivity in Greece, during the period 2008-2016, all sectors of economic activity presented a decline in productivity, except for manufacturing (23%), construction (20%), and agriculture-forestry-fishing (14%) (Figure 3). The growth in labour productivity in the sectors of agriculture-forestry-fishing and construction refers to the first 5-year period 2008-2012. Particularly in the case of construction, this growth is attributed to the remarkably higher rate of employment reduction (in total working hours), compared to the falling rate of gross value-added production. On the contrary, the manufacturing sector increased its labour productivity mostly during the period 2013-2016 (by 14%).

Nevertheless, it is mentioned that the sectors of real estate, renting and business service activities, and financial and insurance activities, together with that of electricity, gas, water supply, sewerage, waste management and remediation activities, retained the best performance in labour productivity, although it decreased over the whole period. Agriculture-forestry-fishing remained the sector with the lowest labour productivity in the Greek economy.

These results suggest the need for the further modernisation and upgrading of sectors producing inter-

FIGURE 2
TFP index for Greece and Germany, constant prices, PPP[1] in relation to US=1, with respect to the prices of the reference period, and TFP index for Greece, constant national prices (2010=1), 2008-2017

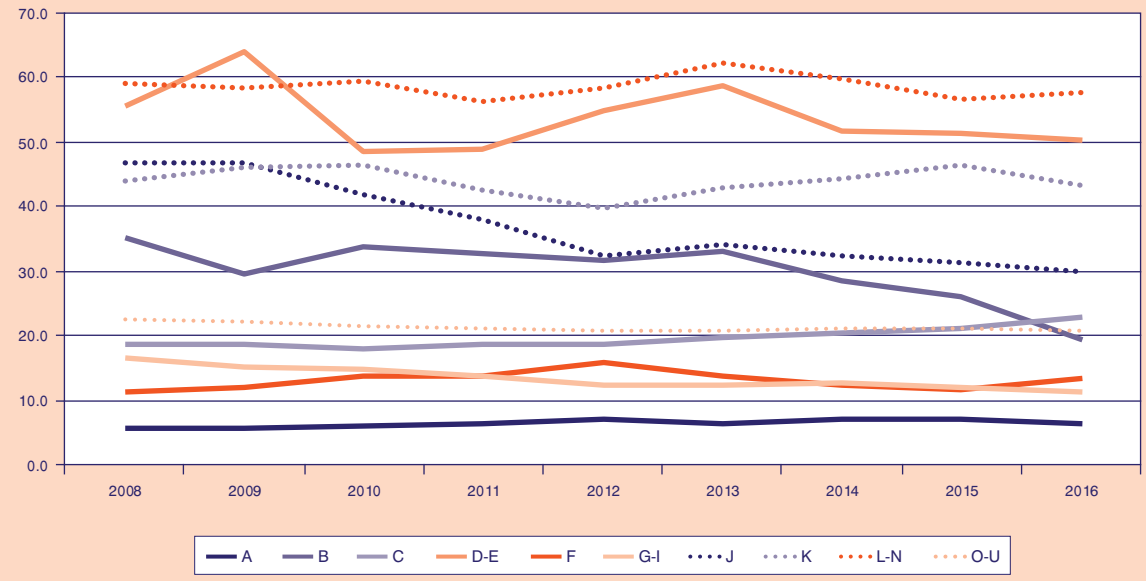


Source: Own processing of data from Penn World Tables (Feenstra et al., 2015).

Note: 1. Prices are adjusted for Purchasing Power Parity (PPP).

5. However, the part of output growth which cannot be explained by changes in production inputs may be differentiated according to the way the dependent variable of the production function is defined (Bell and Ho, 1977).

FIGURE 3
Labour productivity (gross value added per working hour, in euro, constant prices 2010) by sector of economic activity in Greece, 2008-2017



Source: Own processing of data from the OECD.

Notes: A: Agriculture, forestry and fishing, B: Mining and quarrying, C: Manufacturing, D-E: Electricity, gas, water supply, sewerage, waste management and remediation activities, F: Construction, G-I: Wholesale and retail trade, accommodation and food services, transportation and storage, J: Information and communication, K: Financial and insurance activities, L-N: Real estate, renting and business service activities, O-U: Public, social and personal service activities.

nationally tradable goods, such as those of manufacturing and agriculture, whose labour productivity still remains at low levels, in relation to sectors of services, in order to promote the transformation of the production model of the country and its competitiveness.

3. The regional dimension of productivity

According to the OECD (2018), most regions of its member-countries have increased their productivity, but larger inequalities appear within them, so as their growth becomes less inclusive. However, the tradeoff between regional productivity growth and increased regional inequalities cannot be regarded as the general rule. In the case of Greece, the intense and persistent problem of core-periphery inequalities (Tsekeris, 2017) renders necessary the measurement of regional labour productivity and TFP and the corresponding productivity gap among regions. As described in Papaioannou et al. (2017), the measurement of regional productivity can help determine the considerable heterogeneity among regions and identify suitable policies for reducing spatial disparities and supporting regional convergence.

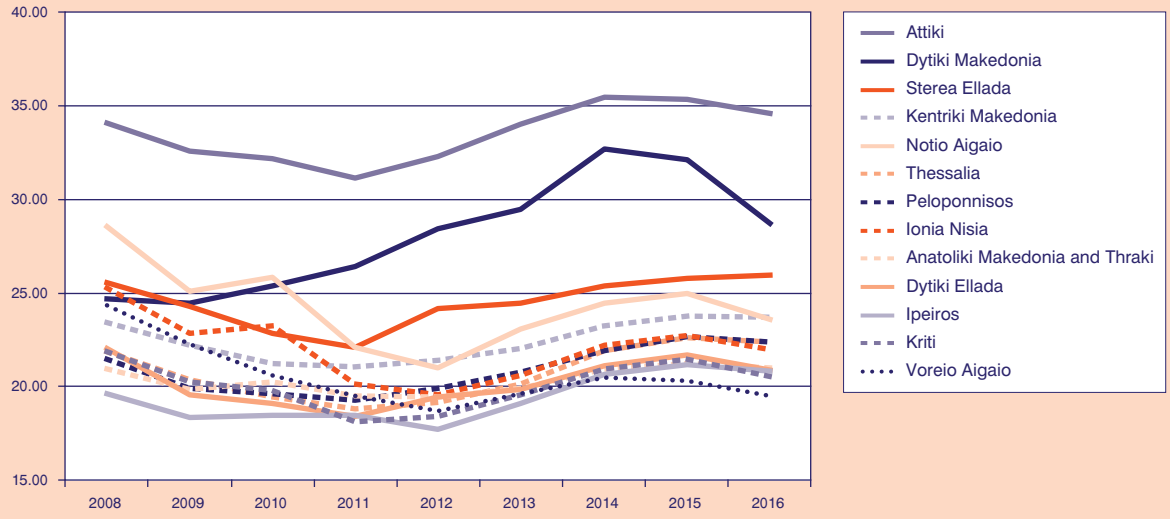
Initially, the labour productivity $P_{r,t}$ (expressed as the ratio of gross value added to total working hours) in each region r in some time period (year) t is calculated (Figure 4). The corresponding productivity gap $P_{\text{GAP},r,t}$ between Attiki (i.e., the region with the highest labour productivity) and the remaining regions of the country is given as:

$$P_{\text{GAP},r,t} = \ln\left(\frac{P_{Attiki,t}}{P_{r,t}}\right), \qquad (4)$$

where $P_{Attiki,t}$ refers to the labour productivity of the region of Attiki. The productivity gap between Attiki and the EU region with the highest labour productivity in each year of the study period is calculated correspondingly (Figure 5).

During the period 2008-2016, Dytiki Makedonia and Sterea Ellada were the regions with the highest la-

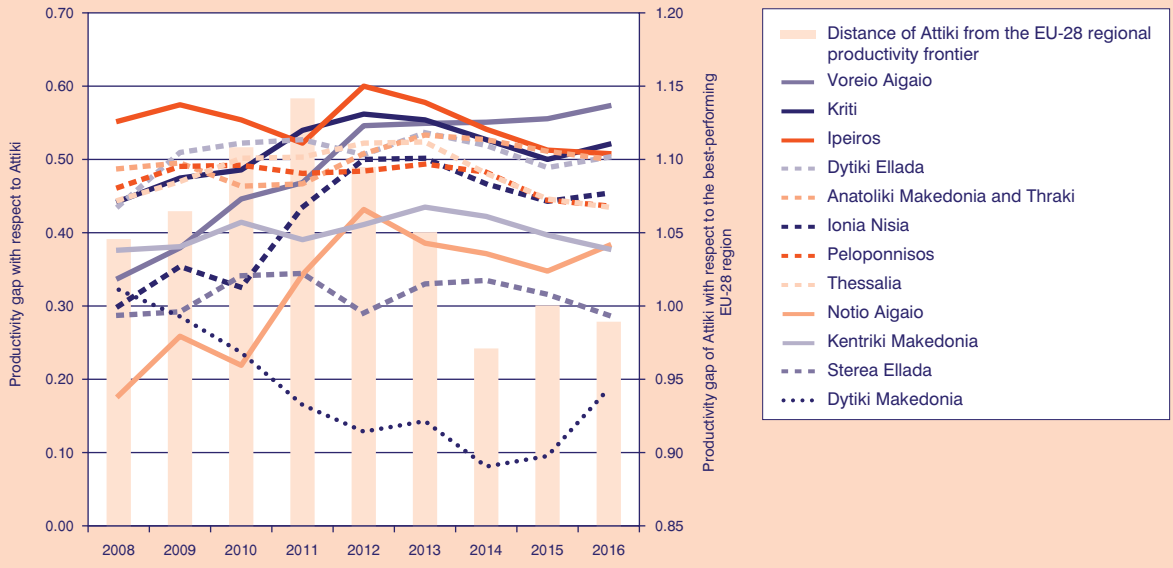
FIGURE 4
Labour productivity (gross value added per working hour, in euro, 2010 constant prices) in the Greek regions, 2008-2016



Source: Own processing of data from Eurostat.

Note: Regions are listed in descending order according to the level of labour productivity in 2016.

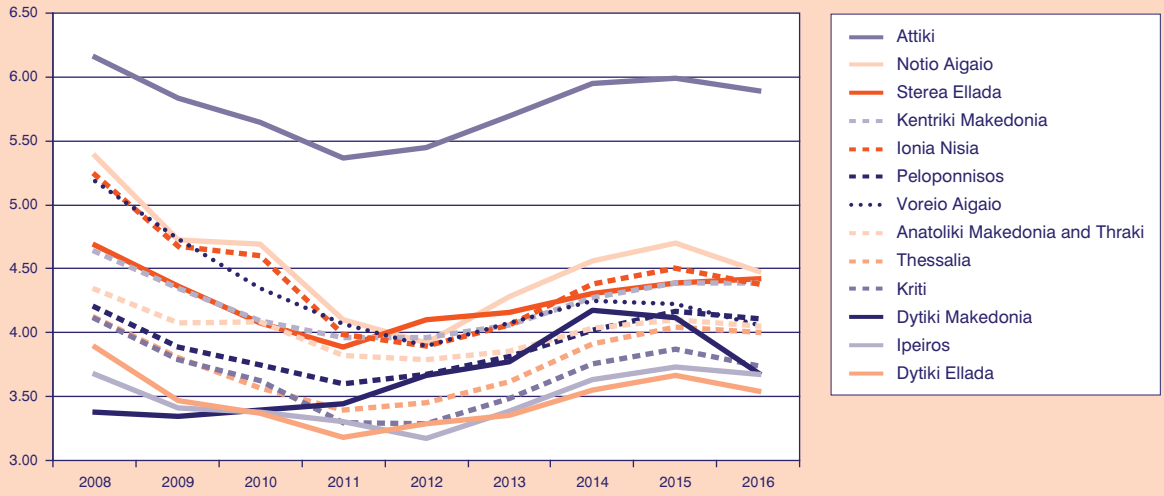
FIGURE 5
Productivity gap between Attiki and the remaining regions of Greece, and between Attiki and the best-performing EU-28 region,[1] 2008-2016



Source: Own processing of data from Eurostat.

Notes: 1. The EU region with the highest labour productivity during 2008-2016 was that of Brussels. Regions are listed in descending order according to the magnitude of their productivity gap from the region of Attiki in 2016.

FIGURE 6
TFP of Greek regions, 2008-2016



Source: Tsekeris and Papaioannou (2019).

Note: Regions are listed in descending order according to the level of TFP in 2016.

bour productivity, following Attiki.[6] To the contrary, during 2008-2013, Ipeiros was the region with the lowest labour productivity (except for 2011, when Kriti presented the lowest labour productivity), while during 2014-2016, the region with the lowest labour productivity was Voreio Aigaio. In the given study period, the productivity gap between Attiki and the other regions increased on average. Also, during 2008-2011, the productivity gap between Attiki and the EU region with the highest labour productivity (i.e., Brussels) also increased, but it then gradually diminished, reaching in 2016 a level lower than that before 2013 (Figure 5).

Next, Figure 6 presents the TFP in each Greek region and Figure 7 depicts the TFP gap between Attiki and the remaining regions of the country, as well as between Attiki and the EU region with the highest TFP. Assuming the existence of constant elasticity of substitution between capital and labour, and constant returns to scale, the regional TFP can be calculated with the use of equation (3), setting $\alpha = 0.333$. This strong assumption about the share of capital (and labour) in income is made due to the absence of relevant data at the regional level. However, it is adopted in the literature of regional economic analysis (e.g., Marrocu et al., 2013; Beugelsdijk et al., 2018). It has also been proven empirically that the sum of capital and labour shares are close to unity, at both the cases of Greek and EU regions (Tsekeris and Papaioannou, 2018; Tsekeris and Papaioannou, 2019, respectively).

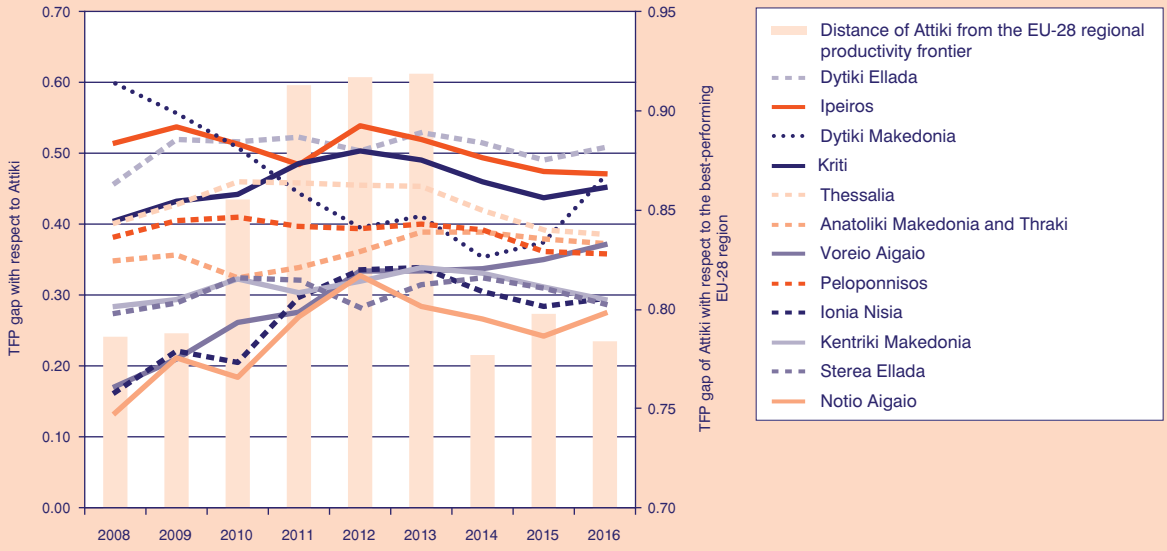
Similar to equation (1), the gap $TFP_{GAP,r,t}$ of the $TFP_{r,t}$ in a region r, in some time period (year) t, can be given as follows:

$$TFP_{GAP,r,t} = \ln\left(\frac{TFP_{Attiki,t}}{TFP_{r,t}}\right), \quad (5)$$

where $TFP_{Attiki,t}$ refers to the TFP of the region of Attiki, which is the region with the highest TFP in the country (Figure 6). It is, however, noted that the ranking of the remaining regions according to the magnitude of TFP differs from that based on the magnitude of labour productivity. Particularly, it is mentioned that, while Dytiki Makedonia is ranked second on the basis of labour productivity, it drops to the 11th position on the basis of TFP. This notable difference can be attributed, among other factors influencing the for-

6. The names of regions follow the Eurostat's NUTS. These names are translated to English as follows: Attica (Attiki), Central Greece (Sterea Ellada), Central Macedonia (Kentriki Makedonia), Crete (Kriti), Eastern Macedonia and Thrace (Anatoliki Makedonia-Thraki), Epirus (Ipeiros), Ionian Islands (Ionia Nisia), North Aegean (Voreio Aigaio), Peloponnesus (Peloponnisos), South Aegean (Notio Aigaio), Thessaly (Thessalia), Western Greece (Dytiki Ellada), Western Macedonia (Dytiki Makedonia).

FIGURE 7
TFP gap between Attiki and the remaining regions of Greece, and between Attiki and the EU-28 region with the best TFP,[1] 2008-2016



Source: Tsekeris and Papaioannou (2019).

Note: 1. The EU region with the highest TFP was that of Brussels during 2009-2011 and 2014-2016, and Groningen in 2008, 2012 and 2013. Regions are listed in descending order according to the magnitude of their TFP gap from the region of Attiki in 2016.

mation of its regional product, to the operation of the electric power generation units of the Public Power Corporation in the constituent prefectures of Kozani and Florina (Tsekeris, 2017). In 2016, the region of Notio Aigaio presented the second highest TFP in the country, although it ranked fifth on the basis of labour productivity. It is further noted that, in 2016, the region of Voreio Aigaio presented the 7th highest TFP in the country, although it was in the last position on the basis of labour productivity.

Similar to labour productivity, during 2008-2012, TFP decreased considerably in all the regions (except for Dytiki Makedonia) and recovered after 2013. Nonetheless, in contrast with labour productivity, whose performance is mixed among regions over time, the TFP of all the regions (except for Dytiki Makedonia) decreased in total during the given study period. The region of Notio Aigaio presents the second highest TFP in all the years of the reference period (except for 2012, when the region of Sterea Ellada had the second highest TFP in the country).

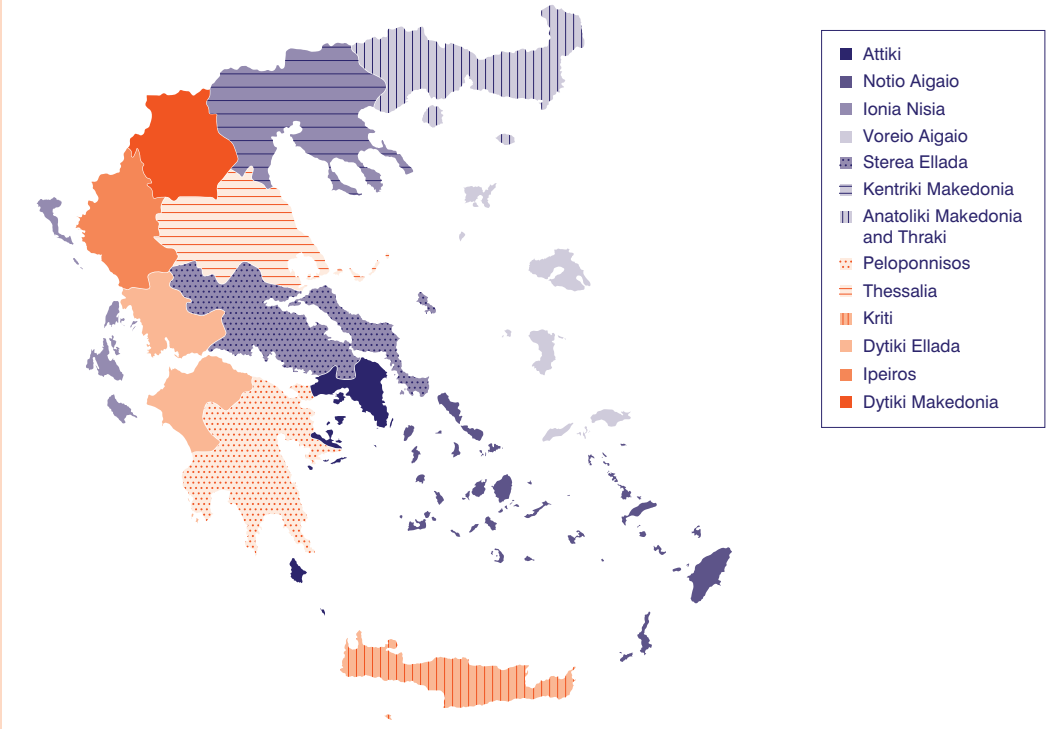
On the contrary, during 2008-2009, Dytiki Makedonia had the lowest TFP, while during 2010-2016, Dytiki Ellada had the lowest TFP (except for 2012, when the region of Ipeiros had the lowest TFP). Similar to the case of the labour productivity gap, during the given study period, on average, the TFP gap between the region of Attiki and the other regions of the country increased.

Map 1 depicts the intense and persistent interregional differences in TFP. The dominance of the region of Attiki is evident and steady over time, against the other regions of the country. Some regions have improved their relative position, in terms of their ranking on the basis of TFP, as they either presented smaller losses (Kentriki Makedonia, Sterea Ellada, Peloponnisos) or increased their TFP (Dytiki Makedonia), in contrast with other regions that presented larger losses (Dytiki Ellada, Voreio Aigaio).

The considerable disparities between the core (Attiki) and peripheral regions, in terms of both labour productivity and TFP, can be attributed to a range of factors, including the complex geomorphological terrain of the country (with the large mountainous blocks and the scattered island complexes, which hinder the accessibility and the ease of service provision), the small size of firms, the difficulty of doing business and creating new and high value-added employment positions, and the limitations to developing or exploiting economies of scope and scale (Papaioannou et al., 2017; OECD, 2019). As shown in Figure 7, the TFP gap between the region of Attiki

MAP 1
TFP in the 13 NUTS-II regions of Greece, (a) in 2008, and (b) in 2016

(a)



(b)

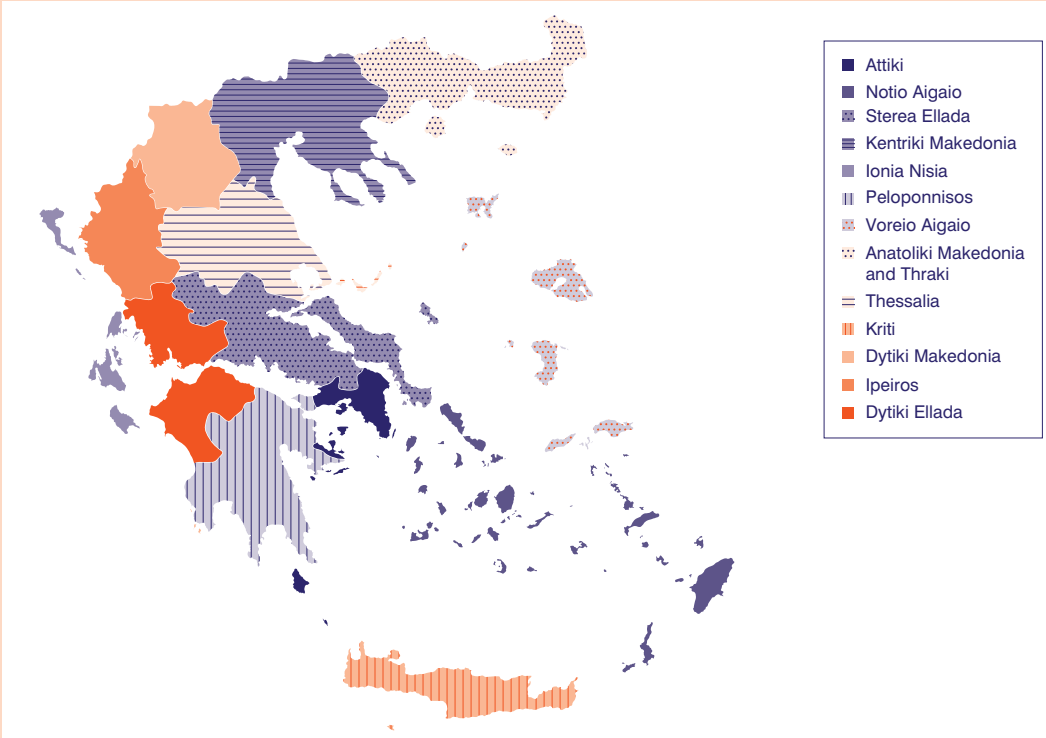
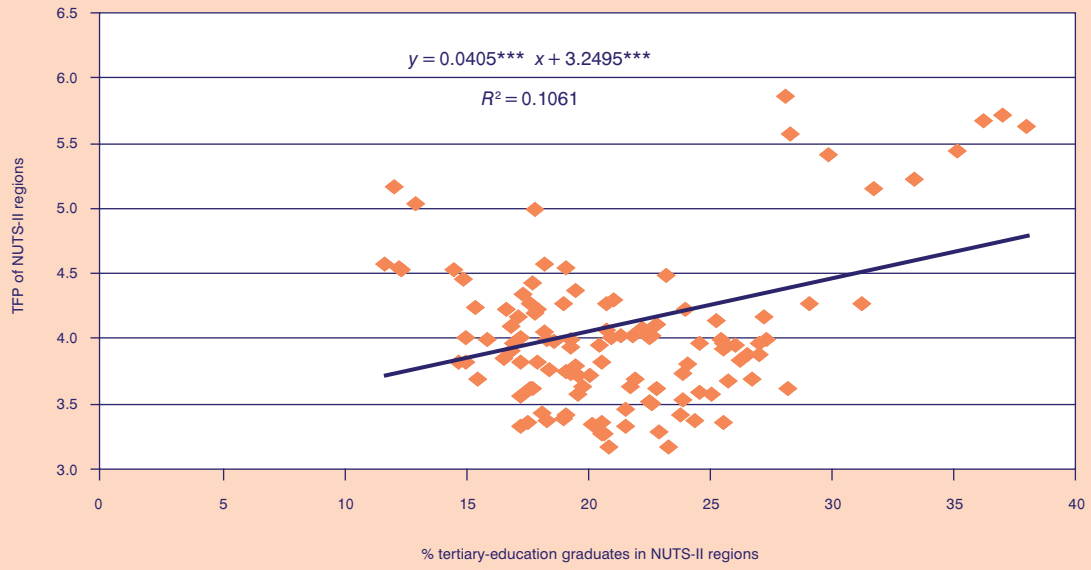


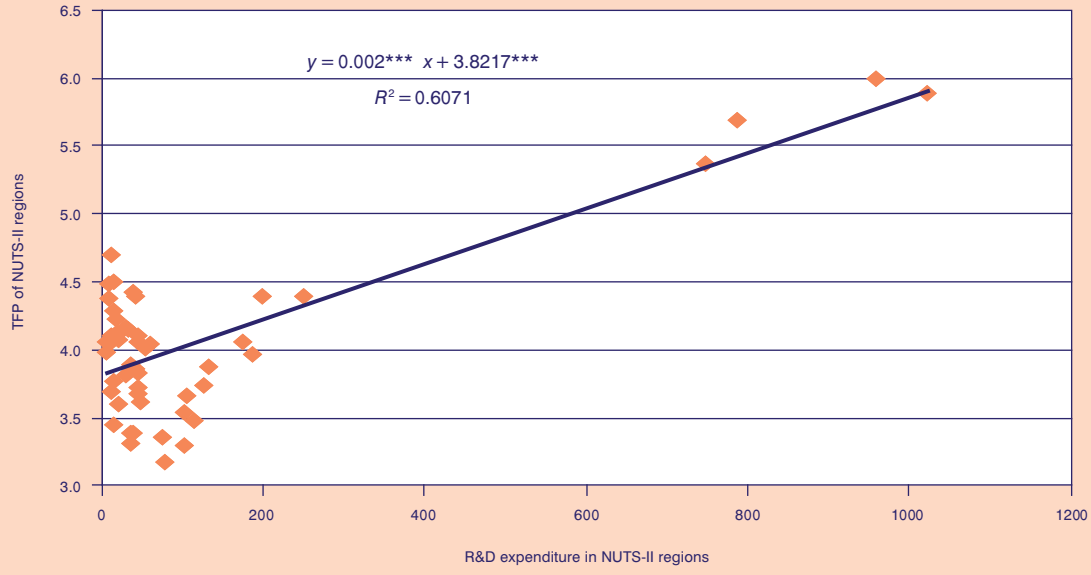
FIGURE 8
Relationship between TFP and human capital (% tertiary education graduates) at the regional level in Greece, 2008-2016



Source: Tsekeris and Papaioannou (2019) and own processing of data from Eurostat.

Note: *** Denotes statistical significance above 99% level of confidence.

FIGURE 9
Relationship between TFP and R&D expenditure (in euro, 2010 constant prices) at the regional level in Greece, 2011-2016



Source: Tsekeris and Papaioannou (2019) and own processing of data from the National Documentation Centre (EKT).

Notes: There are no data for years 2012 and 2014.
*** Denotes statistical significance above 99% level of confidence.

and the best-performing EU region increased considerably during 2010-2013, and then recovered in 2014, reaching the level of 2008.

Provided the importance of the human capital and R&D expenditure on the ability of regions to innovate and increase their productivity, by utilising their capital and labour inputs in a more efficient way, the relationship between those variables and regional TFP is examined here. The human capital is expressed as the ratio of the working population who are tertiary education graduates in each region (Papaioannou et al., 2017). The R&D expenditure corresponds to both the public and the private sector.

The findings indicate that there is a statistically significant ($p<0.01$) positive correlation between human capital and TFP at the NUTS-II level of regions. The regions with the highest and fourth highest TFP, namely, Attiki and Kentriki Makedonia, respectively, concentrate the highest human capital stock in the country (Figure 8 above). Additionally, the regions of Attiki and, to a much lesser extent, Kentriki Makedonia, have the most expenditure on R&D. The correlation between R&D expenditure and TFP at the NUTS-II level of regions is also found to be statistically significant ($p<0.01$) and positive (Figure 9 above).

4. Labour productivity by region and sector

Given the considerable variations in productivity among regions and sectors of economic activity, as described in the previous sections, labour productivity is analysed here by sector in each region of the country. It is stressed that the development process of a region is significantly affected by the typology of firms located in that region and the sectoral composition of local production (McCann, 2013). For this purpose, on the basis of data originating from the business registry of ELSTAT, in years 2008 and 2016, the labour productivity of each sector in a region is calculated as the ratio of the turnover of all firms belonging to that sector to the total number of employees.

The labour productivity patterns observed by sector in each region are partially different, compared to those relying on the analysis only at the sectoral or regional level. Nonetheless, it should be taken into account that the variable of labour productivity is calculated here by adopting a different definition, i.e., the firm turnover per employee, at a more detailed level of sectoral analysis. In 2008, financial and insurance activities, and electricity, gas, steam and air conditioning supply in the region of Attiki are the sectors with the highest labour productivity (Table 1). In 2016, the sectors with the highest labour productivity are those of electricity, gas, steam and air conditioning supply in the region of Attiki, and real estate activities in the region of Sterea Ellada (Table 2).

In both 2008 and 2016, the sector of wholesale and retail trade and repair of motor vehicles and motorcycles, presents, on average, the highest labour productivity. Other sectors of high labour productivity are, on average, those of manufacturing, mining and quarrying, financial and insurance activities (in 2008) and electricity, gas, steam and air conditioning supply (in 2016). In both years, the sectors with the lowest labour productivity (excluding the unknown activities) are, on average, those of public administration, defence and compulsory social security, and education.

The regions of Attiki and Kentriki Makedonia present, on average, the highest labour productivity. It is noted that the increase of labour productivity in the region of Sterea Ellada in 2016 is mainly attributed to the remarkable growth of labour productivity in real estate activities, which is a sector with very high capital intensity (large transaction values due to the real estate prices) and a small number of employees. A notable increase in labour productivity between the years 2008 and 2016 is also observed in the sector of electricity, gas, steam and air conditioning supply, particularly in Kriti, Anatoliki Makedonia and Thraki, Notio Aigaio, and other regions (Table 3). On the contrary, an important decrease in labour productivity is observed in the primary production sector (agriculture, forestry and fishing) in almost all the regions of the country, and in all the services sectors, particularly in public administration, defence and compulsory social security, and education, in almost all the regions of the country.

Next, the relationship between the average firm size and labour productivity by sector and region is examined. Based on the definitions of Eurostat,[7] the average size of a firm can be defined in terms of (a) the average number of employees (number of workers per firm), and (b) the average turnover (turnover per firm). In contrast with the average number of employees (Figure 10), the average firm turnover by sector in each NUTS-II region presents a statistically sig-

7. <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Statistics_on_small_and_medium-sized_enterprises#SME_definition>.

TABLE 1 Labour productivity (firm turnover per employee, in thousand euro, 2010 constant prices) by sector and region in Greece, 2008

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	W
Anatoliki Makedonia and Thraki	48.9	92.4	113.5	7.3	65.3	51.0	118.2	71.1	25.1	27.4	17.4	27.2	25.2	24.4	15.7	20.8	17.4	19.2	13.2	16.3
Kentriki Makedonia	44.7	164.8	94.9	88.9	107.9	63.1	140.0	86.3	31.2	71.1	341.8	31.3	35.3	51.1	17.1	16.6	26.1	35.0	18.4	19.0
Dytiki Makedonia	26.8	178.1	63.1	28.7	72.2	63.5	108.9	70.7	21.4	57.3	23.5	60.7	29.9	45.7	9.4	16.2	36.1	14.5	15.1	8.5
Ipeiros	62.4	40.9	87.5	12.1	59.7	40.5	119.0	70.9	24.2	33.1	16.4	26.6	25.0	21.1	8.4	14.7	10.9	14.1	63.1	9.9
Thessalia	70.6	107.3	113.5	128.9	86.5	57.5	128.8	83.2	29.0	36.3	45.3	43.6	27.2	32.4	12.1	15.0	27.8	20.0	13.0	13.8
Sterea Ellada	107.1	90.2	118.5	30.9	93.9	45.7	136.6	81.0	31.0	42.2	76.6	33.4	31.9	34.8	7.6	18.5	15.5	19.6	18.5	16.1
Ionia Nisia	49.9	52.3	56.3	11.9	50.2	38.1	126.6	83.0	28.9	27.0	34.3	35.3	27.6	37.6	11.5	15.7	11.5	17.4	18.0	10.1
Dytiki Ellada	57.7	37.3	88.9	6.4	68.9	44.4	132.8	86.1	28.0	32.1	64.1	42.3	31.1	22.1	10.2	9.9	16.2	19.4	18.9	11.9
Peloponnisos	68.3	103.5	120.4	10.3	86.4	35.6	135.7	74.2	30.7	23.0	16.7	23.5	27.4	28.5	**4.6**	20.1	18.6	99.1	19.0	15.1
Attiki	159.0	191.3	245.9	496.4	131.9	110.0	232.1	109.3	44.6	170.1	**521.3**	111.5	69.4	74.9	29.8	24.2	61.5	261.1	25.7	16.0
Voreio Aigaio	48.2	101.3	78.6	13.7	58.9	35.8	114.7	71.7	28.3	24.9	24.6	31.9	28.1	42.8	4.7	18.8	18.1	12.1	20.2	12.3
Notio Aigaio	84.3	131.8	66.1	11.2	41.7	54.6	145.5	65.9	36.5	41.7	25.5	51.2	31.9	57.2	18.4	22.6	20.8	41.4	21.4	30.1
Kriti	31.9	150.4	92.1	5.6	75.5	63.7	140.7	123.5	34.2	71.3	15.4	23.3	28.4	55.0	6.5	15.5	47.8	24.1	19.0	14.7

Source: Own processing of data from Business Registry, ELSTAT.

Notes: A: Agriculture, forestry and fishing, B: Mining and quarrying, C: Manufacturing, D: Electricity, gas, steam and air conditioning supply, E: Water supply; sewerage, waste management and remediation activities, F: Construction, G: Wholesale and retail trade; repair of motor vehicles and motorcycles, H: Transportation and storage, I: Accommodation and food service activities, J: Information and communication, K: Financial and insurance activities, L: Real estate activities, M: Professional, scientific and technical activities, N: Administrative and support service activities, O: Public administration and defence; compulsory social security, P: Education, Q: Human health and social work activities, R: Arts, entertainment and recreation, S: Other service activities, W: Unknown activities.

TABLE 2 Labour productivity (firm turnover per employee, in thousand euro, 2010 constant prices) by sector and region in Greece, 2016

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	W
Anatoliki Makedonia and Thraki	12.9	102.2	95.8	46.9	54.7	25.5	100.1	43.9	13.4	49.9	19.0	30.3	14.4	22.2	0.8	3.3	12.8	12.3	8.2	4.0
Kentriki Makedonia	14.5	134.3	96.4	84.9	89.4	44.5	119.8	55.6	17.4	44.9	46.9	31.0	21.1	39.7	3.6	4.1	16.3	14.9	9.8	9.7
Dytiki Makedonia	12.0	96.7	56.9	41.8	131.8	36.1	82.9	44.0	11.1	21.6	20.2	12.9	12.4	21.2	0.8	3.4	10.4	10.2	9.9	7.8
Ipeiros	21.1	38.2	134.4	45.0	52.5	20.4	103.8	45.8	12.7	21.8	35.3	20.4	14.0	20.3	1.6	3.0	7.3	9.8	8.9	0.6
Thessalia	15.3	85.1	122.5	91.9	69.0	51.2	100.9	45.6	14.7	24.1	26.3	21.5	16.2	23.6	0.8	4.4	17.0	13.2	14.1	0.5
Sterea Ellada	18.1	67.0	108.7	45.6	83.9	37.2	101.5	48.3	13.7	36.8	17.9	442.5	16.1	24.6	6.2	3.0	13.2	14.8	11.1	1.9
Ionia Nisia	6.5	72.6	43.7	28.4	50.3	22.2	99.3	51.5	22.0	36.3	14.5	41.9	16.8	40.3	1.2	3.7	11.1	16.8	11.7	11.3
Dytiki Ellada	12.3	84.4	103.3	47.3	60.1	30.3	101.7	45.0	13.3	26.7	15.7	32.8	17.0	16.4	2.0	3.8	12.6	18.3	8.9	0.9
Peloponnisos	9.9	115.1	115.2	46.8	70.9	24.0	109.6	45.2	15.6	28.0	16.3	23.1	15.5	24.5	1.5	3.8	11.0	27.6	10.9	2.5
Attiki	28.9	121.1	228.4	778.1	129.3	121.7	187.8	90.6	21.9	134.5	166.9	107.1	42.6	43.5	4.9	7.8	20.3	133.3	13.4	8.0
Voreio Aigaio	7.2	59.4	75.2	45.8	82.9	16.4	96.8	31.9	16.5	52.5	16.0	44.8	13.5	25.9	2.6	3.0	9.4	12.4	10.2	0.8
Notio Aigaio	9.8	83.9	51.6	63.7	55.5	28.5	107.9	40.2	29.3	57.9	18.6	49.1	18.0	44.0	1.8	4.9	16.5	22.8	12.9	3.6
Kriti	7.1	110.5	95.6	60.6	74.8	36.7	120.3	76.1	28.1	100.3	17.5	47.2	20.3	84.8	1.6	3.7	16.8	15.8	15.6	8.7

Source: Own processing of data from Business Registry, ELSTAT.

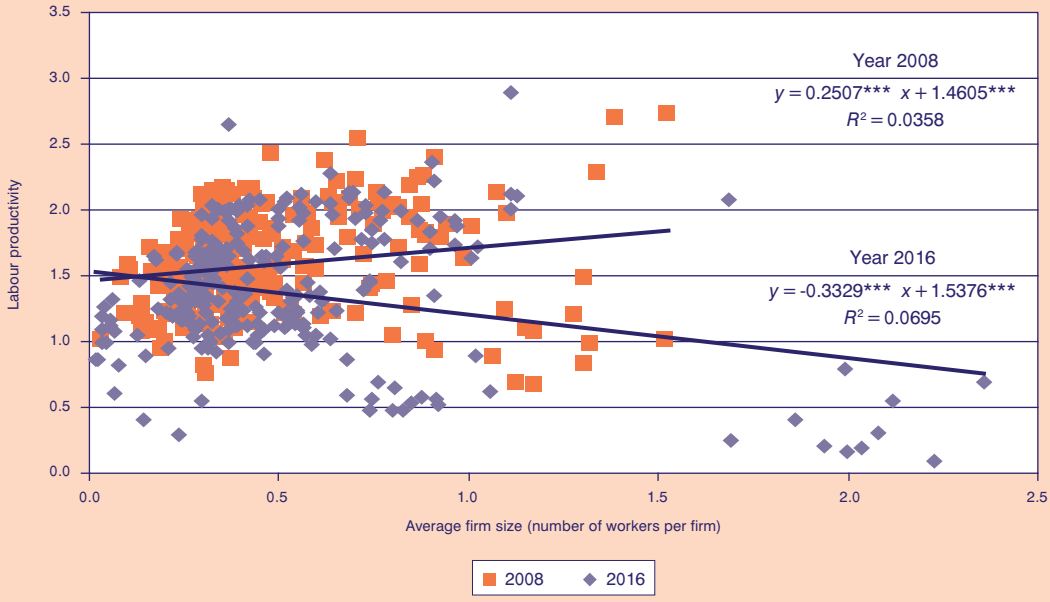
Notes: A: Agriculture, forestry and fishing, B: Mining and quarrying, C: Manufacturing, D: Electricity, gas, steam and air conditioning supply, E: Water supply; sewerage, waste management and remediation activities, F: Construction, G: Wholesale and retail trade; repair of motor vehicles and motorcycles, H: Transportation and storage, I: Accommodation and food service activities, J: Information and communication, K: Financial and insurance activities, L: Real estate activities, M: Professional, scientific and technical activities, N: Administrative and support service activities, O: Public administration and defence; compulsory social security, P: Education, Q: Human health and social work activities, R: Arts, entertainment and recreation, S: Other service activities, W: Unknown activities.

TABLE 3 Change (%) of labour productivity by sector and region in Greece during the period 2008-2016

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	W
Anatoliki Makedonia and Thraki	-73.5	10.6	-15.6	547.0	-16.3	-50.0	-15.3	-38.3	-46.6	82.2	9.4	11.4	-42.7	-8.9	-95.1	-84.3	-26.2	-36.0	-38.4	-75.6
Kentriki Makedonia	-67.6	-18.5	1.5	-4.5	-17.2	-29.6	-14.4	-35.5	-44.4	-36.9	-86.3	-1.0	-40.3	-22.3	-79.1	-75.2	-37.6	-57.4	-46.7	-48.9
Dytiki Makedonia	-55.3	-45.7	-9.8	45.5	82.6	-43.2	-23.9	-37.7	-48.3	-62.2	-14.0	-78.7	-58.5	-53.7	-92.0	-79.0	-71.2	-29.9	-34.6	-7.3
Ipeiros	-66.2	-6.5	53.6	271.4	-12.0	-49.6	-12.7	-35.4	-47.8	-34.3	115.0	-23.4	-43.9	-3.7	-81.5	-79.5	-33.4	-31.0	-85.9	-94.3
Thessalia	-78.4	-20.7	7.9	-28.7	-20.2	-11.0	-21.6	-45.1	-49.3	-33.6	-41.9	-50.7	-40.5	-27.1	-93.7	-70.4	-38.9	-33.7	8.2	-96.6
Sterea Ellada	-83.1	-25.8	-8.3	47.7	-10.6	-18.5	-25.7	-40.4	-55.7	-12.9	-76.6	1225.2	-49.4	-29.3	-17.5	-83.8	-14.4	-24.6	-39.8	-87.9
Ionia Nisia	-87.0	38.8	-22.3	138.1	0.2	-41.7	-21.6	-38.0	-23.8	34.6	-57.7	18.4	-39.2	7.2	-89.3	-76.7	-3.0	-3.2	-35.3	11.5
Dytiki Ellada	-78.6	126.0	16.2	637.7	-12.8	-31.8	-23.4	-47.8	-52.4	-16.8	-75.6	-22.5	-45.3	-25.7	-80.7	-61.7	-22.1	-6.0	-52.9	-92.8
Peloponnisos	-85.5	11.2	-4.3	353.9	-17.9	-32.7	-19.2	-39.1	-49.3	21.8	-2.4	-1.5	-43.4	-14.0	-68.1	-80.9	-40.9	-72.1	-42.8	-83.4
Attiki	-81.8	-36.7	-7.1	56.8	-1.9	10.6	-19.1	-17.2	-50.8	-20.9	-68.0	-4.0	-38.6	-42.0	-83.7	-67.8	-66.9	-48.9	-47.8	-49.9
Voreio Aigaio	-85.1	-41.4	-4.4	234.5	40.8	-54.2	-15.6	-55.5	-41.7	110.4	-35.0	40.3	-52.0	-39.5	-46.2	-84.1	-48.1	2.0	-49.3	-93.2
Notio Aigaio	-88.4	-36.3	-21.9	468.1	33.2	-47.9	-25.8	-39.0	-19.6	38.8	-27.0	-4.1	-43.6	-23.1	-90.3	-78.3	-20.3	-44.8	-39.5	-88.2
Kriti	-77.6	-26.6	3.7	977.2	-0.9	-42.3	-14.5	-38.4	-18.0	40.7	13.5	102.4	-28.3	54.3	-75.6	-76.1	-64.9	-34.6	-17.9	-40.5

Source: Processing of data from Tables 1 and 2.

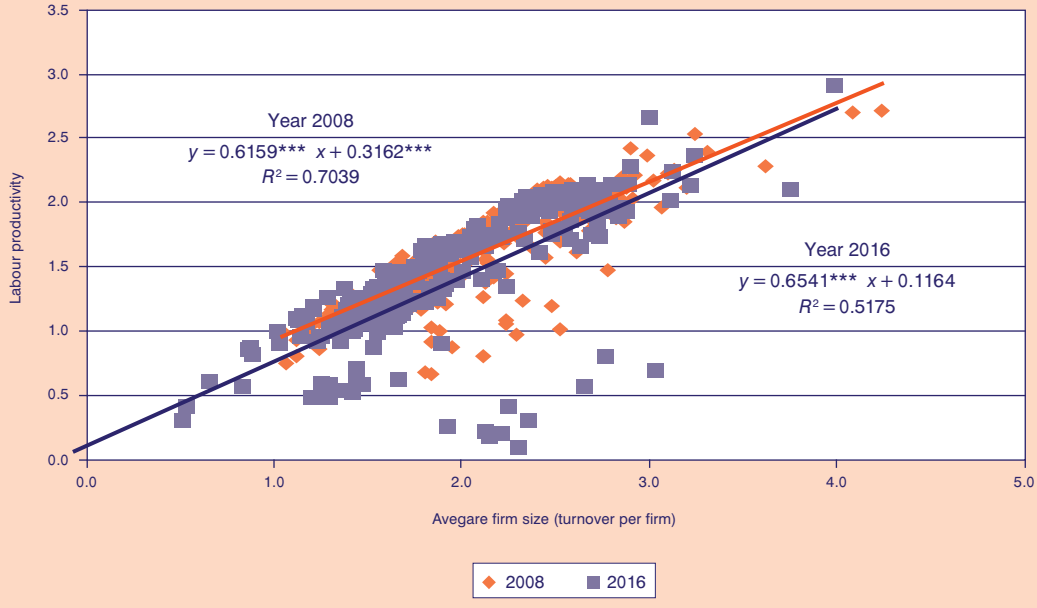
FIGURE 10
Relationship between labour productivity and the average number of workers by sector and region in Greece, 2008 and 2016



Source: Own processing of data from Business Registry, ELSTAT.

Note: *** Denotes statistical significance above 99% level of confidence.

FIGURE 11
Relationship between labour productivity and average firm turnover by sector and region in Greece, 2008 and 2016



Source: Own processing of data from Business Registry, ELSTAT.

Note: *** Denotes statistical significance above 99% level of confidence.

nificant and high correlation with labour productivity (Figure 11 above). However, the value of the coefficient of determination declined from 70% in 2008 to 52% in 2016, possibly indicating a reduced ability or a different strategy of local firms to exploit economies of scale in order to become more productive. These findings are consistent with those of previous studies in the literature concerning the adoption of different strategies of Greek firms, with regard to their size and according to the particular characteristics of each sector (and region), in order to obtain and exploit the required resources for increasing their productivity (Halkos and Tzeremes, 2007; Floros et al., 2014).

5. Conclusions

This article examined the developments, trends and problems pertaining to the productivity of the Greek economy, at the national, sectoral and regional levels. For this purpose, the variables of labour productivity as well as TFP were analysed for the whole country and for each region, by using a regional production function of the Cobb Douglas form, under the assumption of the existence of constant elasticity of substitution and constant returns to scale. Moreover, labour productivity was calculated for the sectors of economic activity at the national level and in each region separately.

In contrast with other countries (in the euro area, the EU and the OECD), Greece presented a reduction of labour productivity during the last decade (2008-2017), hence amplifying the divergence and lowering its competitiveness, namely, increasing its distance from the international/EU production frontier. At the same time, the TFP of the Greek economy also reduced in comparison to other countries. Despite the increase in labour productivity in (internationally) tradable goods sectors, such as manufacturing and agriculture, these sectors are still lagging behind services sectors. The results underline the need for the implementation of suitable policies which will rapidly boost the productivity and efficiency of the Greek economy, especially in internationally tradable sectors, to ensure the conditions for sustainable and resilient growth. Among others, such policies should encompass the larger and faster diffusion of new technologies and participation in global value chains.

During the period 2008-2016, the gap in productivity and TFP between the region of Attiki and the remaining regions of the country increased. Particularly, TFP decreased in all the regions (except for Dytiki Makedonia), although it has somewhat recovered since 2013. The larger reductions in both labour productivity and TFP are observed in the island regions of Voreio Aigaio, Notio Aigaio and Ionia Nisia. To the contrary, the region of Attiki reduced its productivity gap with the best-performing EU region.

The findings indicate some considerable differences in labour productivity among the sectors of a regional economy, as well as between regions with respect to a specific sector. In turn, further research is required to determine, at a finer level of analysis, the production conditions, the capital and labour shares of income, and the TFP in each region and sector of the country.[8] The analysis of labour productivity by sector and region using firm-level data would also be very useful, e.g., with the use of disaggregate data originating from the business registry and the annual industrial surveys. Such types of analysis would allow us to measure and interpret inequalities among the frontier and laggard firms and the main determinants, such as investment, export performance, R&D expenditure, technology level, human capital and knowledge intensity.

The statistically significant and positive correlation between human capital and TFP at the regional level suggests the importance of implementing labour and education policies aiming at improving the coupling (or reducing the mismatch) between the knowledge and skills of the economically active population and the actual needs of firms. At the level of national strategic growth planning, the objectives and policies of the sectoral growth plans (e.g., for transport, energy and the digital market) should be aligned and coordinated. In addition, these plans should be integrated with the special planning frameworks for main economic activities (fisheries, mining, renewable energy, manufacturing, tourism, and logistics). In this way, more locally targeted actions will be taken to strengthen productivity and reduce inequalities, avoiding possible conflicts between sectoral and regional policies.

The exploitation of scale economies, the networking among firms with related activities and the creation of activity clusters (e.g., in manufacturing, ICT, transport

8. Such an alternative and more flexible approach, which allows using different capital and labour shares of income by country/region, thus mirroring possible variations in the production structure, can be provided by the use of a translog production function (Beugelsdijk et al., 2018).

and logistics) are particularly important for the enhancement of innovation and productivity at the local level, through providing suitable incentives, according to the comparative advantages of each region. Nonetheless, the potential effects of selected policies must always be evaluated and weighted, among other criteria, with respect to the productivity growth rate and the reduction of inequalities. For instance, policies for the technological upgrading and ICT adoption of firms in some regions could foster productivity and, at the same time, increase (with the expansion of broadband networks) or reduce (with ICT skills development policies and cloud computing technologies) the inequalities or divergence between core and peripheral regions, and among frontier and laggard firms (Sorbe et al., 2019).

Acknowledgements

The author would like to thank an anonymous referee and Sotiris Papaioannou, Nikolaos Rodousakis and Roxani Karagiannis, Research Fellows at KEPE, for their helpful and constructive comments in previous versions of the paper. The author is responsible for any omission or error.

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