CENTRE OF PLANNING AND ECONOMIC RESEARCH (KEPE)

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SOTIRIS PAPAIOANNOU
THEODORE TSEKERIS
CHRISANTHOS TASSIS

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Sotiris Papaioannou
Senior Research Fellow, KEPE, Coordinator
Theodore Tsekeris
Senior Research Fellow, KEPE
Chrisanthos Tassis
Lecturer, Democritus University of Thrace

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CENTRE OF PLANNING AND ECONOMIC RESEARCH

The Centre was initially established as a research unit, under the title "Centre of Economic Research", in 1959. Its primary aims were the scientific study of the problems of the Greek economy, the encouragement of economic research and cooperation with other scientific institutions.

In 1964, the Centre acquired its present name and organizational structure, with the following additional objectives: first, the preparation of short, medium and long-term development plans, including plans for local and regional development as well as public investment plans, in accordance with guidelines laid down by the Government; second, the analysis of current developments in the Greek economy along with appropriate short and medium-term forecasts, the formulation of proposals for stabilization and development policies; and, third, the additional education of young economists, particularly in the fields of planning and economic development.

Today, KEPE is the largest economics research institute in Greece, focuses on applied research projects concerning the Greek economy and provides technical advice to the Greek government and the country's regional authorities on economic and social policy issues.

In the context of these activities, KEPE has issued more than 650 publications since its inception, and currently produces several series of publications, notably the Studies*, which are research monographs;* Reports *on applied economic issues concerning sectoral and regional problems;* Discussion Papers *that relate to ongoing research projects. KEPE also publishes a tri-annual review entitled* Greek Economic Outlook*, which focuses on issues of current economic interest for Greece.*

PREFACE

The quest for the determinants of productivity was born together with political economy. Adam Smith noted in 1776 that one of the major determinants of the wealth of nations was the “skill, dexterity, and judgment with which its labour is generally applied”. In the theories of economic growth, both exogenous and endogenous, from the 1950s onwards, econometric specifications have been devised in order to assess the impact of physical and human capital and labour on the rate of growth, leaving as a residual the “total factor productivity” that captured the role of technical (and not only) efficiency. KEPE, in its institutional role as the economic research arm of the Greek State, is interested in examining those factors that affect the productivity and the efficiency of the Greek economy. The study at hand, by Drs Papaioannou, Tsekeris, and Tassis, is an instance of KEPE’s concern with productivity. It takes properly into account the importance of the spatial dimension in measuring and quantifying the main determinants of the technical efficiency of all regions of a national economy. The case of Greece in the time period spanning 2000-2012 is of particular interest, amongst others, due to the advent of the persistent economic crisis (in 2008) and the geographical peculiarities of the country, which have resulted in significant disparities between the core region of Attica, where the capital city of Athens is located, and which produces almost half of the country’s GDP, and the periphery.

The authors make a valuable original contribution to the empirical literature of regional efficiency analysis in Greece. Based on the theoretical underpinnings of economic growth and new economic geography, they adopt an interesting econometric methodology to specify and consistently estimate a production function with a two-stage stochastic frontier analysis (SFA). In this way, they simultaneously estimate technical efficiency scores and determine key factors which significantly affect efficiency levels across Greek regions and sectors. The results can provide useful insights in understanding and interpreting diverse sources of *inefficiency in the Greek economy. Hence, suitable policy measures can be designed which are regionally and sectorally targeted and growth-oriented to expedite the economic recovery of the country.*

The findings of the study related to the significance of connectivity/accessibility within and between regions, urbanization economies and their dispersion, productive specialization, geographical concentration and human capital involve obvious policy implications for the effective deployment of the national strategic growth plan of Greece. These implications directly concern the regional and sectoral specification of the growth strategy, including policy measures that can address sectoral inefficiencies and combat regional inequalities and the increasing productivity gap between Attica and the other regions, which strongly experienced the adverse impact of the economic crisis on their efficiency. Such measures may encompass the reinforcement of local comparative advantages, intraregional and interregional transport improvements and strategic planning actions to strengthen local activity clusters and labour skills.

Finally, given the increasing attention given by international organizations such as the European Council to systematically monitor and report national productivity developments, the present study can constitute a valuable input to the measurement and analysis of productivity in Greece. This analysis would support the identification and the assessment of the potential effect of relevant policy options at the sectoral, regional and national level.

NICHOLAS THEOCARAKIS
Chairman of the Board
and Scientific Director

CENTRE OF PLANNING AND
ECONOMIC RESEARCH
December 2017

Productivity improvements have a durable effect on the long-term growth of an economy. However, productive efficiency may significantly vary within each country according to its sectoral and regional economic structure. During the period 2000-2012, the Greek regions witnessed a considerable variation in their total factor productivity growth rates, technology gaps and capital-to-output ratios. Significant variations were also observed in the productivity (in terms of gross value added per worked hour) and the unit labor cost across the Greek regions as well as the regions of OECD countries.

The present study adopts a consistent econometric modeling framework, relying on the foundations of growth theory and new economic geography, to estimate production functions with a two-stage stochastic frontier analysis. The model simultaneously yields efficiency scores and identifies factors which affect inefficiency in the Greek economy across regions and sectors. The findings reveal the existence of significant disparities in the levels of technical efficiency across regions and sectors. The most efficient regions are those of Attiki, Notio Aigaio and Dytiki Ellada. In contrast, Sterea Ellada and Peloponnisos are the least efficient regions. With the exception of Attiki, all other regions witnessed a drop in their efficiency performance from 2008 onwards, signifying the adverse impact of the economic crisis on the productivity of peripheral areas and the widening productivity gap between Attiki and the other regions. Similarly, most sectors of the Greek economy suffered a drop in their efficiency performance after 2008. The most efficient sectors are those of real estate, public administration and financial intermediation, with average scores close to or above 80%. The least efficient sectors are those of agriculture, forestry & fishing, and professional activities, with average scores below 50%.

These findings provide useful implications for policy actions, including the deployment of effective regional-sectoral policies aiming to diminish regional disparities and sectoral inefficiencies. In particular, they emphasize the need for exploiting local comparative advantages to promote regional efficiency. In addition to the significant efficiency-enhancing im-

pact of physical capital, labor force and technological progress, urbanization economies and their dispersion within regions as well as interregional market access have a considerable positive contribution to technical efficiency. Thus, both intraregional and interregional transport improvements should be regarded as important factors to eliminate technical inefficiencies in the Greek economy, while the strategic regional planning should be promoted to strengthen urban agglomerations in a way that enhances the polycentric development of peripheral areas. In addition, the substantially positive influence of regional specialization and sectoral concentration (instead of diversification) on technical efficiency stresses the importance of developing local activity clusters, in the form of industrial areas, science and technology parks, and logistics parks to promote innovation, through knowledge spillovers, and create productivity gains. Human capital, in terms of the share of hours worked by highly educated persons, has a considerable positive impact on reducing the inefficiencies of Greek regions. The latter outcome indicates the need for investing in education, not only in relation to younger generations but also to all age structures until retirement. Finally, political factors, such as the vote share of the government party, parliamentary seat difference between the government and the main opposition party, the governance of a region by a person belonging to the party in power and the electoral cycle, were not found to have any significant impact on the technical inefficiency of Greek regions.

We thank two anonymous referees for their insightful comments which helped us to substantially improve our study. We also thank Professor Nicholas Theocarakis, Professor Sophia Dimelis and our colleague Prodromos Prodromidis for their useful comments and suggestions. Finally we acknowledge the valuable editorial help of Helen Soultanakis and the kind assistance of the Editorial Office and Library stuff of KEPE.

SOTIRIS PAPAIOANNOU
THEODORE TSEKERIS
CHRISANTHOS TASSIS

May 2017

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CHAPTER 1

INTRODUCTION

The positive contribution of physical capital to various measures of productivity and efficiency, either for specific economic sectors or for the total economy, has been widely recognized in the current literature. However, the elasticities derived from empirical studies demonstrate considerable variations, according to the geographical scale, type of sectors, level of aggregation, and duration of the period of analysis. This fact suggests that the measurement of productivity requires an appropriate modeling specification to treat various intrinsic issues related to the sources of inefficiency. Most studies in the existing literature have focused on the country-wide or industry-wide and, to a lesser extent, the regional analysis of productivity.

Our study aims to fill this gap. We measure the efficiency of the regions and sectors of the Greek economy and identify sources of inefficiency at a single stage. We employ a stochastic frontier analysis to simultaneously derive production function estimates, efficiency scores and estimates of factors affecting the inefficiency of the regions and sectors. Provided that production functions do not accurately capture productivity changes, since infrastructure investments affect the location of economic activities (Haughwout, 1998), spatial effects on efficiency related to agglomeration externalities and market access should be taken into account. Several studies in the scant existing literature (Beeson and Husted, 1989; McCoy and Moomaw, 1995; Mitra, 2000; Driffield and Munday, 2001; Otsuka *et al.,* 2010; Otsuka and Goto, 2015) focused on how a single or a limited range of spatial agglomeration forces (e.g., those related to firm density or dispersion) influence the efficiency of a group of regional economies, mostly in the manufacturing sector.

The current study uses an integrated methodological framework of two-stage stochastic frontier analysis (Battese and Coelli, 1995) to offer a comprehensive investigation of a whole range of regional determinants on efficiency. The production function is specified so as to account for both the sectoral and regional dimensions of the economic activity in the country. The estimation framework simultaneously incorporates the effects on efficiency of key determinants associated with the spatial structure of economic activity, including the agglomeration economies and market access from both the interregional and intraregional perspective. In addition to the region's size or density and market access, the explanatory variables refer to the specialization and sectoral concentration, the human capital and fixed effects in each region. Moreover, they encompass a number of political factors, which have been hitherto considered in the existing literature to explain the level, regional allocation and cost-efficiency of public investment, rather than the distance to the production frontier.

The wider effects of spatial agglomeration economies on productivity and the regional and sectoral growth patterns are regarded as an important element in prioritizing capital investments (Andres *et al.*, 2015). However, formal approaches to assess productivity and efficiency changes resulting from agglomeration economies are scarcely implemented in practice. At the international level, the United Kingdom is considered to encompass the most notable assessment procedures for incorporating agglomeration benefits, largely due to urbanization and scale economies, into the macroeconomic analyses of physical capital investments (Economic Development Research Group, 2013). This type of productivity gain is used to extend benefit-cost analysis (BCA) methods to estimate wider productivity effects. Furthermore, the use of other methods, such as the multi-criteria analysis (MCA) for assessing public capital investment projects, increases the need for distinguishing the components of productivity and the sources of (in)efficiency, accounting for spatial agglomeration externalities (Weisbrod, 2015).

The present study allows measuring the outcome of different production processes across the Greek regions and sectors, over a time period where significant capital investments took place. Specifically, it originally implements the estimation framework described before into the Greek economy, taking into account the spatial structure and sectoral composition of the Greek regions. In this way, it extends previous studies (Vagionis and Spence, 1994; Louri, 1988) and contributes to the measurement and analysis of the total factor productivity of the country. The regional production function specified here can more accurately measure productivity growth, due to the ability to capture efficiency improvements resulting from agglomeration externalities, market access and human capital development. In contrast with previous studies (Rodríguez-Pose *et al.,* 2012; Psycharis *et al.,* 2014a; Psycharis *et al.,* 2014b; Petrakos and Psycharis, 2016), which concentrated on the response of other macroeconomic variables, such as regional output, income and employment, this study emphasizes the productivity of the Greek regions. It demonstrates that physical capital, (skilled) labor force, technological progress and spatial economic structure are all significant drivers of regional efficiency.

In turn, useful insights and reliable guidelines for policy purposes can be offered with regard to the regional and sectoral disparities in the total factor productivity, and decisions can be made about the possible location and composition of diverse types of productive investments (such as agricultural and transport infrastructure, and industrial, trade and logistics centres), to support the economic recovery and growth of the country. More specifically, regarding the role of spatial agglomeration-related variables, the results indicate the significant efficiency-enhancing impact of urbanization. The dispersion of urbanization economies within regions is also found to significantly promote efficiency. The results further support the significant positive influence of specialization on regional efficiency. We also find that sectoral concentration helps to reduce regional inefficiencies. With respect to the impact of human capital on technical inefficiency, the results verify that an increase in the share of hours worked by highly educated persons contributes significantly to reducing inefficiencies in Greek regions.

Significant disparities are found in the levels of technical efficiency across regions (see the Map in the Appendix) and industries of the Greek economy. The most efficient regions are those of Attiki, Notio Aigaio and Dytiki Ellada.[1] In contrast, Sterea Ellada and Peloponnisos

[1] The names of regions follow the nomenclature of territorial units for statistics (NUTS) of Eurostat. The translation of these names to English is Attiki: Attica,

were the least efficient regions in 2012. Efficiency scores rose constantly in all regions of Greece up to 2007. The economic crisis had significant adverse effects on the productivity of peripheral regions, widening the core-periphery gap. With the exception of Attiki, all other regions witnessed a drop in their efficiency performance from 2009 onwards. Only the island regions referring to Notio Aigaio and Ionia Nisia performed a very small recovery in technical efficiency in 2012, compared to 2011.

Similarly, most sectors of the Greek economy witnessed a drop in their efficiency levels after 2008. The industries with the highest efficiency scores are those of real estate, public administration and financial intermediation, with average scores close to or above 80% during 2000-2012. On the other hand, the least efficient industries are those of agriculture, forestry & fishing, and professional activities, with average efficiency scores below 50%.

Our study proceeds as follows: Chapter 2 discusses the findings of the relevant theoretical and empirical literature. Chapter 3 describes the econometric specification and construction of variables. Chapter 4 presents descriptive statistics of all variables used in the econometric analysis. Chapter 5 provides us with measures of regional and sectoral inefficiency and identifies factors which contribute to the reduction of inefficiency. Finally, Chapter 6 summarizes and concludes.

Kentriki Makedonia: Central Macedonia, Anatoliki-Makedonia-Thraki: Eastern Macedonia and Thrace, Thessalia: Thessaly, Dytiki Makedonia: Western Macedonia, Sterea Ellada: Central Greece, Ipeiros: Epirus, Ionia Nisia: Ionian Islands, Peloponnisos: Peloponnesus, Dytiki Ellada: Western Greece, Kriti: Crete, Voreio Aigaio: North Aegean, Notio Aigaio: South Aegean.

CHAPTER 2

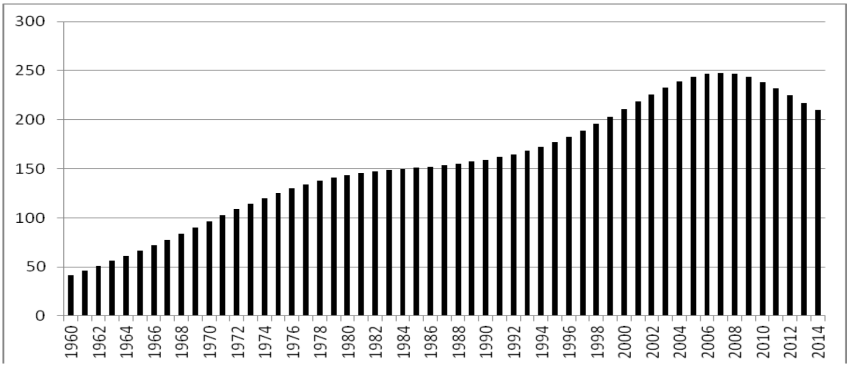
THEORETICAL BACKGROUND

2.1. Theoretical issues

2.1.1. Introduction to theory and stylized facts

Economic growth is one of the most extensively discussed topics in modern macroeconomics. The level of economic development of a country is determined by the amount of GDP produced within a year. Figure 2.1.1 shows the evolution of potential GDP of the Greek economy from 1960 onwards, as estimated with the use of the Hodrick-Prescott filter. Similarly Figure 2.1.2 illustrates the evolution of the output gap and GDP growth of the Greek economy.[2]

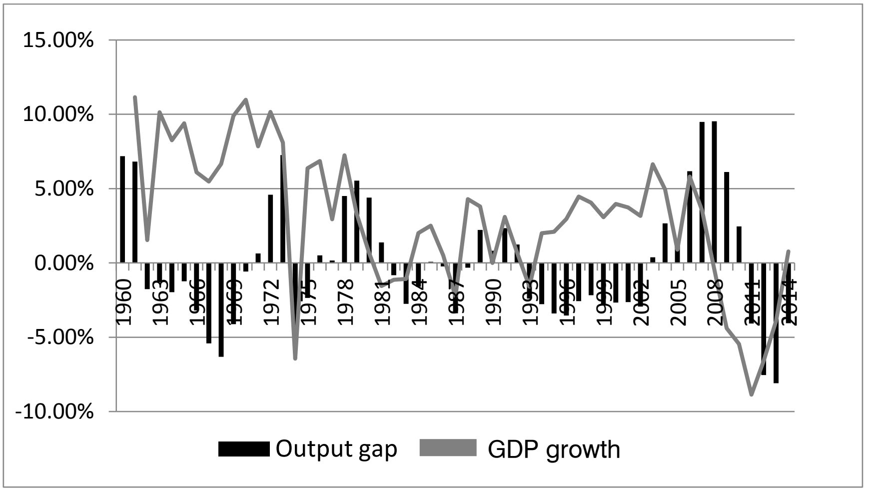
FIGURE 2.1.1
Potential GDP of the Greek economy, constant 2005 prices, USD



Source: Authors' calculations.

[2] Potential GDP is the amount of output that can be produced in the long run without the existence of inflationary pressures.

FIGURE 2.1.2
Output gap – GDP growth of the Greek economy



Source: Authors' calculations.

Despite the fact that significant fluctuations, as well as variations in GDP growth rates are observed during the cycle (Figure 2.1.2), it is clearly demonstrated that real income increases over time, albeit at different rates from period to period. This is due to the continuous improvement of productivity, the expanding labor supply, the impact of investments in gross fixed capital formation and the effects of technological change and innovation. These factors lead to a permanent increase of total long-term supply (movement of the supply curve from S_1 to S_2). The increase in aggregate supply allows the economy to operate at a higher level of total demand (movement of the demand curve from D_1 to D_2), which in turn leads to a significant and sustainable increase of actual income, without the appearance of inflationary pressures (Figure 2.1.3). Economic growth can also be depicted schematically by the outward shift of the production possibility curve (Figure 2.1.4).

After a careful inspection of Table 2.1.1, we observe that the growth rates of EU countries vary significantly. Average GDP growth rates during 1996-2014 range from below 1% (in countries like Greece and Italy) to higher than 4% (Poland, Ireland and Latvia). It is also clearly

FIGURE 2.1.3
Shift of the supply curve

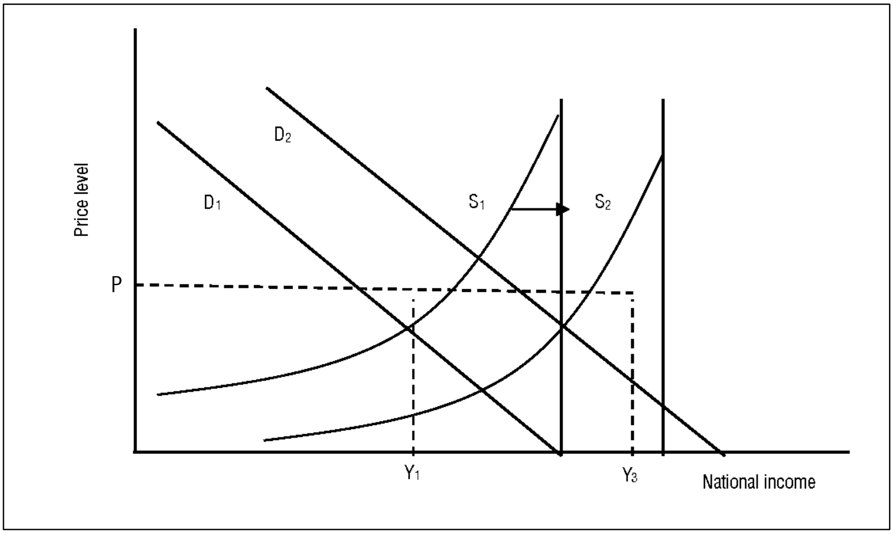


FIGURE 2.1.4
Shift of the production possibility frontier

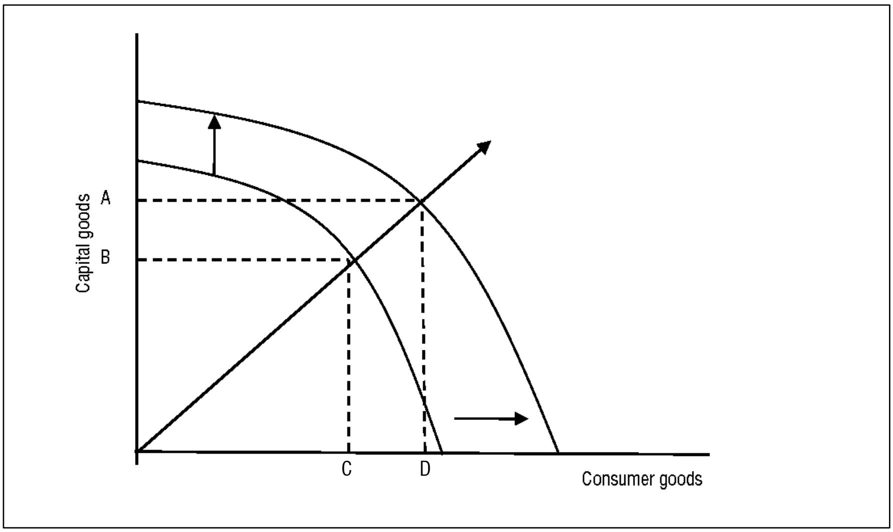


TABLE 2.1.1
Average growth rates of EU countries, 1996-2014
(in ascending order)

Country	1996-2014	1996-2008	2008-2014	Country	1996-2014	1996-2008	2008-2014
Italy	0.48%	1.32%	-1.30%	Malta***	2.21%	2.44%	2.12%
Greece	0.97%	3.60%	-4.12%	Finland	2.25%	3.72%	-0.71%
Portugal	1.12%	2.23%	-1.06%	Czech Republic	2.31%	3.37%	0.38%
Denmark	1.23%	1.98%	-0.43%	Sweden	2.39%	2.97%	0.88%
Germany	1.29%	1.57%	0.74%	Slovenia	2.54%	4.25%	-0.52%
France	1.57%	2.14%	0.33%	Lithuania****			0.80%
Belgium	1.73%	2.30%	0.56%	Romania	2.69%	3.94%	1.21%
Austria	1.82%	2.48%	0.56%	Bulgaria*	2.72%	4.00%	0.95%
Netherlands	1.90%	2.87%	0.07%	Luxembourg***	2.83%	3.43%	1.62%
Croatia	2.04%	3.98%	-1.55%	Slovakia**	3.66%	4.97%	1.87%
Cyprus	2.10%	3.87%	-0.97%	Estonia***	3.79%	6.09%	-0.14%
United Kingdom	2.11%	2.74%	0.60%	Poland	4.06%	4.55%	3.14%
Spain	2.12%	3.57%	-0.71%	Ireland	4.26%	6.17%	-0.26%
Hungary	2.17%	3.19%	0.08%	Latvia	4.46%	6.57%	-0.55%

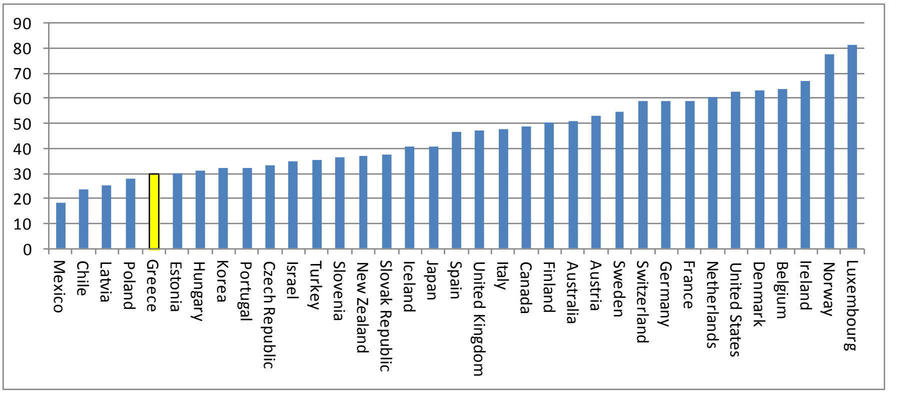
Source: Eurostat (2014). *From 1997 onwards. **From 1998 onwards. *** From 2001 onwards. **** From 2006 onwards.

demonstrated that the comparative performance of all countries deteriorated during 2008-2014, due to the impact of the economic crisis, with average GDP growth rates being negative or slightly positive in most countries. During the latter period, Greece had the worst performance with an average growth rate of -4.1%.

The question that arises is what factors determine such differences in growth rates among countries. Some of these factors are changes in consumer and business confidence, changes in demand conditions, as well as monetary and fiscal policy, all of which having a temporary influence on economic growth. Other factors, such as the increase of population or the improvement of productivity, have a more durable effect and determine the growth rate of an economy over a long-term horizon.

Figure 2.1.5 presents the average annual levels of labor productivity of OECD countries, expressed in GDP per hour of work. It is obvious that the productivity of the Greek economy is very low and remains at levels below $30 per hour of work. At the same time, the productivity of some other European countries (e.g. Norway and Luxemburg) is more than double that of Greece.

FIGURE 2.1.5
GDP per hour of work (constant 2005 prices, USD), 2014



Source: OECD Productivity Database (2014).

In the following section, we provide a brief overview of the main theories of economic growth. Most of this chapter is devoted to the analysis of neoclassical and endogenous growth models. These models describe the main mechanisms under which economic growth emerges in the long run and attempt to identify the determinants that affect this process. The basic conclusion that arises is that supply side factors are the main drivers of long-run economic growth. Technological progress and productivity advancements contribute substantially to long-run economic growth.

2.1.2. The neoclassical growth model

The neoclassical growth model was simultaneously developed by Solow (1956) and Swan (1956). Its basic assumptions are a) the existence of diminishing returns to capital and labor, and b) the existence of a fixed savings rate by households. The income of the economy is determined in competitive equilibrium simultaneously by households, which maximize their intertemporal welfare function, and by firms which maximize their profits.

Due to the existence of diminishing returns in the neoclassical growth model, per capita output of the economy may increase over time if the capital-labor ratio increases. However, in the long-run, equilibrium, the capital-labor ratio remains constant. Thus, the Solow-Swan model suggests that the only way to achieve positive growth rates of GDP is to eliminate diminishing returns in labor and capital by introducing the parameter of technological progress, which is considered as exogenously determined.

The neoclassical model with technological progress assumes that the macroeconomic production function incorporates the parameter of technology A, which reflects the current level of knowledge and grows at a constant rate. It is assumed that the production function of an economy has the following form (for details see Note in Appendix):

$$Y = (AL)^{1-a} K^{a} \qquad (2.1)$$

where Y is the output and A the technological parameter, and the parameters L and K are the inputs of labor and capital, respectively, while α and $1-\alpha$ are the income shares of capital and labor, respectively.[3] A production function of this form renders technological progress as an augmenting factor that improves the efficiency of labor (Harrod neutral technical progress). It also assumes that the relative income shares and, hence, the returns to the inputs of capital and labor are constant. Namely, the growth of output is equivalent to the growth of production inputs. This production function implies that constant sha-

[3] Technical change of a given production function might also exhibit Hicks neutrality when it is neither labor augmenting nor capital augmenting or Solow neutrality when it is capital saving.

res of output are allocated to capital and labor, even though the capital-labor ratio may change over time. Therefore, per capita output will grow in the long run at a rate which is equal to the growth rate of technological progress.[4] Intuitively, as capital accumulates, technological progress offsets the negative effects of diminishing returns of inputs. The economy approaches, in the long run, a steady state in which the only parameter that affects the rate of economic growth is the exogenous rate of technological progress.[5]

It should be noticed that the assumption of exogenous technological progress is considered as rather unrealistic, as it implies that research and innovation are not affected by the decisions of economic agents. This is in sharp contrast to the way economies operate, as research and innovation are outcomes of a systematic effort by the private and public sector of the economy. However, assuming endogenous technological progress within a neoclassical model is not feasible, as it comes in contrast to the hypothesis of competition. The introduction of this hypothesis requires the adoption of monopolistic competition, as a way to protect copyrights and allow the economic exploitation of rents. Such modifications have been introduced in various forms of first generation endogenous growth models.

2.1.3. Endogenous growth models

The neoclassical theories of Solow (1956) and Swan (1956) assume that the growth rate of the economy depends on exogenous technological progress. In contrast, endogenous growth theory supports that the rate of technological progress is determined within the economy, which provides the incentives and opportunities to create new technology. Technological progress originates from learning and innovation and emerges in the form of new products, new markets

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4 It should be noted that technological change cannot necessarily be introduced into the production function in this form. It could increase the efficiency of capital (Solow neutrality) or increase the efficiency of both inputs (Hicks neutrality). However, the growth rate of per capita output, in equilibrium, follows the growth rate of technological progress.

5 A variant of the neoclassical model of Solow-Swan is the model of Cass (1965) and Koopmans (1965), in which the savings rate becomes endogenous.

and new production methods. Innovation, in turn, is considered as the result of R&D undertaken by the private sector. Therefore, economic policies related to trade, competition, education, taxes and intellectual property rights may indirectly affect technological progress and ultimately affect the costs and benefits of R&D.

First generation endogenous growth models

A first wave of innovation-based models is widely known as first generation endogenous growth models. One version was conceived by Paul Romer (1990), who made the assumption that the economy-wide productivity is an increasing function of the degree of product diversity. In this theory, innovation causes increased productivity through new product varieties. Through the following production function, final output is produced by the input of labor L and a flow of intermediate goods:

$$Y = L^{1-a} \int_0^A x(i)^a di, \qquad 0 < a < 1 \qquad (2.2)$$

where $x(i)$ is the flow of intermediate products i, while A represents the amount of intermediate goods which are available for use. Intuitively, increasing the variety of products, as measured by A, increases the productivity of the economy.

Other versions of first generation endogenous growth models arose in the studies of Grossman and Helpman (1991) and Aghion and Howitt (1992). They focus on innovation which leads to the increased quality of new products and the replacement of old ones, through the process of ‘creative destruction’. According to these models, the total amount of output is obtained by a continuous stream of intermediate products, according to the following function:

$$Y = L^{1-a} \int_0^1 A(i)^{1-a} x(i)^a di, \qquad (2.3)$$

where now each intermediate product i has a separate productivity parameter equal to $A(i)$. In the first generation endogenous growth models, each sector of the economy operates under monopoly conditions and produces its intermediate product with a constant marginal cost.

Such innovation-based models assume that a constant variety of new improved products emerges, whose productivity is higher than that of products being replaced. The growth rate of output is a positive function of the percentage of income that is spent on R&D. Therefore, the economy grows over time by saving income and investing it in R&D, which, in turn, is influenced by several government policies that create incentives and provide opportunities for the private sector.

Second generation (Schumpeterian) endogenous growth models

First generation endogenous growth models state that growth is driven by the economy-wide stock of R&D and that growth is proportional to the total amount of R&D. Following Jones' (1995a) critique that predictions of these models were not consistent with the observed empirical evidence, second generation growth models emerged, such as the semi-endogenous (Jones, 1995b; Kortum, 1997; Segerstrom 1998) and the Schumpeterian growth models.

The main prediction of Schumpeterian growth models (Aghion and Howitt, 1998; Dinopoulos and Thompson, 1998; Peretto, 1998; Howitt, 1999; Peretto and Smulders, 2002) is that long-run economic growth is driven by research intensity. In relation to the first generation endogenous growth models, they maintain the assumption of scale effects. However, they assume that, as the economy expands and new varieties are discovered, the effectiveness of R&D becomes diluted, as it is spread among a greater number of product lines. To ensure sustained TFP growth, R&D has to increase over time to counteract the increasing range of products that lower the productivity effects of R&D.[6] In this manner, growth is driven by research intensity and R&D has permanent effects on growth. The empirical studies of Ha and Howitt (2007) and Madsen (2008, 2010b) found that the Schumpeterian growth models are consistent with the evidence and output growth is driven by research intensity.

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6 Whether R&D will have permanent or temporary growth effects depends on whether there are scale effects in ideas production. If the knowledge scale parameter in the ideas production function γ is lower than one, as in semi-endogenous growth theory, then R&D has only transitory growth effects. In contrast, if $\gamma = 1$, as in Schumpeterian growth models, then this implies that, as long as the research intensity is positive, the economy will continue to grow.

Human capital

Human capital-based theories of economic growth stem from Becker (1964; 1993) and Schultz (1971) and support that a higher stock of human capital, in the form of investing in education, makes people and workers more efficient. Such theories argue that investment in human capital brings about social benefits that are higher than their private returns. Mamuneas and Savvides (1999) calculated the social return on human capital and showed that, in Greece, the social return of education is higher than its private return (5.7% vs. 2.7%). This difference between social and private returns implies the existence of positive externalities in the economy and justifies state intervention to achieve the optimal level of human capital.

The basic idea behind growth theories based on knowledge and human capital is that a well-trained labor force is in a relatively more favorable position to assimilate and adopt new technologies, the use of which leads to increased productivity and ultimately higher economic growth. According to Nelson and Phelps (1966), the ability of a country to imitate and absorb technologies from other countries and the capacity to innovate and produce technology is a function of the available stock of human capital. Similarly, the higher the quality of human capital, the higher the aggregate productivity, as workers adapt more effectively to new technologies and refine their specialization.

In this context, Lucas (1990) tried to explain the lack of capital flow from developed to less developed countries, where the marginal product of capital is comparatively higher. His main conclusion was that differences in capital returns should not be considered as the most significant factor for the attraction of foreign investments. He argued that developed countries are in a more favorable position to attract investment as they have a higher availability of human capital and can make efficient use of their resources.

A first attempt to model the process of human capital accumulation is described in Arrow's (1962) model of learning by doing, in which human capital is the indirect outcome of physical capital accumulation. It is argued that through learning by doing workers learn more efficient ways to use physical capital which, in turn, leads to a higher level of knowledge and the elimination of diminishing returns. A second group of models assumes that there is a formal sector in the economy in which resources are allocated to create new human capital (Lucas, 1988).

2.1.4. Regional dimension of growth

In addition to the existing level of capital investment, government policies and institutional settings, the geographical characteristics of countries and regions may lead to differences in the technology available to individuals and/or affect the return of investments in physical and human capital (Acemoglu, 2008). The regional dimension of economic growth has been stressed in several studies, with the use of regional production functions and growth accounting models, which allow the identification of spatial differences in physical capital stock, labor force and technology contributions to the productivity growth of specific regions and the country's TFP (Armstrong and Taylor, 2000; McCann, 2013). Under certain assumptions, if we can model the production function of one region, we can model the production function of all regions within the same economic system, since, in the long run, the regional integration process will make all regional production functions converge (McCann, 2013). Such regional models can offer valuable insight in deploying active regional policies (e.g., industrial concentration and restructuring) and plans to reduce regional disparities, strengthen territorial cohesion and achieve fast and balanced regional productivity growth.

Armstrong and Taylor (2000) reviewed both theoretically and empirically a set of government policies, such as location control and pro-business measures, capital subsidies (investment grants) and labor subsidies that have been employed in the UK, other EU countries and elsewhere to promote regional economic performance and reduce regional disparities. McCann (2013) further discussed various analytical approaches for understanding the nature of regional growth. Among others, he emphasized that regional growth may take place via the location behavior of a firm and that localized development may be dependent on the sectoral origins of growth.

The adoption of the neoclassical growth model, where the per capita growth rate tends to be inversely related to the starting level of per capita output (or income), implies the interregional convergence, due to diminishing returns to capital, as each addition to the capital stock generates very large additions to output when the capital stock of a region is small, and vice versa. Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996) verified the phenomenon of convergence among the US states as well as between a sample of regions in Europe and other countries worldwide for a long period of time. Specifically, they demonstrated that poorer regional economies tend to grow faster in per capita terms than richer economies. The above well-documented phenomenon in a set of regional economies where a negative relation is found between the per capita growth rate of output (or income) and the initial level of output (or income) is known as (absolute or unconditional) *β*-convergence.

In brief, let $\gamma_{i,t,t+T} \equiv \log\left(y_{i,t+T}/y_{i,t}\right)/T$ be the average annual per capita GDP growth rate of region i between the initial year t and the final year $t+T$, where T is the length of the time period of analysis, and let $\log\left(y_{i,t}\right)$ be the logarithm of the region's i GDP per capita at year t. If we estimate the regression:

$$\gamma_{i,t,t+T} = \alpha - \beta \log\left(y_{i,t}\right) + \varepsilon_{i,t}, \tag{2.4}$$

and we find $\beta > 0$, then it is considered that the dataset shows (absolute or unconditional) *β*-convergence. If a set of regional economies are converging in the sense that the dispersion σ of their real per capita GDP levels tends to decrease over the sample period, namely, $\sigma_{t+T} < \sigma_t$, where σ is the standard deviation (or some other measure of variance) of $\log\left(y_{i,t}\right)$ at year t, then the dataset exhibits *σ*-convergence.

Although the *β*-convergence and *σ*-convergence are concepts related to each other, the former is regarded to capture, over time, structural characteristics concerning the transformation of a group of regional economies from poorer to richer and vice versa (Sala-i-Martin, 1996). Hence, *β*-convergence is a necessary but not a sufficient condition for *σ*-convergence. Jones (2002) reported that the convergence hypothesis is validated only for the rich but not for the poor countries. The basic explanation that has been offered by the neoclassical growth model is that poor countries do not share the same steady-state level of income with rich countries and that they tend to converge to their own equilibrium level, which is comparatively lower than that of industrialized economies. In addition, Armstrong and Taylor (2000) showed that significant growth disparities exist among regions, which cannot be fully explained by neoclassical economics. They highlighted that the economic prosperity of regions is highly dependent upon their performance in international markets.

It is further noted that the β-convergence analysis only makes it possible to conclude that the behavior of a set of regional economies is compatible with the neoclassical growth model, but it does not suggest whether output gaps between those economies widen or narrow (Gluschenko, 2012). Moreover, the consideration of the industry mix (sectoral composition) of regional economies in the specification of the production function can offer further insight into explaining the productivity growth and convergence among regions. In particular, differences in the productivity growth and convergence rates across sectors can help to understand why productivity gaps between regions exist and (dis)appear (Carree *et al.*, 2000).

2.2. Aggregate total factor productivity

2.2.1. Growth accounting-based estimates

In this section we will try to briefly illustrate the productivity performance of the Greek economy, in terms of TFP growth and in relation to other high-income OECD countries. We first start with growth accounting. A Cobb Douglas production function of the following form is assumed:

$$Y_{i,t} = A_{i,t}\left(K_{i,t}\right)^{a}\left(L_{i,t}\right)^{(1-a)}, \qquad (2.5)$$

where $Y_{i,t}$ represents the GDP of each country i in period t, K is the physical capital stock of each country and L is the labor input, measured in total hours worked. A is a labor and capital neutral technology parameter, associated with TFP, t is a time index and a is the income share of capital, which varies across countries and time.

It is noted that the Cobb-Douglas production function has been widely used in the last three decades to determine the contribution of public capital on economic growth. In particular, Aschauer (1989a, 1989b) adopted a Cobb-Douglas form of a national-level production function to indicate that decreases in the growth of infrastructure investment were a primary factor in the decline in US productivity. Munnell and Cook (1990) also showed that regions (states) that have invested more in infrastructure tend to have more output, private investment and employment growth, while a higher concentration of firms and employees enhances regional productivity. Furthermore, Mikelbak and Jackson (2000) highlighted the crucial role of spatial factors on the relationship between public capital and the economy, signifying that national-level analysis considers only the net effect of various spatial processes involved; when these processes are considered, the net positive effect of public capital on production is possibly smaller than that found at the country level. Later studies (Romp and De Haan, 2007) confirmed the important positive role of public capital on economic growth, but also stressed that the impact reported was not as big as earlier studies suggested, as the estimated national benefits are not tied to any one location and there may be significant spatial variations.

The data used here for growth accounting were taken from the Penn World Table 8.0 Database (see Feenstra *et al.,* 2015). Penn World Tables is a National Accounts' database that contains properly updated and internationally compared economic time series. The availability of unique data for physical capital at the aggregate level and the long time range are the main reasons that this database was chosen to analyze the TFP growth of the Greek economy. Values for output and physical capital are in 2005 chained PPP dollars. The income shares of capital and labor, a and $1-a$, were measured directly with the use of labor compensation data (provided by the Penn World Table 8.0 Database). The variable of total hours worked is measured as the product of the average hours per person by the number of persons engaged.

After taking logarithms and first-differencing both sides of equation (2.5), we obtain:

$$\ln\left(\frac{Y_{i,t}}{Y_{i,t-1}}\right) = \ln\left(\frac{A_{i,t}}{A_{i,t-1}}\right) + a\ln\left(\frac{K_{i,t}}{K_{i,t-1}}\right) + (1-a)\ln\left(\frac{L_{i,t}}{L_{i,t-1}}\right) \qquad (2.6)$$

Equation (2.6) indicates the main sources of growth of an economy.[7] In particular, the growth rate of output, $\ln(Y_{i,t}/Y_{i,t-1})$, is comprised of three main components: the growth rate of hours worked, $\ln(L_{i,t}/L_{i,t-1})$, multiplied by its income share $(1 - \alpha)$, the growth rate of capital, $\ln(K_{i,t}/K_{i,t-1})$, multiplied by its income share (α) and TFP growth, $\ln(A_{i,t}/A_{i,t-1})$. TFP is the part of output growth not attributable to inputs and includes technological change and the efficiency with which the inputs are used.

Estimates of TFP growth and the related contribution of labor and capital for the Greek economy are reported in Table 2.2.1. We observe that the economic growth of Greece has changed paths over time, with the main characteristic being the considerable fluctuations of GDP growth rates. Specifically, the average growth rate of the Greek economy for the period between 1976 and 2011 was 2.62%. Accordingly, total hours worked and physical capital followed a similar path over time, with the main feature being the existence of major fluctuations. The average growth rate of total hours worked was 0.38%, while the average growth rate of physical capital was 3.82%. The growth contribution of hours to GDP growth was 0.27% for the whole period, while the growth contribution of physical capital was 1.21%. The TFP growth contribution was 1.15%.

We also observe that, except for the decade of the 1990s, TFP growth rates for the Greek economy remained at very low levels. This becomes more obvious when we compare its TFP growth performance relative to that of other high-income countries (Table 2.2.2). For the whole period between 1976 and 2011, the performance of the Greek economy remained at moderate levels, with an average TFP growth rate at 1.15%. The highest TFP growth rates over the entire period are reported for Ireland, Germany and Japan. On the contrary, Canada, New Zealand and Switzerland have experienced quite low or even negative TFP growth rates during this period.

7 It is assumed that inputs are paid according to their marginal products and therefore the income shares of labor and capital sum up to 1.

TABLE 2.2.1
TFP growth rates for the Greek economy

Year	GDP growth	Total hours worked growth	Physical capital growth	Growth contribution of total hours worked	Growth contribution of total physical capital	TFP growth
1976	6.59%	0.17%	5.11%	0.12%	1.59%	4.89%
1977	2.14%	-0.14%	4.99%	-0.10%	1.55%	0.69%
1978	6.78%	-0.23%	6.12%	-0.16%	1.90%	5.04%
1979	2.56%	0.36%	5.47%	0.25%	1.70%	0.62%
1980	1.56%	1.12%	5.03%	0.77%	1.56%	-0.78%
1981	-0.12%	4.70%	4.56%	3.24%	1.42%	-4.78%
1982	-2.06%	-1.09%	1.76%	-0.75%	0.55%	-1.85%
1983	-1.23%	0.69%	2.79%	0.48%	0.86%	-2.57%
1984	2.74%	-3.04%	2.44%	-2.10%	0.76%	4.08%
1985	4.05%	2.49%	3.70%	1.72%	1.15%	1.18%
1986	2.43%	-0.36%	3.99%	-0.25%	1.24%	1.45%
1987	-1.38%	-2.06%	2.57%	-1.42%	0.80%	-0.75%
1988	6.70%	1.55%	4.22%	1.07%	1.31%	4.33%
1989	5.20%	2.02%	3.45%	1.40%	1.07%	2.74%
1990	0.97%	0.92%	3.07%	0.63%	0.95%	-0.62%
1991	5.92%	-1.91%	5.08%	-1.32%	1.58%	5.66%
1992	1.67%	3.17%	2.86%	2.18%	0.89%	-1.40%
1993	1.64%	2.38%	4.80%	1.64%	1.49%	-1.49%
1994	5.22%	0.80%	4.56%	0.55%	1.42%	3.25%
1995	3.88%	1.03%	3.33%	0.71%	1.03%	2.14%
1996	1.65%	0.95%	1.22%	0.67%	0.36%	0.62%
1997	7.66%	0.93%	6.27%	0.64%	1.94%	5.08%
1998	3.88%	-2.53%	3.26%	-1.74%	1.01%	4.61%
1999	3.78%	-0.01%	3.62%	0.00%	1.12%	2.67%
2000	8.46%	-0.24%	7.53%	-0.16%	2.35%	6.27%
2001	5.07%	0.35%	4.48%	0.24%	1.41%	3.42%
2002	5.39%	1.81%	5.97%	1.25%	1.86%	2.29%
2003	-0.78%	1.01%	-2.03%	0.70%	-0.62%	-0.87%
2004	3.59%	1.53%	3.49%	1.06%	1.08%	1.45%
2005	0.75%	3.70%	1.83%	2.61%	0.54%	-2.40%
2006	5.07%	0.64%	4.20%	0.42%	1.43%	3.22%
2007	-0.32%	0.15%	1.31%	0.09%	0.47%	-0.88%
2008	4.22%	-2.97%	8.06%	-1.93%	2.82%	3.33%
2009	-0.16%	1.96%	5.40%	1.31%	1.80%	-3.27%
2010	-1.94%	-1.50%	2.86%	-1.00%	0.95%	-1.89%
2011	-7.11%	-4.52%	0.16%	-3.01%	0.05%	-4.16%

In most countries, output growth is mainly driven by the high contribution of TFP growth. This evidence confirms the findings of Jones and Olken (2008), having shown that shifts in the growth process are largely due to changes in productivity growth and do not rely on changes in the factors of production. Prescott (1998) has also argued that TFP is the basic determinant of income differences across the world economy. Comparable evidence has been offered by Kehoe and Prescott (2002), indicating that the rate of TFP can adequately explain long economic periods of many developed countries.

Based on growth accounting, we derive measures of technology gaps for Greece as well as for each OECD country *i* at time *t*, which emerge as their level of TFP relative to the level of TFP of the US economy ($TFP_{US,t}$), as follows:

$$Technology\ gap = \ln(\frac{A_{USAt}}{A_{it}}) = \ln(\frac{Y_{USAt}}{Y_{it}}) - a_K \ln(\frac{K_{USAt}}{K_{it}}) - (1-a_K)\ln(\frac{L_{USAt}}{L_{it}}) \quad (2.7)$$

Figure 2.2.1 illustrates the evolution of the technology gap of the Greek economy across time. It is clear that the distance of the Greek economy from the technology frontier has remained practically unchanged, as the technology gap in 2011 was almost equal to that of 1975. We observe a slight deceleration of the technology gap during 1996-2002, but then it widened again, at the end of the 2000s with the advent of the crisis. The existence of a large technology gap implies that the level of technological progress of the Greek economy is low and substantially lower than that of most developed countries. However, it also implies that there is significant space for convergence of the Greek economy towards the technology frontier.

Table 2.2.3 offers a comparative illustration of technology gaps among OECD countries. There is a significant number of countries (Norway, Ireland, Sweden, the Netherlands, Switzerland, Germany etc.) which have managed to improve their relative position over time and now operate at the technology frontier. In contrast, there also exist countries which have practically failed to converge (Greece, New Zealand, Portugal) or have diverged (Italy, Iceland), demonstrating their inability to take advantage of the technological progress achieved in other economies.

TABLE 2.2.2
TFP growth rates across OECD countries

Country	1976-1990		1990-2000		2000-11		1976-2011	
	Average TFP growth	Average TFP growth contribution	Average TFP growth	Average TFP growth contribution	Average TFP growth	Average TFP growth contribution	Average TFP growth	Average TFP growth contribution
Canada	-0.12%	-3.58%	0.24%	9.89%	-1.21%	-118.12%	-0.37%	-15.96%
New Zealand	0.94%	43.02%	1.07%	31.77%	-1.00%	-81.89%	0.37%	16.68%
Switzerland	0.31%	14.69%	0.29%	13.37%	1.10%	40.06%	0.49%	21.88%
Australia	0.68%	20.12%	1.34%	40.74%	-0.51%	-27.21%	0.61%	20.28%
Iceland	1.77%	46.74%	0.62%	25.80%	-0.52%	-202.88%	0.71%	31.43%
Sweden	0.44%	20.98%	1.77%	60.24%	0.61%	30.21%	0.80%	36.62%
Portugal	1.40%	40.08%	0.97%	20.73%	-0.47%	-28.76%	0.81%	26.39%
Belgium	1.38%	71.60%	1.68%	57.16%	-0.03%	-1.83%	0.84%	45.98%
United States	0.93%	28.83%	1.37%	41.59%	0.64%	38.35%	0.95%	34.55%
Spain	1.49%	64.04%	1.27%	26.43%	0.24%	7.67%	1.02%	32.85%
Denmark	1.38%	63.61%	1.99%	59.85%	0.16%	16.49%	1.06%	54.03%
Italy	1.87%	49.82%	1.62%	53.98%	-0.10%	-10.08%	1.13%	43.86%
Greece	0.91%	36.97%	2.44%	59.89%	0.54%	29.32%	1.15%	43.72%
Austria	1.03%	42.77%	2.62%	62.45%	0.70%	42.81%	1.26%	50.57%
Luxembourg	2.31%	70.43%	2.69%	38.09%	-1.09%	-54.32%	1.26%	33.58%
France	1.61%	76.98%	1.79%	62.28%	0.68%	40.29%	1.27%	62.55%
Norway	1.95%	53.91%	2.88%	63.26%	-0.29%	-18.72%	1.28%	42.79%
Netherlands	1.13%	57.33%	2.22%	51.02%	1.33%	55.08%	1.30%	52.98%
Finland	1.59%	53.78%	2.25%	86.76%	0.60%	32.94%	1.41%	58.14%
United Kingdom	1.74%	71.03%	2.27%	65.94%	0.39%	31.39%	1.43%	62.65%
Germany	2.00%	75.43%	2.29%	66.57%	1.18%	61.20%	1.67%	66.50%
Japan	2.05%	42.27%	1.94%	64.32%	1.32%	144.61%	1.67%	57.01%
Ireland	2.67%	60.71%	4.04%	54.33%	0.90%	20.40%	2.39%	47.66%

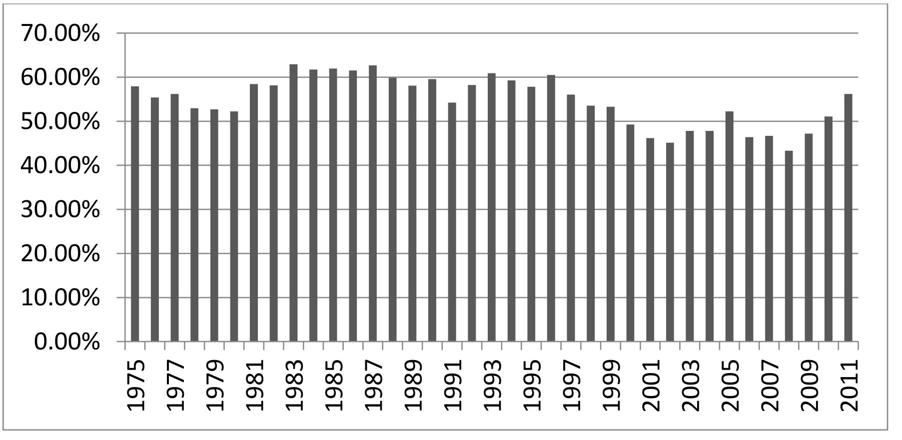
Note: Countries are sorted by average TFP growth over the period 1976-2011.

TABLE 2.2.3
Technology gaps across OECD countries

Country	1975-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2011
Norway	-20.09%	-21.88%	-22.61%	-29.74%	-33.60%	-41.51%	-28.82%
Ireland	30.40%	22.12%	14.61%	-0.17%	-20.17%	-27.44%	-20.88%
Sweden	9.46%	13.39%	3.74%	2.68%	-0.44%	-3.38%	-1.80%
Netherlands	4.88%	7.89%	6.01%	4.88%	5.00%	1.43%	-0.31%
Switzerland	-7.00%	-5.13%	-1.59%	5.51%	9.90%	12.19%	6.29%
Germany	23.65%	25.70%	18.83%	8.25%	9.05%	8.98%	6.42%
Luxembourg	19.56%	22.33%	7.56%	-2.21%	-4.22%	-3.33%	6.46%
United Kingdom	21.07%	16.13%	13.18%	12.91%	7.41%	3.52%	7.34%
France	16.14%	13.37%	11.91%	11.25%	10.39%	8.90%	10.81%
Canada	-26.42%	-21.05%	-18.42%	-11.01%	-6.92%	-1.31%	12.01%
Belgium	4.29%	6.21%	4.08%	0.10%	4.40%	4.92%	13.28%
Denmark	21.24%	22.43%	16.39%	13.23%	12.17%	15.43%	19.79%
Austria	28.97%	34.21%	31.88%	22.03%	18.92%	20.14%	21.03%
Finland	41.56%	36.99%	33.02%	34.50%	25.94%	23.85%	23.37%
Australia	12.78%	12.25%	13.34%	13.68%	13.31%	14.41%	23.53%
Spain	29.28%	27.02%	23.64%	21.29%	21.15%	25.10%	25.58%
New Zealand	23.95%	23.17%	12.83%	12.38%	13.99%	16.32%	25.83%
Italy	26.58%	24.34%	23.33%	21.15%	20.28%	27.11%	30.48%
Japan	49.47%	46.55%	42.78%	32.99%	35.89%	38.20%	37.42%
Greece	54.57%	60.64%	60.35%	58.09%	54.52%	47.83%	48.47%
Iceland	32.50%	28.38%	26.68%	34.80%	37.69%	38.24%	49.97%
Portugal	55.76%	53.16%	49.64%	50.60%	47.20%	56.89%	58.54%

Note: Countries are sorted by their average technology gaps in the period 2006-2011.

FIGURE 2.2.1
Technology gap (Greek economy)



2.2.2. Endogenous TFP growth

It has been argued that relying on a standard growth accounting framework would neglect endogenous formation of capital deepening and attribute TFP only to its direct effect on growth (Klenow and Rodriguez-Clare, 1997; Prescott, 1998; Barro, 1999). Madsen (2010a) showed that standard growth accounting exercises attribute too much growth to capital deepening. Therefore, we also present results after deriving measures of TFP growth which control for endogenous formation of capital deepening. We follow Madsen (2010b) and Madsen *et al.* (2010) to model the production function in per worker terms in the following way:

$$\frac{Y_{i,t}}{L_{i,t}} = A_{i,t}^{1/(1-a)}\left(\frac{K_{i,t}}{Y_{i,t}}\right)^{a/(1-a)}. \tag{2.8}$$

Taking logs and differentiating the above equation yields the following output per worker growth equation:

$$g_{Y/L_{i,t}} = \frac{1}{1-a} g_{A_{i,t}} + \frac{a}{1-a} g_{K/Y_{i,t}} \tag{2.9}$$

where $g_{Y/L}$ is the labor productivity growth. The term g_A is the growth rate of TFP and its contribution is magnified by a factor $1/(1 - \alpha))$ accounting for TFP induced capital deepening. The term $g_{K/Y}$ is the growth rate of the capital to output ratio and its contribution is weighted by the factor $1/(1 - \alpha))$. By adopting the above specification, we allow for TFP to contribute to growth directly through technological progress and higher efficiency, as well as indirectly through the channel of capital deepening. Table 2.2.4 presents the capital to output ratios for Greece and other countries. The capital to output ratio in Greece marked a considerable increase up to the mid 1990s. After a slight decrease until the mid 2000s, it started to accelerate at the end of the 2000s, as a consequence of the downturn faced by the Greek economy. This indicator is relatively high when compared to that of other OECD countries. The highest capital to output ratio is observed in Japan, Italy and Iceland (higher than 4), while the lowest is observed in Ireland (1.80). It is worth mentioning that capital to output ratios have remarkably increased over time in most OECD countries.

Endogenous growth accounting estimates for Greece and OECD countries are presented in Tables 2.2.5 and 2.2.6, respectively. Table 2.2.5 reassures us that the economic growth of Greece has followed different paths over time with considerable fluctuations in labor productivity growth rates. The average labor productivity growth rate for the period between 1976 and 2011 is 2.33%. The growth of capital to output ratio followed a similar path over time with the main feature being the existence of major fluctuations. Similarly, TFP growth rates remained at low or even negative levels up to the mid 1990s. Then, we observe a remarkable acceleration of TFP growth up to the mid 2000s, which is followed by a significant drop due to the advent of the crisis. The average growth rate of the capital to output ratio is 1.23% and its contribution to labor productivity growth for the whole period is 0.59%. The TFP growth contribution for the whole period is 1.73%, which is almost 75% of the average labor productivity growth. This outcome signifies the importance of TFP for the long-term economic growth.

The comparative description of Table 2.2.6 confirms that the performance of the Greek economy has been poor, relative to other OECD

TABLE 2.2.4
Capital to output ratios across OECD countries

Country	1975-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2011
Ireland	1.35	1.54	1.55	1.45	1.21	1.31	1.80
Sweden	1.94	2.04	2.06	2.28	2.17	2.09	2.11
Norway	2.10	2.22	2.25	2.20	2.05	2.10	2.34
United Kingdom	2.33	2.39	2.24	2.36	2.29	2.26	2.37
New Zealand	2.13	2.19	2.26	2.31	2.22	2.23	2.54
Canada	1.77	1.97	2.04	2.30	2.30	2.36	2.76
Netherlands	2.77	2.99	2.96	2.92	2.80	2.80	2.80
Switzerland	2.29	2.45	2.57	2.79	2.98	3.03	2.93
United States	3.31	3.35	3.19	3.18	3.02	3.02	3.07
Germany	2.65	2.86	2.87	2.84	3.02	3.10	3.10
Austria	2.86	3.17	3.27	3.32	3.39	3.39	3.34
Belgium	2.65	2.82	2.83	2.98	3.10	3.18	3.36
Luxembourg	3.99	4.05	3.42	3.14	3.13	3.10	3.40
Greece	2.61	3.03	3.18	3.24	3.20	3.13	3.44
Denmark	3.20	3.29	3.31	3.40	3.22	3.29	3.47
France	3.12	3.30	3.30	3.38	3.37	3.34	3.48
Australia	3.18	3.37	3.36	3.43	3.27	3.27	3.54
Finland	3.82	3.88	3.89	4.42	3.94	3.75	3.73
Spain	2.57	2.90	2.90	3.12	3.26	3.35	3.76
Portugal	2.35	2.60	2.53	2.67	2.92	3.34	3.92
Japan	2.78	3.15	3.28	3.59	4.06	4.26	4.28
Italy	3.25	3.51	3.54	3.71	3.81	3.93	4.29
Iceland	3.82	3.88	3.85	4.24	4.04	4.03	4.38

Note: Countries are sorted by average capital to output ratios in the period 2006-2011.

TABLE 2.2.5
Endogenous TFP growth rates for the Greek economy

Year	Labor productivity growth	Growth of capital to output ratio	Growth contribution of capital to output	TFP Growth
1976	6.63%	-1.47%	-0.66%	7.29%
1977	2.31%	2.89%	1.30%	1.01%
1978	7.27%	-0.66%	-0.30%	7.56%
1979	2.23%	2.95%	1.33%	0.90%
1980	0.44%	3.53%	1.59%	-1.15%
1981	-4.71%	4.80%	2.16%	-6.87%
1982	-0.96%	3.89%	1.75%	-2.71%
1983	-1.91%	4.10%	1.85%	-3.75%
1984	5.96%	-0.30%	-0.14%	6.09%
1985	1.57%	-0.34%	-0.15%	1.72%
1986	2.84%	1.56%	0.70%	2.13%
1987	0.69%	4.02%	1.81%	-1.12%
1988	5.29%	-2.45%	-1.10%	6.39%
1989	3.23%	-1.74%	-0.78%	4.01%
1990	0.05%	2.12%	0.95%	-0.90%
1991	8.14%	-0.83%	-0.37%	8.52%
1992	-1.48%	1.19%	0.54%	-2.02%
1993	-0.74%	3.22%	1.45%	-2.19%
1994	4.52%	-0.66%	-0.30%	4.81%
1995	2.89%	-0.55%	-0.25%	3.14%
1996	0.70%	-0.43%	-0.18%	0.88%
1997	6.96%	-1.38%	-0.62%	7.58%
1998	6.61%	-0.61%	-0.27%	6.89%
1999	3.86%	-0.16%	-0.07%	3.94%
2000	9.08%	-0.92%	-0.42%	9.50%
2001	4.84%	-0.59%	-0.27%	5.11%
2002	3.65%	0.58%	0.26%	3.39%
2003	-1.78%	-1.24%	-0.54%	-1.23%
2004	2.08%	-0.10%	-0.05%	2.13%
2005	-2.91%	1.09%	0.46%	-3.36%
2006	4.53%	-0.87%	-0.45%	4.98%
2007	-0.47%	1.64%	0.92%	-1.38%
2008	7.46%	3.91%	2.11%	5.36%
2009	-2.10%	5.72%	2.86%	-4.96%
2010	-0.44%	4.91%	2.46%	-2.90%
2011	-2.56%	7.54%	3.78%	-6.34%

TABLE 2.2.6
Endogenous TFP growth rates across OECD countries

Country	1976-1990		1991-2000		2001-2011	
	Average TFP growth	Average TFP growth contribution	Average TFP growth	Average TFP growth contribution	Average TFP growth	Average TFP growth contribution
Luxembourg	3.82%	240.33%	5.28%	107.70%	-3.16%	10.11%
Canada	-0.25%	153.53%	1.04%	-563.66%	-2.95%	194.26%
New Zealand	1.75%	59.82%	2.13%	136.64%	-2.20%	220.11%
Norway	3.26%	103.48%	4.23%	161.43%	-1.15%	104.71%
Belgium	2.08%	101.13%	2.65%	141.72%	-1.10%	98.73%
Australia	1.14%	139.12%	2.76%	132.39%	-0.76%	-55.12%
Iceland	2.63%	51.84%	0.94%	73.60%	-0.61%	99.52%
Italy	3.03%	113.18%	2.61%	76.81%	-0.50%	109.72%
Portugal	2.27%	33.57%	1.91%	85.83%	-0.44%	806.65%
Denmark	2.09%	106.97%	3.02%	106.29%	-0.15%	114.31%
United Kingdom	2.67%	190.51%	3.89%	99.20%	0.05%	182.43%
Greece	1.37%	-51.74%	4.10%	129.75%	0.07%	191.85%
Spain	2.46%	161.56%	2.38%	79.95%	0.18%	-1.19%
Sweden	0.65%	84.89%	3.35%	117.19%	0.34%	217.48%
Finland	2.68%	57.36%	4.07%	126.46%	0.39%	122.73%
France	2.40%	122.82%	2.97%	59.29%	0.52%	28.14%
Austria	1.60%	426.46%	4.09%	99.21%	0.61%	111.06%
Ireland	4.04%	169.00%	6.53%	-116.17%	0.99%	78.76%
United States	1.67%	199.46%	2.83%	122.47%	1.02%	-1.36%
Netherlands	1.61%	95.22%	2.98%	101.10%	1.15%	141.39%
Japan	3.24%	93.59%	2.37%	101.55%	1.66%	145.82%
Germany	3.18%	77.13%	2.83%	84.45%	1.67%	-14.16%
Switzerland	0.61%	100.44%	0.38%	107.85%	1.96%	132.16%

Note: Countries are sorted by average TFP growth over the period 2001-2011.

countries, both for the recent period of 2001-2011 as well as for the earlier period between 1976 and 1990. However, during 1991-2000, we observe remarkable TFP growth rates, which are the highest amongst other OECD countries. It is worth noting that this period is marked by the existence of comparatively high TFP growth rates, while it is also confirmed that TFP growth is the main factor for long-term economic growth.

2.3. Regional total factor productivity and convergence

2.3.1. Total factor productivity of the Greek regions

We follow growth accounting to construct TFP growth rates for (NUTS II) regions of the Greek economy and technology gaps vis-à-vis Attiki, which we consider as the technology leading region. The data for growth accounting were taken from the National Accounts of ELSTAT and are discussed in detail in Section 3.

Table 2.3.1 presents capital to output ratios for each region during 2000-2012. This ratio remained relatively stable up to 2008 for most of the Greek regions. However, due to the deep recession that started after 2008, we observe that capital to output ratios have increased substantially in all regions during the period 2009-2012. Peloponnisos and Sterea Ellada are the regions with the highest capital to output ratios. The lowest capital to output ratios are observed in Attiki and Voreio Aigaio.

Table 2.3.2 presents TFP growth rates for the Greek regions during 2000-2012. Reflecting broader developments that took place in the Greek economy during 2001-2012 (see tables and figures of the previous sub-section), we observe that the TFP growth performance of the Greek regions for the given period has been rather disappointing. In nine out of the 13 regions, we observe negative average TFP growth rates, with the most negative ones concerning the regions of Notio Aigaio and Ipeiros. For the region of Peloponnisos, we observe a zero average growth rate of TFP, while only three out of the 13 regions achieved a slightly positive change of TFP. These are Attiki (0.11%), Kentriki Makedonia (0.16%) and Dytiki Ellada (0.51%).

However, this situation varies considerably if we compare different sub-periods. Specifically, during 2001-2004, TFP growth rates remained highly positive for almost all regions. During 2005-2008, it is clear that TFP growth rates slowed down and became negative in most regions. The period 2009-2012 is marked by the advent of the crisis and the consequent appearance of very negative TFP growth rates across all regions. The most negative ones are observed in Voreio Aigaio, Notio Aigaio and Ionia Nisia.

The figures in Table 2.3.3 confirm that TFP growth is the most important contributor to the growth of Greek regions. The highest growth contribution of TFP for the whole period is observed in Ionia Nisia and Dytiki Ellada. On the contrary, we observe a negative contribution of TFP in Dytiki Makedonia. Negative contributions of TFP growth are observed only for the region of Ipeiros in 2001-2004 and the regions of Dytiki Makedonia and Notio Aigaio during 2005-2008.

It should be stressed that the growth accounting method which is applied here offers a descriptive rather than an explanatory analysis of the changes and growth contribution of TFP across Greek regions. The explanation and interpretation of productivity changes is provided by the results of the empirical econometric analysis, through the estimation of spatial fixed effects and the regional and other determinants, to allow the formulation of conclusions and relevant policy suggestions.

Technology gaps of Greek regions vis-à-vis Attiki are shown in Table 2.3.4. As a result of negative TFP growth rates in 2005-2008 and 2009-2012, technology gaps have substantially increased in all (peripheral) regions during the period 2001-2012. For example, while we note that the region of Notio Aigaio had a technology gap of only 8.15% in 2000-2004, it ended up with a technology gap of 24.75% during 2009-2012. A similar situation is observed in all other regions with technology gaps widening significantly during the crisis. It should be noted that almost half of the regions have shown persistently high technology gaps, which have, however, increased in recent years. These are the regions of Dytiki Ellada, Thessalia, Ipeiros, Kentriki Makedonia, Anatoliki Makedonia-Thraki, Sterea Ellada and Peloponnisos. The regions of Notio Aigaio and Dytiki Makedonia are those with the lowest technology gaps vis-à-vis Attiki.

TABLE 2.3.1
Capital to output ratios across Greek regions

Region	2000-04	2005-08	2009-12	2000-12
Attiki	4.03	3.91	4.85	4.24
Voreio Aigaio	3.89	3.93	5.09	4.27
Notio Aigaio	3.99	4.08	5.49	4.48
Dytiki Ellada	4.04	4.30	5.79	4.66
Ionia Nisia	4.36	4.56	6.18	4.98
Kriti	4.42	4.76	6.46	5.15
Ipeiros	4.46	5.11	6.68	5.34
Dytiki Makedonia	4.65	4.94	7.11	5.50
Anatoliki Makedonia-Thraki	4.99	5.27	6.47	5.53
Thessalia	4.84	5.25	6.89	5.59
Kentriki Makedonia	6.39	6.38	7.89	6.85
Peloponnisos	6.68	6.86	8.39	7.26
Sterea Ellada	8.80	9.18	11.45	9.73

Note: Regions are sorted by average capital to output ratios in 2000-2012.

TABLE 2.3.2
TFP growth rates across Greek regions

Region	2001-2004	2005-2008	2009-2012	2001-2012
Notio Aigaio	0.09%	-0.17%	-6.81%	-2.30%
Ipeiros	1.20%	-1.24%	-3.80%	-1.28%
Sterea Ellada	0.82%	-1.65%	-2.78%	-1.20%
Ionia Nisia	3.53%	-0.77%	-5.90%	-1.04%
Thessalia	2.77%	-0.67%	-4.48%	-0.79%
Kriti	3.69%	-0.94%	-4.96%	-0.74%
Voreio Aigaio	2.59%	1.78%	-6.07%	-0.57%
Dytiki Makedonia	4.82%	-1.43%	-4.04%	-0.22%
Anatoliki Makedonia-Thraki	2.81%	0.42%	-3.47%	-0.08%
Peloponnisos	3.80%	-0.59%	-3.20%	0.00%
Attiki	2.03%	0.65%	-2.36%	0.11%
Kentriki Makedonia	3.29%	0.49%	-3.31%	0.16%
Dytiki Ellada	4.55%	1.20%	-4.22%	0.51%

Note: Regions are sorted by average TFP growth over the period 2001-2012.

TABLE 2.3.3
TFP growth contribution across Greek regions

Region	2001-2004	2005-2008	2009-2012	2001-2012
Dytiki Makedonia	77.53%	-626.07%	156.19%	-130.78%
Notio Aigaio	78.65%	-46.67%	84.96%	38.98%
Kriti	73.49%	15.90%	68.72%	52.70%
Peloponnisos	114.64%	48.84%	61.28%	74.92%
Thessalia	37.01%	128.83%	62.05%	75.96%
Anatoliki Makedonia-Thraki	82.83%	90.78%	57.84%	77.15%
Voreio Aigaio	137.08%	77.54%	90.68%	101.77%
Kentriki Makedonia	83.78%	228.50%	44.97%	119.08%
Ipeiros	-30.84%	403.68%	67.33%	146.72%
Attiki	15.57%	622.75%	41.77%	226.70%
Sterea Ellada	230.90%	1008.11%	31.05%	423.35%
Dytiki Ellada	94.17%	1447.32%	74.70%	538.73%
Ionia Nisia	98.90%	1678.16%	63.55%	613.54%

Note: Regions are sorted by average TFP contribution over the period 2001-2012.

TABLE 2.3.4
Technology gaps across Greek regions

Region	2000-2004	2005-2008	2009-2012	2000-2012
Notio Aigaio	8.15%	13.07%	24.75%	14.77%
Dytiki Makedonia	18.54%	16.88%	28.92%	21.22%
Ionia Nisia	20.96%	21.75%	33.68%	25.12%
Voreio Aigaio	26.63%	25.83%	31.80%	27.97%
Kriti	32.02%	35.89%	44.23%	36.97%
Dytiki Ellada	39.51%	36.51%	40.61%	38.93%
Thessalia	34.21%	39.43%	46.12%	39.48%
Ipeiros	34.63%	43.03%	48.80%	41.57%
Kentriki Makedonia	42.03%	42.22%	43.25%	42.46%
Anatoliki Makedonia-Thraki	41.67%	42.62%	43.50%	42.53%
Sterea Ellada	37.28%	48.07%	52.35%	45.24%
Peloponnisos	43.91%	47.23%	51.66%	47.32%

Note: Regions are sorted by their average technology gaps in the period 2000-2012.

2.3.2. Regional convergence in Greece

In relation to the process of convergence of the Greek regions, the σ-convergence is expressed by three measures of dispersion: (i) the standard deviation σ of the log of the regional GDP per capita, (ii) the coefficient of variation, which measures the dispersion of the regional GDP per capita relative to the national average, and (iii) the population weighted coefficient of variation, known as the Williamson index (Williamson, 1965), where each regional deviation is weighted by the population share of that region. Figure 2.3.1 illustrates the evolution of the regional dispersion of per capita GDP over the study period.

By and large, only slight differences are identified in the per capita GDP dispersion among the Greek regions. Nonetheless, a distinct adverse influence of the economic crisis on the *σ*-convergence process can be observed, especially with the use of the standardized measures of dispersion. In particular, the value of standard deviation fluctuates over the study period and in 2012 increased to the level of 2009 (0.077). The coefficient of variation demonstrates a significant increase (divergence) between 2010 and 2012, where it reaches the level of 2001. The Williamson index shows a mild but steady increase during 2004-2012. The observed trends signify persistent structural imbalances in the production model of the country, which were amplified during the economic crisis.

Based on the results of the diagrammatic analysis of *β*-convergence (Figure 2.3.2), there is a clear trend of interregional convergence over the study period, as the *β* coefficient in equation (2.4) has the expected (positive) sign, i.e., $\beta=0.011$. A large part of this convergence can arguably be attributed to a structural change process of shifting labor force from low to high productive sectors, which is relatively faster in the initially less productive regions (Paci and Pigliaru, 1999), as well as to a process of gradual homogenization of regional economic structures (Cuadrado-Roura *et al.,* 1999). Nevertheless, the relatively high scattering of observed values and the low R^2 value (10%) suggest the existence of considerable regional variations and the lack of a close relationship between the growth rate and the log of the initial (as of year 2000) GDP per capita. On the one side, in line with the theoretical considerations mentioned in previous sections, regions with the

FIGURE 2.3.1
Regional dispersion (σ-convergence) of per capita GDP in Greece, 2000-2012

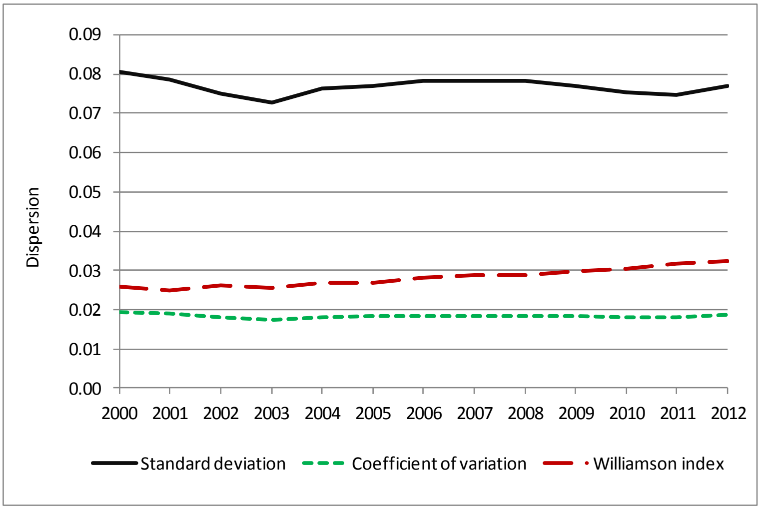
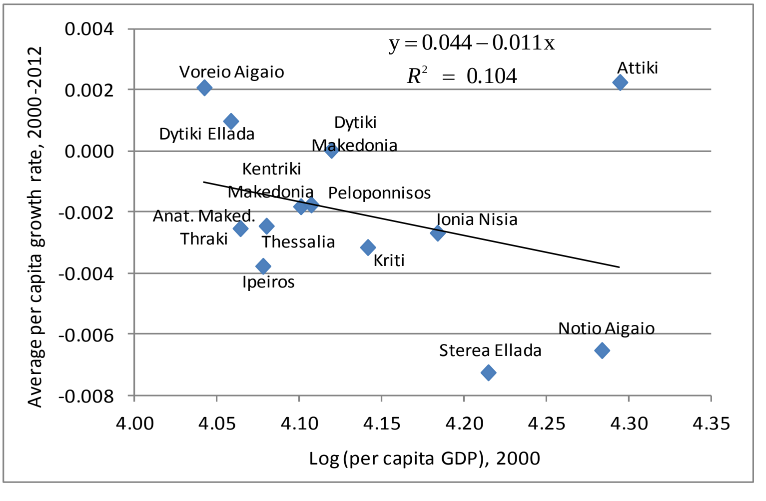


FIGURE 2.3.2
Diagrammatic analysis of β-convergence of the Greek regions, 2000-2012



lowest levels of per capita GDP (i.e. Voreio Aigaio and Dytiki Ellada) demonstrate increased convergence rates. On the other side, Attiki not only remains the wealthiest region in the country but also shows the highest growth rate in relation to the initial GDP per capita, compared to the other regions. This outcome further verifies that the prominent role of Attiki in the spatial economy of Greece has been strengthened during the period of the economic crisis.

2.4. Regional determinants of productivity

2.4.1. Theoretical background

The spatial dimension of mechanisms affecting productivity has long been recognized and mostly studied in the current literature from the view of the geographical concentration of activities in a given region. Marshall (1890) is regarded to be among the first scholars who examined the role of localization, in terms of the concentration of specialized industries in particular localities, on efficiency. However, formal theoretical frameworks for analyzing the relationship between productivity and the spatial allocation of economic activities have largely appeared during the last three decades.

More specifically, the so-called new trade theory and non-comparative advantage trade theory (Krugman, 1979; Krugman, 1980; Helpman and Krugman, 1985) signified the productivity effects in regions with large market size. This interplay between productivity benefits and location/spatial distribution characteristics can also be found in the central place models of regional science (Mulligan *et al.*, 2012). By and large, the geographical concentration of firms in a region with large demand helps them to become more specialized and extroverted, and realize scale economies and reduce trade costs. Larger or more concentrated markets related to higher economic densities offer a better matching of specialized labor skills, products and needs, sharing of information, resources and best practices to save costs and handle risks, and knowledge spillovers associated with production techniques, product attributes, and research & development (R&D), due to the increased interaction and better coordination of businesses and people. The external economies available to all the firms of a region irrespective of sector and arising from its urban size and density are usually referred to as urban concentration or *urbanization* economies.

A more complete framework for understanding and interpreting the role of location and spatial distribution of economic activities in productivity and efficiency measures is provided by the New Economic Geography (NEG) theory (Krugman, 1991a; Fujita *et al.*, 2001). In particular, the NEG framework underlines the productivity gains caused by the increased agglomeration of economic activities and the reduced transport (and other transaction) costs among them. In more centralized (or less dispersed) regions, internal scale economies of specialized input suppliers arise from reduced transaction costs and lower labor acquisition costs, leading to the increased productivity and profitability of supply firms. Moreover, the enhanced accessibility of firms to large markets and of consumers to large supplies of diverse goods promotes the location advantages of a region. The improved *market access*, as a function of the proximity and ease of reaching sizeable economic activities, generates more economies of scale for distribution channels and industrial or service clusters, which, in turn, further increases the productivity of labor and physical capital in the region.

Beyond the geographical proximity and density effects and market access, other spatial externalities which affect productivity may also arise, due to the *specialization* and *diversification* or concentration of economic activities within a region, relative to other regions. On the one side, the Marshall-Arrow-Romer (MAR) externalities, which have been formulated in a common theoretical framework by Glaeser *et al.* (1992), based on the contributions of Marshall (1890), Arrow (1962) and Romer (1986), refer to knowledge spillovers originating from the proximity of firms within an industry. The fact that neighboring firms can better learn from each other than geographically isolated firms facilitates innovation, productivity and growth. Also, according to Porter (1990), firms should specialize geographically, as the local competition provides incentives to develop or adopt new technology, innovate and become more productive.

On the other side, the impact of diversity on productivity is considered to be less straightforward and rather ambiguous. Jacobs (1969) argued that industrial diversity (or variety) promotes innovation and productivity growth. Specifically, the Jacobian or 'diversification' externalities, which arise from the interaction of firms in different sectors in search of productive and competitive sources, may support the knowledge transfers among dissimilar industries and the increasing returns in regional production (Siegel *et al.,* 1995 Frenken *et al.*, 2007). However, the geographical concentration of economic activity may increase productivity, in the case where the concentrated industries are mature and of relatively large size (Holmes and Stevens, 2002; Lee *et al.,* 2010).

It is argued that diversification externalities are more pronounced in densely populated regions, whose economies have possibly entered the later stages of development and integration, and mostly encompass high technology, more adaptive and innovative industries interacting with each other through well-defined cooperation networks (Paci and Usai, 1999; van der Panne, 2004; Prager and Thisse, 2012). When a critical market mass is achieved, the regional specialization can also be considered as a catalyst for the (industrial) productivity and technological progress (De Lucio *et al.,* 2002; Ejermo, 2005), but the net benefits of geographical concentration may vary across time and be realized only in the short run, rather in the long run (Hanson, 2001).

Geographical characteristics related to easy access to the sea or inland water transport corridors and raw material or energy resources, the topography, soil characteristics and the climate may also have an impact on the total productivity of a region (Gallup *et al.,* 1999; Ioannides, 2013). Such spatial fixed effects constitute comparative advantages that have historically proven to exercise a strong influence on productivity and are regarded to remain dominant, despite the ongoing technological progress and increased specialization of regional economies.

Summing up, the direction and the degree to which the specialization and diversification or concentration of a region affects its productivity depend on the particular conditions pertaining to that region as well as other regions with which it interacts. In addition to the interregional interaction, within-region variations in spatial agglomeration (or dispersion) forces may also have an impact on productivity, at different economic sectors and geographical scales (Cutrini, 2010). Last, it should be stressed that, in conjunction with the various forms and circular processes of agglomeration that induce productivity gains (or losses), region-specific unobserved or omitted factors might also account for changes in productivity and efficiency.

2.4.2. Empirical evidence

During the last two decades, there is increasing empirical evidence about the relationship among agglomeration economies/externalities and regional productivity. This evidence has enriched current theoretical knowledge (see previous subsection and the references below) about the local mechanisms of agglomeration externalities and their relation to regional inequalities and public policy making. Krugman (1991b) explained how agglomeration externalities can lead to the localization of particular industries and a core-periphery pattern, as a result of changes in transport costs, economies of scale and the share of manufacturing in national income. Puga (2010) further analyzed the magnitude, sources and microeconomic foundations of agglomeration economies, beyond the local comparative advantages, clustering effects and spatial variations in wages, rents and productivity. Such foundations lie in the better firm adaptation and the more efficient searching, learning, matching and sharing of local infrastructure, facilities, suppliers and skilled workers in large urban agglomerations. As mentioned by Combes *et al.* (2011), the proper identification of agglomeration economies is crucial for the justification of many public policies related to building clusters, industrial facilities and large infrastructure projects. In general, larger urban scale (or density) is associated with better technology for firms, more labor productivity, higher prices for outputs and lower costs of other factors, but variations among sectors should be taken into account.

Compared to earlier empirical studies, which employed the average production function to estimate the regional differences in the productive efficiency among industries, Beeson and Husted (1989) used a stochastic frontier production function to show that higher levels of more-educated labor force and urbanization are both associated with higher levels of manufacturing efficiency across US states. Similar methodology was followed by McCoy and Moomaw (1995) to indicate the positive urbanization effect on the manufacturing efficiency in Canadian cities, and by Driffield and Munday (2001) to show the positive role of regional agglomeration on the technical efficiency of UK industries.

Regarding studies for other countries, Mitra (1999) stressed the significance of agglomeration economies in the case of two selected Indian industries (electrical machinery and cotton/cotton textiles), using a stochastic frontier model with firm-level data. The same author (Mitra, 2000) demonstrated the total factor productivity (TFP) growth effects of urbanization and industrial spread in various manufacturing industries in India. Moreover, based on the stochastic frontier analysis, Otsuka *et al.* (2010) showed that both agglomeration economies and improvement of market access have a positive influence on the productive efficiency of the Japanese manufacturing and non-manufacturing industries, while this finding was verified by Otsuka and Goto (2015) for the case of distinct Japanese manufacturing sectors. In a nutshell, current empirical analyses highlight the role of the location advantage of large markets in order for firms to exploit economies of scale in production, due to increasing returns to scale, spillover effects (e.g., backward and forward linkages), and transport cost reductions.

Nevertheless, agglomeration diseconomies, which reflect decreasing returns to scale, may also arise beyond a density threshold and lead to negative effects on productivity, due to increased congestion, pollution and factor prices (Carlino, 1979; Martin and Sunley, 2003; Broersma and Oosterhaven, 2009). Specifically in the case of Chinese urban areas, Ke and Yu (2014) carried out a stochastic frontier analysis (SFA) to show that, whereas industrial agglomeration and human capital enhance technical efficiency, the density of employment negatively affects the productivity growth in large cities, which they proposed should specialize and diversify in advanced producer services, rather than manufacturing. Particularly with regard to the specialization (and diversification) externalities, several examples of public policies focusing on increased specialization to boost productivity growth can be found in Europe (Marrocu *et al.,* 2013) and elsewhere. For instance, Aiginger and Davies (2004) demonstrated the association between the increasing industrial specialization and the decreasing geographical concentration, because of the de-concentration effect of the reduced transport costs, in the EU countries. In Korea, the government concentrated its limited resources in large urban areas or large industrial park areas to generate positive urbanization and specialization externalities on productivity and economic growth (Lee *et al.*, 2010).

In Greece, the analysis of the regional dimension of the total factor productivity and productive (in)efficiency has been rather overlooked in the existing literature. The significance on (mainly industrial) productivity of non-constant returns to scale has been recognized, although it has been attributed to diverse types of agglomeration externalities. More specifically, Vagionis and Spence (1994) showed that the largest gains in TFP are found in the noncentral regions hosting industrial area projects, which can provide employment opportunities and infrastructure-induced economies of agglomeration, and in medium-sized cities due to the deployment of new technology, while the availability of grants and incentives offers a significant advantage. The crucial role that urbanization economies play was demonstrated by Louri (1988), who found that the productivity of manufacturing firms is driven by their strong tendency to be located in large urban centres.

The dominance of market or efficiency-oriented firm location processes can largely explain the fact that the state policies for a more 'even' regional development, either through the establishment of industrial areas or investment grants and other allowances, were not, on the whole, successful (Labrianidis and Papamichos, 1990). In essence, a combination of investment incentives and environmental restrictions, as well as lower land rent and relatively easy access to amenities, contributed to the concentration of industrial activities in the metropolitan regions of Athens and Thessaloniki, and their neighboring prefectures (Petrakos and Psycharis, 2004; Petrakos *et al*., 2012).

Although increasing diversification could potentially produce favorable economic outcomes, the spatial structure of the Greek regions has allowed only the metropolitan regions and possibly a few large cities to benefit, as most regions have an industrial base with limited variety (Petrakos *et al.,* 2012). Rodríguez-Pose *et al.* (2012) showed the significant positive long-run effect of the per capita public investment on regional economic growth, but not on convergence, at the prefecture (NUTS-III) level, stressing that the benefits may not necessarily come from direct intervention in specific regions but from spillover effects among them.

Several recent studies have shown that the spatial structure of economic activity and the sectoral composition played a significant role in how the economic crisis affected the development and inequalities both across and within Greek regions. In particular, Psycharis *et al.* (2014a), Psycharis *et al.* (2014b) and Palaskas *et al.* (2015) found that the most urbanized and high-income level regions were the most affected by and vulnerable to economic crisis, compared to the lagging regions, although the former are also the regions that benefited most during the upturn of economic activity. The higher specialization in manufacturing and other tradable and export-oriented sectors, such as tourism, and the inter-linkages between urban–rural areas were found to increase the resistance of regions to the crisis. In addition, Petrakos and Psycharis (2016) demonstrated that the crisis has intensified regional inequalities by strengthening the prominent role of the Athens metropolitan region, which involves a mix of tradable and sheltered activities, in the development map of the country.

The present study extends previous ones and contributes to the measurement and analysis of the total productivity of the Greek economy. It provides a synthesis of the variable returns-to-scale effects on economic efficiency, which can be attributed to the urbanization, the intraregional dispersion of urban concentration, the regional specialization, diversification externalities, and the interregional market access. Moreover, the current analysis considers the effects of local human capital, whose role has been found to be significantly positive on the productivity of the Greek regions (prefectures), in terms of the tertiary education graduates (Karagiannis and Benos, 2011). Last, the effect of various political attributes is examined to test whether the regional productivity has been amplified or reduced due to a political capital, in terms of a politician's influence in policy making.

2.5. Political determinants

Economic literature has dealt with institutional and political factors to explain long-run economic performance. This line of research argues that potential economic growth is affected by governments and institutions that encourage free trade and competition, promote investments and secure property rights. Countries or regions with good social infrastructure, i.e., effective policies and institutions, tend to have higher investments and increased returns in both physical and human capital investments (Jones, 2002). Political decisions can lead to changes in firm behavior through various channels. A number of factors include taxes and regulations, which, in turn, influence the incentives of firms to invest, eliminate redundant labor and capital, and reallocate existing resources. Political decisions may also be accompanied by changes in practices that involve enforcement and corruption, which, in turn, influence investments and productivity (Fisman and Svensson, 2007). On the other hand, political behavior may raise uncertainty, to the extent that the objectives of newly elected governments are unknown, and create a substantial drag on economic activity.

Another part of the literature relates to the effects of political parties and electoral competition on economic performance. According to the seminal contribution of Nordhaus (1975), public investment choices of politicians are focused on macroeconomic austerity at the beginning and increased spending at the end of their term, in order to maximize the probability of reelection. In this political business cycle, in the short run, voters consider recent performance more than earlier performance, ignoring the optimal tradeoff between unemployment and inflation. Partisan theory states that different political parties have differential preferences on economic policy. Hibbs (1977) showed that left-wing governments are more concerned with low unemployment, while right-wing governments are more concerned with low inflation. Alesina (1987) and Alesina and Sachs (1988) empirically confirm Hibbs' results for the case of the USA. Alesina and Roubini (1992) found that, in the short term, left-wing governments expand the economy when elected. However, they do not find supportive evidence for the existence of permanent effects on the real economy. More recently, Pettersson-Lidbom (2008) found for Sweden that left-wing governments lower the unemployment rate by increasing public employment and spending and taxing more than right-wing governments.

Other channels through which politics affect economic performance include the political connections of firms in their own regions or sectors. In economic environments characterized by weak institutions, such connections can provide various economic benefits, including direct subsidies, preferential access to inputs, credit from state-controlled banks and government contracts. Pork-barrel politics can be broadly defined as the practice of targeting expenditure towards particular districts or regions based on political considerations. A first claim is that politicians prefer to allocate spending to those regions which are more likely to vote for them. In such a way, the majority of funding is allocated to political strongholds (Cox and McCubbins, 1986) or to those regions in which they can gain the most from additional spending (Dixit and Londregan, 1998).Cadot *et al.*(2006) claimed that the influence of certain interest groups or political factors, such as the difference in votes recorded by the two main parties, have a marked impact on the decisions of central governments.

However, an alternative theory states that central politicians are more interested in those regions where additional spending has a disproportionate effect on the election outcome. In such a way, politicians prefer to spend more on regions where possibilities to increase their vote share relative to the opposition party are strong (swing vote effect) (see Jacobsen, 1987). A simple measure of this idea is related to the closeness of a political race between the largest two parties. In such a way, the larger the distance between the two main parties, the lower the interest of politicians to spend more in these regions.

Specifically, in relation to the effect of political variables on regional economic growth and the resource allocation of public investment in Greece, Lambrinidis *et al.* (2005) indicated that regional allocations of infrastructure investment were increased across prefectures in years preceding national elections. Later, Tsekeris (2011) showed that the central government has increased motivation to influence the outcome of a future election, through allocating a larger share in non-road transport investment, in those prefectures where the reelection prospects are uncertain, compared with those wherein it dominates, and the electoral race is more competitive. Extending his previous work, Tsekeris (2014) demonstrated that the direction and significance of the effects of political factors on the sectoral allocation dynamics of regional public investments in Greece are quite diverse according to the type of investment.

Rodríguez-Pose *et al.* (2012) indicated that political variables, such as the difference in the vote shares between the governing and the main opposition party, influence the growth impact of different types of public investment across Greek prefectures, but this outcome disappears after the control of political-period-specific spatial-invariant variables. In addition, Rodríguez-Pose *et al.* (2016a) found a significant influence on the electoral results, as Greek governing parties rewarded those constituencies returning them to office, while regions where the governing party (whether Liberal or Socialist) has held a monopoly of seats have been the greatest beneficiaries of this type of pork-barrel politics. Rodríguez-Pose *et al.* (2016b) further identified differences in the pork-barrelling tactics of the two governing parties: the Socialists, who applied more expansionary fiscal policies, relative to Liberals, tended to reward their electoral fiefs, while the Liberals invested more in regions controlled by the opposition to win over new votes or seats.

CHAPTER 3

ECONOMETRIC SPECIFICATION AND CONSTRUCTION OF VARIABLES

3.1. Econometric specification

In this study, we apply a stochastic frontier analysis (SFA). In addition to SFA, another widely used methodology in this field is the Data Envelopment Analysis (DEA). While DEA is a nonparametric methodology and does not require the specification of a functional form, it is not able to distinguish between the random error term and inefficiency. Although stochastic methods require the imposition of a certain functional form, they are able to distinguish noise from non-negative inefficiency and this is the main reason for choosing to follow this technique.

We base our analysis on the model specification proposed by Battese and Coelli (1995), in which the technical inefficiency model is simultaneously estimated with the stochastic production frontier model at one stage.[8] In this context, we model for the existence of unobserved inefficiency across regions and industries with a stochastic frontier model described as follows:

$$Y_{ijt} = f(X_{ijt};\beta)\cdot \exp\{V_{ijt}\}\cdot TE_{ijt} \qquad (3.1)$$

where Y_{ijt} is the output of region *i,* sector *j* at time *t*, X_{ijt} is a vector of production inputs and β are the production function parameters to be

[8] In earlier studies (see references in subsection 2.4), a two-stage estimation procedure was used, where the production frontier and efficiency measures were estimated at the first stage and then the efficiency levels were regressed on a number of explanatory variables, assumed to influence efficiency. However, this two-stage estimation procedure has serious drawback, if the vector of efficiency variables is correlated with the vector of production function parameters, rendering the coefficient estimates of the production function biased (Wang and Schmidt, 2002).

estimated. The function $f(X_{ijt};\beta)$ refers to the production frontier, common to all regions and industries, while $\exp\{V_{ijt}\}$ is a stochastic component that describes random shocks to production, which are region and industry specific. Consequently, $f(X_{ijt};\beta)\cdot\exp\{V_{ijt}\}$ forms the stochastic production frontier, with TE_{ijt} being the output-oriented technical efficiency of each region and industry. Then, TE_{ijt} can be described as:

$$TE_{ijt} = Y_{ijt} \,/\, f\left(X_{ijt}\cdot\beta\right)\cdot\exp\{V_{ijt}\} \tag{3.2}$$

with Y_{ijt} reaching its most efficient level, equal to $f\left(X_{ijt}\cdot\beta\right)\cdot\exp\{V_{ijt}\}$ when $TE_{ijt} = 1$. When $TE_{ijt} < 1$, we observe a deviation of output from its most efficient level. A common assumption is that technical efficiency is a positive random variable, denoted as $TE_{ijt} = \exp\{-U_{ijt}\}$. Therefore, output is expressed as:

$$Y_{ijt} = f(X_{ijt};\beta)\cdot\exp\{V_{ijt}\}\cdot\exp\{-U_{ijt}\} = f(X_{ijt};\beta)\cdot\exp\{V_{ijt}-U_{ijt}\} \tag{3.3}$$

Following the discussion of Section 2.1, we can express the output of each region i and industry j using a Cobb Douglas production function of the following form:

$$Y_{ijt} = Ae^{\lambda t}\left(L_{ijt}\right)^{\beta_1}\left(K_{ijt}\right)^{\beta_2}\cdot\exp\left(V_{ijt}-U_{ijt}\right), \tag{3.4}$$

where Y is the value added at time t, in region i and sector j, A is the level of existing technology common to all regions and industries, λ is the rate of technical change and t is a time trend which captures technical progress over time. L is the labor input expressed as the number of total hours worked and K is total physical capital. The parameters β_1 and β_2 are the value added elasticities of labor and physical capital, respectively. V_{ijt} and U_{ijt} are the two components of the error structure, which compose the main feature of the stochastic frontier. In particular, V_{ijt} is a standard random residual assumed to be i.i.d. following a normal distribution $N(0,\sigma_v^2)$ and U_{ijt} is a nonnegative random error, associated with the technical inefficiency of production and assumed to be distributed independently from V_{ijt}. Thus, U_{ijt} has an asymmetric distribution equal to the upper half of the $N(0,\sigma_u^2)$ distribution. After taking a logarithmic transformation of equation (3.4), the value added in each region and industry can be expressed as:

$$\ln\left(Y_{ijt}\right)=\beta_0+\lambda t+\beta_1\ln\left(L_{ijt}\right)+\beta_2\ln\left(K_{ijt}\right)+V_{ijt}-U_{ijt} \qquad (3.5)$$

As a way to study the influences of human capital and regional variables on technical inefficiency, we model the mean μ_{ijt} of the truncated distribution of U_{ijt} as follows:

$$\mu_{ijt}=\delta_0+\delta_{HC}HC_{ijt}+\sum\nolimits_k\delta_{Rk}R_{ijtk}+\sum\nolimits_m\delta_{Pm}P_{ijtm}+\delta_{\Pi}\Pi_i+\delta_I I_j+\delta_T T_t+w_{ijt} \qquad (3.6)$$

where HC is the human capital variable and δ_{HC} is the corresponding coefficient. As discussed previously, we expect that this variable would affect negatively regional inefficiency. The set of variables R corresponds to the spatial agglomeration-related factors, P is a vector of variables which proxy for political influences on regional efficiency and δ_R and δ_P are the corresponding coefficients. Equation (3.6) also includes vectors corresponding to region *(Π)* and industry *(I)* specific effects to account for time-invariant unobserved heterogeneity. We also include time dummies *(T)* to control for common production shocks. The term w_{ijt} expresses a random variable, defined by the truncation of the normal distribution.

All the parameters included in the log linear production function (3.5) and the technical inefficiency model (3.6), along with the model variances $\sigma^2=\sigma_v^2+\sigma_u^2$ and $\sigma_u^2/\left(\sigma_v^2+\sigma_u^2\right)$, are estimated simultaneously at one stage by using the maximum likelihood estimator.[9] By applying likelihood ratio tests, several hypotheses can be tested. Such an

9 The parameter σ_v^2 is the overall variance of the error term, σ_v^2 is the variance of V_{ijt}, while σ_u^2 is the variance of the inefficiency term U_{ijt}.

important hypothesis is whether $\gamma = 0$. A rejection of the null hypothesis that $\gamma = 0$, against the alternative that $\gamma > 0$, would imply that deviations from the frontier are due to inefficiency effects.

3.2. Construction of variables

3.2.1. Construction of production function variables

The empirical analysis of this study is based on a panel dataset encompassing 10 broad sectors of the Greek economy and 13 regions for the period 2000-2012[10,11]. The necessary data follow the NACE Rev2 industrial classification, according to the European System of National and Regional Accounts (ESA 2010), and were provided by the National Accounts of ELSTAT (2015). Data for value added were provided in current prices at the regional sectoral level and were converted to 2010 constant prices by using an economy-wide GDP deflator.[12]

Since we estimate a production function, we need to have a suitable measure of capital stock for each region and sector. However, data for physical capital stocks in Greek sectors and regions are not

[10] The ten broad sectors are: 1. Agriculture, forestry and fishing, 2. Mining, quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific, technical, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

[11] The 13 Greek regions (NUTS II classification level) are: 1. Anatoliki Makedonia-Thraki, 2. Kentriki Makedonia, 3. Dytiki Makedonia, 4. Ipeiros, 5. Thessalia, 6. Ionia Nisia, 7. Dytiki Ellada, 8. Sterea Ellada, 9. Attiki, 10. Peloponnisos, 11. Voreio Aigaio, 12. Notio Aigaio, 13. Kriti.

[12] The GDP deflator is constructed as the ratio of constant GDP (expressed in 2010 prices) to current GDP. Data for GDP in period 2011-2012 were provided on a provisional basis.

officially available. Therefore, we constructed the series of capital stock for each region and sector based on the perpetual inventory method. Initial values for capital stocks in 2000 were given by applying the following formula:

$$K_{ijt} = \frac{I_{ijt}}{g_{ijt} + \delta_j} \tag{3.7}$$

where K is the variable of physical capital stock of region i, sector j at time t. I is the amount of gross fixed capital formation in year 2000 (expressed in 2010 prices), g is the average three-year period growth rate of real value added of region i and sector j at time t, while δ is a measure of the depreciation rate of physical capital in sector j.[13]

In order to obtain physical capital stock series for each year $t+1$ during the period 2001-2012, we applied the following formula:

$$K_{i,j,t+1} = I_{i,j,t+1} + \left(1-\delta_j\right) \cdot K_{i,j,t}. \tag{3.8}$$

We also needed a value for the depreciation rate of capital, δ. The value of δ was chosen to be consistent with the observed current price data for consumption of fixed capital, as provided by the STAN Industry Database (OECD, 2010), and the physical capital stocks (see Skountzos and Stromplos, 2011) for each sector in year 2000, so that it should hold that:

$$\delta_j = \frac{C_j}{K_j}, \tag{3.9}$$

where δ is the depreciation rate of physical capital in sector j, C is the consumption of fixed capital and K is the value of physical capital stock in this sector.

The variable of total hours worked is measured as the product of the average actual hours worked per employed person by the num-

[13] Data for gross fixed capital formation were provided in current prices at the regional-sectoral level by the National Accounts of ELSTAT. They were converted to 2010 constant prices by using the economy-wide GDP deflator. Data for gross fixed capital formation in 2011-2012 were provided on a provisional basis.

ber of employed persons. The data for hours worked in each sector-region were obtained from ELSTAT (2015).[14]

3.2.2. Construction of the inefficiency equation explanatory variables

The human capital variable HC is obtained as the percentage of hours worked by persons having tertiary education to the total amount of hours worked in each region and industry. Regarding the specification of the regional agglomeration-related variables, the economies of urbanization or urban concentration can be generally expressed in terms of some measure of average density (e.g., number of inhabitants per unit area) or spatial separation of the total economic activities (e.g., output value per unit distance among regional economic centres or capital cities). Additionally, given that the spatial unit of analysis refers to the NUTS II-level of Region (Peripheria), a variable of the dispersion of the above measures is also used, to account for possible significant intra-regional variations of their values, among the constituent prefectures (at the NUTS III level) of each region.

In the case of average density, the ratio of the total population to the land area of region i is calculated. By defining as P_p the population of a prefecture p belonging to region i, and A_p its land area (in km^2), the average population density of that region is:

$$D_i = \frac{\sum_p P_p}{\sum_p A_p} = \frac{P}{A} \tag{3.10}$$

The dispersion of population density within region i is based on the generalized spatial entropy index (Batty, 1974). Let us define the

[14] Due to industry classification changes made in 2008, sectors are not equivalently comparable for hours worked in periods 2000-2008 and 2008-2014. Therefore, we proceeded to some necessary adjustments in order to construct the complete series of hours worked for the whole period 2000-2012 and across the ten broad sectors mentioned previously. Further information is available upon request.

population ratio as $\pi_p = \frac{P_p}{\sum_p P_p} = \frac{P_p}{P}$. Then, the measure of density dispersion can be expressed as:

$$E_i = \sum_p \pi_p \ln\frac{P_p}{A_p} - \ln\frac{P}{A}. \tag{3.11}$$

From equation (3.8), E_i can be interpreted as the difference between the expected log of population density in region i (first term) and the actual log of density (second term). When these two terms become equal, the distributions of population and land area coincide and $E_i = 0$.

In the case of average spatial separation, the measure of internal (intraregional) market access is adopted. Specifically, the variable of market potential is used to represent market access, which denotes the importance of scale economies and transport costs. This variable recognizes that the location of firms can be favored by the proximity to other sizeable firms, customers or output markets, to have the largest possible market for selling their products/services (Fujita *et al.,* 2001; Fujita and Thisse, 2002). It was originally proposed by Harris (1954) and has been widely used to indicate how spatial proximity to large markets affects regional economic development and inequalities (Redding and Venables, 2004; Crafts, 2005; Hanson, 2005; Head and Mayer, 2011). The internal market potential IMP_i of region i is expressed as the average market potential of its N constituent prefectures p. The market potential MP_p of prefecture p is given as a function of the weighted average of the GDP of all other prefectures p', where the weights are inverse to the bilateral distance $D_{pp'}$. Namely,

$$IMP_i = \frac{1}{N}\sum_p MP_p = \frac{1}{N}\sum_p \sum_{p'} \frac{GDP_{p'}}{D_{pp'}}. \tag{3.12}$$

The distance $D_{pp'}$ denotes the road network length between the centroid (capital) of each prefecture.[15] In the case of island prefectures,

[15] The approximation of transport/trade costs with the measure of distance has

the coast-wise shipping network length is taken into account. It is expected that agglomeration economies increase (decrease) in a region as the linkages of economic activities among its constituent prefectures become more dense (sparse). The market potential MP_p of prefectures in each region is normalized and expressed as an index in the scale 0 to 1. The dispersion of internal market access $DIMP_i$ among the constituent prefectures p within a region i is defined here as the standard deviation of the corresponding internal market potential IMP_i. Namely:

$$DIMP_i = \sqrt{\frac{1}{N}\sum\nolimits_p \left(MP_p - IMP_i\right)^2}. \tag{3.13}$$

In a similar fashion, the external (interregional) market potential EMP_i of region i is given as a function of the weighted average of the GDP of all other regions i', where the weights are inverse to the bilateral distance $D_{ii'}$ among the capital cities of each region, as follows:

$$EMP_i = \sum\nolimits_{i'} \frac{GDP_{i'}}{D_{ii'}}. \tag{3.14}$$

The increase of EMP_i is regarded to positively influence efficiency, as it provides a measure of the accessibility and centrality of each region i, in terms of its position within the country according to geographical and economic considerations. This measure is also normalized and expressed as an index in the scale 0 to 1.

As far as the variable of regional specialization is concerned, the dissimilarity entropy index is adopted (Cutrini, 2010). Specifically, the measure of specialization S_i of region i denotes the dissimilarity between the economic structure of this region (composed of K sectors,

proven very robust in the related literature and its use in Harris's equation is considered to provide reliable estimates of market access, compared to other more sophisticated (NEG theoretic) structural estimates (Bruna *et al.*, 2016).

as they were described before) and that of the whole country. It can be expressed as:

$$S_i = \sum_{\kappa}^{K} \frac{V_{i\kappa}}{V_i} \ln\left(\frac{V_{i\kappa}/V_i}{V_\kappa/V} \right), \tag{3.15}$$

where $V_{i\kappa}$ denotes the gross value added (GVA) of sector κ in region i, V_i the total GVA (of all sectors) in region i, V_κ the national (of all regions) GVA in sector κ and V the national GVA of all sectors. This variable offers a proxy for specialization externalities, which are regarded to positively affect the efficiency-enhancing processes of learning and knowledge spillovers in some region.

Correspondingly, based on Cutrini (2010), the within-region specialization WS_i is respectively calculated by averaging the specialization in each sector κ of the N prefectures p composing region i, weighted by the GVA share of each sector κ in the total GVA of this region. Namely:

$$WS_i = \sum_{\kappa}^{K} \frac{V_{i\kappa}}{V_i} \left[\frac{1}{N} \sum_{p} \frac{V_{pi\kappa}}{V_{pi}} \ln\left(\frac{V_{pi\kappa}/V_{pi}}{V_{i\kappa}/V_i} \right) \right], \tag{3.16}$$

where $V_{pi\kappa}$ denotes the gross value added (GVA) of sector κ in prefecture p of region i, V_{pi} the total GVA (of all sectors) in prefecture p of region i, $V_{i\kappa}$ the i region's (of all its prefectures) GVA in sector κ and V_i the i region's GVA of all sectors.

The diversification across different industries of the production structure in region i can be proxied by the use of the measure of Hirschmann-Herfindahl index HH_i, which is well-known and widely adopted in the related literature (Aiginger and Pfaffermayr, 2004; Lee *et al.,* 2010). This index is the weighted arithmetic mean of the sectoral shares of a region, with the sectoral shares themselves being used as the weights. Namely:

$$HH_i = \sum_{\kappa}^{K} \left(\frac{V_{i\kappa}}{V_i} \right)^2. \tag{3.17}$$

The smaller (larger) the value of the HH_i index, the higher the degree of sectoral diversification (concentration) is in this region. By definition, the sectoral shares are constrained to values between zero and unity, but $HH_i \geq 1/K$, which is reached when all shares are equal.

Regarding the set of political variables in each region, it includes: a) the vote share of the government party, weighted by the population of the constituent prefectures, b) the parliamentary seat difference between the government and the main opposition party, c) a dummy variable which is equal to one if the head of the region (or regional governor) belongs to the party in power and zero otherwise, and d) the electoral cycle, in terms of the number of years until the next election. According to the electoral cycle theory (Gartner, 1994), we would expect that governments in periods before election would allocate spending in such a way that would favorably influence the final outcome of the elections. It should be made clear that the choice of the time period is dictated by the availability of data for all the variables that will be employed in the econometric analysis. With this in mind, a brief analysis of the descriptive statistics of all variables follows in Section 4.

CHAPTER 4

DESCRIPTION OF DATA

4.1. Productivity trends at the sectoral and regional level

The discussion in Section 2 signified that productivity is the main determinant of long-term economic growth. In this section, we continue our discussion by analyzing how productivity has evolved over time in the main industries (sectors) of the Greek economy. We also compare relative productivity levels and unit labor costs and, finally, we discuss the evolution of productivity across regions of the Greek economy.

4.1.1. Productivity and unit labor costs at the sectoral level

Figure 4.1.1 shows comparatively the evolution of the index of gross value added per hour worked for the Greek economy and the Euro area. It is evident that during the last years this index has declined substantially and is lower than the relative index for the Euro area. Similarly, Figure 4.1.2 shows the evolution of the index of unit labor cost. Despite the fact that the productivity of the Greek economy fell sharply during the last years, the unit labor cost index did not increase, probably due to the large wage cuts during the same period. In contrast, it also declined during the crisis and remains at levels below those of the Euro area.

In the industry of Mining and utilities, the relative index of productivity marked a dramatic decline in the last four years and is well below that of the Euro area (Figure 4.1.3). Also, we observe a significant increase in the relative unit labor cost index (Figure 4.1.4). In Construction, we may notice significant fluctuations over time of the relative productivity index (Figure 4.1.5). The same pattern is also observed for the unit labor cost index (Figure 4.1.6). In 2014, the productivity of the

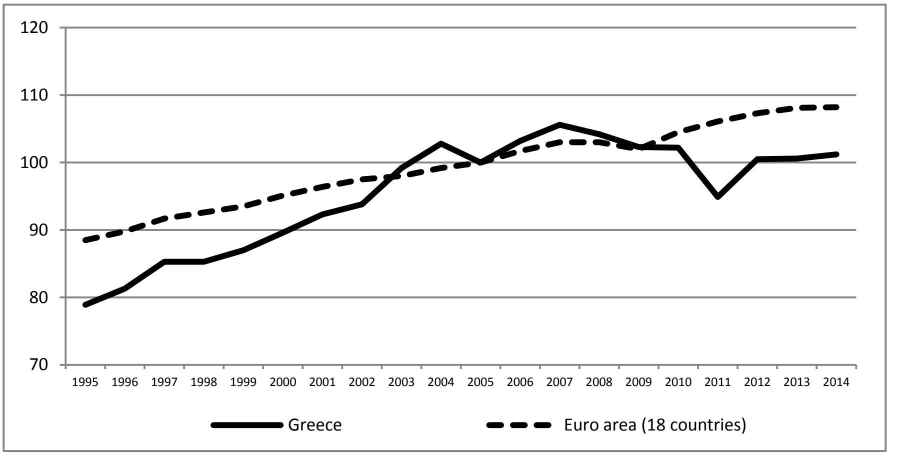
Construction sector was lower than that of the Euro area, while the index of unit labor cost was relatively higher. Regarding the sector of Manufacturing, the index of gross value per hour worked marked a substantial decline during 2009-2011 (Figure 4.1.7). After 2011, we observe a moderate increase. However, the relative index remains well below its corresponding level for the Euro area. Similarly, the unit labor cost index is substantially higher than that of the Euro area (Figure 4.1.8).

In the broad sector of Wholesale and retail trade, accommodation and food services, transportation and storage, we observe a very negative evolution of the gross value per hour worked during 2008-2011 (Figure 4.1.9). After 2011, we observe a sharp increase of the relative index, which remains well below that for the whole Euro area. Similarly, the unit labor cost index declined significantly during 2012-2014 and fell below that of the Euro area (Figure 4.1.10). In the industry of Information and communication, we also observe a significant drop in productivity during 2008-2012 and then a slight pickup in 2012-2013 (Figure 4.1.11). However, the unit labor cost index has also fallen sharply during the last years, despite the concurrent decrease of productivity (Figure 4.1.12).

In Finance and insurance, the index of productivity fell sharply during 2008-2012 and increased during 2012-2014 (Figure 4.1.13). It is the only index of productivity in which the Greek economy led the Euro area in 2014. The relative unit labor cost index is slightly lower than that of the Euro area (Figure 4.1.14). Finally, in the sector of Professional, scientific and technical activities, administrative and support service activities, we observe that the productivity index declined substantially after 2014 and now falls short of that of the Euro area (Figure 4.1.15). Respectively, the unit labor cost index marked a substantial increase and is much higher than that of the Euro area economy (Figure 4.1.16).

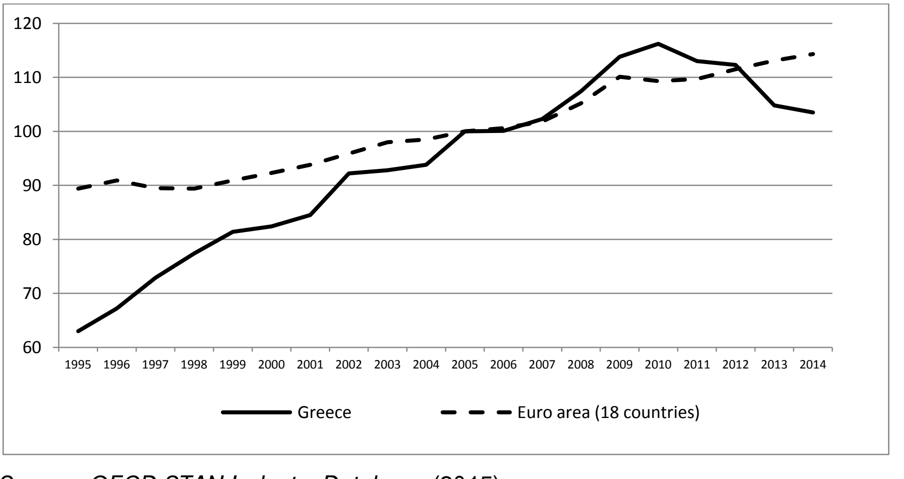
By and large, we observe that the productivity of the Greek economy fell sharply in almost all sectors during the last years and its relative level is well below that of the Euro area. In relation to this, we observe that in most of the sectors, the decline in productivity was followed by an increase in the unit labor cost index, despite the nominal wage decreases in recent years.

FIGURE 4.1.1
Gross value added per hour worked (Index, Total economy)



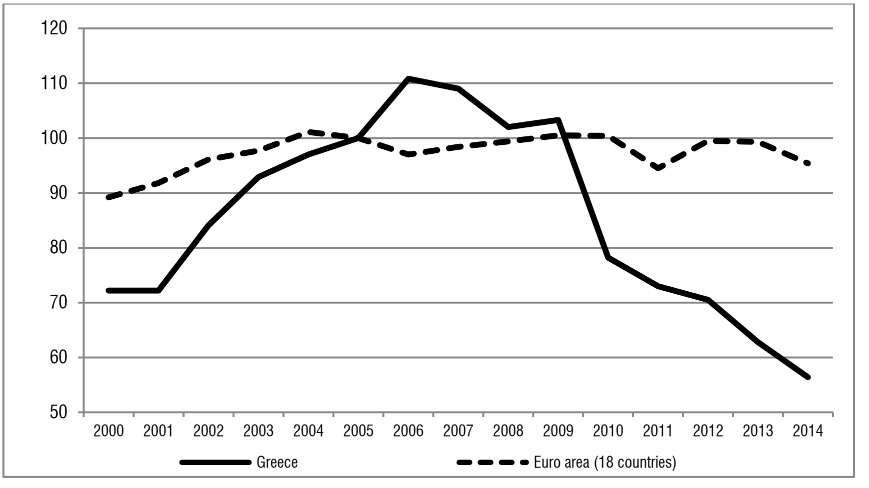
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.2
Unit labor cost (Index, Total economy)



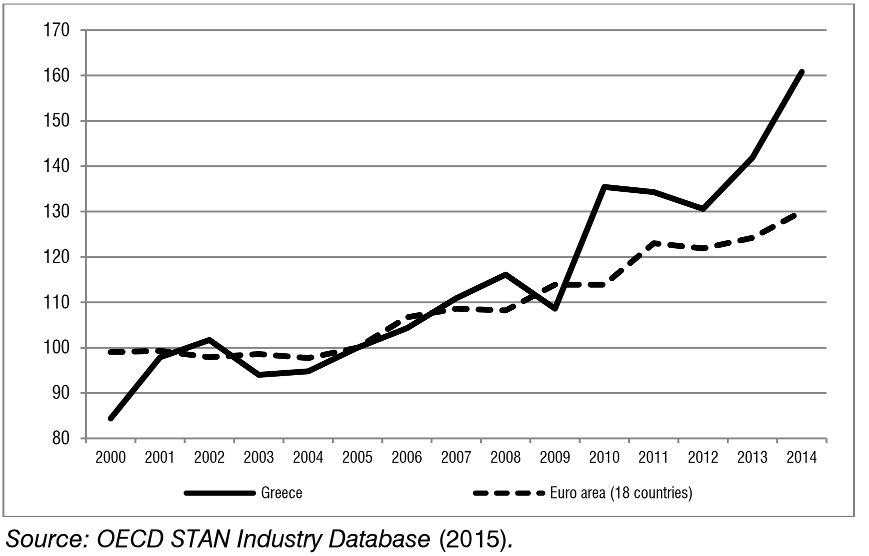
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.3
Gross value added per hour worked (Index, Mining and utilities)



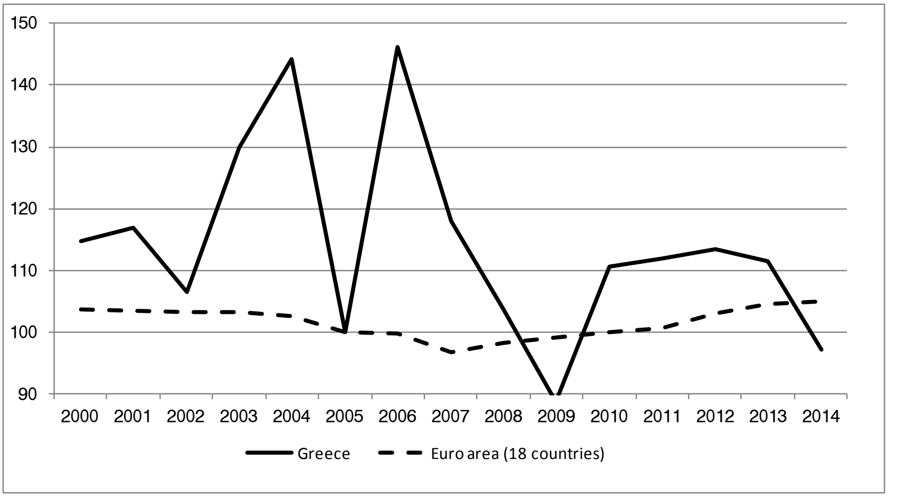
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.4
Unit labor cost (Index, Mining and utilities)



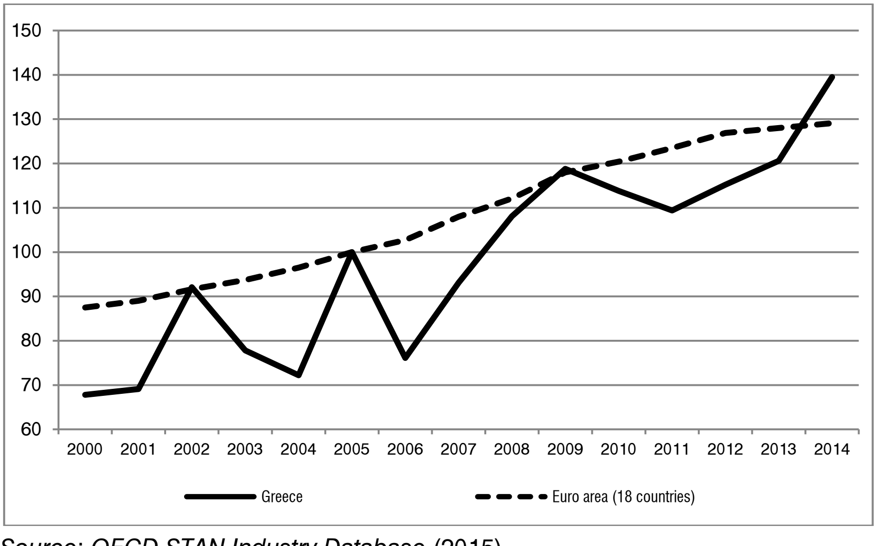
Source: OECD STAN Industry Database (2015).

FIGURE 4.1.5
Gross value added per hour worked (Index, Construction)



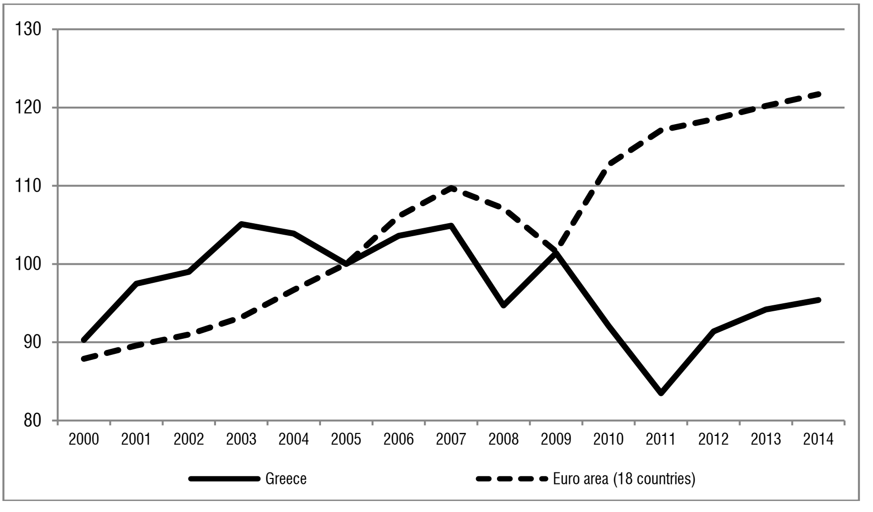
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.6
Unit labor cost (Index, Construction)



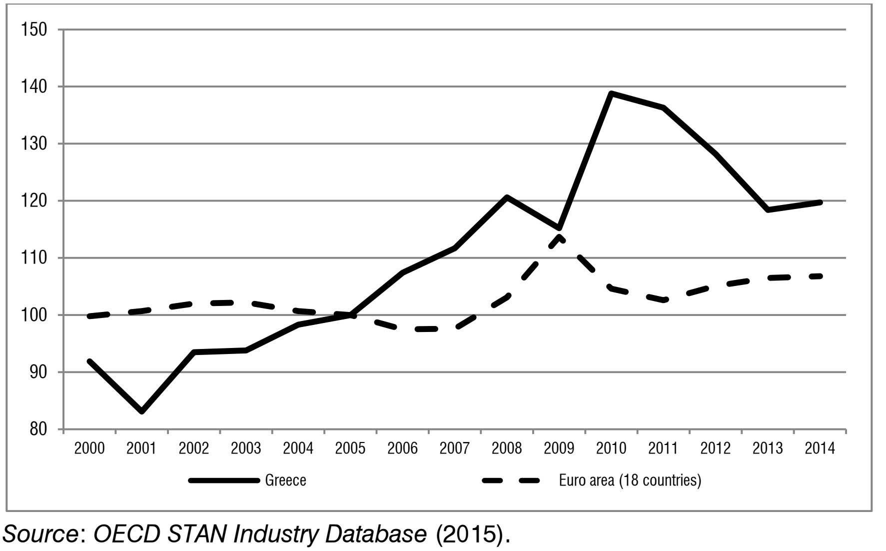
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.7
Gross value added per hour worked (Index, Manufacturing)



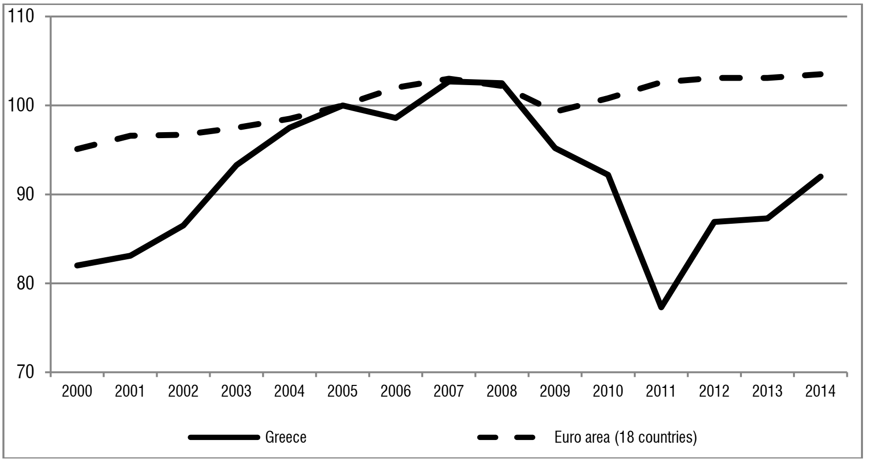
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.8
Unit labor cost (Index, Manufacturing)



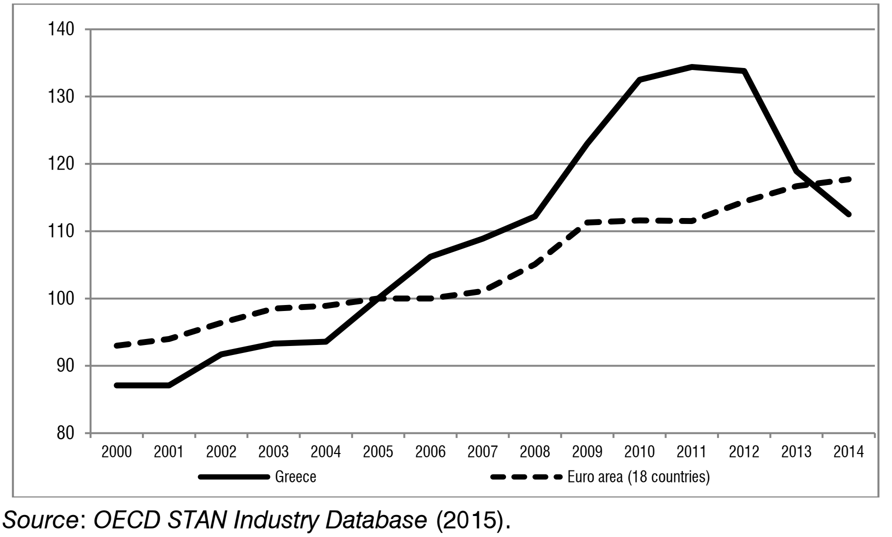
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.9
Gross value added per hour worked (Index, Wholesale and retail trade, accommodation and food services, transportation and storage)



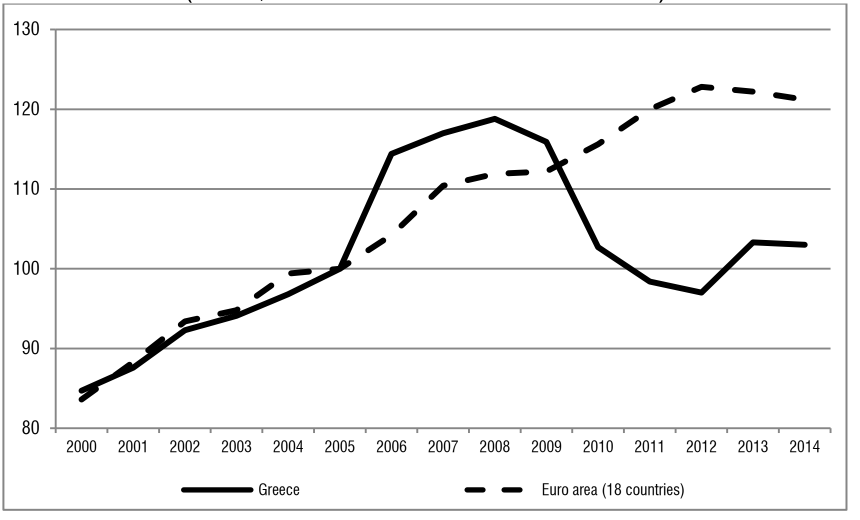
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.10
Unit labor cost (Index, Wholesale and retail trade, accommodation and food services, transportation and storage)



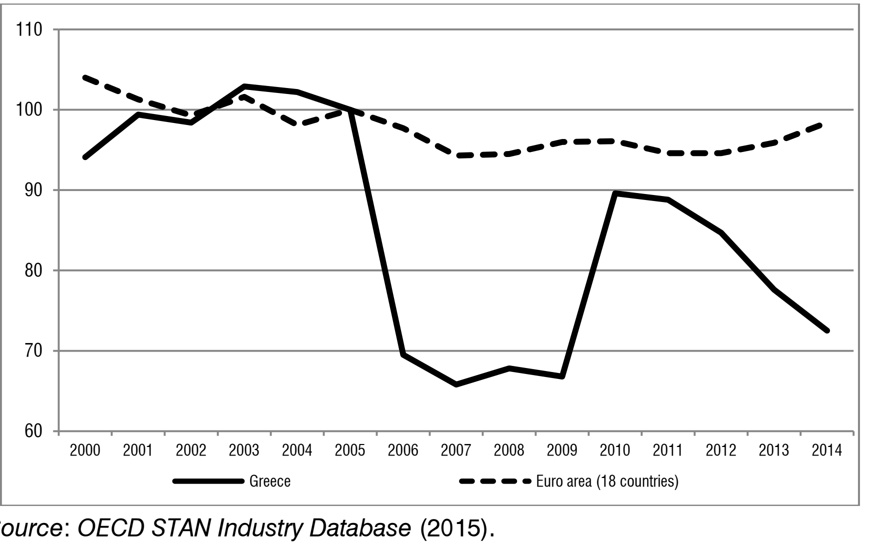
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.11
Gross value added per hour worked
(Index, Information and communication)



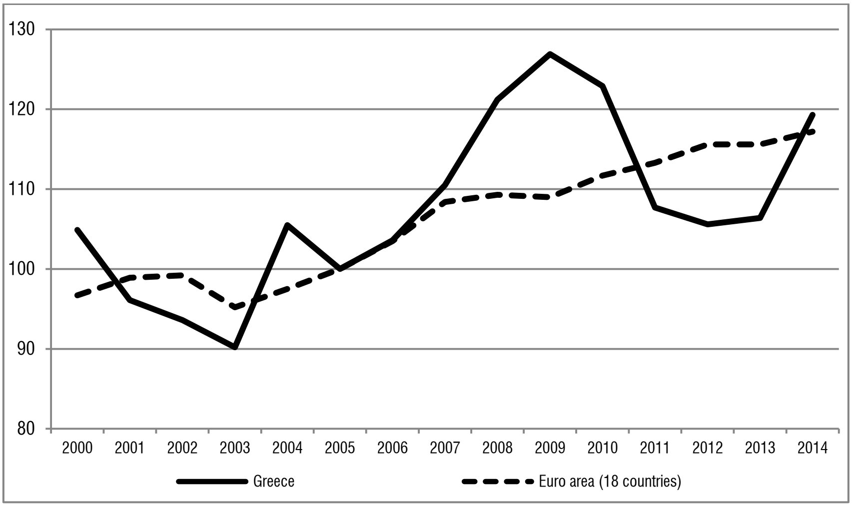
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.12
Unit labor cost (Index, Information and communication)



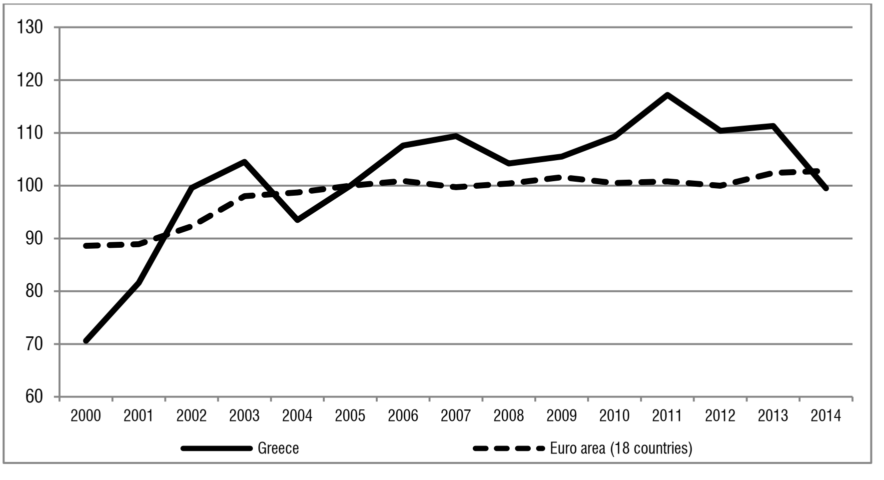
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.13
Gross value added per hour worked
(Index, Financial and insurance activities)



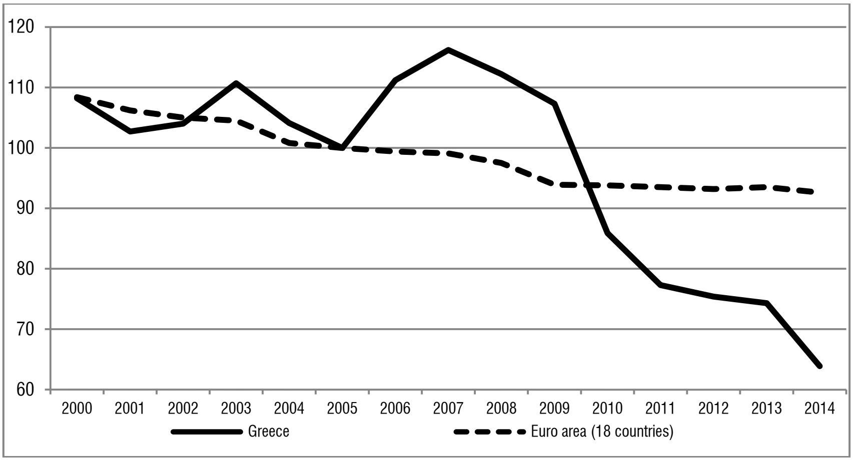
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.14
Unit labor cost (Index, Financial and insurance activities)



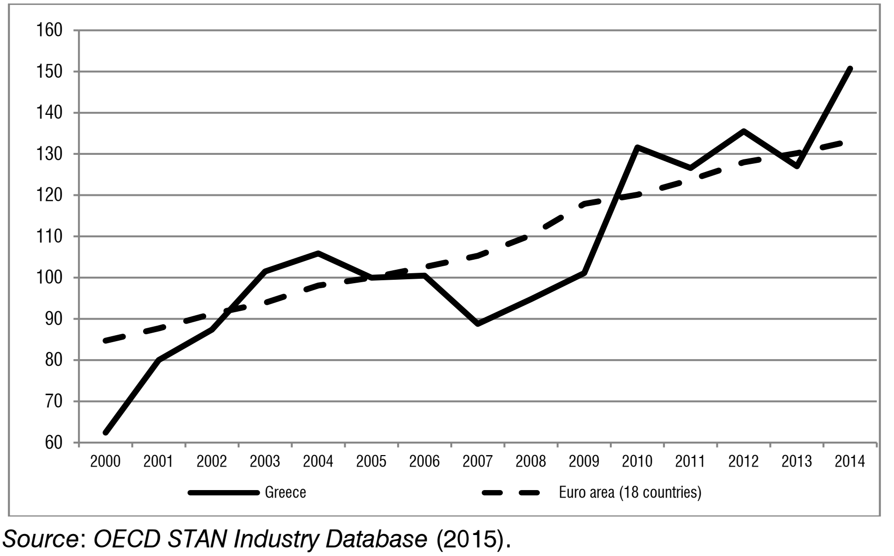
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.15
Gross value added per hour worked (Index, Professional, scientific and technical activities, administrative and support service activities)



Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.16
Unit labor cost (Index, Professional, scientific and technical activities administrative and support service activities)

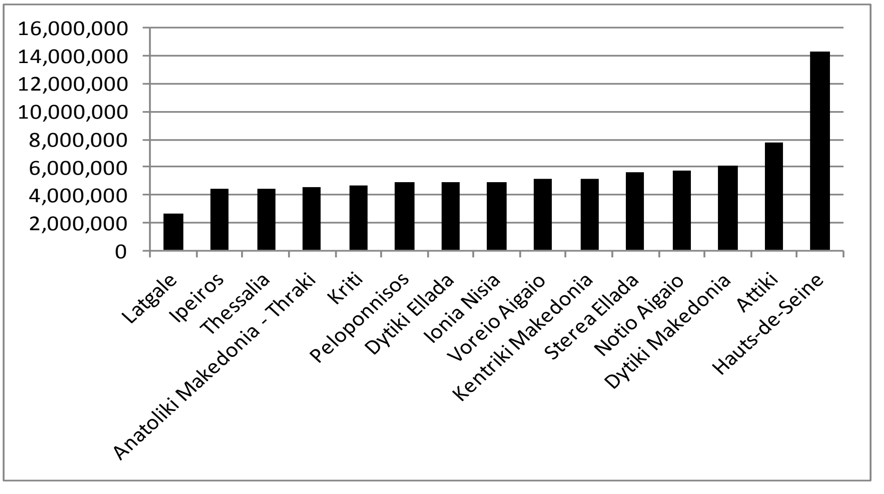


Source: *OECD STAN Industry Database* (2015).

4.1.2. Productivity at the regional level

In Figures 4.1.17-4.1.26, we observe the relative productivity levels of the Greek regions in the total economy and its broad sectors, for 2012. In these figures, we also include the most and least productive regions of the European Union for comparative purposes. At the total economy level (Figure 4.1.17), we notice that the most productive region of the Greek economy is Attiki, while the least productive region is Ipeiros. We also observe that most regions of the Greek economy lag significantly behind the most productive region of the European Union (Hauts-de-Seine), in terms of output per hour worked.

FIGURE 4.1.17
Productivity of Greek regions (Total economy, 2012, USD per worker, constant PPP, 2010 prices)

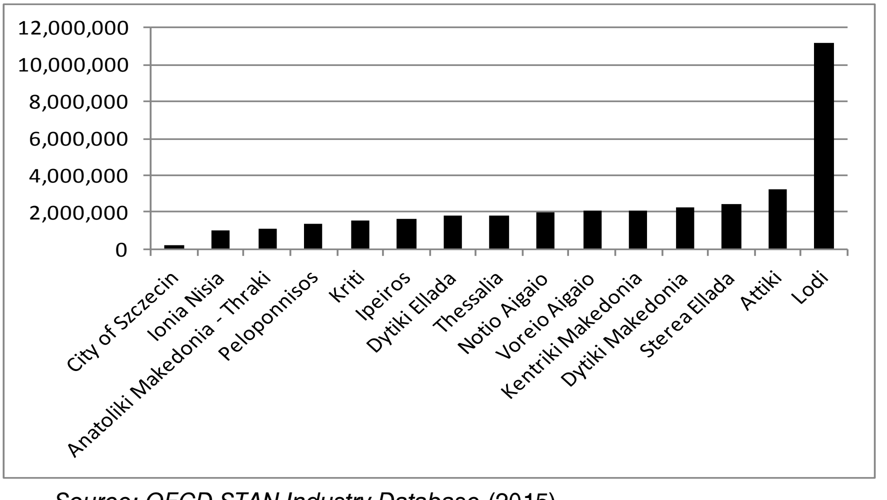


Source: OECD STAN Industry Database (2015).

Figures 4.1.18-4.1.26 show relative productivity levels of the Greek regions for each sector of economic activity. Attiki is the most productive region in most of sectors under examination. We further observe that in the sectors of Agriculture, forestry and fishing, and Construction and Manufacturing (Figures 4.1.18-4.1.20), all regions of the Greek economy lag significantly behind the most productive region of the European Union. In the sector of Distributive trade, repairs, transport, accommodation and food service activities, we also distinguish that the productivity levels of most Greek regions lag significantly behind those of the most productive region of the European Union (Figure 4.1.21). However, the regions of Notio Aigaio, Attiki and Ionia Nisia are closer to the productivity frontier. The same also holds for the industry of Information and communication (Figure 4.1.22), with the regions of Kriti, Ipeiros and Dytiki Makedonia being closer to the most productive region of the European Union.

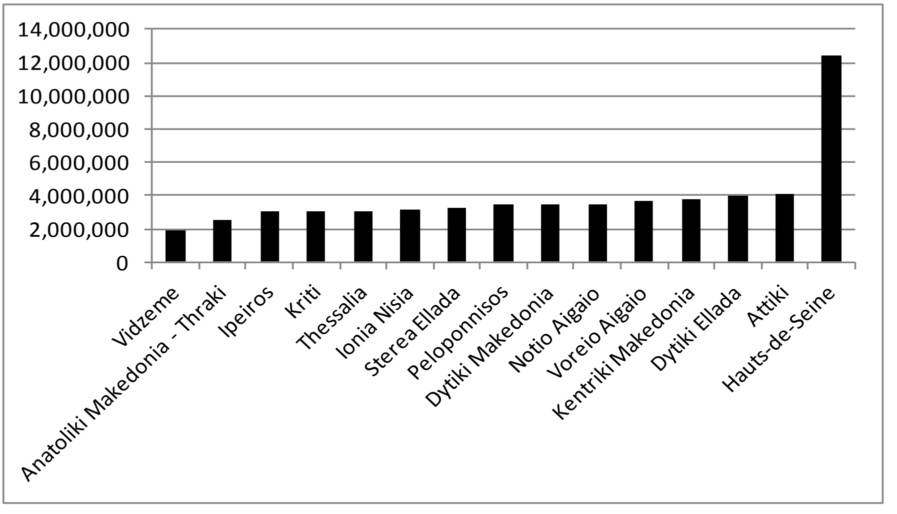
With the exception of Attiki, all other regions of the Greek economy lag significantly, in terms of productivity, in the sector of Finance and insurance (Figure 4.1.23). Regarding the Real estate sector, all regions of the Greek economy remain very close to the most productive region of the European Union (Figure 4.1.24). In Professional, scientific, technical activities, and administrative, support and service activities (Figure 4.1.25), all regions of the Greek economy lag significantly behind the most productive region of the European Union. Finally, in Public administration, compulsory social security, education and human health, all regions of the Greek economy were close to the most productive region of the European Union (Figure 4.1.26).

FIGURE 4.1.18
Productivity of Greek regions (Agriculture, forestry and fishing, 2012, USD per worker, constant PPP, 2010 prices)



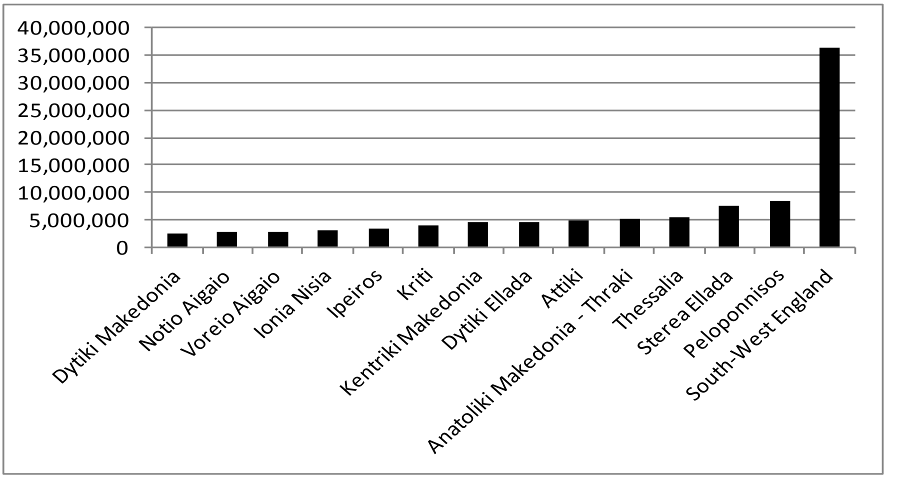
Source: OECD STAN Industry Database (2015).

FIGURE 4.1.19
Productivity of Greek regions (Construction, 2012, USD per worker, constant PPP, 2010 prices)



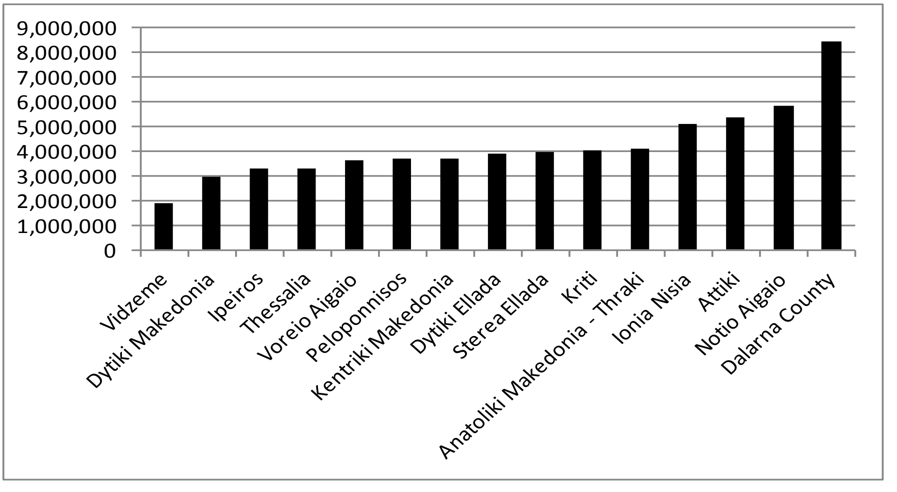
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.20
Productivity of Greek regions (Manufacturing, 2011, USD per worker, constant PPP, 2010 prices)



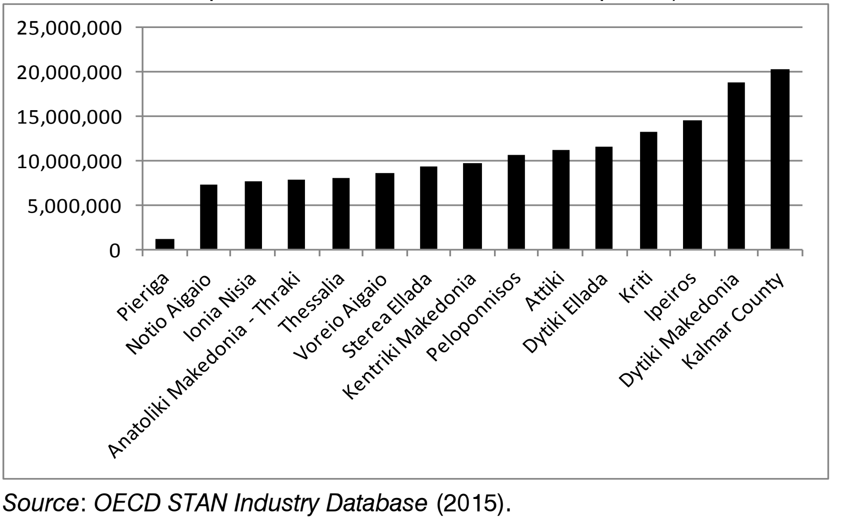
Source: OECD STAN Industry Database (2015).

FIGURE 4.1.21
Productivity of Greek regions (Distributive trade, repairs, transport, accommodation and food service activities, 2012, USD per worker, constant PPP, 2010 prices)



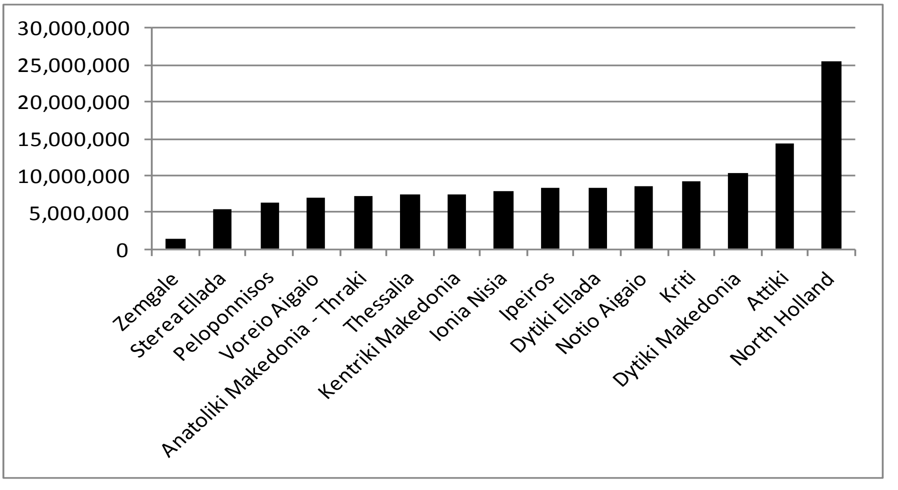
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.22
Productivity of Greek regions (Information and communication, 2012, USD per worker, constant PPP, 2010 prices)



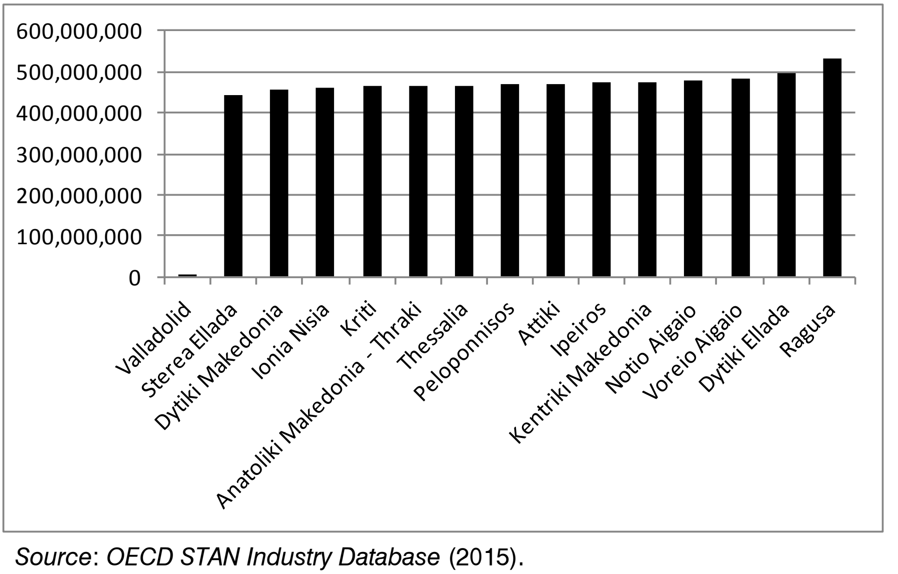
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.23
Productivity of Greek regions (Financial and insurance activities, 2012, USD per worker, constant PPP, 2010 prices)



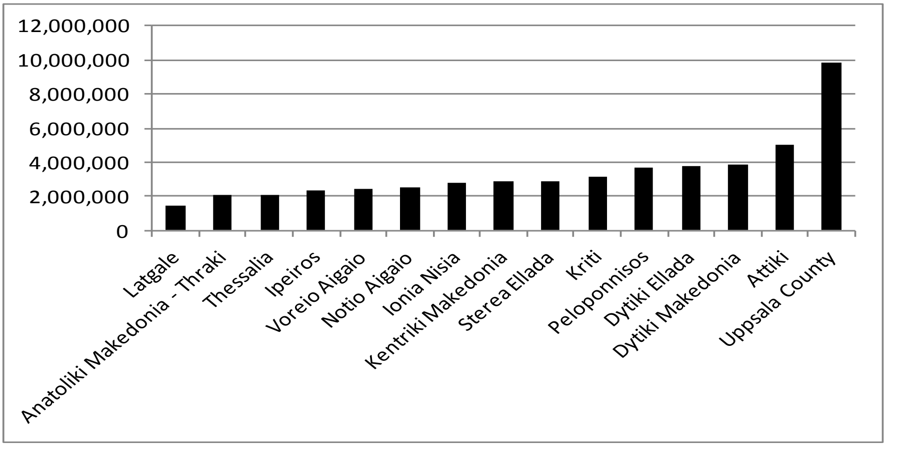
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.24
Productivity of Greek regions (Real estate activities, 2012, USD per worker, constant PPP, 2010 prices)



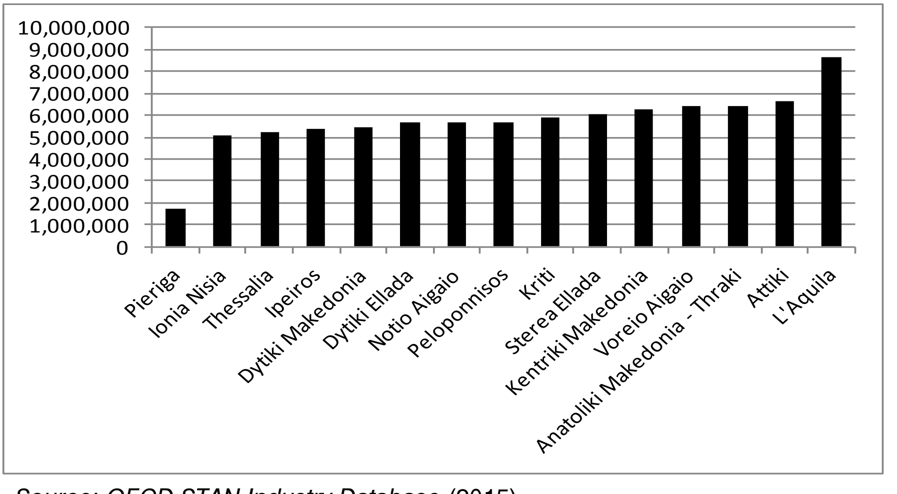
Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.25
Productivity of Greek regions (Professional, scientific, technical activities, administrative, support service activities, 2012, USD per worker, constant PPP, 2010 prices)



Source: *OECD STAN Industry Database* (2015).

FIGURE 4.1.26
Productivity of Greek regions (Public administration, compulsory social security, education, human health, 2012, USD per worker, constant PPP, 2010 prices)



Source: *OECD STAN Industry Database* (2015).

4.2. Human capital at the sectoral and regional level

In this section, we demonstrate the evolution of the variable of human capital across sectors and regions of the Greek economy. It is noted that the variable of human capital is measured as the percentage share of total hours worked by persons with tertiary education.

4.2.1. Human capital at the sectoral level

Figures 4.2.1-4.2.10 illustrate the evolution of human capital across broad sectors of the Greek economy during the period 2000-2012. We observe that the share of hours worked by persons with tertiary education has increased in all sectors of the Greek economy during this period. In 2012, the highest shares of hours worked by more educated employees are observed in the sectors of Information and communication, Financial and insurance activities, Real estate activities and Professional, scientific, technical, administrative and support service activities. On the contrary, the lowest share of hours worked by persons with tertiary education is observed in the sector of Agriculture, forestry and fishing, that is, only 5% in 2012 (Figure 4.2.1). This ratio was even lower in 2000, at only 2% of total hours worked.

In the sector of Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities (Figure 4.2.2) the share of hours worked by employees with tertiary education increased from 19% in 2000 to 27% in 2012. In Construction (Figure 4.2.3), this share rose from 9% (in 2000) to 19% (in 2012). We also observe an increase of this share in the sector of Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities (Figure 4.2.4) from 18% (in 2000) to 27% (in 2012). In the sectors of Information and communication, and Financial and insurance activities (Figures 4.2.5 and 4.2.6, respectively) we notice very high ratios of hours worked by people with tertiary education, having increased remarkably in the period 2000-2012, from 50% (in both sectors) to 78% (in Information and communication) and 70% (in Financial and insurance activities). Similar high rates are also observed in Real estate activities, and Professional, scientific, technical, administrative and support service activities (Figures 4.2.7 and

4.2.8, respectively). In Real estate activities, although this index remained almost constant and close to 40%, in 2012 rose sharply and reached 70%. In contrast, in Professional, scientific, technical, administrative and support service activities, we observe significant fluctuations in this ratio, with a slight decrease recorded between 2006 and 2012 (from 76% to 74%).

Similarly, the broad sector of Public administration, education, health and social care (Figure 4.2.9) shows very high rates of hours worked by persons with tertiary education, which rose from 59% in 2000 to 69% in 2012. Finally, in the sector of Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies (Figure 4.2.10), we observe a significant increase from 24% in 2000 to 40% in 2012. It is quite clear that, despite the advent of the crisis, the percentage of hours worked by people with higher education continued to grow during 2008-2012, possibly implying a) that firms are trying to retain their levels of human capital during the crisis and b) that more educated people are less vulnerable in economic downturns.

FIGURE 4.2.1
Share of hours worked by persons with tertiary education
Agriculture, forestry and fishing

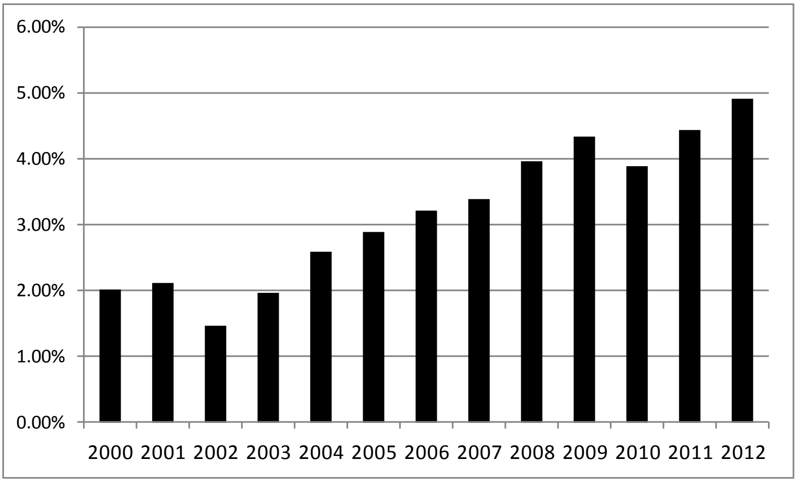


FIGURE 4.2.2
Share of hours worked by persons with tertiary education

Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities

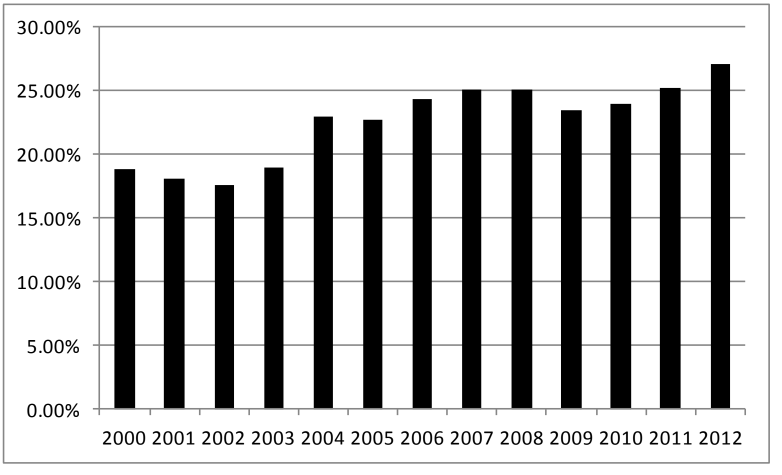


FIGURE 4.2.3

Share of hours worked by persons with tertiary education
Construction

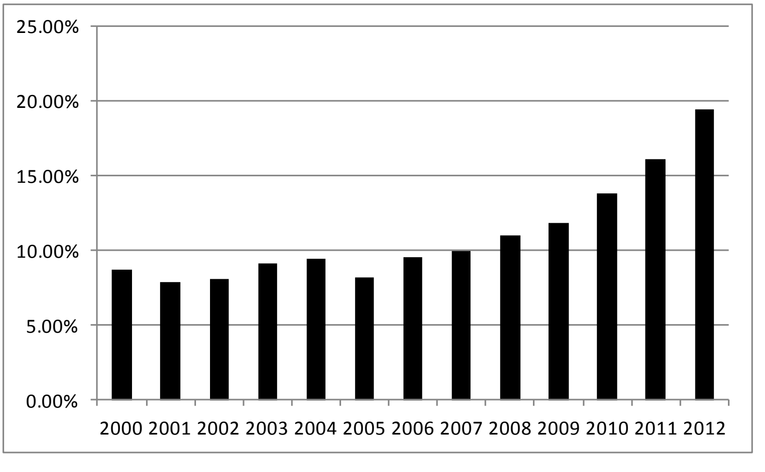


FIGURE 4.2.4
Share of hours worked by persons with tertiary education

Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities

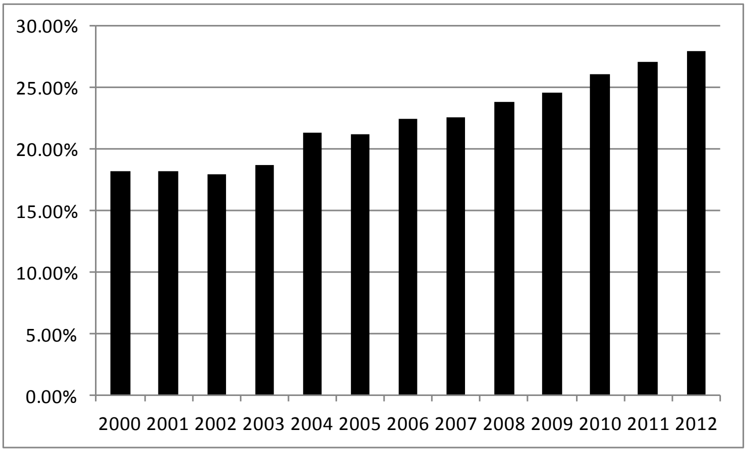


FIGURE 4.2.5
Share of hours worked by persons with tertiary education

Information and communication

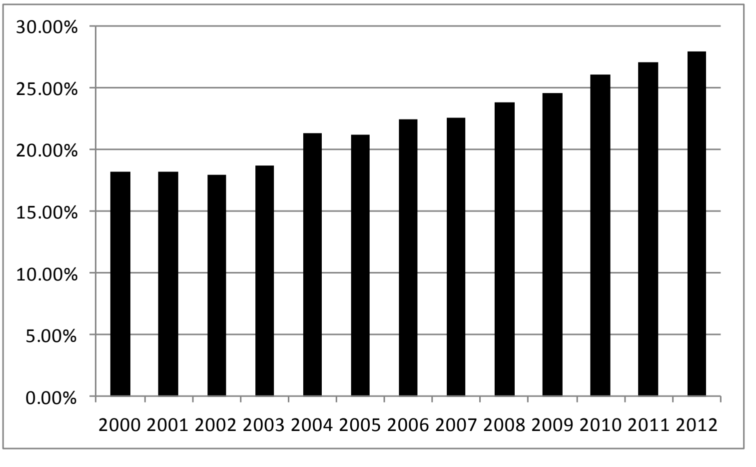


FIGURE 4.2.6

Share of hours worked by persons with tertiary education

Financial and insurance activities

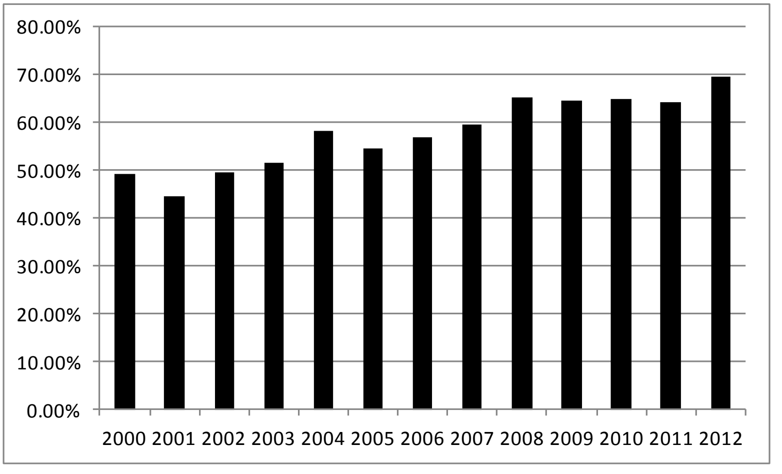


FIGURE 4.2.7

Share of hours worked by persons with tertiary education

Real estate activities

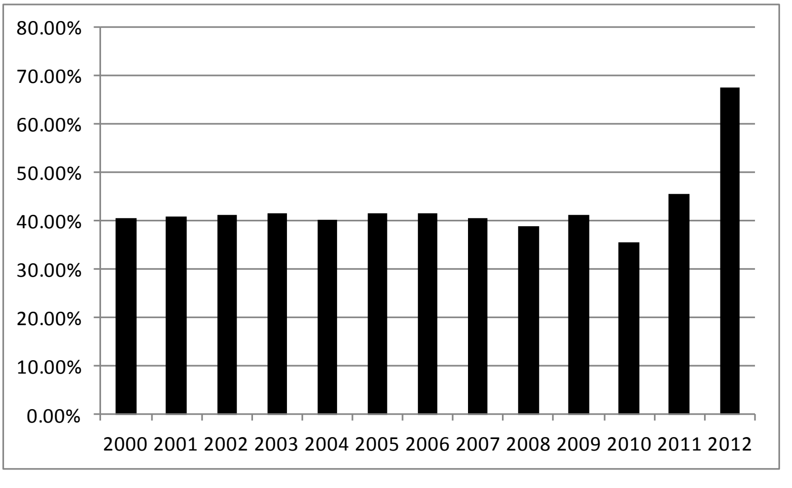


FIGURE 4.2.8

Share of hours worked by persons with tertiary education

Professional, scientific, technical, administrative and support service activities

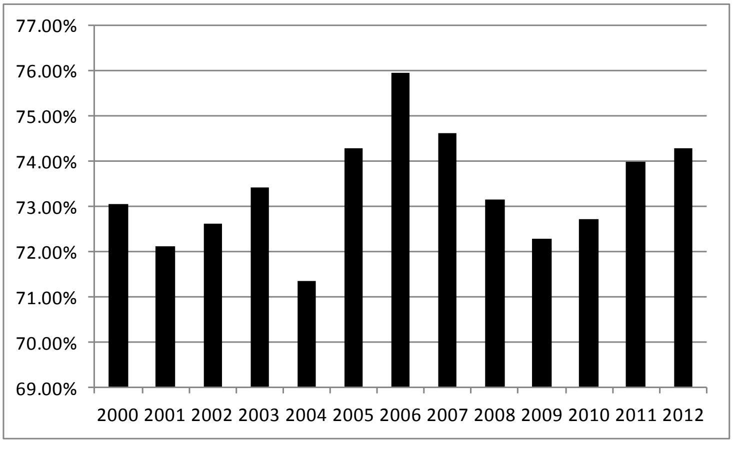


FIGURE 4.2.9

Share of hours worked by persons with tertiary education

Public administration and defense, compulsory social security, education, human health and social work activities

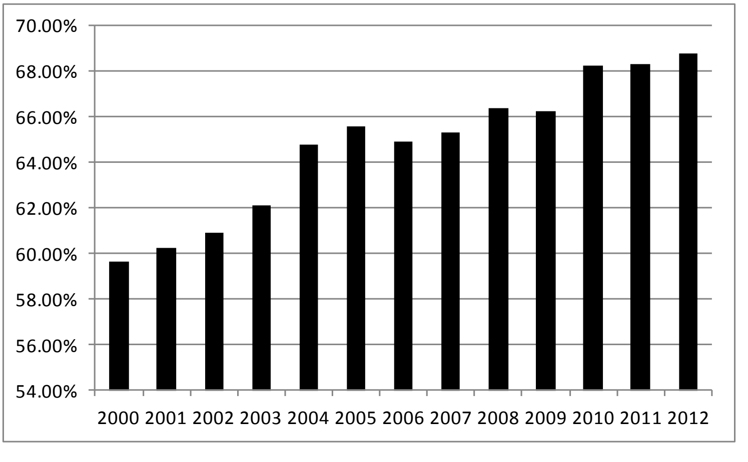
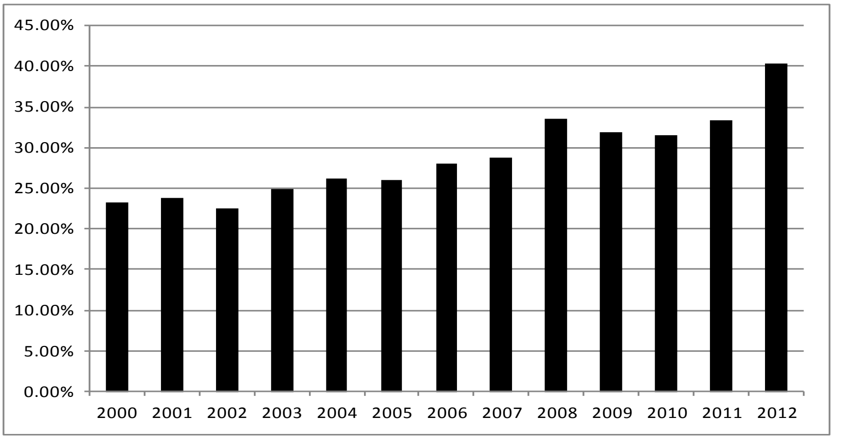


FIGURE 4.2.10
Share of hours worked by persons with tertiary education

Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies



4.2.2. Human capital at the regional level

Figures 4.2.11-4.2.23 demonstrate how the variable of human capital has evolved in the Greek regions during the period 2000-2012. Similar to the trends observed in most sectors, we observe that the variable of human capital has followed an increasing trend in all regions of the Greek economy. In 2012, the highest shares of hours worked by more educated employees are observed in the regions of Attiki and Kentriki Makedonia (53% and 40%, respectively).

More specifically, in Anatoliki Makedonia and Thraki (Figure 4.2.11), we observe that the proportion of hours worked by people with tertiary education increased from 18% in 2000 to 32% in 2012. Similarly, in Kentriki Makedonia (Figure 4.2.12), this share increased from 25% in 2000 to almost 40% in 2012. In the region of Dytiki Makedonia (Figure 4.2.13), the ratio of hours worked by people with higher education, after some fluctuations, increased from 21% in 2000 to

28% in 2012. In Ipeiros (Figure 4.2.14) and Thessalia (Figure 4.2.15), we observe that this share increased from 20% in 2000 to more than 30% in 2012.

Similarly, in the region of Ionia Nisia (Figure 4.2.16), we notice an increase in this ratio from 16% in 2000 to 24% in 2012, while in Dytiki Ellada (Figure 4.2.17) a significant rise in this share took place from 12% in 2000 to 25% in 2012. In the region of Sterea Ellada (Figure 4.2.18), an initial decline in the share of hours worked by highly educated people was observed from 15% in 2000 to almost 10% in 2002. However, this share then increased significantly and reached 25% in 2012.

FIGURE 4.2.11

Share of hours worked by persons with tertiary education

Anatoliki Makedonia - Thraki

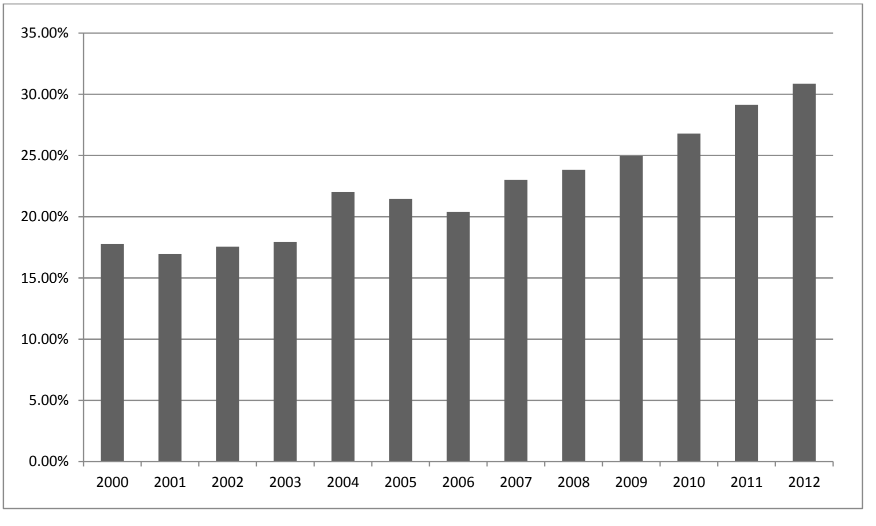


FIGURE 4.2.12

Share of hours worked by persons with tertiary education

Kentriki Makedonia

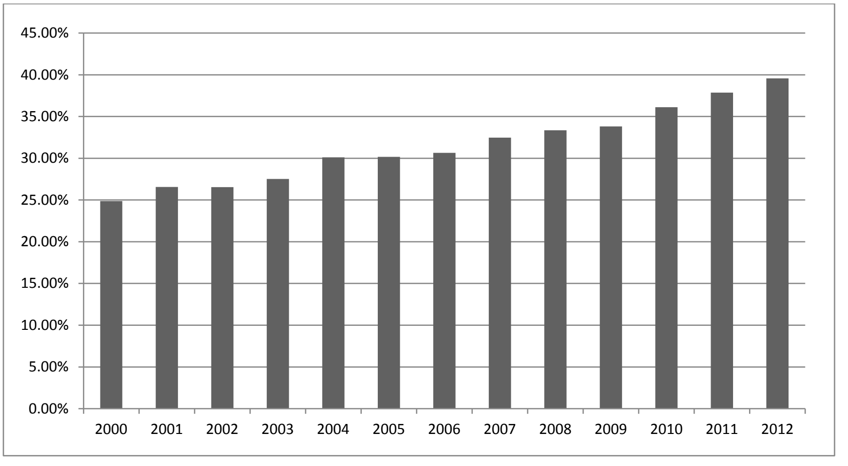


FIGURE 4.2.13

Share of hours worked by persons with tertiary education

Dytiki Makedonia

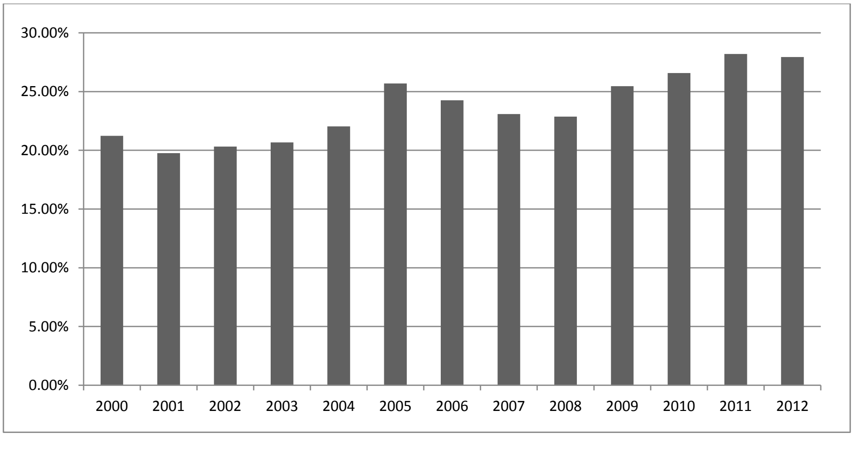


FIGURE 4.2.14

Share of hours worked by persons with tertiary education

Ipeiros

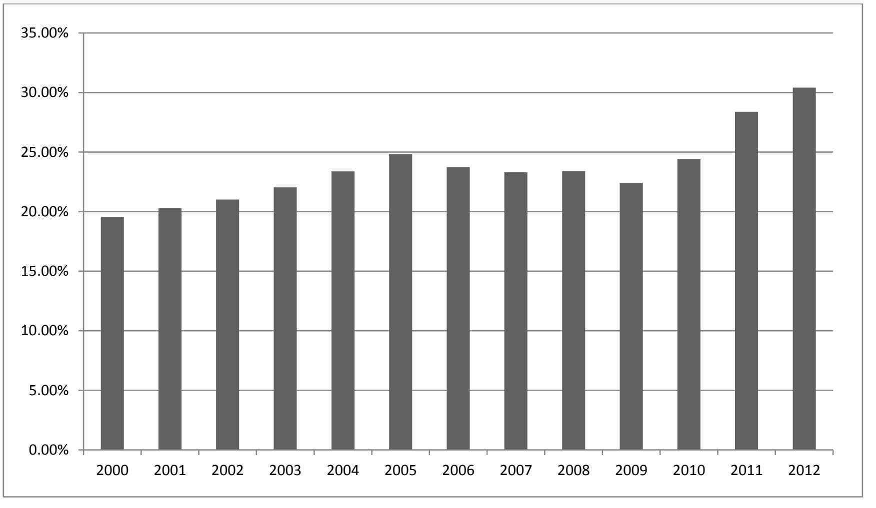


FIGURE 4.2.15

Share of hours worked by persons with tertiary education

Thessalia

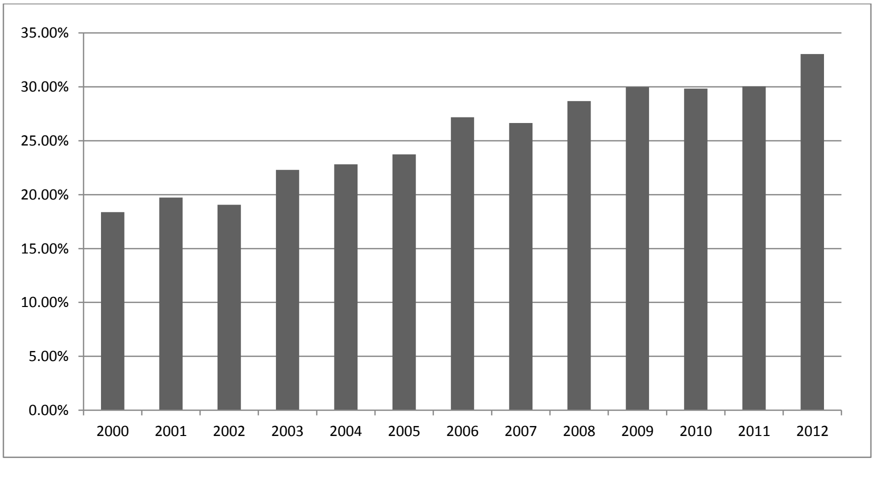


FIGURE 4.2.16

Share of hours worked by persons with tertiary education

Ionia Nisia

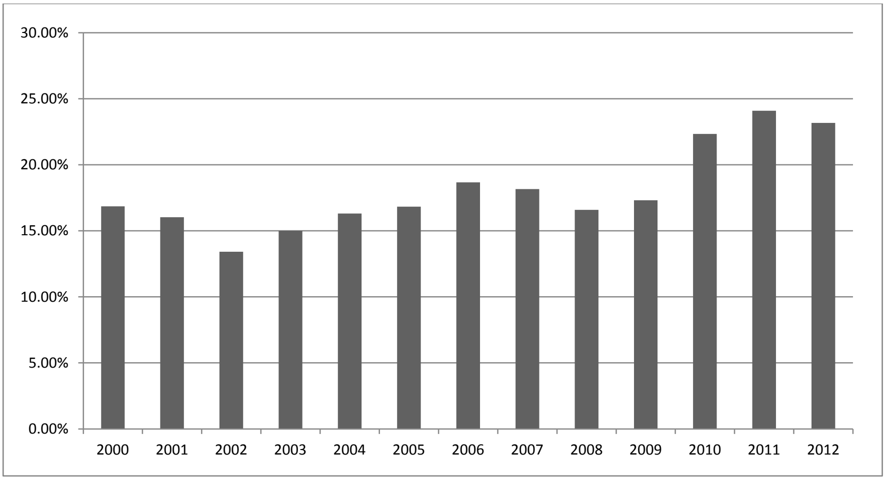


FIGURE 4.2.17

Share of hours worked by persons with tertiary education

Dytiki Ellada

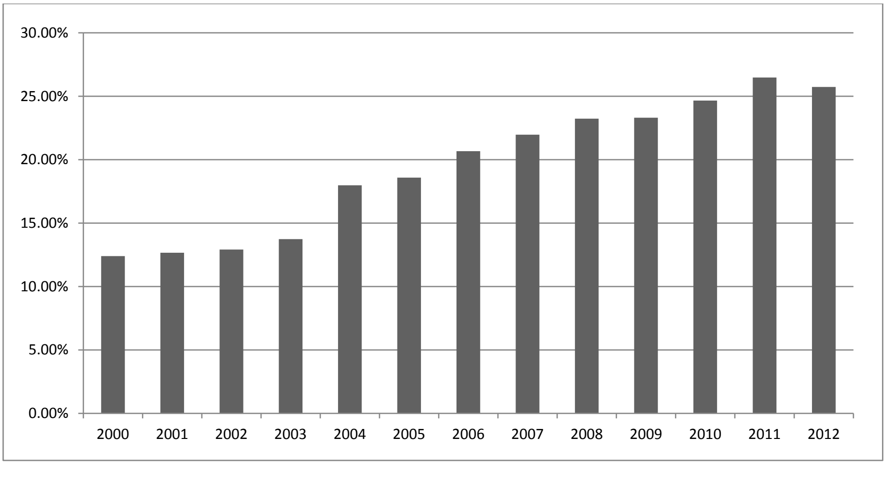
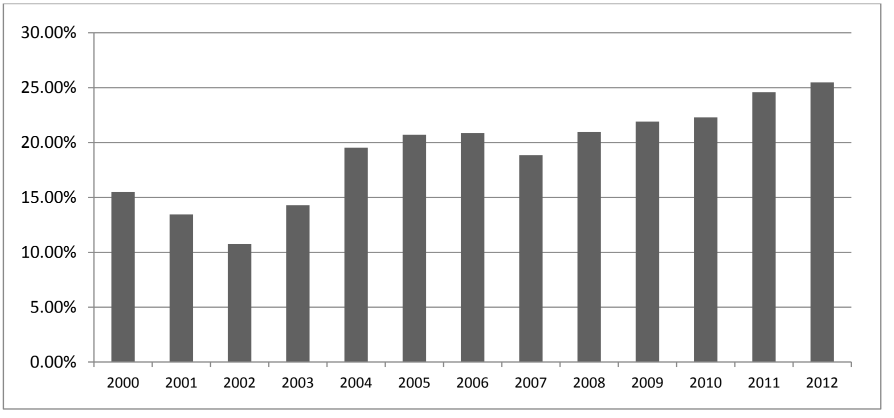


FIGURE 4.2.18

Share of hours worked by persons with tertiary education

Sterea Ellada



Attiki is the region with the highest percentage of hours worked by people with tertiary education. This share increased from 38% in 2000 to 53% in 2012 (Figure 4.2.19). In the region of Peloponnisos (Figure 4.2.20), we notice a relatively stable ratio at around 20%, while in Voreio Aigaio (Figure 4.2.21) a significant increase took place, reaching 30% in 2012. In the region of Notio Aigaio (Figure 4.2.22), the share of hours worked by persons with tertiary education marked a gradual rise from 15% in 2000 to 20% in 2010. From then, this ratio accelerated and reached 31% in 2012. Finally, in the region of Kriti (Figure 4.2.23), we notice that the share of hours worked by persons with tertiary education increased significantly over the entire period, reaching 28% in 2012.

Tables 4.2.1-4.2.3 show in a more comprehensive way the shares of hours worked by persons with tertiary education in pairs of regions and sectors (for the years 2000, 2008 and 2012, respectively). It is worth noting that for certain pairs of regions, for the sector of Real estate, zero rates of the share of hours worked by persons with tertiary education are observed. This is probably due to local peculiarities of the sector of Real estate in the specific regions.

FIGURE 4.2.19

Share of hours worked by persons with tertiary education

Attiki

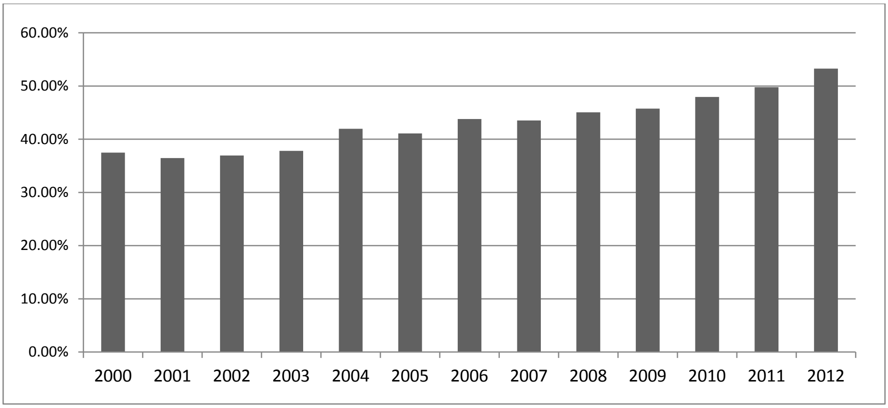


FIGURE 4.2.20

Share of hours worked by persons with tertiary education

Peloponnisos

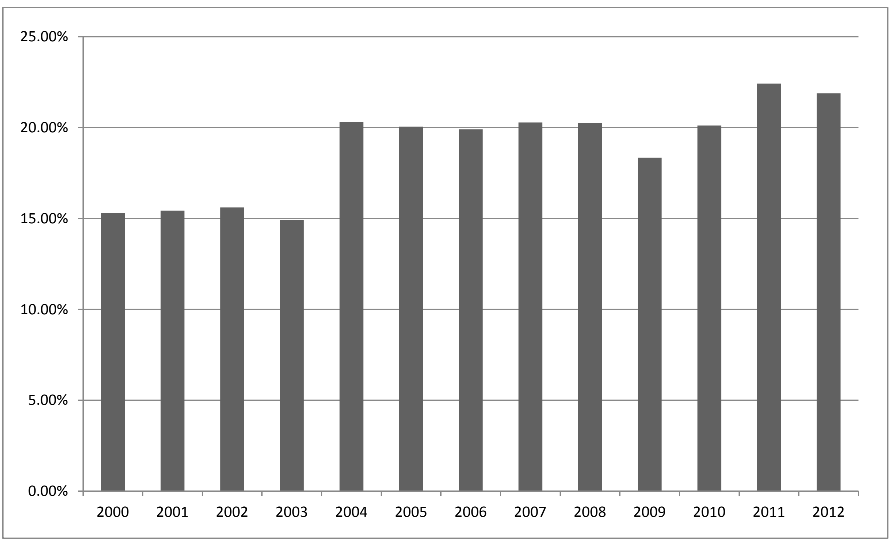


FIGURE 4.2.21

Share of hours worked by persons with tertiary education

Voreio Aigaio

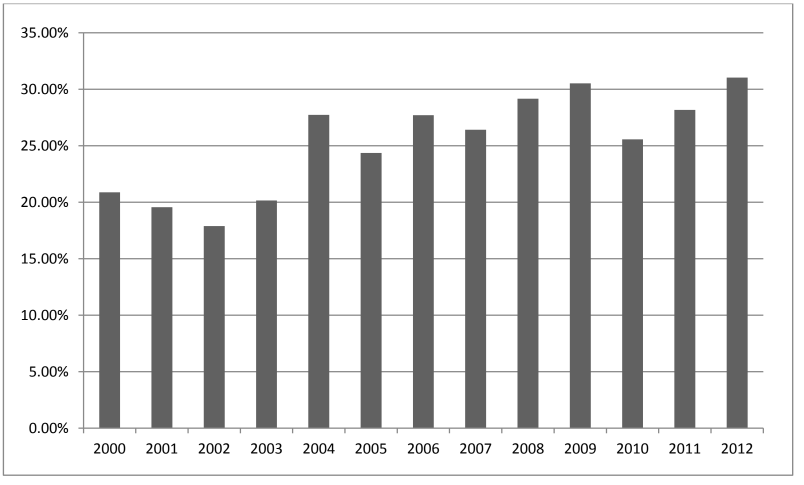


FIGURE 4.2.22

Share of hours worked by persons with tertiary education

Notio Aigaio

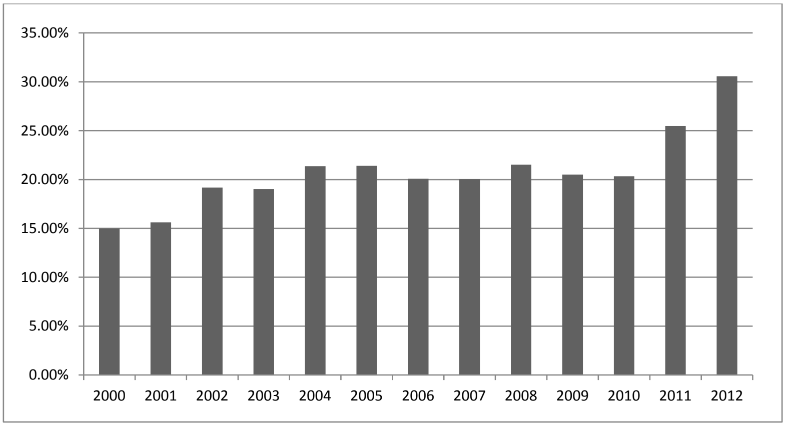


FIGURE 4.2.23

Share of hours worked by persons with tertiary education

Kriti

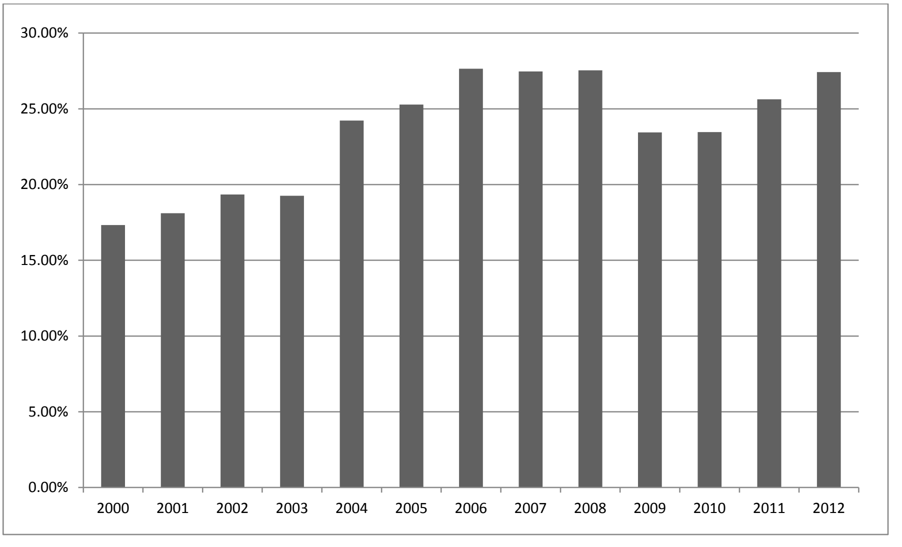


TABLE 4.2.1
Human capital across sectors and regions (2000)

Sectors	Anatoliki Makedonia-Thraki	Kentriki Makedonia	Dytiki Makedonia	Ipeiros	Thessalia	Ionia Nisia	Dytiki Ellada	Sterea Ellada	Attiki	Peloponnisos	Voreio Aigaio	Notio Aigaio	Kriti
1.	1.07%	3.08%	0.94%	1.02%	2.02%	0.71%	0.83%	2.60%	8.98%	1.88%	5.53%	0.64%	1.23%
2.	13.83%	17.24%	13.87%	12.43%	11.67%	5.89%	8.61%	11.42%	26.44%	12.24%	13.49%	8.68%	14.59%
3.	9.73%	8.70%	8.18%	4.97%	3.87%	6.07%	4.06%	7.29%	14.22%	5.07%	0.96%	4.81%	5.93%
4.	13.08%	18.72%	17.98%	10.46%	15.38%	8.81%	8.60%	10.33%	25.52%	11.84%	16.50%	9.09%	13.14%
5.	29.04%	46.45%	88.14%	43.83%	66.58%	70.13%	37.48%	24.13%	52.10%	24.96%	29.62%	26.01%	40.24%
6.	43.93%	54.98%	51.94%	44.10%	41.42%	32.74%	27.97%	5.49%	53.76%	36.95%	20.48%	39.87%	49.74%
7.	31.59%	42.41%	62.45%	0.00%	42.49%	41.62%	0.00%	0.00%	47.85%	0.00%	0.00%	28.91%	17.04%
8.	70.91%	74.59%	65.10%	71.82%	69.28%	60.38%	66.63%	76.92%	74.39%	80.50%	62.66%	53.98%	71.33%
9.	56.17%	62.28%	58.65%	57.71%	57.14%	64.45%	56.85%	55.05%	61.88%	55.27%	56.84%	51.33%	54.92%
10.	29.71%	32.46%	34.36%	25.60%	18.48%	12.24%	4.60%	16.92%	30.63%	26.66%	24.13%	19.07%	26.61%

1. Agriculture, forestry and fishing, 2. Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific and technical activities, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

TABLE 4.2.2
Human capital across sectors and regions (2008)

Sectors	Anatoliki Makedonia-Thraki	Kentriki Makedonia	Dytiki Makedonia	Ipeiros	Thessalia	Ionia Nisia	Dytiki Ellada	Sterea Ellada	Attiki	Peloponnisos	Voreio Aigaio	Notio Aigaio	Kriti
1.	2.74%	5.45%	2.65%	2.45%	2.73%	0.78%	2.97%	4.20%	22.45%	2.91%	4.71%	2.87%	3.29%
2.	17.14%	20.61%	13.23%	13.29%	23.67%	16.96%	13.64%	16.42%	35.01%	12.51%	13.55%	22.99%	18.85%
3.	11.72%	13.30%	12.94%	3.07%	12.15%	4.89%	4.44%	8.99%	14.91%	4.01%	7.31%	4.59%	9.17%
4.	15.54%	23.79%	15.41%	14.40%	20.41%	9.65%	14.58%	13.12%	32.72%	13.88%	18.70%	13.99%	20.69%
5.	27.13%	69.99%	56.18%	49.38%	40.57%	100.00%	48.92%	42.60%	74.64%	42.96%	46.51%	27.40%	61.21%
6.	53.57%	69.75%	42.38%	51.42%	54.99%	64.02%	55.37%	52.21%	68.98%	48.80%	63.04%	41.31%	58.09%
7.	19.05%	39.91%	100.00%	0.00%	55.96%	40.68%	0.00%	0.00%	44.94%	0.00%	0.00%	0.00%	31.81%
8.	63.91%	78.97%	78.05%	72.90%	69.37%	55.15%	68.64%	71.20%	74.13%	71.05%	77.33%	64.09%	69.14%
9.	61.03%	70.18%	66.29%	62.98%	67.40%	59.06%	64.64%	57.44%	69.23%	61.58%	58.81%	52.40%	65.32%
10.	27.85%	35.66%	11.16%	30.09%	25.57%	23.35%	28.17%	23.63%	36.52%	29.59%	35.78%	19.15%	36.19%

1. Agriculture, forestry and fishing, 2. Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific and technical activities, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

TABLE 4.2.3

Human capital across sectors and regions (2012)

Sectors	Anatoliki Makedonia-Thraki	Kentriki Makedonia	Dytiki Makedonia	Ipeiros	Thessalia	Ionia Nisia	Dytiki Ellada	Sterea Ellada	Attiki	Peloponnisos	Voreio Aigaio	Notio Aigaio	Kriti
1.	3.57%	7.64%	2.72%	4.29%	7.78%	3.56%	2.36%	4.58%	12.78%	4.31%	1.46%	1.04%	4.25%
2.	19.88%	25.33%	18.62%	15.76%	19.78%	15.63%	21.85%	20.97%	38.03%	10.85%	14.17%	17.11%	18.25%
3.	21.23%	22.14%	8.22%	18.06%	22.61%	15.04%	12.92%	8.21%	30.09%	11.81%	14.83%	3.24%	11.72%
4.	23.79%	24.36%	19.84%	23.08%	27.99%	15.00%	18.91%	17.89%	37.34%	16.29%	26.80%	25.04%	20.71%
5.	73.64%	77.01%	100.00%	38.36%	48.13%	46.99%	47.78%	71.73%	81.97%	59.38%	93.81%	69.21%	49.14%
6.	71.32%	75.44%	46.11%	56.74%	62.38%	53.22%	47.77%	56.08%	73.94%	28.83%	27.17%	71.20%	54.09%
7.	40.88%	35.73%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	93.34%	29.93%	0.00%	0.00%	83.19%
8.	63.84%	74.09%	85.03%	79.02%	80.39%	65.93%	76.57%	53.96%	76.01%	81.02%	58.01%	58.00%	80.94%
9.	61.10%	74.22%	63.19%	66.09%	65.09%	60.51%	65.65%	67.91%	72.37%	58.76%	55.03%	66.30%	62.48%
10.	34.71%	43.37%	47.64%	36.98%	26.84%	22.01%	20.73%	32.63%	48.71%	21.02%	26.11%	30.89%	31.15%

1. Agriculture, forestry and fishing, 2. Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific and technical activities, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

4.3. Presentation of the agglomeration-related variables

The agglomeration-related variables may exhibit significant variations across and within regions in Greece due to the considerable geomorphological peculiarities of the country, which reflect the mountainous blocks and the scattered island complexes, and due to the concentration of major activities in and around the leading metropolitan areas of Athens and Thessaloniki. Table 4.3.1 shows descriptive statistics of these variables and their correspondence between (across regions) and within (over time) variations in the study period. More specifically, the standard deviation of the region-average population density is found to be almost twice the mean (i.e. a coefficient of variation equal to 2), signifying the considerable variability pertaining to the urbanization economies across regions. The region of Dytiki Makedonia has the lowest population density, while Attiki has the largest population density.

The variable of intra-regional population density dispersion takes its lowest value (by definition) in the region of Attiki and its highest value in Kentriki Makedonia, implying that the latter is the most polycentric region of the country. The equivalent proxies (for capturing urbanization economies) of the internal market potential (MP) index and internal market potential dispersion lead to similar findings and interpretation, but the region with the lowest internal MP index, which proxies for urbanization economies, is Voreio Aigaio. Furthermore, significant variations are observed in the external (interregional) market potential across regions in mainland Greece, where Anatoliki Makedonia and Thraki, in the northeastern part of the country, has the smallest value of the MP index, while Sterea Ellada, in the central part and close to Attiki, has the largest value.

TABLE 4.3.1
Descriptive statistics of the agglomeration-related variables and the corresponding between (across regions) and within (over time) variations

Variable	Mean	Standard deviation	Minimium	Maximum
Population density (inhabitants per km^2)	132.746	264.455	28.369 (Dytiki Makedonia, 2012)	1057.649 (Attiki, 2008)
Between		274.417	28.829	
Within		3.260	109.430	
Density dispersion	0.083	0.100	0 (Attiki)	0.403 (Kentriki Makedonia, 2010)
Between		0.103	0	0.396
Within		0.003	0.064	0.099
Specialization	0.123	0. 149	0.020 (Kentriki Makedonia, 2006)	0.672 (Dytiki Makedonia, 2005)
Between		0.154	0.022	0.606
Within		0.017	0.046	0.188
Internal Specialization	0.022	0. 029	-0.035 (Ionia Nisia, 2001)	0.124 (Dytiki Makedonia, 2010)
Between		0.028	-0.003	0.107
Within		0.008	-0.011	0.050
Internal MP index (%)	7.692	15.356	1.661 (Voreio Aigaio, 2002)	61.950 (Attiki, 2012)
Between		15.932	1.772	60.460
Within		0.337	5.821	9.183
Internal MP dispersion (euro per km)	23.802	26.737	0 (Attiki)	123.584 (Kentriki Makedonia, 2008)
Between		27.480	0	106.973
Within		3.696	7.518	40.413
Diversification	0.186	0.044	0.124 (Peloponnisos, 2004)	0.308 (Notio Aigaio, 2008)
Between		0.045	0.126	0.283
Within		0.011	0.144	0.213
External MP index (%)	7.692	2.385	4.120 (Anatoliki Makedonia Thraki, 2012)	11.092 (Sterea Ellada, 2012)
Between		2.474	4.170	10.140
Within		0.0705	7.470	7.898

Regarding the specialization variable, the region of Kentriki Makedonia is found to be the least specialized, while Dytiki Makedonia is the most specialized (mainly due to its high added value share in non-manufacturing industrial activities, i.e., mining, quarrying, electricity, etc.).[16] The latter region also shows the highest internal (intraregional) specialization, mostly due to the high specialization of Kozani prefecture and, to a lesser extent, of Florina prefecture. Ionia Nisia is the region having the least internal specialization. The most sectorally diversified (or least concentrated) region is Peloponnisos, as the value of its diversification index is closest to the lower limit (that is here equal to $1/K = 1/11 = 0.09$), while the least sectorally diversified (or most concentrated) region is Notio Aigaio.

16 It is noted that the construction of the specialization and diversification variables has included 11 (instead of 10) broad sectors of economic activity, through distinguishing between the manufacturing and non-manufacturing industrial activities.

CHAPTER 5

ECONOMETRIC RESULTS

The results are initially presented here in relation to the empirical analysis at the regional level. We first refer to Table 5.1, which illustrates correlation coefficients between the explanatory variables of our model. These coefficients reassure us that no serious multicollinearity problem exists. At this point, it is noted that the spatial separation variables of the internal (intraregional) market potential and its standard deviation are used here to represent the efficiency impacts of urbanization economies and their dispersion. The alternative couple of variables which proxy urbanization economies with the average regional population density and its entropy dispersion measure (as they were discussed in Section 3) were found to be very highly correlated with the former variables (at the levels of 98% and 86%, respectively). However, the former variables are selected for the current model specification to provide the baseline econometric results, since they were found to considerably improve the overall statistical significance and model estimation performance.

Table 5.2 reports baseline maximum likelihood estimates of equations (3.5) and (3.6) across regions. The estimated production function includes the inputs of labor and physical capital, as well as a time trend (*t*) to proxy for technological progress. The technical inefficiency equation is simultaneously estimated using stepwise the variables of human capital, measured as the share of hours worked by highly educated persons, interregional specialization, external market potential, diversification, internal market potential and internal market potential dispersion. It also includes time and regional dummies to control for common macroeconomic shocks and region-specific effects, respectively.

TABLE 5.1
Correlation coefficients between explanatory variables

	In (Capital)	In(Hours worked)	Time trend	Hours worked by highly skilled workers	Regional diversification	Inter-regional specialization	External market potential	Internal market potential	Internal market potential dispersion	Government vote ratio	Parliamentary difference	Next elections	Head of region
In(Capital)	1.00												
In(Hours worked)	0.94	1.00											
Time trend	0.14	-0.03	1.00										
Hours worked by highly skilled workers	0.64	0.62	0.46	1.00									
Regional diversification	-0.53	-0.56	0.04	-0.25	1.00								
Interregional specialization	-0.28	-0.41	-0.03	-0.16	0.27	1.00							
External market potential	-0.21	-0.32	0.00	-0.48	0.23	0.26	1.00						
Internal market potential	0.71	0.75	0.00	0.74	-0.26	-0.17	-0.39	1.00					
Internal market potential dispersion	0.39	0.38	0.02	0.15	-0.28	-0.14	-0.16	-0.17	1.00				
Government vote ratio	-0.12	-0.07	-0.28	-0.39	0.02	0.05	0.14	-0.19	-0.01	1.00			
Parliamentary difference	0.57	0.57	0.24	0.55	-0.19	-0.25	-0.27	0.51	0.24	0.13	1.00		
Next elections	-0.04	0.01	-0.28	-0.17	-0.01	0.01	0.00	0.00	-0.01	0.22	-0.07	1.00	
Head of region	0.00	0.09	-0.37	-0.20	-0.04	-0.08	0.05	0.07	-0.09	0.30	-0.05	0.13	1.00

From the reported results in column 1 at the Table 5.2, we can distinguish a significant positive effect of physical capital and labor on output, a result which is plausible and compares well with the results of the relevant literature. The coefficient on time trend appears to be positive but not statistically significant. In order to determine whether deviations from the estimated frontier are due to inefficiency effects, we test the null hypothesis that $\gamma=0$, against the alternative that $\gamma>0$. As it is evident, the parameter γ is significantly different from zero, which implies that inefficiency effects are present and that we should proceed with the estimation of parameters related to the sources of inefficiency.

As far as the impact of human capital on technical inefficiency is concerned, the results verify that a rise in the share of hours worked by highly educated persons contributes significantly to reducing inefficiencies in Greek regions. Regarding the role of spatial agglomeration-related variables, the results indicate the significant negative impact of urbanization economies, as proxied by the average intraregional (internal) market potential, on technical inefficiency. Namely, there are positive externalities associated with the total regional economy, arising from the average increase of urban size and the reduction of transport costs, as proxied by distance, between urban centres of a region. These findings verify and enrich the existing theory concerning the benefits of regional agglomeration economies on productivity (Krugman, 1991b; Puga, 2010; Combes *et al.,* 2011). The dispersion of urbanization economies across the prefectures of the region, as proxied by the standard deviation of internal market potential, is also found to significantly enhance efficiency. This outcome suggests that a polycentric (rather than a monocentric) regional economic structure favours the efficiency of Greek regions. Similarly, improvement of the external market potential contributes to the reduction of inefficiencies in Greek regions. This finding supports the policy decisions on large infrastructure investments aimed at promoting interregional connectivity across the country, as these decisons are associated with increased economies of scale and reduced transport costs.

The results further provide supporting empirical evidence on the significant positive influence of specialization on technical efficiency. This outcome can be related to the better adoption of new technology, innovation and knowledge spillovers originating from the geographical

TABLE 5.2
Regional level econometric estimates
(baseline)

	1	2	3	4	5
Production function					
β_0	0.89** (3.70)	0.62** (2.82)	1.04 (0.42)	1.20 (1.35)	2.84* (1.76)
ln (Hours worked)	0.81** (9.02)	0.56** (15.00)	0.78* (1.66)	0.68** (3.31)	0.33** (7.65)
ln (Total physical capital)	0.24** (3.65)	0.46 (39.60)	0.26 (0.54)	0.34* (1.72)	0.57** (23.30)
Time trend	0.003 (0.72)	-0.01** (-27.14)	0.002 (0.09)	-0.001 (-0.06)	-0.02** (-6.10)
Inefficiency model					
δ_0	0.33** (2.07)	0.43** (35.55)	0.29 (0.48)	0.30 (0.69)	1.38** (7.66)
Hours worked by highly skilled persons	-0.74 (-0.88)	-0.03 (-0.64)	-0.05 (-0.05)	-0.10 (-0.10)	-0.40** (-3.17)
Interregional specialization		-1.06** (-7.41)	-0.22 (-0.25)	-0.24 (-0.27)	-0.40** (-2.75)
External market potential			-0.01 (-0.18)	-0.01 (-0.16)	-0.09** (-2.02)
Regional diversification				-0.07 (-0.07)	-0.94** (-6.58)
Internal market potential					-0.05** (-5.54)
Internal market potential dispersion					-0.001** (-4.46)
Time effects	included	included	included	included	included
Region effects	included	included	included	included	included
σ^2 (p-value)	0.01** (6.56)	0.001** (5.87)	0.02 (1.07)	0.01** (3.29)	0.0004** (10.94)
γ (p-value)	0.05** (4.50)	0.00009** (2.20)	0.13 (1.15)	0.22** (2.20)	0.06** (2.20)
Log likelihood	179.14	305.26	150.67	166.90	404.90
Observations	169	169	169	169	169

a. t-statistics are included in parentheses.
b. ** and *denote significance at 5% and 10% levels, respectively.

concentration of firms within a sector. Moreover, the findings suggest that sectoral concentration (rather than diversification) in a region helps to reduce the inefficiencies of the Greek regions. This outcome can arguably be attributed to the lack of a sufficient degree of regional integration, the relatively low or medium levels of technology, inadequate competition and the shortage of cooperation networks to realize positive diversification economies.

Overall, the results suggest that regional characteristics related to a more educated labor force, urbanization economies, improvement of market access, higher specialization and sectoral concentration have a significant positive influence on the technical efficiency of Greek regions. In addition, the results indicate that time-invariant region-specific as well as region-invariant time-specific effects also significantly account for changes in technical efficiency. Estimates that refer to year-specific and region-specific dummy variables are shown in Table A.1, which is included in the Appendix. These estimates rely on the model specification shown in column 5 of Table 5.2. Almost all estimated coefficients of these dummy variables are statistically significant and reassure us that time- and region-specific effects are correctly included in the model specification. We should note that year 2000 is regarded as the base year, while Anatoliki Makedonia is regarded as the base region. The estimated coefficients of time dummies have a negative sign, indicating that year-specific factors exert a negative influence on technical inefficiency. On the contrary, coefficient estimates of regional dummies have a positive sign, implying that region-specific effects have a positive impact on inefficiency.

Tables 5.3 and 5.4 demonstrate the econometric results of alternative model specifications, which incorporate all possible explanatory variables, as they were described in Section 3. These results verify the significant positive (negative) impact on technical efficiency (inefficiency) of urbanization and its dispersion, as proxied by the regional population density and its dissimilarity entropy index. Conversely, intraregional (or within-region) specialization is found to have no statistically significant impact on technical efficiency (Table 5.3). Similarly, none of the political variables introduced here is found to have a statistically significant influence on the technical inefficiency of Greek regions (Table 5.4).

TABLE 5.3
Regional level econometric estimates
(different specifications for checking robustness)

	1	2	3
Production function			
β_0	5.71** (3.06)	1.76** (3.47)	3.57 (1.05)
ln (Hours worked)	0.23** (3.63)	0.31** (5.83)	0.30** (5.28)
ln (Total physical capital)	0.55** (9.06)	0.63** (14.41)	0.57** (5.24)
Time trend	-0.02** (-5.22)	-0.02** (-6.25)	-0.02** (-6.86)
Inefficiency model			
δ_0	1.62** (5.47)	0.83** (4.56)	1.39** (3.59)
Hours worked by highly skilled persons	-0.12 (-0.89)	-0.41** (-3.15)	-0.56** (-4.45)
Population density		-0.002** (-2.82)	
Population density dispersion		-1.78** (-2.05)	
Interregional specialization			-0.76** (-4.87)
Intraregional specialization	-0.01 (-0.02)	-0.07 (-0.22)	-0.27 (-0.77)
Regional diversification	-1.07** (-4.78)	-1.31** (-5.26)	
External market potential	-0.09** (-2.11)	0.03 (0.77)	-0.10** (-2.32)
Internal market potential	-0.04** (-4.99)		-0.05** (-4.66)
Internal market potential dispersion	-0.002** (-2.88)		-0.0007 (-0.79)
Time effects	included	included	included
Region effects	included	included	included
σ^2 (p-value)	0.0005** (9.00)	0.0006** (9.13)	0.0004** (5.31)
γ (p-value)	0.02 (0.51)	0.000006* (1.67)	0.02 (0.12)
Log likelihood	402.67	384.74	395.42
Observations	169	169	169

a. t-statistics are included in parentheses.
b. ** and *denote significance at 5% and 10% levels, respectively.

TABLE 5.4
Regional level econometric estimates
(including political variables)

	1	2	3	4
Production function				
β_0	1.16** (5.33)	5.04** (4.58)	1.33** (7.76)	1.57 (0.70)
ln (Hours worked)	0.35** (6.60)	0.17** (2.92)	0.34** (7.47)	0.32** (6.07)
ln (Total physical capital)	0.61** (12.40)	0.62** (16.27)	0.62** (14.66)	0.63** (9.78)
Time trend	-0.01* (-1.90)	-0.02** (-6.91)	-0.04** (-14.43)	-0.02** (-7.34)
Inefficiency model				
δ_0	1.19** (5.90)	1.47** (7.14)	1.22** (6.07)	1.30** (9.69)
Hours worked by highly skilled persons	-0.32** (-2.22)	-0.27** (-2.16)	-0.32** (-2.43)	-0.36* (-1.87)
Interregional specialization	-0.28 (-1.58)	-0.29* (-1.85)	-0.33* (-1.91)	-0.39** (-2.15)
Regional diversification	-1.28** (-4.55)	-0.83** (-3.17)	-1.08** (-3.55)	-0.91** (-6.54)
External market potential	-0.10** (-2.36)	-0.08** (-1.99)	-0.08* (-1.82)	-0.08 (-1.63)
Internal market potential	-0.05** (-4.88)	-0.05** (-7.27)	-0.05** (-7.15)	-0.05** (-5.07)
Internal market potential dispersion	-0.002** (-2.41)	-0.001* (-1.90)	-0.001** (-2.25)	-0.001 (-1.63)
Government vote ratio	-0.01 (-0.10)			
Parliamentary difference		-0.001 (-1.29)		
Next elections			-0.08 (-0.40)	
Head of the region				-0.0002 (-0.02)
Time effects	included	included	included	included
Region effects	included	included	included	included
σ^2 (p-value)	0.0005** (7.42)	0.0004** (7.42)	0.0005** (8.17)	0.0004** (7.46)
γ (p-value)	0.05 (1.02)	0.03 (1.01)	0.03 (0.92)	0.02 (0.04)
Log likelihood	398.77	406.89	393.11	400.98
Observations	169	169	169	169

a. t-statistics are included in parentheses.
b. ** and *denote significance at 5% and 10% levels, respectively.

We further obtain predictions of the technical efficiency levels by using its conditional expectation definition: $TE_{ijt} = \exp\left\{-U_{ijt}\right\}$. Figures 5.1-5.13 depict the evolution of the efficiency levels of Greek regions for the period 2000-2012. Table 5.5 provides us with a comparison of technical efficiency scores between regions in the same period.

Regarding the region of Anatoliki Makedonia and Thraki (Figure 5.1), we observe that the level of technical efficiency increased from 54% in 2000 to 64% in 2007. Thereafter, with the advent of the crisis, this score began to decline and returned to the level of 55% in 2012. Similarly, in Kentriki Makedonia (Figure 5.2), technical efficiency increased from 55% in 2000 to 68% in 2007 and then gradually decreased, reaching 55% in 2012. In the region of Dytiki Makedonia (Figure 5.3), the corresponding index increased from 55% in 2000 to 69% in 2006 and then fell to 55% in 2012. In Ipeiros (Figure 5.4) and Thessalia (Figure 5.5), we observe a strengthening of technical efficiency levels up to 62% and 69%, respectively, and a gradual decline after 2007. In the region of Ionia Nisia (Figure 5.6), we notice an increase of technical efficiency from 60% in 2000 to 70% in 2007 and then a decline to 55%.

In Dytiki Ellada (Figure 5.7), a remarkable rise took place from 60% in 2000 to 73% in 2007, followed by a significant drop to 60%, during 2008-2012. In the region of Sterea Ellada (Figure 5.8), an increase in efficiency scores was observed during 2000-2007 from 45% to 51%. Thereafter, technical efficiency gradually declined and reached 42% in 2012. Attiki is the region with the highest level of technical efficiency (Figure 5.9). This score was 91% in 2000, but then steadily increased and reached 100% in 2003. Since then, the efficiency score of the Attiki region remained stable at 100%. In the region of Peloponnisos (Figure 5.10), we observe an initial increase from 47% in 2000 to 58% in 2008 and, then, a drop to 47% in 2012. Regarding the island regions of Greece, a similar pattern has emerged. Namely, in Voreio Aigaio (Figure 5.11), we observe a significant increase up to 71% in 2007 and then a decline to 58% in 2012. In Notio Aigaio (Figure 5.12), technical efficiency marked a gradual rise from 67% in 2000 to 81% in 2008 and then fell to 67% in 2012. Finally, in the region of Kriti (Figure 5.13), we observe an initial rise of technical efficiency from 58% in

2000 to 71% in 2007. Then, a fall took place with this ratio reaching 57% in 2012.

In a nutshell, it is found that there exist significant disparities in the levels of technical efficiency across Greek regions. The most efficient regions are those of Attiki, Notio Aigaio and Dytiki Ellada. In contrast, Sterea Ellada and Peloponnisos were the least efficient regions in 2012. Efficiency scores rose constantly in all regions of Greece up to 2007. With the exception of Attiki, which is found to exploit its advantageous central position as the largest dominant market to create economies of scale in production, all the other regions witnessed a drop in their efficiency performance from 2009 onwards. Only the island regions of Notio Aigaio and Ionia Nisia showed a very small recovery in technical efficiency in 2012, compared to 2011. These outcomes signify the considerable adverse impact of the economic crisis on the productivity of the peripheral areas of the country.

FIGURE 5.1
Efficiency scores in Anatoliki Makedonia-Thraki

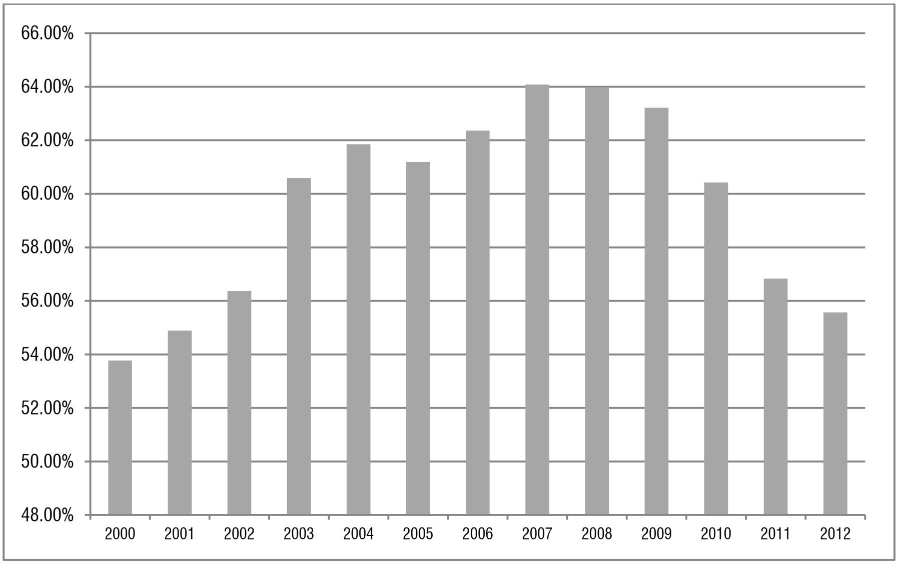


FIGURE 5.2
Efficiency scores in Kentriki Makedonia

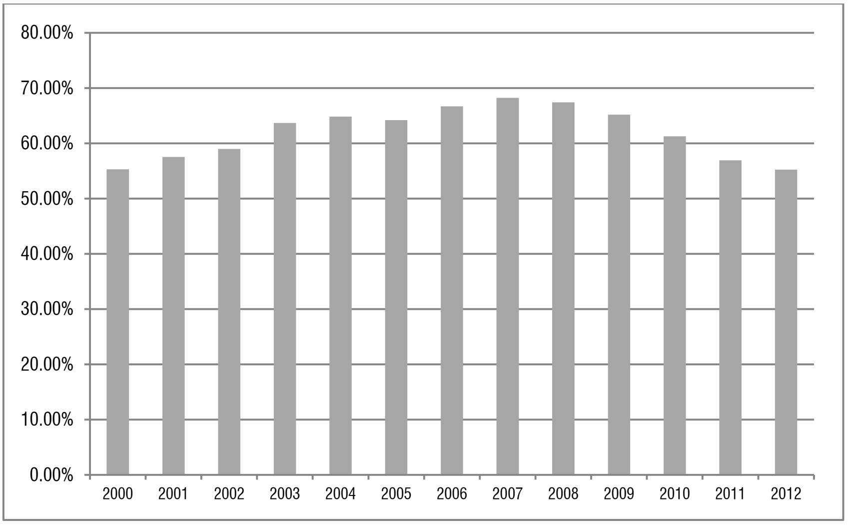


FIGURE 5.3
Efficiency scores in Dytiki Makedonia

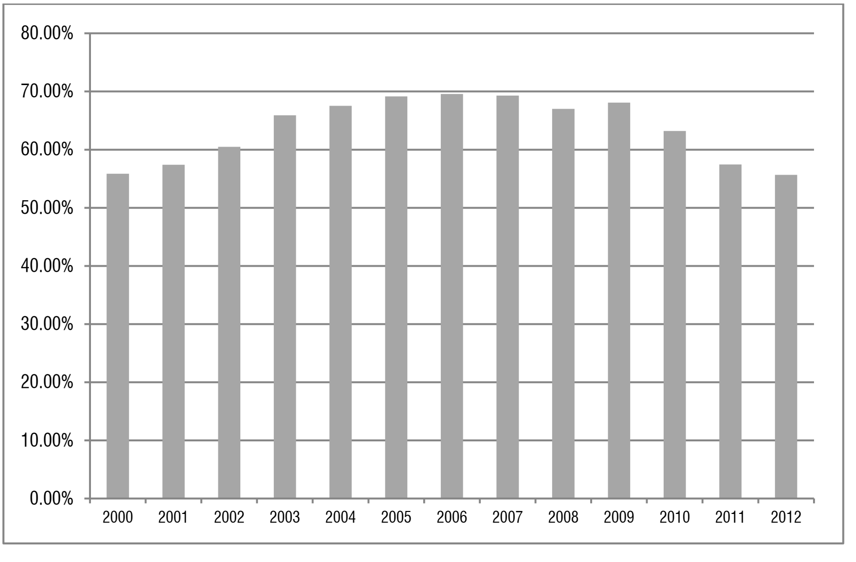


FIGURE 5.4
Efficiency scores in Ipeiros

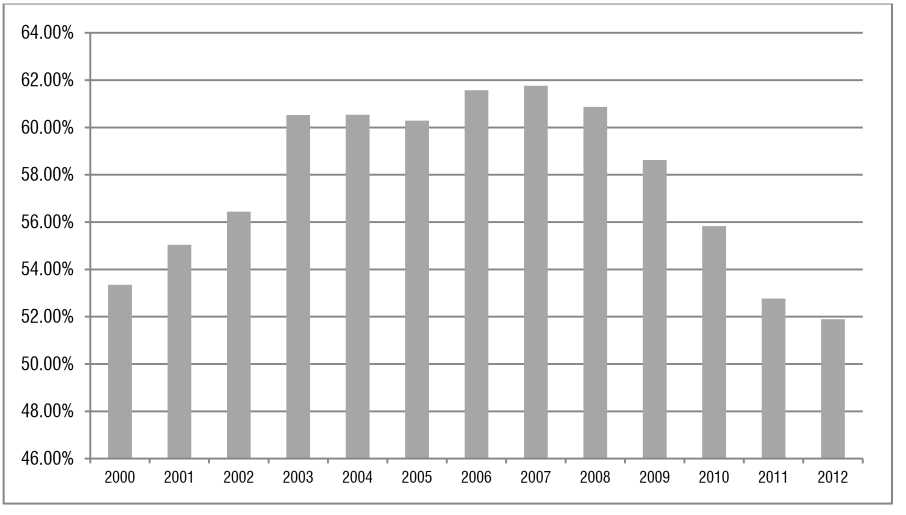


FIGURE 5.5
Efficiency scores in Thessalia

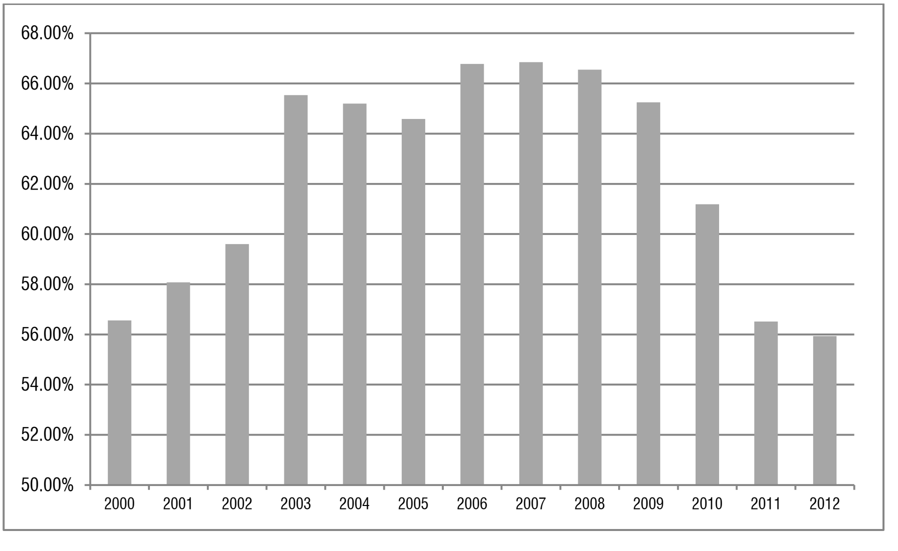


FIGURE 5.6
Efficiency scores in Ionia Nisia

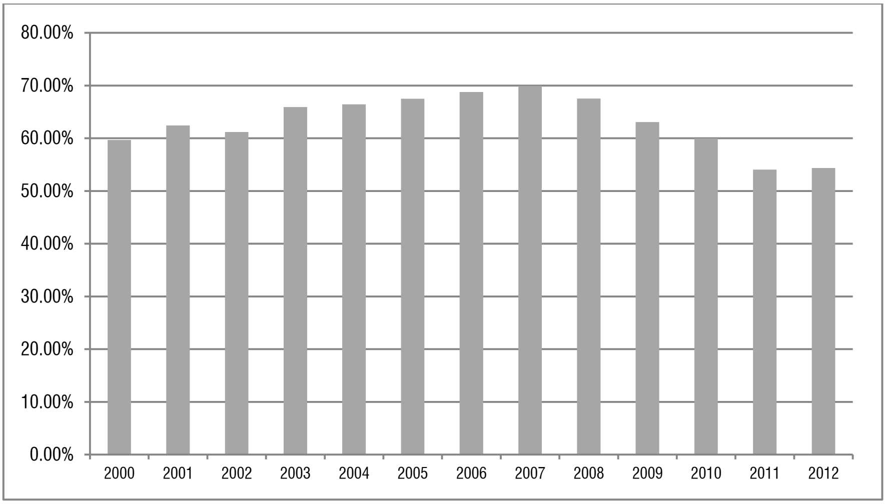


FIGURE 5.7
Efficiency scores in Dytiki Ellada

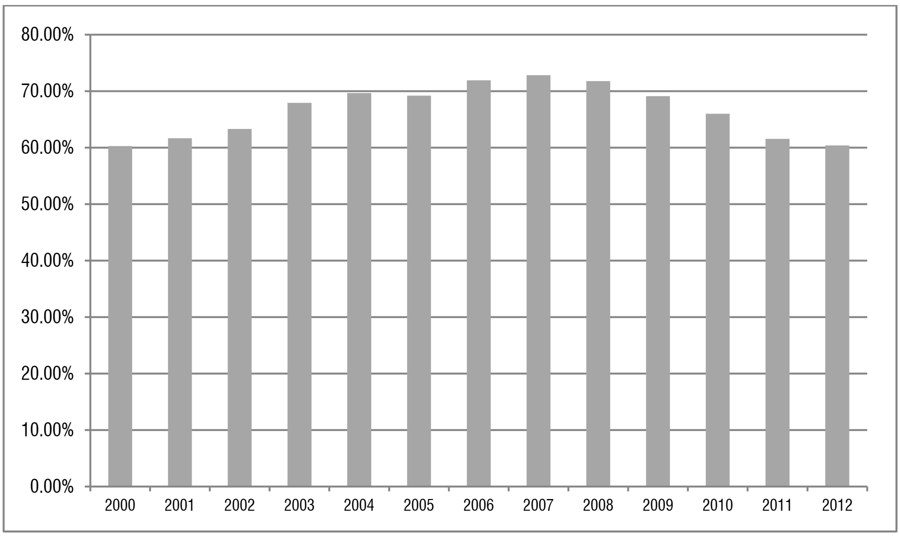


FIGURE 5.8
Efficiency scores in Sterea Ellada

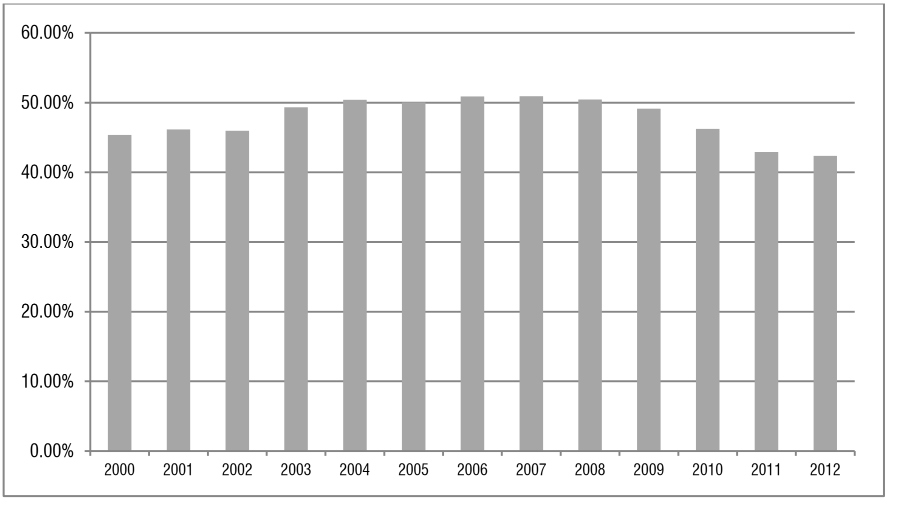


FIGURE 5.9
Efficiency scores in Attiki

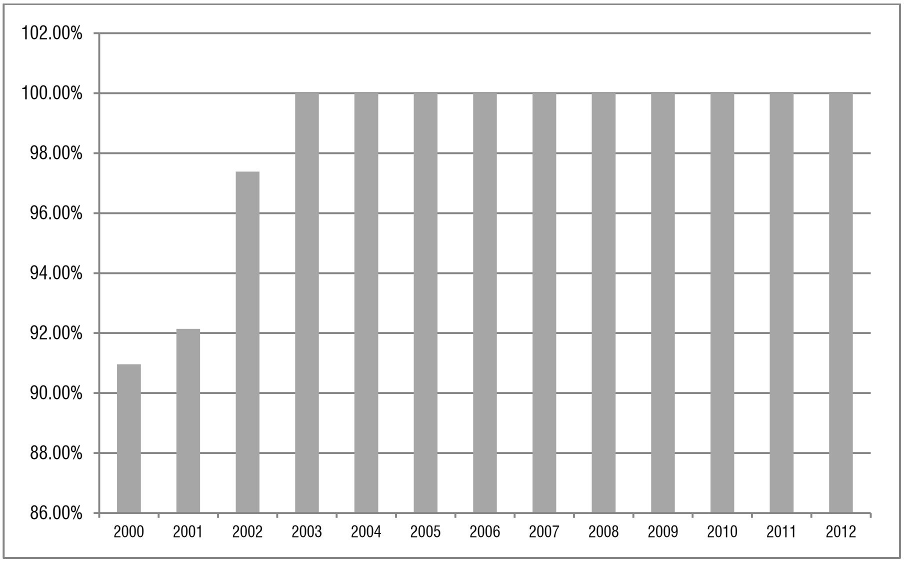


FIGURE 5.10
Efficiency scores in Peloponnisos

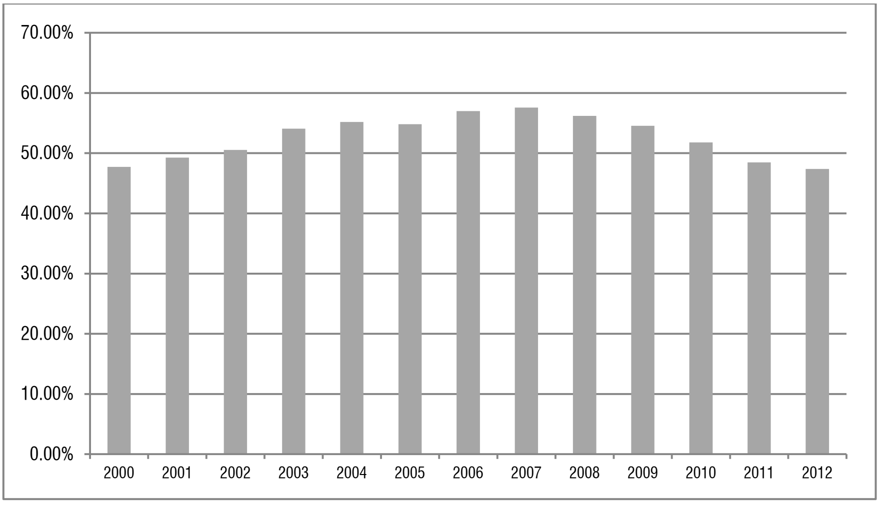


FIGURE 5.11
Efficiency scores in Voreio Aigaio

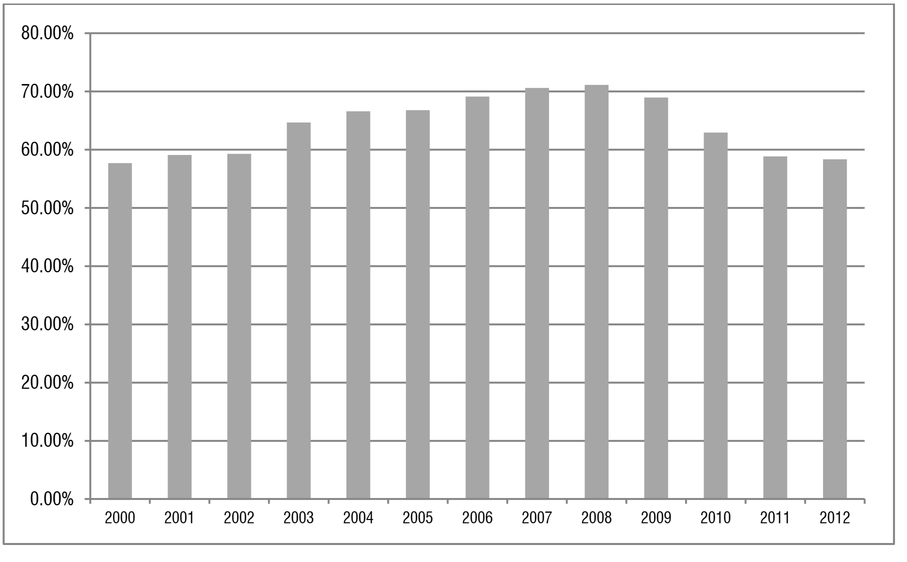


FIGURE 5.12
Efficiency scores in Notio Aigaio

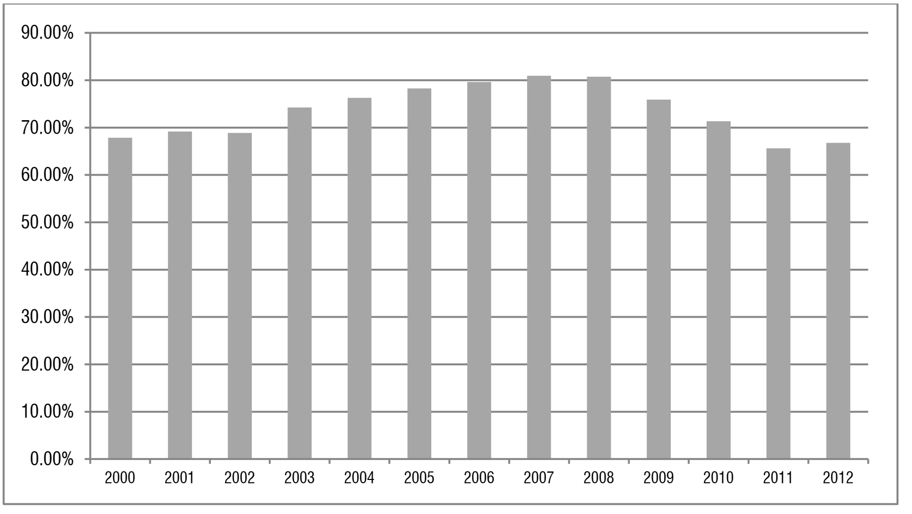


FIGURE 5.13
Efficiency scores in Kriti

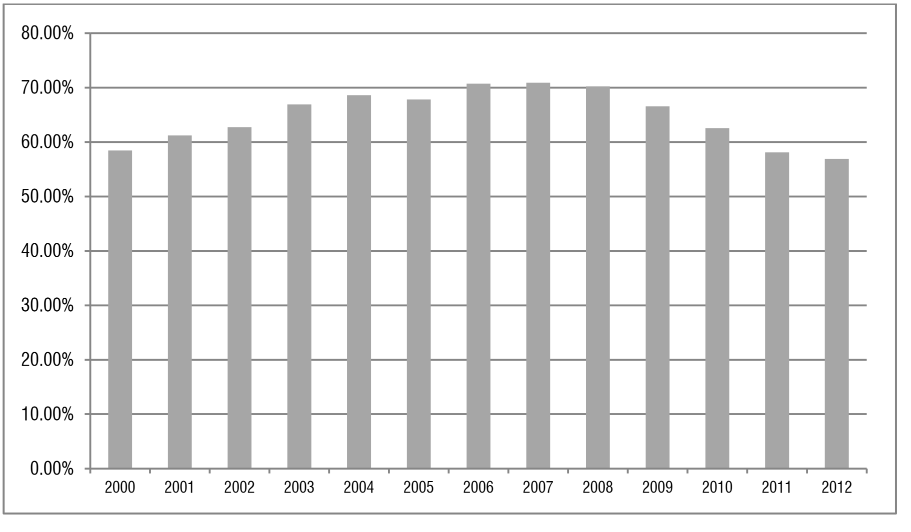


TABLE 5.5
Comparative efficiency of all regions across years

Region	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Anatoliki Makedonia-Thraki	53.77%	54.89%	56.37%	60.59%	61.86%	61.19%	62.36%	64.08%	63.96%	63.22%	60.42%	56.83%	55.57%
Kentriki Makedonia	55.32%	57.53%	59.00%	63.70%	64.84%	64.22%	66.70%	68.24%	67.42%	65.21%	61.30%	56.94%	55.25%
Dytiki Makedonia	55.86%	57.40%	60.48%	65.91%	67.55%	69.15%	69.57%	69.29%	67.00%	68.08%	63.21%	57.44%	55.66%
Ipeiros	53.35%	55.04%	56.44%	60.52%	60.54%	60.29%	61.58%	61.76%	60.87%	58.63%	55.83%	52.77%	51.89%
Thessalia	56.56%	58.08%	59.60%	65.54%	65.20%	64.59%	66.78%	66.85%	66.55%	65.25%	61.19%	56.51%	55.93%
Ionia Nisia	59.69%	62.44%	61.19%	65.93%	66.45%	67.50%	68.77%	69.95%	67.53%	63.08%	59.99%	54.05%	54.36%
Dytiki Ellada	60.29%	61.68%	63.33%	67.95%	69.66%	69.21%	71.94%	72.84%	71.79%	69.13%	66.02%	61.56%	60.41%
Sterea Ellada	45.34%	46.14%	45.97%	49.32%	50.40%	50.03%	50.88%	50.92%	50.46%	49.14%	46.21%	42.90%	42.36%
Attiki	90.96%	92.14%	97.38%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
Peloponnisos	47.72%	49.28%	50.56%	54.08%	55.19%	54.82%	57.00%	57.59%	56.20%	54.57%	51.80%	48.48%	47.37%
Voreio Aigaio	57.70%	59.10%	59.30%	64.68%	66.60%	66.80%	69.13%	70.62%	71.12%	68.96%	62.95%	58.85%	58.35%
Notio Aigaio	67.85%	69.18%	68.86%	74.25%	76.30%	78.27%	79.63%	80.94%	80.76%	75.91%	71.33%	65.64%	66.79%
Kriti	58.45%	61.20%	62.74%	66.91%	68.63%	67.83%	70.72%	70.91%	70.22%	66.57%	62.55%	58.10%	56.92%

Next, we proceed by presenting the results of the empirical analysis at the industry level. Table 5.6 reports econometric estimates of equations (3.5) and (3.6) across sectors. The estimated production function includes the inputs of labor and physical capital, as well as a time trend (*t*) to proxy for technological progress. The technical inefficiency equation simultaneously accounts for the variable of human capital, as well as time and sectoral dummies. The results confirm that a rise in the share of hours worked by highly educated persons contributes significantly to reducing inefficiencies in Greek industries. However, the latter finding is statistically significant only for the model specifications presented in columns 1 and 2 (without fixed effects and only with time-specific effects, respectively).

Figures 5.14-5.23 show the efficiency scores of the broad sectors of the Greek economy for the period 2000-2012. Table 5.7 provides a comparative presentation of the technical efficiency levels of all sectors at different years. In detail, technical efficiency of the broader sector of Agriculture has fallen from 35% in 2000 to 25% in 2012 (Figure 5.14). Similarly, in the sector of Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities (Figure 5.15) the efficiency score increased from 68% in 2000 to 80% in 2008 and then decreased to 62% in 2012. In Construction (Figure 5.16), we observe a sharp decline from 90% in 2008 to 55% in 2012.

In the broad sector of Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities (Figure 5.17), there is a significant drop in efficiency from 89% in 2008 to 79% in 2012. In the broad sector of Information and communications (Figure 5.18), an initial increase is observed from 38% in 2000 to 48% in 2007. Thereafter, technical efficiency decreased to 30% in 2012. Financial and insurance sector (Figure 5.19) seems to have retained its efficiency score at the high levels of 80%-85% during the years of the crisis. Similarly, in the Real estate sector (Figure 5.20), we observe that after a rise from 84% in 2000 to 92% in 2010, there was only a slight decline to 91% during 2011-2012. In the broad sector of Professional, scientific, technical, administrative and support service activities (Figure 5.21), we notice that after a rise

TABLE 5.6
Econometric estimates at the sectoral level

	1	2	3	4
Production function				
β_0	6.46** (6.70)	7.16** (6.78)	9.11** (9.12)	9.11** (9.12)
ln (Hours worked)	0.28** (13.49)	0.25** (9.83)	0.21** (5.95)	0.21** (5.87)
ln (Total physical capital)	0.47** (14.92)	0.46** (15.54)	0.43** (11.03)	0.43** (10.46)
Time trend	-0.02** (-2.23)	-0.01 (-0.42)	-0.01 (-0.71)	-0.005 (-0.19)
Inefficiency model				
δ_0	0.77** (3.93)	0.03 (0.10)	0.04 (0.05)	0.04 (0.05)
Hours worked by highly skilled persons	-5.20** (-4.92)	-4.06** (-4.06)	-0.77 (-0.77)	-0.78 (-0.78)
Time effects		included		included
Industry effects			included	included
σ^2 (p-value)	0.28** (4.42)	0.30** (3.92)	0.43 (0.51)	0.43 (0.51)
γ (p-value)	0.56** (7.14)	0.54** (4.37)	0.89** (5.86)	0.89** (6.07)
Log likelihood	-69.76	-68.21	-42.32	-39.72
Observations	130	130	130	130

a. t-statistics are included in parentheses.
b. ** and *denote significance at 5% and 10% levels, respectively.

from 70% to 80% during 2000-2007, technical efficiency followed a significant drop to 45% in 2012.

In the broad sector of Public administration and defense, compulsory social security, education, human health and social work activities (Figure 5.22), there was an increase of efficiency to nearly 92% in 2009 and then a gradual fall to almost 86% in 2012. Similarly, in the broad sector of Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies (Figure 5.23), we notice an initial increase of the technical efficiency from 41% in 2000 to 62% in 2009 and then a gradual drop to 46% in 2012.

In brief, as in the case of regions, the results highlight the existence of significant disparities in the technical efficiency scores across Greek industries. Most sectors of the Greek economy witnessed a drop in their efficiency after 2008. On the one hand, the industries with the highest efficiency are those of real estate, public administration and financial intermediation, with average scores close to or above 80%, during 2000-2012. On the other hand, the least efficient industries are those of Agriculture, forestry and fishing, and Professional activities, with average efficiency scores below 50%. The latter outcome stresses the intersectoral dimension of the Greek economic crisis, whose adverse effects were diffused across a significant number of various economic activities. Tables 5.8-5.10 provide us with the technical efficiency scores of sectors across regions for the years 2000, 2008 and 2012, respectively.

FIGURE 5.14
Efficiency in Agriculture, forestry and fishing

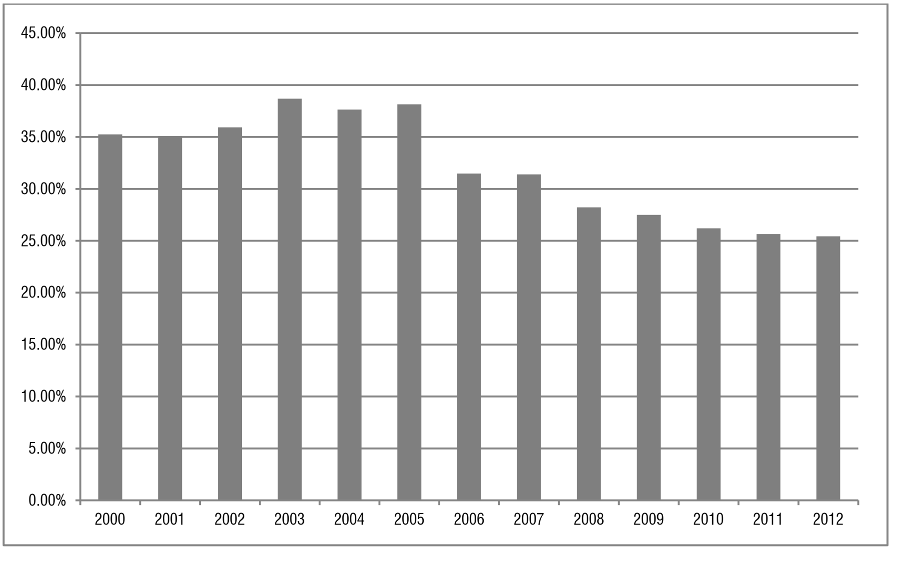


FIGURE 5.15
Efficiency in Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities

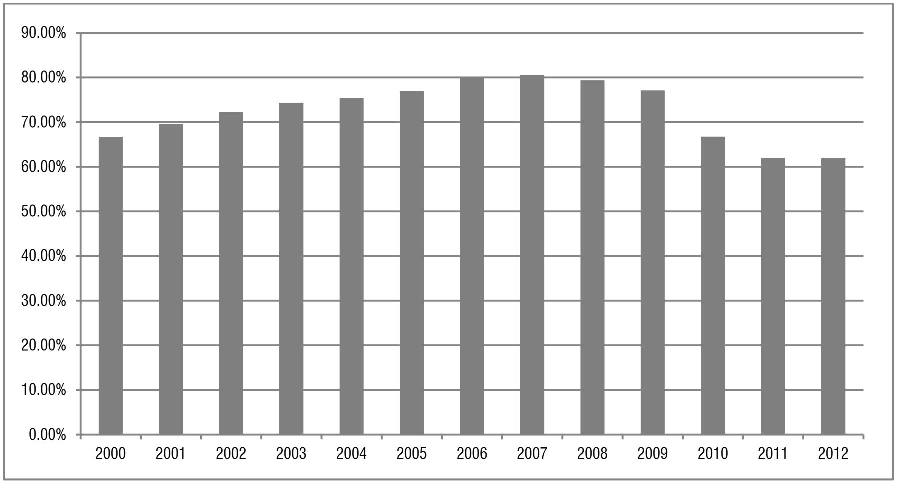


FIGURE 5.16
Efficiency in Construction

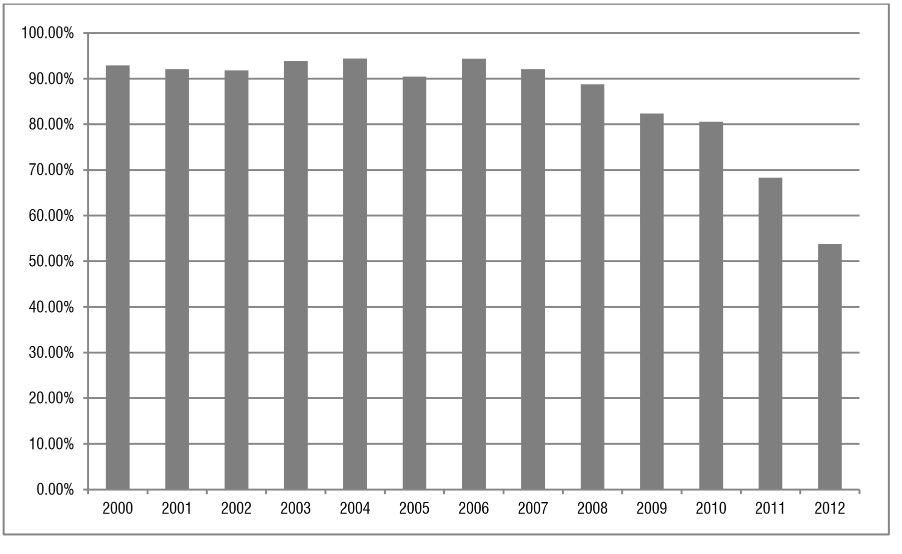


FIGURE 5.17
Efficiency in Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities

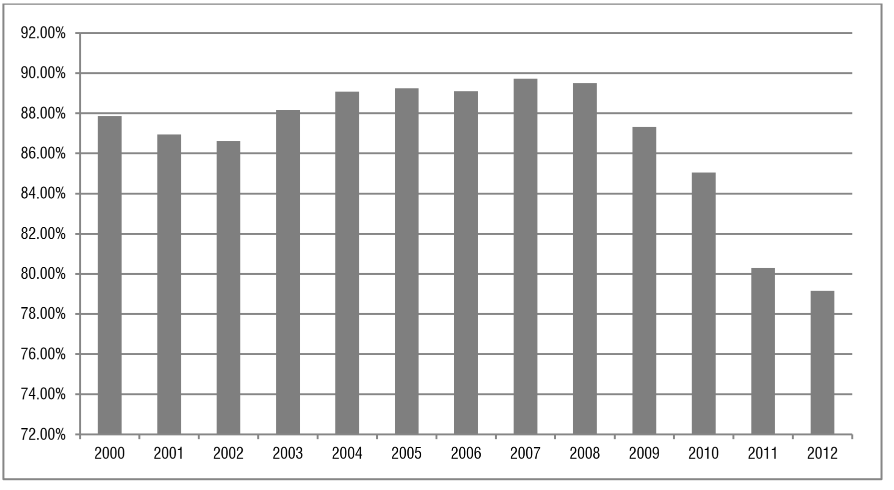


FIGURE 5.18
Efficiency in Information and communication

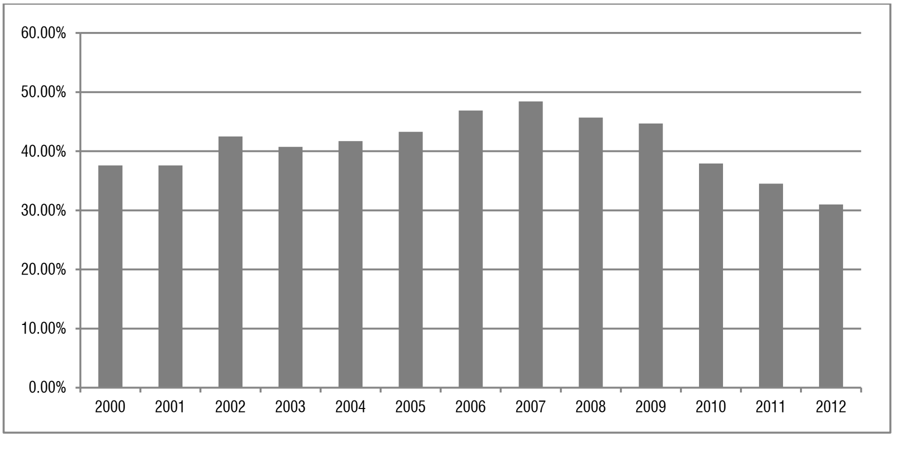


FIGURE 5.19
Efficiency in Financial and insurance activities

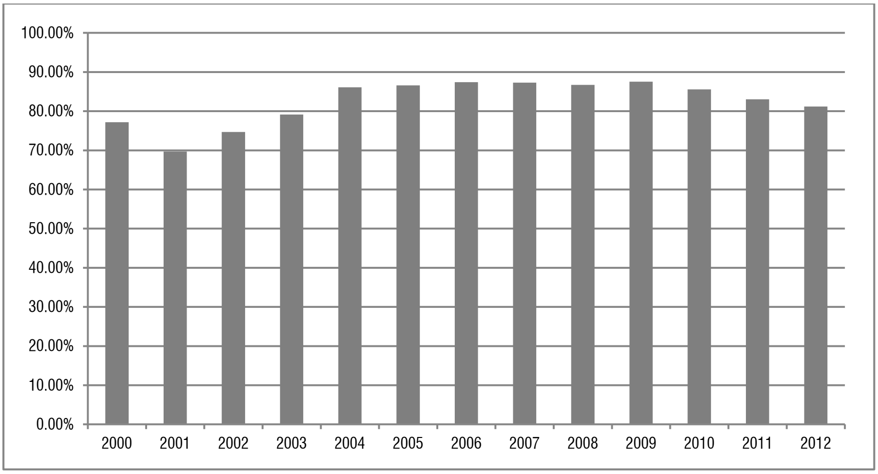


FIGURE 5.20
Efficiency in Real estate activities

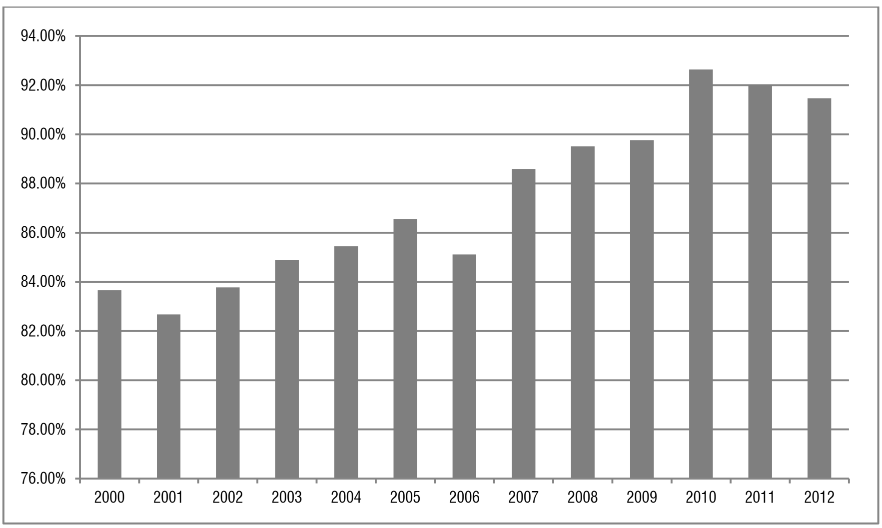


FIGURE 5.21
Efficiency in Professional, scientific, technical, administrative and support service activities

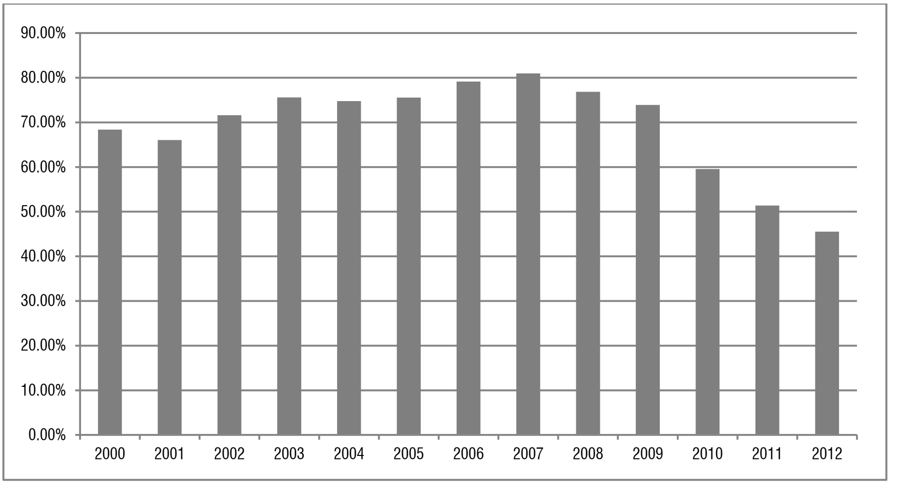


FIGURE 5.22
Efficiency in Public administration and defense, compulsory social security, education, human health and social work activities

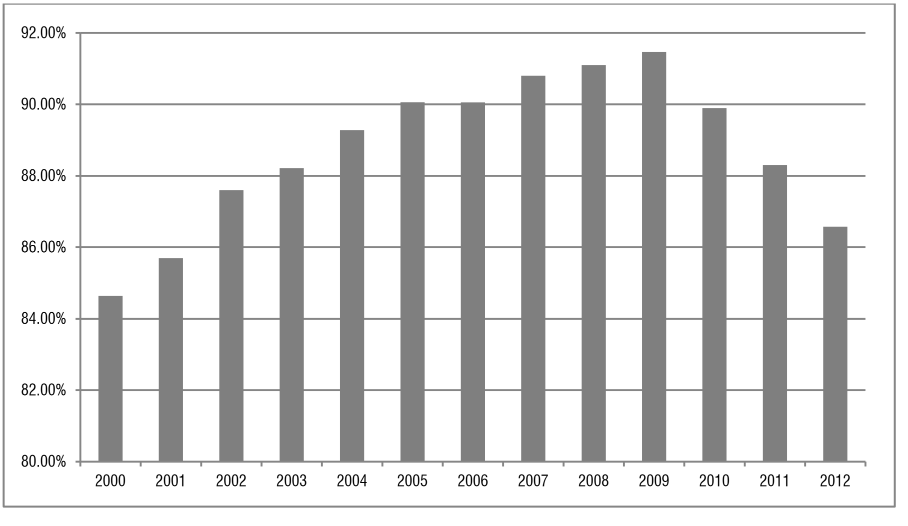


FIGURE 5.23
Efficiency in Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies

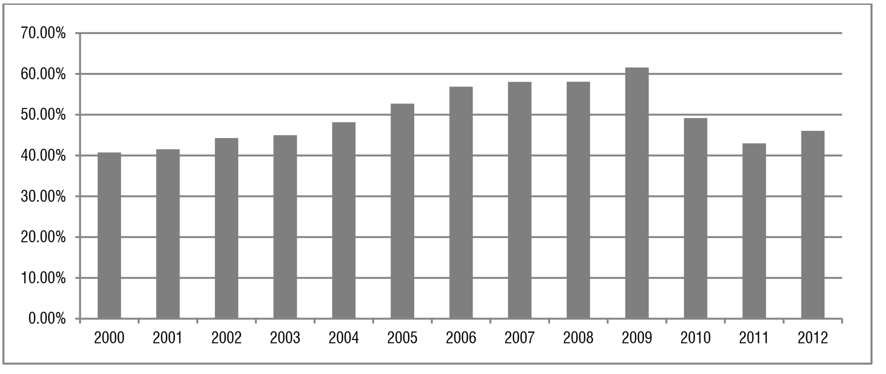


TABLE 5.7
Comparative efficiency of all sectors (selected years)

	2000	2004	2008	2012
Agriculture, forestry and fishing	35.26%	37.64%	28.22%	25.43%
Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities	66.71%	75.46%	79.37%	61.90%
Construction	92.90%	94.41%	88.76%	53.81%
Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities	87.87%	89.08%	89.51%	79.16%
Information and communication	37.61%	41.71%	45.69%	30.99%
Financial and insurance activities	77.17%	86.09%	86.73%	81.20%
Real estate activities	83.66%	85.44%	89.51%	91.47%
Professional, scientific and technical activities, administrative and support service activities	68.40%	74.78%	76.84%	45.53%
Public administration and defense, compulsory social security, education, human health and social work activities	84.65%	89.28%	91.10%	86.58%
Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies	40.76%	48.18%	58.07%	46.05%

TABLE 5.8
Efficiency of sectors across regions (2000)

	Anatoliki Makedonia-Thraki	Kentriki Makedonia	Dytiki Makedonia	Ipeiros	Thessalia	Ionia Nisia	Dytiki Ellada	Sterea Ellada	Attiki	Peloponnisos	Voreio Aigaio	Notio Aigaio	Kriti
1.	53.99%	100.00%	40.72%	46.35%	69.34%	37.06%	70.33%	56.20%	100.00%	58.59%	36.52%	48.76%	66.89%
2.	100.00%	100.00%	84.08%	96.12%	100.00%	77.89%	100.00%	100.00%	100.00%	100.00%	76.41%	100.00%	100.00%
3.	100.00%	100.00%	100.00%	100.00%	100.00%	98.00%	100.00%	100.00%	100.00%	100.00%	98.73%	100.00%	100.00%
4.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5.	34.99%	65.08%	23.16%	29.05%	41.40%	21.93%	44.78%	36.98%	100.00%	38.39%	23.88%	31.81%	42.30%
6.	68.11%	100.00%	50.47%	58.47%	88.25%	47.90%	91.92%	77.62%	100.00%	75.23%	49.12%	62.05%	83.26%
7.	65.29%	100.00%	46.08%	60.17%	82.20%	43.84%	91.30%	73.27%	100.00%	76.22%	47.93%	59.36%	83.62%
8.	63.35%	100.00%	48.42%	54.26%	81.90%	44.56%	83.26%	65.35%	100.00%	67.38%	44.10%	59.40%	78.48%
9.	100.00%	100.00%	99.28%	100.00%	100.00%	89.36%	100.00%	100.00%	100.00%	100.00%	90.43%	100.00%	100.00%
10.	58.18%	100.00%	43.50%	50.39%	76.91%	41.56%	80.11%	62.60%	100.00%	63.70%	40.32%	53.84%	72.56%

1. Agriculture, forestry and fishing, 2. Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific and technical activities, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

TABLE 5.9

Efficiency of sectors across regions (2008)

	Anatoliki Makedonia-Thraki	Kentriki Makedonia	Dytiki Makedonia	Ipeiros	Thessalia	Ionia Nisia	Dytiki Ellada	Sterea Ellada	Attiki	Peloponnisos	Voreio Aigaio	Notio Aigaio	Kriti
1.	72.90%	100.00%	54.98%	62.72%	93.83%	50.26%	94.96%	76.04%	100.00%	79.28%	49.63%	65.83%	90.31%
2.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
3.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
4.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5.	47.66%	83.69%	33.71%	38.97%	59.47%	27.83%	59.13%	48.09%	100.00%	50.02%	31.18%	43.04%	54.76%
6.	90.34%	100.00%	69.97%	78.07%	100.00%	60.65%	100.00%	94.86%	100.00%	99.34%	60.57%	83.96%	100.00%
7.	91.13%	100.00%	57.45%	81.59%	100.00%	59.58%	100.00%	99.36%	100.00%	100.00%	65.00%	85.83%	100.00%
8.	87.25%	100.00%	63.80%	73.42%	100.00%	61.10%	100.00%	89.81%	100.00%	93.43%	57.98%	78.79%	100.00%
9.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
10.	79.25%	100.00%	62.07%	67.74%	100.00%	55.01%	100.00%	83.59%	100.00%	85.81%	53.25%	73.01%	96.46%

1. Agriculture, forestry and fishing, 2. Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific and technical activities, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

TABLE 5.10
Efficiency of sectors across regions (2012)

	Anatoliki Makedonia-Thraki	Kentriki Makedonia	Dytiki Makedonia	Ipeiros	Thessalia	Ionia Nisia	Dytiki Ellada	Sterea Ellada	Attiki	Peloponnisos	Voreio Aigaio	Notio Aigaio	Kriti
1.	61.50%	100.00%	46.49%	52.80%	78.47%	42.22%	80.48%	64.16%	100.00%	66.89%	42.34%	55.91%	76.20%
2.	100.00%	100.00%	95.35%	100.00%	100.00%	87.36%	100.00%	100.00%	100.00%	100.00%	87.42%	100.00%	100.00%
3.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
4.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
5.	36.32%	69.68%	25.86%	33.76%	49.51%	26.46%	50.11%	38.13%	100.00%	40.83%	23.76%	33.16%	47.55%
6.	73.57%	100.00%	58.64%	65.15%	96.60%	52.55%	100.00%	79.51%	100.00%	87.80%	55.46%	66.44%	94.64%
7.	73.40%	100.00%	48.58%	69.00%	100.00%	55.17%	100.00%	84.02%	100.00%	81.79%	54.97%	72.58%	82.85%
8.	73.78%	100.00%	53.12%	61.27%	91.66%	50.42%	93.38%	78.86%	100.00%	77.27%	51.13%	67.52%	88.03%
9.	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
10.	65.99%	100.00%	48.36%	56.40%	86.45%	46.62%	88.67%	69.29%	100.00%	74.02%	46.04%	60.12%	82.47%

1. Agriculture, forestry and fishing, 2. Mining and quarrying, manufacturing, electricity, gas, steam, air conditioning and water supply, sewerage, waste management and remediation activities, 3. Construction, 4. Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, 5. Information and communication, 6. Financial and insurance activities, 7. Real estate activities, 8. Professional, scientific and technical activities, administrative and support service activities, 9. Public administration and defense, compulsory social security, education, human health and social work activities, 10. Arts, entertainment, recreation, other service activities, activities of households as employers, undifferentiated goods and services producing activities of households for own use, activities of extraterritorial organizations and bodies.

CHAPTER 6

CONCLUSIONS

The purpose of this study was twofold: first, to measure the efficiency of the Greek economy across regions and sectors, and, second, to identify sources related to inefficiency, mainly at the regional level. Based on the foundations of growth theory and new economic geography, we employed a stochastic frontier analysis to simultaneously estimate production functions, obtain efficiency scores and identify factors affecting inefficiency. In addition to capturing the effects of human capital and political factors, emphasis was placed on determinants associated with the spatial structure of economic activity, including the agglomeration economies and market access from both the interregional and intraregional perspective. The following paragraphs summarize, conclude and offer policy implications from the measurement of the regional and sectoral efficiency of the Greek economy and the analysis of the inefficiency determinants.

Measurement of efficiency: The findings revealed the existence of significant disparities in the levels of technical efficiency across regions and industries of the Greek economy. The most efficient regions are those of Attiki, Notio Aigaio and Dytiki Ellada. In contrast, Sterea Ellada and Peloponnisos were the least efficient regions in 2012. We should note that efficiency scores rose constantly across all regions of Greece up to 2007. With the exception of Attiki, all other regions witnessed a drop in their efficiency performance from 2008 onwards, signifying the adverse impact of the economic crisis on the productivity of peripheral areas. Nonetheless, the island regions of Notio Aigaio and Ionia Nisia have witnessed a small recovery in their efficiency scores during 2012. The results are consistent with those of other studies in the related literature (e.g., Petrakos and Psycharis, 2016) in pointing out the adverse impact of the economic crisis on regional inequalities and the strengthening role of the Athens metropolitan region in the development pattern of Greece.

Similarly, most sectors of the Greek economy suffered a drop in their efficiency levels after 2008, following the crisis outbreak. The industries with the highest efficiency scores are those of Real estate, public administration and financial intermediation, with average scores close to or above 80%. On the other hand, the least efficient industries are those of Agriculture, forestry & fishing and Professional activities, with average efficiency scores below 50%.

It is also stressed that, during the last years, the productivity of almost all sectors of the Greek economy was followed by an increase of the unit labor cost index and was found to be well below the average productivity of the Euro area. These outcomes underline the need for taking up immediate and targeted policy measures to increase the technical efficiency of the Greek regions and sectors and reduce the widening productivity gaps between Attiki and the other regions, as well as among Greece and the Euro area countries.

Analysis of inefficiency determinants: The analysis of the determinants of technical inefficiency contributes to the understanding and explanation of systematic variations in the production efficiency among regions and between sectors of the Greek economy over time. Furthermore, it offered several important results, which can provide useful implications for policy actions, including the deployment of effective regional-sectoral policies aiming to enhance territorial cohesion and diminish regional disparities and sectoral inefficiencies.

More specifically, the outcome that time-invariant region-specific effects do significantly account for changes in technical efficiency suggests the need for emphasizing the exploitation of the particular local comparative advantages of each region (e.g., land fertility, weather conditions, coastlines, geographical access to raw materials and the sea) to increase productivity performance.

It was shown that the spatial variations in productivity can be attributed not only to differences in the availability of physical capital, labor force and technological progress, but also to technical inefficiencies related to the interregional market access, urbanization economies, specialization, sectoral concentration and the human capital in each region. Hence, these time-variant regional effects must be taken into account and properly considered to diminish the distance of the Greek economy from the production frontier.

In particular, the results verified most of the existing literature and demonstrated that urbanization economies have a significantly positive impact on the technical efficiency of regions. In addition, the dispersion of urbanization economies within regions as well as the interregional market access were also found to significantly enhance efficiency. Therefore, both intraregional and interregional transport improvements should be regarded as important to address technical inefficiencies of the Greek economy and its spatial inequalities. Moreover, these findings denote the importance of strategic regional planning to promote urban agglomerations in a way that enhances the polycentric development of peripheral areas. Such types of efficiency enhancing organization of economic activities in space are crucial for growing the rate of return of public investment and addressing the resource limitations due to increased fiscal constraints.

The econometric results further show the substantially positive influence of the specialization and sectoral concentration (instead of diversification) on regional efficiency. Consequently, they stress the significant role of the development of local activity clusters, in the form of industrial areas, science and technology parks, and logistics parks (or freight villages), to promote innovation through knowledge spillovers, and to create productivity gains through increasing returns to scale originating from the specialization and concentration of high added value goods and services.

We also found a considerable positive impact of human capital on technical efficiency, as the results showed that a rise in the share of hours worked by highly educated persons contributes significantly to reducing inefficiencies in Greek regions. The positive association between the increased educational levels of the labor force and regional efficiency suggests that higher productivity is likely to be achieved through investment in education and training. Public spending on education remains at very low levels in Greece and, therefore, increases in government expenditure in this field are a necessary means to create competitive advantage. Investments in education should not only relate to younger generations but may apply to all age structures until retirement. Finally, although in the current literature political factors have been found to significantly influence the level and distribution of regional public investment, they were not found to have a significant impact on the technical inefficiency of the Greek regions.

APPENDIX

TABLE A.1

Regional level econometric estimates (baseline) inclunding dummy variables

Production function					
β_0	2.84* (1.76)				
ln (Hours worked)	0.33** (7.65)				
ln (Total physical capital)	0.57** (23.30)				
Time trend	-0.02** (-6.10)				
Inefficiency model					
δ_0	1.38** (7.66)	Year 2007	-0.15** (-11.90)	Region Attiki	2.12** (4.11)
Hours worked by highly skilled persons	-0.40** (-3.17)	Year 2008	-0.13** (-9.81)	Region Peloponnisos	0.54** (2.27)
Interregional specialization	-0.40** (-2.75)	Year 2009	-0.11** (-7.23)	Region Voreio Aigaio	0.13* (1.70)
External market potential	-0.09** (-2.02)	Year 2010	-0.05** (-2.55)	Region Notio Aigaio	0.65* (1.79)
Regional diversification	-0.94** (-6.58)	Year 2011	0.03 (0.97)	Region Kriti	0.17** (2.15)
Internal market potential	-0.05** (-5.54)	Year 2012	0.05* (1.78)	Time effects	included
Internal market potential dispersion	-0.001** (-4.46)	Region Kentriki Makedonia	0.48** (9.61)	Region effects	included
Year 2001	-0.03** (-2.54)	Region Dytiki Makedonia	0.52** (2.58)	σ^2 (p-value)	0.0004** (10.94)
Year 2002	-0.05** (-3.90)	Region Ipeiros	0.23** (2.06)	γ (p-value)	0.06** (2.20)
Year 2003	-0.12** (-13.44)	Region Thessalia	0.43** (2.17)	Log likelihood	404.90
Year 2004	-0.13** (-10.55)	Region Ionia Nisia	0.28** (2.36)	Observations	169
Year 2005	-0.12** (-7.40)	Region Dytiki Ellada	0.43* (1.70)		
Year 2006	-0.15** (-11.90)	Region Sterea Ellada	0.89** (2.79)		

Notes: a) t-statistics are included in parentheses.
b) ** and *denote significance at 5% and 10% levels, respectively.

TECHNICAL NOTE ON THE PRODUCTION FUNCTION

In the Solow-Swan model, the production function assumes the form of a well-behaved neoclassical production function of the form:

$$Y(t) = F(A(t), K(t), L(t)).$$

This production function satisfies the assumptions of constant returns to scale and of diminishing returns w.r.t. the factors of production and fulfills the Inada conditions. Such a production function should be Harrod neutral (or labor augmenting), as shown by Hirofumi Uzawa (see Acemoglu 2008, p. 60), for a steady state to exist. By opting for a Cobb-Douglas production function, which satisfies the assumptions above, it is easy to show that all types of technical progress (factor augmenting or Hicks neutral, labor augmenting or Harrod neutral, and capital augmenting or Solow neutral) can be accommodated. It is also more amenable to econometric manipulation and it is the standard production function used in the literature.

MAP
The 13 NUTS-II Regions and their constituent 51 NUTS-III Prefectures of Greece

NUTS-II: Attiki
1.Attiki

NUTS-II: Sterea Ellada
2.Evia
3.Evritania
4.Fokida
5.Fthiotida
6.Viotia

NUTS-II: Kentriki Makedonia
7.Halkidiki
8.Imathia
9.Kilkis
10.Pella
11.Pieria
12.Serres
13.Thessaloniki

NUTS-II: Kriti
14.Chania
15.Iraklio
16.Lasithi
17.Rethymno

NUTS-II: Anatoliki Makedonia-Thraki
18.Drama
19.Evros
20.Kavala
21.Rodopi
22.Xanthi

NUTS-II: Ipeiros
23.Arta
24.Ioannina
25.Preveza
26.Thesprotia

NUTS-II: Ionia Nisia
27.Kerkyra
28.Kefallonia
29.Lefkada
30.Zakynthos

NUTS-II: Voreio Aigaio
31.Chios
32.Lesvos
33.Samos

NUTS-II: Peloponnisos
34.Arkadia
35.Argolida
36.Korinthia
37.Lakonia
38.Messinia

NUTS-II: Notio Aigaio
39.Cyklades
40.Dodecanisa

NUTS-II: Thessalia
41.Karditsa
42.Larisa
43.Magnisia
44.Trikala

NUTS-II: Dytiki Ellada
45.Achaia
46.Etoloakarnania
47.Ilia

NUTS-II: Dytiki Makedonia
48.Florina
49.Grevena
50.Kastoria
51.Kozani

a: Mount Athos

Notes: The names of regions follow the nomenclature of territorial units for statistics (NUTS) of Eurostat. 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 Macedonia).

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