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Faculty of Technology, Policy and Management

# RESTARTING GREECE

## Secular Stagnation of Total Factor Productivity Growth and the Greek Innovation System

TU Delft Delft University of Technology

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# Secular Stagnation of Total Factor Productivity Growth and the Greek Innovation System

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By

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# Preface

In 2015, Greece experienced the worst year in economic, happiness, and popularity terms in its recent history. The next year, my brother and his team from Aristotle University of Thessaloniki won the 1st prize in a global competition, held by Microsoft. They had provided a technological solution to a social problem (bullying). That's when I realized the importance of technology in our lives, the technological revolution we are living in, the opportunities and the risks ahead. As a result, I decided to study Management of Technology at TU Delft.

Prior to starting my MSc studies, I was already interested in YES! Delft, its activities and events, and especially the Ready to Startup course, which I attended successfully last year. YES! Delft is a technology incubator supporting startups in the field of Robotics, AI, Blockchain, Medtech, Cleantech, and Complex Technologies. In 2018, it was ranked by UBI as the #2 World Top Business Incubator, affiliated with a university. Consequently, I had the chance to experience the inspiring environment, with over 150 active startups, at one of the leading tech incubators in Europe every week. Last semester, I completed my internship as Investment Consultant at YES! Delft, where I was responsible for setting up the Strategic Funding Program, a position that gave me access to a large network of entrepreneurs and investors. I coordinated the activities relating to the financial support, (re)capitalization and financing of the participants in the YES! Delft programs in consultation and cooperation with the YES! Delft team. My position helped me to better understand the needs and wants of investors (private funding), governments (public funding), entrepreneurs, and of course customers. Two months ago, I took part in the Startup Flight, a business trip organized by YES! Delft students, in Silicon Valley. The academic knowledge and experience I had, became more coherent and meaningful, through perceiving the "real thing". Silicon Valley is the place where this technological revolution has been mainly taking place during the last 50 years, and I think I understood (to the highest possible extend) why, during this trip.

During my second year at this MSc, I decided to follow the Economics and Finance specialization, due to my strong interest in this field, partly because of my aspirations and partly because of my Greek origins, after also being inspired by Dr. Servaas Storm. This master thesis embodies almost everything I was contemplating and discussing about during the last 4 years regarding the past, present, and future of Greece. The Netherlands welcomed and inspired me, throughout a life-changing journey, from which the knowledge and experience I gained will unequivocally determine the rest of my life. I still strongly believe not only in the power of technological and business model innovation to create a sustainable and prosperous economy, but also in the critical significance of developing passionately and carefully our emerging innovation ecosystem. Having just visited the Bay Area, I definitely advocate that geography is destiny, although one can easily observe not only the positive, but also the adverse effects of Financialization, even in Silicon Valley. Emerging innovation systems, like the one in Greece, need to avoid the same mistakes. In this new age, location is not a problem anymore, and paraphrasing Carl Sagan: somewhere, something incredible is waiting to be built.

This report was written in the midst of two election periods. First, the European elections in May, and then the Greek elections on the 7th of July. Undoubtedly, this context enhanced my interest in the topic and enriched my understanding on the debates I read, watched, but also took part in. I would like to express my gratitude to Prof. dr. C.P. (Cees) van Beers for his insights and comments on secular stagnation of economic growth, and his inspiring lectures on frugal innovation. In addition, I would like to deeply thank Dr. Servaas Storm for the inspiration, knowledge and different perspectives he provided during his engaging lectures, as well as the insightful, eye-opening, and pleasurable discussions we had during the execution of this project. I would also like to present recognition to Dr. Udo Pesch for his contribution to my understanding of technology from a philosophical perspective, through his lectures in the Technology Dynamics course, and our discussions on the philosophy of technology, and its relationship with art, music and cinema.

It was an enjoyable and life-altering journey. I really hope I will have the chance to work with all of you again in the future.

*Delft, July 2019*

*Vyron Chrysovergis*

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# Executive Summary

In 2008, the Global Financial Crisis originated from the collapse of the U.S. financial system and lead to a global recession, whose impact still exists in the world economy, and particularly in the European one. The economic divergence in the Eurozone resulted in different outcomes for the Northern "health core" and the Southern "sick periphery", with the latter still suffering and trying to recover. Greece is the most remarkable case in the periphery, as far as financial assistance and presence in the headlines are concerned. Three economic adjustment programmes and €293 billion in financial assistance, toxic public discussion portraying Greece as "the perpetrator or the victim", neologisms across media and politics such as Grexit or Grecovery, "brain drain", demographic problems, and representation of Greece as the weakest EU link from which European disintegration will start, were some of the elements that shaped our reality the last decade. This environment was not conducive for the country to overcome the crisis, and currently Greece is weakened and left in stagnation. We will be talking not only about a lost decade, but a lost generation, unless this reality changes. The Greek economy needs to restart, and that is the motivation for this thesis project.

The adverse position of the Greek economy when it was hit by the crisis originated from the economic and technological stagnation that was there before 2008. Therefore, we need to understand the reasons behind this long-term stagnation, called "secular stagnation" of economic growth. To do that, we investigate the potential output growth, which is determined by the Total Factor Productivity (TFP) growth. On this basis, we use a longstanding time series data to explore whether the decline of TFP growth was precipitated by the 2008 Global Financial Crisis, or it was happening long before. Consequently, we investigate whether there was secular stagnation of TFP growth in the Greek economy. Initially, we provide literature review on the concept of Secular Stagnation in an economy, and we continue with a literature review on the impact of TFP in the Greek economy. After examining the theory behind secular stagnation of TFP growth, we show that TFP growth can be defined as (i) Solow's Residual, (ii) Weighted Average Factor Productivity growth, and (iii) Weighted Average Factor payment growth. Thereafter, we provide the basic arithmetic for these three definitions, and present our findings, based on our calculations with data from the EU KLEMS project, covering the period from 1995 to 2014. We conclude that there has been secular stagnation of TFP growth in the Greek economy.

Furthermore, labor productivity growth is a source of TFP growth, and hence we focus on its slowdown. Labor Productivity growth can be decomposed into two components; the within- and between-sector Labor Productivity growth. Using shift-share analysis, we present this decomposition of Labor Productivity growth for the Greek economy and conclude that its decline was due to within-sector productivity slowdown in almost all sectors, even though employment shifts between sectors were present, but their impact was negligible. At this point, we scrutinized the movements of real wage between dynamic and stagnant sectors in terms of productivity growth. According to Baumol, a "Cost Disease" exists when the real wage in sectors with negligible or no productivity growth (stagnant) is the same or higher than the real wage in sectors with higher productivity growth (dynamic). Our findings reveal that Real Wage growth in dynamic sectors was slightly higher than in stagnant sectors, providing us with no evidence that this "disease" occurred in the Greek economy.

Next, we argue that the observed decline in Final Demand originates from the lack of technological competitiveness and the increased competition of Greek firms with low-wage countries. Sluggish demand leads to decreased capacity utilization, and thus depressed profit rate leading to reduction of investments for innovation and R&D, entrapping the indebted Greek economy into a state of decline. In order to provide evidence for that, we decomposed profit rate, particularly for manufacturing firms. The findings of this decomposition provide evidence that reduction of capacity utilization affected negatively the profit rate of firms, which in turn adversely influences investments to R&D and innovative activities that could be conducive for Greece to escape the vicious cycle of decline. This cycle is presented in a causal scheme, firstly put forward by Storm, and we argue that two principal solutions exist to escape this trap. The first regards demand revival and the second a long-term and inclusive development strategy that will focus on sustainable economic growth, innovation, entrepreneurship, and hence technological competitiveness. For that, we focused on the framework, based on which this strategy should be created, the National Innovation System. The concepts of National Innovation System and Innovation Management are critical and have to be considered by the Greek government. We therefore presented the pertinent theoretical foundation, the core elements of effective innovation systems

and their implementation in a brief literature review, the Triple Helix Model theory, the "Entrepreneurial University" concept, and in order to include all three parts of an Innovation System (academia, state, market) we provided an enterprise perspective on Innovation Management that can be helpful to Greek firms and industrial sectors to enhance their innovative capacity and technological competitiveness.

Finally, we directed our attention into the distinct characteristics of the Greek economy and Innovation System. Initially, we presented the industrial environment and the industries with growth potential, as well as the effect of education and research on economic and TFP growth. We subsequently assessed the Greek Innovation system, presenting the strengths and weaknesses of the sub-systems it is comprised of, and after exploring its deficiencies, we focused on an optimistic part of this system, the high-tech Startup ecosystem in Greece. We concluded with policy recommendations for the Greek government on productivity and innovation, as well as strategic recommendations for the Greek Innovation system. In particular, we recommended that the Greek government should encourage activities and technologies in certain fields, extend the comparative advantage base, invest in labor and capital to create an export-oriented entrepreneurial productive system, and an effective education system with emphasis on entrepreneurship. Also, simplification of regulatory and administrative procedures, establishment of a single institution dedicated to productivity, and alignment of the financial environment with the NIS are essential policies that need to be implemented. Regarding the Greek Innovation system, we advocated a lasting nationwide consensus on the future strategy. Concerning the specific subsystems, we suggested that the overregulated business environment and legislation should be improved and simplified, the public and private R&D expenditure should be increased, and education should emphasize technical training, STEM fields as well as support of entrepreneurship. The funding environment should be supported with simplification of the tax and justice system, the political environment should be stabilized, and the networking actions, in particular for the diaspora, should be increased and incentivized. Ultimately, society needs to become more supportive to innovative entrepreneurship, and overcome risk-aversion and "fear of failure".

***Keywords:*** Greek Crisis, Secular Stagnation, TFP Growth, Labor Productivity, Innovation System

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# Chapter 1: Introduction

*"The Chinese use two brush strokes to write the word 'crisis.' One brush stroke stands for danger; the other for opportunity. In a crisis, be aware of the danger--but recognize the opportunity."*

*John F. Kennedy*

## 1.1. The Eurozone Crisis

'Crisis' originates from the ancient Greek word "κρίσις" (krisis), meaning thinking and decision. When we use it nowadays, what first comes to mind is the 2008 Global Financial Crisis. After the crash of the housing market bubble, the U.S. financial system collapsed, creating a global recession, with ruins still present in the world economy, especially in the European one. Due to the divergence between the Eurozone economies, the impact of this crisis was not uniform. The Northern "healthy core", including Germany, Netherlands, Austria and France, was able to recover relatively quickly and reach the economic state before the crisis. In contrast, the Southern "sick periphery", including Greece, Italy, Portugal and Spain (GIPS), is until now striving to reach the previous state (Storm, 2017a). That reality is connected strongly to the economic and monetary discrepancies between these two divisions, the unsustainable private and public debts of the GIPS (Greece, Italy, Portugal and Spain) countries, their trade deficits, and policies that were implemented by the European Union as a reaction to the crisis.

Notwithstanding the fact that since 1999, economic convergence was evidently increased among the members of the European Union, the core and periphery division is still significant (Campos & Macchiarelli, 2016), creating a deviation from the rules that were decided to smoothly operate the single currency initiative (Arghyrou, 2017). This European economic integration initiative is part of a greater project to establish peace and prosperity in the war-ridden continent where western civilization was born, and as a result its success is of critical importance not only for its advocates but also for humanity as a whole. Britain's decision to leave, the rise of extremists and populists in numerous electorates across EU, and a general dissatisfaction among pro-EU voters point to the worrying realization that this historic initiative is under pressure (Oliver, 2016).

Unequivocally, Greece is the most notable case of the periphery group, regarding not only presence in headlines, but also financial assistance received for economic adjustment. In the GIPS group, where countries received assistance programmes, public opinion is comprised largely of dissatisfaction, mainly because of their adverse effects in welfare along with the widely popular perception that national sovereignty in economic policy was reduced by the EU and International Monetary Fund. On the Northern side of the union, public opinion is characterized by disapproval of the policies that use public and private savings to save the incautious members. Consequently, this two-sided dissatisfaction leads to an undesired convergence, Euroscepticism (Arghyrou, 2017). So, even if austerity advocates retreat (Goodhart, 2014), how is this divergence going to stop? How will the "sick periphery" grow faster than the "healthy core"? These are the first questions that initiated the "krisis", the thinking framework for this thesis project, aiming to be useful for scholars and decision-makers, to eventually get out of this long-lasting and dangerous crisis that affects not only the economic welfare but also demographics and culture. As Joseph Stiglitz writes in his book 'The Euro and its threat to the future of Europe', the European project is "too important to be destroyed by the Euro".

Eurozone's strategy to initially handle the crisis was to create bailout funds and support the countries that needed them, in exchange for fiscal consolidation and structural reforms (Baldwin & Giavazzi, 2015). However, the heterogeneity of the economic, political and institutional circumstances of distinct countries, and the diversity of their governments with different capabilities and views, technically and ideologically, resulted in various difficulties during the implementation of those measures, with public and special-interest resistance being extraordinary, especially in Greece (Manasse & Katsikas, 2018). Additionally, since its birth in 1992,

Eurozone's governance was not complete structurally, particularly regarding fiscal and macroeconomic adjustment policy, as well as banking regulation (Copelovitch, Frieden, & Walter, 2016). These deficient structures of the Eurozone played a major role in the mishandling of the crisis, so while the trigger was across the Atlantic, the bullet hit Europe. In 2014, Mario Draghi, the president of the European Central Bank, named this deficiencies Europe's "Achilles' Heel" (Jones, Kelemen, & Meunier, 2016). Is he right?

## 1.2. The Greek Case

Even though the Greek economy is smaller than the Italian or Spanish one, especially when considering the possibility of an exit that would in turn pull the Eurozone apart, it has been a dominant element of global headlines the last decade (Giugliano & Odendahl, 2016). This headline oversupply and extraordinary media coverage, apart from presenting the true facts, it also focused on chosen, negative aspects of the Greek society that eventually added "insult to injury", through the created perception that this has always been the case for Greece, and that "the Greeks are responsible for whatever happens to them" (Skartsis, 2018). Greece's economic crisis constitutes one of the greatest challenges that Europe faced, particularly in 2015, and it can be argued that it still is a big factor of success for the future of the European economic, monetary, and -arguably- political integration.

Greece is one of the founding members of the Union, and its value for Europe is beyond any economic fact. Europe's name, values, history, and foundations, are closely tied to the Greek history and mythology. However, the Greek economy is still facing an economic and recently demographic crisis, that is connected not only to the 2008 Global Financial Crisis and Eurozone's reaction policies, but also to the falsified growth and hidden stagnation that had started after 1980 and which had created for Greece a really unfavorable set of circumstances for sustainable growth and capabilities for reacting successfully to the Crisis. Greece is still considered as an upper-middle income country, and indeed there are many resemblances with other high-income countries. According to the World Bank, it was one of the handful of countries that managed to escape the middle income trap (Agénor, Canuto, & Jelenic, 2012). Being a member of every elite group on the planet, and considered for years as a success story, the Greek story is even more fascinating when we realize that this was a borrowed achievement and not the outcome of "high productivity, innovation, a generous investment in human capital, reforms, and high-quality inclusive institutions" (A. N. Hatzis, 2018).

From this brief introduction, it becomes clear that there is urgent need for deep and effective structural reforms, a task that seems ambitious not only due to the recent years and the several rounds of legislation made by the governments, but also because of the nature of the Greek economy, one characterized by protectionism, political corruption, and a public sector dependent on special interests (Ioannides & Pissarides, 2015). As a result, till 2015, almost every decision taken by the Parliament was met with public resistance, protests, political instability and extremism, and very frequent elections. After the unforgettable summer of 2015, and the establishment of the left-wing SYRIZA government, the public resistance front seems to be decreasing and several reforms have been successfully implemented. Nonetheless, the focus was mainly on fiscal austerity, high taxation, and cuts in earnings (Ioannides & Pissarides, 2015), and therefore the need for lenders to realize that incentives should be given aiming to constructive structural reforms is still there. Two mistakes, one compounding the other, were made: the first has to do with the disregards of Greece's economic asymmetries and problems when it entered the Eurozone. The second was the fiscal austerity, as an answer to the crisis and the dismal indicators of the Greek economy (Ioannides & Pissarides, 2015), causing a destructive demand fall.

Improving competitiveness through reforms pointed mostly to the market for goods and services are required to increase productivity, become more export-oriented and attract foreign investment. This is a process that is under way, especially after 2015 when resistance was reduced, a process that naturally and historically follows every crisis. Hopefully, not only unit labor costs will be affected by these reforms, but also the current dreadful demographic state (Ioannides & Pissarides, 2015), which is characterized by an aging society and the most ambitious young Greeks leaving the country, trying to reach their potential where they are supported to do so.

If this reality does not change in the coming years, we will not be talking about a lost decade, but about a lost generation, and even worse, a lost nation. We need to act, and serve our small part to the attempt that is currently being made to restart Greece. That is the motivation for this thesis project.

This section is followed by a brief historical background, to gain a better insight about the origins of the crisis. Then, we dive further into the various diagnoses of the crisis through a literature review, where a knowledge gap is identified. After that, the problem is introduced and the objectives are described, along with their scientific and societal relevance. Next, the main research question and the sub-research questions are presented. Subsequently, the four steps of the research methodology are described, and then we dive deeper into the Greek economy.

## 1.3. A brief historical background – Origins of the crisis

Greece joined the European Union on the 1st of January 1981, accompanied with a political system that promised a transformation of the country, the long-desired "Change". As the former Governor of the Bank of Greece, George Provopoulos states, the next two decades, were characterized by "double-digit inflation rates and interest rates, anemic real growth rates, large fiscal and external imbalances, and several balance-of-payments crises". Thus, the real transformation seemed to have been realized in 2001, when Greece entered the Eurozone. The next seven years, the country's economic performance reached 4% real growth in average, and with European Central Bank controlling inflation expectations, inflation fell to single digit rates. Interest rate spreads between 10-year German and Greek sovereign bonds fell to levels ranging from 10 to 50 basis points, from over 600 during the 1990s (Provopoulos, 2014). However, fiscal and external imbalances were unsustainably being created, resulting to the violent explosion of the Greek sovereign-debt crisis in 2009, just like an accident waiting to happen (Provopoulos, 2014). As a matter of fact, the Bank of Greece initiated warnings, early 2008, pertinent to the dangers caused by these macroeconomic imbalances and competitive weaknesses (Bank of Greece, 2014). And although the bell was tolling loudly for the financial markets, these dangers were not evident to them until October 2009 (Gibson, Hall, & Tavlas, 2014). By then, the recently-elected government of George Papandreou surprisingly announced that fiscal deficit would be much higher than its previous estimations. As a consequence, interest rate spreads climbed relentlessly upward, and the Greek crisis had officially began (Provopoulos, 2014).

Greek public debt was rapidly labelled as unsustainable by the global markets, even though default was avoided by the stepping in of the Troika, comprised by the International Monetary Fund, the European Commission (EC), and the European Central Bank. The Troika financed debt repayments under the conditions of a rough adjustment program, the so-called "Memorandum". This first bailout agreement (May, 2010) was an effort to promote reforms, stabilize Debt-to-GDP ratio (127%), face the public finance collapse, the liquidity shortage and the sharply increased sovereign bond interest rates (A. N. Hatzis, 2018). Contrary to Troika's expectations, debt did not stop rising, and the Greek economy was experiencing an extensive recession, without precedent. As a result, the second adjustment program was voted and approved by the government in 2012, including again fiscal measures, but this time also a nominal debt reduction of about €110 billion. Once again, the real economy suffered, unemployment climbed at 29%, and social upheaval escalated. The chain of events that followed lead to the rise of SYRIZA in power, with the newly-elected Prime Minister Alexis Tsipras collaborating with Yanis Varoufakis, a popular economist due to his diagnosis for the crisis and his proposed solutions. Their negotiations with the creditors failed ultimately at the end of June 2015, leading to capital controls, closed banks, and a referendum that risked an exit from the Eurozone. At the end of this unforgettable summer for every Greek, a third program was created and approved, with a three-year horizon.

The budget deficit (15.4% of GDP in 2009), the trade deficit (14% of GDP in 2008) and the current account deficit (14.7% of GDP in 2008) are the three separate deficits, which are usually mentioned when discussing the Greek crisis (A. N. Hatzis, 2018). They reached their peak after the 2008 crisis and the unpredictable reactions by the conservative government of Kostas Karamanlis (2004-2009) and the social democratic government of George Papandreou (2009–2010). These three deficits and the huge public debt as a percent of GDP (142.8% in 2009, 177.4% at the end of 2017), along with other discouraging indicators are not the whole story, but rather the symptoms. Aristides Hatzis, an esteemed Professor of Law & Economics at the University of Athens, argues that the root causes of the poor performance of the Greek economy should be identified elsewhere (A. N. Hatzis, 2018). In an attempt to identify the root causes, the next section provides a brief literature review of the numerous diagnoses for the Greek crisis.

## 1.4. Diagnosis of the Greek Crisis: A Literature Review

As mentioned previously, the divided Eurozone economies experienced fundamentally different recoveries. The "healthy core" returned to normal growth, whereas the "sick periphery" still suffer extended periods of high unemployment and low growth. House et.al. (2017) created a model to investigate why this is the case, and they concluded that although there was noise in their data, there is a clear pattern suggesting that a significant part of these different recoveries is caused by *fiscal austerity*. More specifically, the reductions in governments purchases contributed largely to their respective reduced output (House, Proebsting, & Tesar, 2017). Even more for the GIPS countries, austerity had a substantially adverse impact on GDP. They further argue that if these governments had refrained from fiscal contraction, their output would have been significantly higher, resulting in a smaller Debt-to-GDP ratio (House et al., 2017).

From 2008 to 2015, not only Greece but also Spain and Portugal cut heavily their nominal wages by 2.77%, 1.43% and 0.92%, respectively (Storm, 2017a). In Spain labor productivity growth was strongly increased in relation to the North, at the cost of rising unemployment and collapse of the construction sector. This did not happen in Greece and Portugal, where labor productivity was not boosted (Storm, 2017a). The programmes that were applied in Greece consisted of a mix of *austerity* and *internal devaluation* measures (Koratzanis & Pierros, 2017). While originally expected to bring public debt to sustainable levels and boost competitiveness of the private sector, Greece is still not creditworthy, its exports are not growing and its macroeconomic outlook seems uncertain. Trying to balance public finances and revive economic growth using austerity measures has not been proven optimal for Greece; in fact, the balance sheet of private companies was roughly damaged and the Greek economy entered a *debt-deflation trap* (Koratzanis & Pierros, 2017). This fact may be proven destructive not only when diagnosing the reasons of the Greek crisis, but also for the future productive potential of the Greek economy and its long run growth.

Other economists focus on the impact of large *shadow economies*, when austerity is the followed policy. Bitzenis et. al. (2016) argued that during a recession in countries with these kind of shadow economies, such as Greece, fiscal austerity leads to worse results. Therefore, the goal should be to reduce the shadow economy in order to increase government revenues and eventually overcome the crisis (Bitzenis, Vlachos, & Schneider, 2016). As far as *monopolies* are concerned, Greece has the most protected and monopoly-driven economy in the Eurozone, and no reforms have been applied in its recent history to change that and increase productivity to reach the European level (Ioannides & Pissarides, 2015). Regarding the *tax system*, public revenues are converging to the level of its European partners, notwithstanding the following facts: First, indirect taxes are much higher than the Eurozone average. Second, direct taxes are notably lower. Third, the system is very complicated and costly. Four, tax evasion is significantly large due to an inefficient collection system, in particular for the VAT, leading to significant revenue losses (Christodoulakis, 2018). Consequently, for both systems the need for reform is urgent.

A notable part of the literature, worthy of attention, argues that high levels of public debt have an adverse impact on economic growth. In the long run, through this negative correlation it is argued that both in developed and developing economies, the higher the public debt, the slower the growth (Adam & Bevan, 2005; Diamond, 1965; Saint-Paul, 1992; Schclarek, 2004). As mentioned, Greek debt increase during the last 4 decades is significant. Although there is not a notable amount of empirical literature focusing on the Greek economy, and the existing studies were conducted during the crisis (Alogoskoufis, 2012; Laopodis, Merika, & Triantafillou, 2014), Spilioti and Vamvoukas investigated the influence of public debt on output growth in Greece during the last 40 years. Their findings agree with the pertinent literature, and they argue that there is "a statistically significant relationship between government debt and GDP growth". Specifically, debt affects positively GDP when their ratio is up to 110%, and when that ratio is higher it affects negatively (Spilioti & Vamvoukas, 2015).

Last but not least, *innovation* and *technological progress* greatly influence the sustainable economic growth in developed countries. Despite that and contrary to its *intellectual wealth* and scientific potential, in the Greek part of the euro area, globally competitive industries and big corporations with high added value and sophisticated jobs are very rare. Two important pertinent facts are the following: Greece has received, through the adjustment programs, a total of 293 billion euro from the Eurozone members and the International Monetary Fund. However, this financial support provides a short-term comfort. Additionally, according to the European

Commission Innovation Union Scoreboard 2015 (European Commission, 2017), 9% of the scientific publications stemming out of Greece are between the most cited publications in the world. But, most of these researchers and entrepreneurs leave Greece, and migrate to work in Europe or the US. This new, modern composition of the Greek diaspora is composed of a remarkable number of highly-skilled scientists.

On the contrary, the Greek economy is highly dependent on less knowledge-intensive service industries in tourism, trade and transportation. Mostly small and medium sized enterprises constitute the industrial sector, which is weakened after the crisis and not export-oriented. There are some exceptions, mainly those companies that focused on supplying the foreign market, which became stronger, more competitive and ultimately survived the crisis successfully. Greek industry competitiveness needs to increase, shifting the whole economy on a sustainable growth track in the long-term. For this to happen, radical political reforms and substantial investments are essential. Thus, *an effective national innovation system*, with a long-term development strategy and bipartisan collaboration, is required.

To conclude, the economic situation that was build up during the previous 4 decades in addition to the crisis and the adjustment programmes lead the Greek economy into a long-lasting stagnation. Worsening the situation, the primary surpluses that the country is forced to achieve based on the third bail-out program, are above 3% of GDP for the next few years. Basically, what stems out from the literature that happened in Greece is that its economy and reality met face to face. A debt-financed growth bubble, harsh and failed adjustment programmes, severe fiscal austerity, little debt restructuring, not enough and wrong structural reforms, depression of domestic demand, small foreign demand, and soaring inequality. However, a *knowledge gap* can be identified regarding the connection of the crisis to the secular stagnation of the Total Factor Productivity growth in the Greek economy. The next section elaborates on that gap.

## 1.5. Research problem

Public discussion has been representing Greece as “the perpetrator or the victim”, while neologisms such as Grexit or Grecovery were very common across media, politics and everyday life. Greece was numerously portrayed as the weakest link in the European Union and the point where its disintegration could start (Wodak & Angouri, 2014). In addition, the toxic political climate inside the country did not contribute in a positive way to overcome the crisis by following the right policies. However, the important question is *whether the economic stagnation in Greece is a result of the 2008 Global Financial crisis and Eurozone’s reaction or it was being built long before the crisis.*

As defined by Diego Comin, “Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production”. On this basis, its magnitude is determined by the efficiency and intensity the resources are utilized in production (Comin, 2006). TFP growth can be considered as a source of potential output growth, because of the GDP and productivity growth relationship (Simon & Levy, 1963; Storm, 2017b). Therefore, when we observe stagnation in economic growth, we should examine carefully the slowdown of TFP growth. So, if we want to extensively understand the slowdown in Greece’s potential economic growth, we should focus on the slowdown of its TFP growth. On the basis of this, we need a long-term time series of data to investigate whether the decline of TFP growth was precipitated by the 2008 Global Financial Crisis, or it has been happening long before. Consequently, we will try to reveal *whether there was a long-run slowdown of TFP growth in the Greek economy.*

Furthermore, labor productivity growth is also a source of TFP growth, resulting from the indication that TFP growth is responsible for the turndown of economic growth (Storm, 2017b). According to pertinent literature, labor productivity growth is decomposed into two components: “the change of a sector’s labor composition between two observed times and the change of a sector’s labor productivity growth between two observed times” (Timmer & Szirmai, 2000). As a consequence, if we decompose labor productivity growth we will be able to *conclude to what degree the decline in Greek productivity growth resulted from (i) a structural shift through which the employment share of the technologically dynamic sectors decreased and the one of technologically stagnant sectors increased or (ii) decreasing productivity growth rates in specific sectors.*

After exploring the long-run slowdown of TFP and Labor productivity growth, we will explain the decline in output and Final demand. This decline in Final Demand is created by the lack of technological competitiveness and the increased competition of Greek firms with low-wage countries, and leads to decreased capacity utilization and hence profit rate, ultimately resulting in reduction of investments to R&D innovation. By decomposing the profit rate, especially for manufacturing firms, we will provide evidence for this process and after presenting the causal scheme that includes the negative feedback mechanisms we will be able to answer *whether Greece is trapped in a vicious cycle, in a state of decline, from which it needs to escape through improving its innovative capacity and technological competitiveness. On this basis, what is the role of education and the National Innovation system?*

There is economic evidence that R&D subsidies and a large quantity of highly-skilled workers decrease the marginal cost of executing R&D and improve the rate of innovation development and hence, the TFP growth rate (Comin, 2006). In addition, the greater the size of markets the larger the innovators' profits, resulting to more innovation and even higher TFP growth (Comin, 2006). Clearly, in order to prevent a relapse into recession and produce long-run economic prosperity in Greece, attraction of foreign capital as well as highly-educated workers and scientists is needed, along with high-tech entrepreneurship and quickly-growing companies. Thus, a solid national innovation system is urgently required. Research in economics has shown that technological progress and innovation are critical for sustainable economic growth. In 1942, Joseph Schumpeter created the notion of creative destruction, and since then an abundance of evidence has proved the positive relationship among innovation and growth. Thus, we will try to investigate *what are the most important factors of a stable innovation system, of one that uses the national high scientific potential. What are the advantages and disadvantages of the Greek innovation system? What kind of policies are required to improve it?*

## 1.6. Four Objectives – Scientific and Societal Relevance

The *first objective* of this project is to research whether the decline of the Greek TFP growth was occurring before the 2008 Global Financial Crisis. For that, we will employ three growth accounting concepts as explained by Servaas Storm (2017), and use the relevant data supplied by the EU KLEMS project. Utilizing shift share analysis, we will reach the *second objective*, which is to understand further this decline through the turndown of labor productivity growth, and evaluate to what degree it was caused by a sectoral shift of employment or intra-sectoral decline of labor productivity growth. Additionally, the potential existence of the Baumol's Cost Disease will be investigated. According to Baumol (1966), this Cost Disease exists when the real wage in sectors with negligible or no productivity growth is the same or higher than the real wage in sectors with higher productivity growth. Thereafter, we will decompose the profit rate, in particular for manufacturing, in order to provide evidence on whether the decline in Final Demand depressed capacity utilization and hence the profit rate, resulting in lower investments to R& innovation, and hence entrapping the Greek economy into a state of decline. So, the *third objective* is to show this vicious cycle, from which the Greek economy needs to escape, through improving its innovative capacity and technological competitiveness. Finally, the *fourth objective* is to provide policy recommendations regarding the development of a sustainable, solid and constructive national innovation system, based on the distinct needs and characteristics of the Greek economy.

The outcomes of this study will serve as a further diagnosis for the secular stagnation of the Greek economy, but more specifically for the secular decline of TFP growth in Greece. It will hopefully be useful as an insight for the Greek government to assess the economic past of the country, and thus extract appropriate action plans to successfully deal with this stagnation. Apart from Greece, the European union can potentially benefit, if we consider the role Greece plays for the monetary and political integration. Moreover, it can be conducive to the Greek entrepreneurs, executives, investors, and scholars to better analyze the economic condition of the country, and serve as a supplement to their decision-making process. Finally, looking further into the future, through the last part of this study, policy recommendations and strategies for an effective innovation system will be proposed, aiming be helpful to policy-makers. As mentioned in the introduction, in this last part, we will try to create a "krisis" framework, a thinking framework, to overcome this long-lasting crisis. We humbly hope that we can play a small part in giving an optimistic view of what can be accomplished, a highly-needed optimism for the Greek society and diaspora.

## 1.7. Research Question

The societal and scientific considerations mentioned in the previous chapter lead the author to the following two-part research question:

> *How can the secular stagnation in the Greek economy be explained through the slowdown of Total Factor Productivity (TFP) growth and which are the appropriate policies and strategies that need to be followed in order to develop an effective National Innovation System in Greece?*

## 1.8. Sub-research questions

In order to tackle the main research question, we suggest five sub-research questions:

*1. How should we calculate the decline of Total Factor Productivity (TFP) growth?*

Three approaches to growth accounting, as explained by Servaas Storm (2017), will be utilized in order to investigate whether there has been a long-rung slowdown of TFP growth in Greece. These include Solow's Residual Growth, Weighted Average Productivity Growth, and Weighted Average Factor Payment (Productivity) Growth. After comparing these three methods, we will argue on the most meaningful way to interpret TFP growth.

*2. Has there been a long-run decline in Total Factor Productivity (TFP) growth in Greece?*

By answering this question, we will provide the necessary evidence to proceed to the next step to answer the main research question. In order to do that, we will compare the three results of the growth accounting methodologies based on the data by EU KLEMS. After cross-checking and confirming the quality of these methods, we will use the most probable TFP growth scenario, to proceed to the next question.

*3. Considering labor productivity growth as a source of TFP growth, is the decline in sectoral or aggregate labor productivity growth due to a between-sector employment shift or a within-sector slowdown?*

To answer this question, labor productivity growth needs to be decomposed based on these two possible scenarios, utilizing *shift-share analysis*. We will be able to indicate the most probable scenario, by looking at the decomposed and weighted labor productivity growth in each sector. Then, we can move to the next question.

*4. Has the decrease in Final Demand, in combination with the lack of technological competitiveness and increased competition from low-wage countries, lead to reduction of capacity utilization and hence depressed profit rate, entrapping the Greek economy into a state of decline?*

To provide evidence for that, we have to decompose the profit rate, especially for manufacturing firms. After this decomposition, we will be able to conclude whether capacity utilization and profit rate were decreased, leading to depressed R&D investments that would lead to increasing innovation and technological competitiveness. After these results, we will provide the causal scheme that explains the vicious cycle in which the Greek economy is trapped. Demand revival and improvement of innovative capacity and technological competitiveness are essential in order to escape. Therefore, we will direct our attention to the last sub-question.

*5. Considering the most important factors of an effective innovation system, and the distinct characteristics of the Greek innovation system, what are the required policy recommendations for the government and strategies for the private sector to improve it?*

In this last part of the study, we will try to identify the elements of an effective, stable and sustainable national innovation system. Thereafter, we will provide an overview of the strengths and weaknesses of the Greek innovation system, also based on the results of the previous sub-research questions. Eventually, and after combining the abovementioned elements along with the EU factor, we will propose appropriate policy measures and long-term national strategies to improve the current situation. This section will provide an answer to the second part of the main research question.

## 1.9. Research methodology

On the basis of the above sub-research questions, we propose four steps as the research methodology for this study.

Throughout the *first step*, we will concentrate on the estimation of the TFP growth decline in the Greek economy. For that purpose, we first need to conceptually elaborate on the theoretical aspect of the Total Factor Productivity Growth, by presenting relevant literature. After showing the relationship of output and labor productivity with TFP growth, we will try to prove the long-run slowdown of TFP growth in Greece, utilizing the three growth accounting methodologies, as derived by Storm (2017), Solow's Residual, Weighted Average Factor Payment, and Weighted Average Factor Productivity. Regarding the data, we will use those provided by the EU KLEMS project. After comparing the three outcomes and answering the first two sub-research questions, we will argue how TFP growth can be most meaningfully interpreted. According to Storm (2017), this is done through labor productivity growth.

Consequently, we will proceed to the *second step* by indicating that Greek labor productivity growth has been declining long before the crisis. The purpose of this step is to answer the third sub-research question and prove whether this decline is due to between-sector employment shift or within-sector slowdown of labor productivity. This will be done through decomposition, utilizing shift-share analysis. For each sector, labor productivity growth will be decomposed on the basis of these two scenarios. After the analysis, we will be able to see which scenario is more probable for each sector. Finally, we will try to see whether Baumol's Cost Disease was existing in the Greek economy.

Thereafter, we will provide evidence to connect the decline in Final Demand due to lack of technological competitiveness and increased competition with low-wage countries with the decreased capacity utilization and depressed profit rate. To do that, during the *third step,* we will decompose the profit rate, particularly for Greek manufacturing firms, and we will investigate whether the decline in Final demand is connected with the decline in capacity utilization and profit rate, which in turn leads to lower investments to R&D and innovation. After that, we will be able to present the causal scheme that includes the negative feedback mechanisms that explain the decline trap, from which Greece needs to escape through demand revival and a long-term development strategy for sustainable economic growth, through innovation, entrepreneurship and technological competitiveness. That will lead us to next step, which regards the Greek Innovation System.

As far as the fifth sub-research question and the second part of the main research question are concerned, the *fourth step* will try to tackle them. Taking into consideration the previous results, we will show the urgent need for an effective and sustainable national innovation system for Greece. We will firstly provide the theoretical foundations for such a task, by describing the key elements of effective innovation systems, using theories such as the *Triple-Helix Model, and Innovation Management.* Then, we will give a short overview of the Greek economy and discuss its distinct characteristics, its strengths and weaknesses, the EU factor, and the previous results. By assessing the Greek innovation system, we will ultimately propose specific policy recommendations for the Greek government and the private sector.

Our approach for this last sub-research question will be different than the one we follow for the previous questions, that is instead of a quantitative analysis based on macroeconomic equations, we will dive into the pertinent literature as well as the distinct characteristics and comparative advantages of the Greek Innovation System. Initially, we will focus on the literature regarding National Innovation Systems, by providing a critical review on the work that has been executed since the inception of the concept, thirty years ago. Moreover, we will direct our attention into the Triple Helix Model and the role of education in entrepreneurship. Before

describing the Greek Innovation System and proposing our recommendations, we will provide a short overview of Innovation Management concepts, which could potentially be useful for strategic decisions by executives in the private sector of the Greek economy. This transition in the methodology, from a quantitative to a qualitative one, is necessary as there is currently no quantitative method to evaluate and measure the effectiveness of a National Innovation System. The two frameworks are interconnected with the causal scheme mentioned above, through which it becomes clear that innovation leads to higher productivity. So, if the Greek economy manages to escape this decline and increase its innovative capacity, the vicious cycle will become a virtuous one, by rising exports that lead to higher demand, increased utilization, and thus profit rate. A positive feedback mechanism will be created through qualitative changes in institutional, legal, and social dimensions, that will impact the quantitative aspect of the macroeconomic equations we used in the first chapters. This is how the two part of this study are combined.

# Chapter 2: The economy of Modern Greece

*"I think the basic thing that happened is we have lost our story. Humans think in stories, and we try to make sense of the world by telling stories."*

*Yuval Noah Harari*

In this chapter, we present a more elaborate description of the Greek economy, along with some historical and political elements that are conducive to a deeper understanding of the factors that shaped the current state of affairs in Greece. The first section provides a brief overview of the recent economic and political history of modern Greece, in which the most significant events of the last two centuries are included. The next sections dive into macroeconomic factors pertinent to the purpose of this project, calculated by the author and based on data from the EU KLEMS project, covering the period from 1995 to 2014. Sub-chapter 2.2 concerns the output growth and output share of the Greek economy, while the following connects output with TFP and Labor productivity growth. Finally, graphs for employee compensation and final demand are presented, which give an initial idea about the impact of governmental policies and the EU on the Greek economy, before and after the crisis.

## 2.1. A deeper dive into the recent Economic and Political History of Greece

Two centuries ago, the Greek revolution took place against the Ottoman Empire, and Modern Greece was established. Since then, the country achieved to turn into a prosperous democracy. From 1930 and the next 50 years, the income's per capita average annual rate of growth was 5,2%, while Japan's average was 4,9%, and Germany's 3,0% (A. Hatzis, 2019). Nonetheless, this uninterrupted growth, after the 2nd World War and a fierce Civil War, was based on problematic institutions at a large degree, leading Greece to joining the European Community in 1981 and then the Eurozone. Undoubtedly, that European membership contributed to the improvement of those flawed institutions and paved the road for cheap global borrowing.

Konstantinos Karamanlis was the political figure with the most significant influence during these high growth decades. He was a conservative reformist that lead the economic transformation of Greece during 1955 to 1963, through fast industrialization and investments in tourism and infrastructure. This period was followed by political upheavals that ended with a military coup, in 1967. Restoration of democracy was achieved by Karamanlis, who then connected Greece with the European communities (A. Hatzis, 2019).

Since ancient times, *shipping* was the key element of the Greek economy and one of the oldest occupations for Greeks. This tradition continued in the modern years, after the Treaty of Kucuk Kaynarca in 1774, which authorized Greek ships to escape the Ottoman control, by registering with Russian flags (Polemis, 2007). After the revolution for independence and during the 19th century, shipping continued to represent the major success of the modern Greek economy. The slowdown of world trade after the two World Wars adversely affected Greek shipping. Powerful businessmen, such as Aristotle Onassis, supported the industry and shipping managed to remain one of the very few sectors in which Greeks are exceptionally good, coming 3rd internationally regarding number of ships and 5th regarding registration. However, a significant number of Greek captains register their ships under the Cypriot flag, mainly for tax purposes, but also because of the linguistic and cultural commonalities. *Finally, a number of Greek economists link the attributes the survival of the shipping industry to the characteristics of small companies in the technology sector (Doxiadis, 2019). As they claim, these are: footloose, compact and highly-skilled teams, in an essentially global market.*

*Tourism* is the other major Greek industry, which during the 60s and 70s, started to grow into a profitable sector through foreign exchange. Although members of the Greek government were against such a development, because they perceived it as a source of income without stability and closely related to political shocks. Despite more concerns by the Church and other conservatives, tourism managed to grow significantly and was strongly

supported by succeeding governments, as they realized it brought highly necessary foreign exchange revenues. Tourism is the heart and lung of the Greek economy, a sector that can fundamentally contribute its rebirth.

The end of the 19th century and the events that followed during the beginning of the 20th century between Greece and Turkey, had enormous consequences on the agricultural sector. After the Treaty of Lausanne, an end was put to the "tsifliks" and a significant number of Greek refugees from Asian Minor moved to these deserted locations. During 1920, 96% of land properties were lean than 24 acres (97.000 $m^2$). This small-scale farm ownership pattern has been the case till the present day, with the number of larger farms declining marginally (Freris, 1986). When Greece joined the EC, its economy was greatly different from the other countries in the community, especially because of the larger percentage of the agriculture sector in its GDP. In 1981, 17% of the GDP was due to agriculture, along with 30% of the employment, compared to the 5% of GDP and no more than 10% of employment in the other EU countries, apart from Ireland and Italy (Freris, 1986). Following the Common Agricultural Policy, Greece implemented all the reforms needed ahead of schedule, resulting to a rise in prices to meet the other countries within the EC. Consequently, the consumer was now supporting the farmers through price, instead of the large subsidies that were previously the main pillar of the Greek agricultural sector. The Greek trade balance was damaged because CAP subsidies abolished the production of products for which Greece had a comparative advantage (Oltheten, Pinteris, & Sougiannis, 2003). Whereas the income of farmers experienced a slight rise after CAP, the trend of a continuously declining agricultural sector, in line with the rest of the EU, continued to exist (Oltheten et al., 2003).

Coming back to the political aspect, the monarchy ended in 1974 with the establishment of the Greek Republic under the current constitution. Karamanlis was the Prime Minister till 1980, when the charismatic politician and economist, Andreas Papandreou, dominated the elections and the politics of the next decade with the socialist party, called PASOK. That party governed Greece till 1996, except of 4 years (1989-1993) when the conservative Karamanlis' party, New Democracy, got power back with Constantine Mitsotakis, a liberal reformist politician. After the death of Papandreou, PASOK regained power with Kostas Simitis, a reformist social democrat. Simitis was prime minister for 8 years, and he was associated with high growth rates and the country's entrance to the Eurozone. He was followed by Kostas Karamanlis (nephew of Konstantinos Karamanlis), whose financial policies along with the Global Financial Crisis, brought about the Greek Debt crisis of 2009. George Papandreou (son of Andreas) won the 2009 elections with PASOK and was the one responsible to deal with the crisis. In May 2010, Greece signed the 1st bailout agreement with the Eurozone countries and the IMF. Over €250 billion in loans were given to Greece after the 3rd bailout programme, signed in 2015. The fiscal austerity measures that were agreed, resulted not only in fiscal consolidation, but also stagnation of the economy (A. Hatzis, 2019).

## 2.2. Output Growth and Output Share

We used the time series data on Gross Value Added, as provided by the EU KLEMS project, in order to capture the above description in a graph of Output Growth. The data covers the period from 1995 to 2014, and covers 10 industries (see Appendix B). For the purpose of this study, Output Growth stands for Gross Value Added or Gross Domestic Product. The 10 industrial sectors are divided into four categories, in order to have a clearer picture of the situation. These categories are: Agriculture and Mining, Manufacturing, Services, and Other. Services are comprised of Educational Services, Health Care and Social Assistance, Art, Entertainment, Recreation, Food, government and other services. The Other sector consists of Utilities and Construction, Wholesale, Retail and Transportation, Information, Financial, Insurance, and Real Estate (FIRE), and Professional Based Services (PBS) (see Appendix B). The growth rates are averaged according to the industries and three periods that divide the time series data from 1995 to 2014, into three parts. The first one, from 1995 to 2001, is the period when PASOK under Costas Simitis governed the country and ends with the entrance of Greece to the Eurozone. The second one, from 2001 to 2008, includes both PASOK and New Democracy governance along with the Olympic Games in Athens (2004) and the build-up of the sovereign debt crisis. Eventually, the third period covers the crisis years and ends in 2014, just before the signing of the 3rd bailout agreement, with SYRIZA in power.

As we can observe in Figure 1, there is a declining movement of output growth in the Greek economy, in almost all sectors except Agriculture & Mining. For that sector, we observe a similar trend to the Manufacturing sector

during the first two periods, while there is an extraordinary increase during the crisis years, in contrast to the Manufacturing sector, in which the decline continues till 2014. The Services and Others sectors follow a similar patter with the Aggregate line, in which we observe a mild stagnation and slight increase during the first two periods, and a great decline after the crisis hit the Greek economy. The pattern of the Services, Other and Aggregate lines are the result of the radical progress in Information Technology during the 90s in a global level that lead to the remarkable growth of the Information, FIRE, PBS and Services sectors. For a more elaborate analysis, Table 1 in the Appendix offers these results in a numerical way.

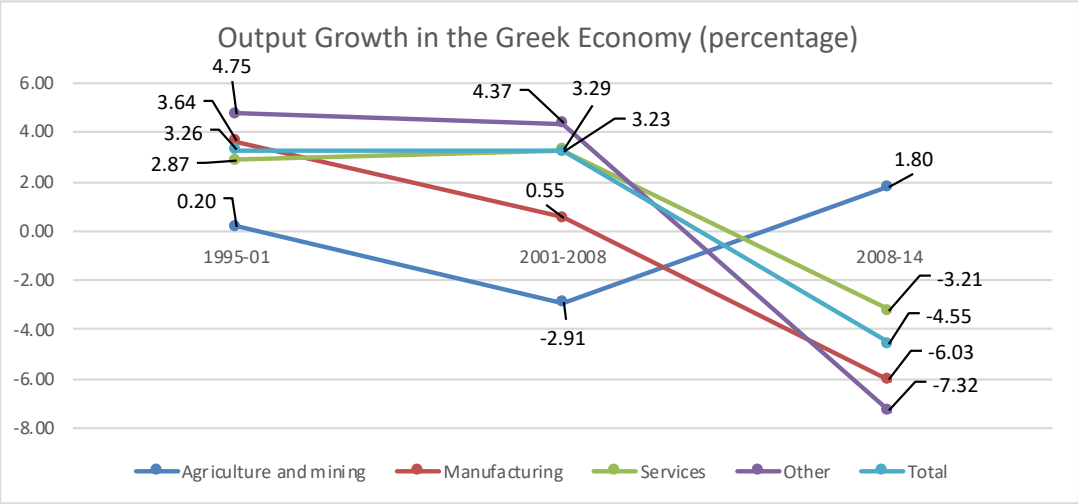


***Figure 1:*** *Output Growth in the Greek economy (source: author; based on data by EU KLEMS)*

As mentioned before, the Greek agricultural sector was a much more significant constituent for its GDP than for the other EU countries. The most important characteristics of Greek agriculture are small-scale and fractured lots, dry climate, and hilly topography. The Common Agricultural Policy had a critical effect on the Greek agriculture, which essentially explains the pattern for the first two periods of the decline. The price increase of these goods that resulted from the CAP, as described above, transferred capital from consumers to producers, adversely affected the trade balance, and reallocated resources not according to the country's comparative advantages. Nevertheless, there is still a strong debate and no consensus on whether the CAP policies were positive or negative for the Greek agricultural sector (Oltheten et al., 2003).

As far as Manufacturing is concerned, the removal of protection as a result of Greece's entry into the European Union, had a negative influence on it. The protected environment of the previous decades was removed and the deficiencies, such as moderate utilization of technology, were perceptible. Trade was redirected from traditional pathways and foreign competition grew significantly, especially in the Manufacturing sector. Before 1995, when our time series start, the Greek industrial sector was also adversely affected by the income policies of the 80s (PASOK), the enlargement of the portion of the state in economic activities, and the uncertainty of the macroeconomic setting (Oltheten et al., 2003).

The Output Share for each sector is depicted in Figure 2, where the 10 industrial sectors are divided into four basic categories, as explained before. The three periods are the same as above and consist of the time series data provided by EU KLEMS, ranging from 1995 to 2014. We observe that during these 20 years, there have not been any exceptional shifts in output share between the sectors. A small part of agricultural share of output is transferred to the Other sectors during the first two periods, and a slightly larger portion is transferred from Manufacturing to Services during the crisis period. In general, the chart illustrates that there was no noticeable shift between these sectors.

In his paper "The New Normal: Demand, Secular Stagnation, and the Vanishing Middle Class", Servaas Storm (2017) provides an explanation on the connection of Output Growth to TFP growth, in an arithmetic way, which

is elaborately presented in the 3rd chapter. After assuming that the potential Labor Supply's Growth is negligible, it follows that potential Output Growth is the outcome of Labor productivity growth. Then, the Cobb-Douglas production function is utilized and Output Growth is substituted, following the assumption that Capital Productivity growth is constant. Thus, it follows that Total Factor Productivity Growth can be defined as a source of potential Labor Productivity Growth. Using this second equation to the first, results in viewing TFP growth as the source for Output Growth. In consequence, we should analyze the pattern of TFP growth to better understand the trend of Output Growth, and see whether TFP has also been in stagnation 15 years before Greece entered the bailout agreement with the EU countries and the IMF. Our 2nd sub-question can be now clearly expressed: *Has there been a long-run decline in total factor productivity (TFP) growth in Greece?*

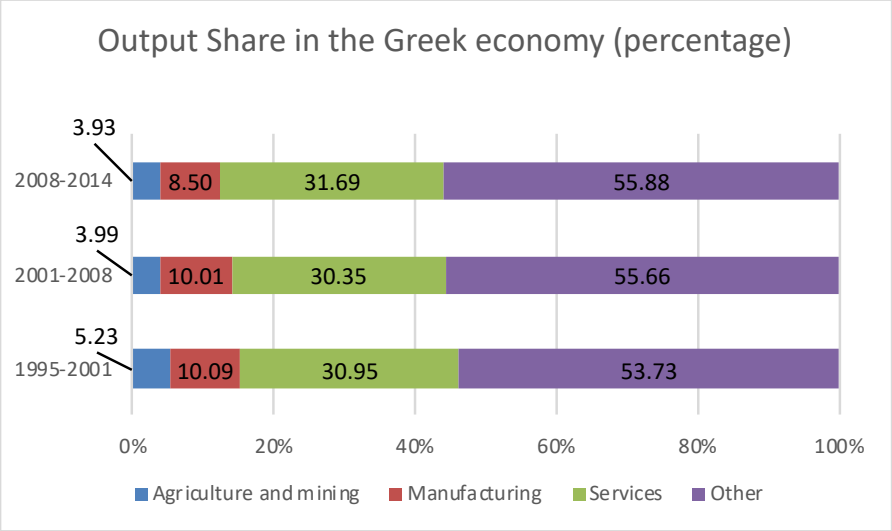


***Figure 2:*** *Output Share in the Greek economy (source: author; based on data from EU KLEMS)*

## 2.3. Output, TFP, and Labor Productivity Growth

Servaas Storm (2017) also gives evidence to support that potential Labor Productivity Growth determines Total Factor Productivity Growth. Arithmetic explanation is provided in the 4th chapter. Hence, any changes in the Labor Productivity growth will influence TFP growth, and any changes in the structure of the Employment Share will influence TFP growth. The following two graphs give an initial understanding of Labor productivity Growth and Employment Share in the Greek economy. To make the depiction clearer, the graphs present the four industrial categories as previously, during the same three periods, ranging from 1995 to 2014. Labor Productivity growth in Greece is in stagnation, as seen from the blue Aggregate line, with the

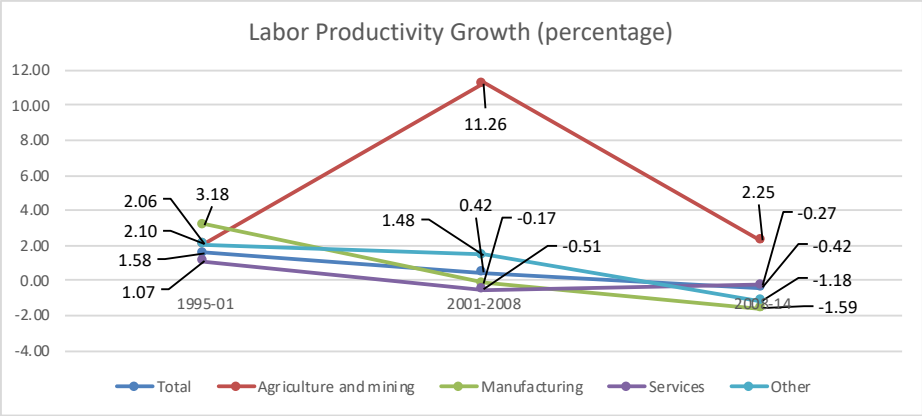


***Figure 3:*** *Labor Productivity Growth in the Greek economy (source: author; based on data from EU KLEMS)*

exception of the Agricultural Sector, which is depicted with the red line. We observe that the Manufacturing, Services, and Other sectors are stagnating (along with the Aggregate line) with a small decline, during all three periods, except Services that show a slight increase during the crisis period, while it is generally considered as a less dynamic sector because of a lower Labor Productivity Growth. The Agriculture and Mining sector shows a great increase of Labor Productivity Growth before the crisis, which is the result of the rapid implementation of the reforms by the Common Agricultural Policy, whereas after the crisis all the deficiencies of the CAP as well as the memorandum policies lead to that distinguishable decline.

As described in the first chapter, Labor Productivity Growth, can be decomposed into two different parts that both change and influence it. The shift in the employment share between sectors and the change in productivity within one sector. The latter (within-sector) can be understood by the above graph, with the more detailed and numerical table in the Appendix, while the former (between-sector) stems from the employment shifts, e.g. from Manufacturing to Services, as shown in Figure 4.

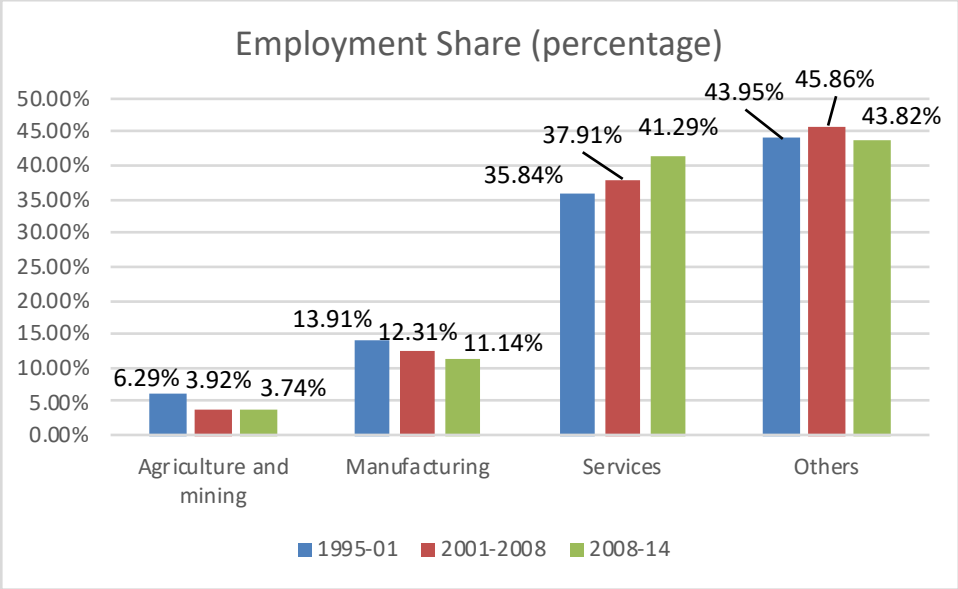


***Figure 4**: Employment Share (through hours worked) in the Greek economy (source: author; based on data from EU KLEMS)*

Employment shifts can be observed mostly from the generally dynamic sectors, Agriculture, Mining, and Manufacturing, to the less dynamic Services sectors. The declining trend in the employment share of Agriculture and Manufacturing can be attributed to the fact that the Services sector attracts employees because of the increase in Output Growth, that is also connected with the Labor productivity slight increase after the crisis. The Others sector experience an increase in the Employment Share between the first two periods of observation and a decline after the crisis.

The above two figures illustrate the declining tendency of Labor Productivity Growth in almost all sectors and in aggregate, as well as the noticeable employment shifts between the two largest and dynamic sectors to the less-dynamic sectors. At this point, our 3rd sub-question can be more clearly expressed: *Considering labor productivity growth as a source of TFP growth, is the decline in sectoral or aggregate labor productivity growth due to a between-sector employment shift or a within-sector slowdown?*

## 2.4. Employee Compensation and Final Demand

Greece's participation in the European community was a significant event not only for the Greek history but also for the European. Greece's entry was seen as a protection for its democratic institutions after the 7-year dictatorship. For Europe, Greece's membership symbolized the Mediterranean enlargement, which continued with Spain and Portugal. All these three-member states had undergone the democratic system return, in a similar way during the same period. Clogg (2002) describes an event that took place throughout the discussion in the British Parliament to make Greek membership officially valid. Then, a foreign office minister argued that

Greece's membership should be viewed as "a fitting repayment by the Europe of today as the cultural and political debt that we all owe to a Greek heritage almost 3,000 years old." (Clogg, 2002). Even though Greeks believed that this would mean economic advantages, the reasons behind its entry are mostly political (Oltheten et al., 2003).

After the dictatorship, the Greek economy was in a worsening situation. It was negatively influenced by the oil crises of 73' and 79', and the governments that gained the power had to deal with increasing demands of income redistribution and a more extensive welfare state. As mentioned, this resulted in populist decisions that did not contribute to stability. The EU did not have the appropriate mechanisms to control this process, resulting in an unsustainable economic environment. During the 90s however, it is argued that membership in the Eurozone along with the Convergence Criteria created discipline model that improved remarkably the Greek economic performance, with stabilizing fiscal and monetary policies (Oltheten et al., 2003). Macroeconomic stability ameliorated economic growth, and EU's funds were allocated for economic and social convergence. Despite that and after 1995, average annual Real Wage Growth has been declining in almost all sectors, as can be seen from Figure 5. Industries and periods are categorized and divided as previously.

In figure 5, one can observe the stagnation of Real Wage Growth in almost all sectors and between the three periods of observation, except of a slight increase in Manufacturing between the first and second period of observation. The orange line depicting the changes in Agriculture and Mining follows a pattern similar to the one in the Labor Productivity Growth graph, showing the biggest difference and the lowest growth, during the after-crisis period. The Final Demand growth follows a similar pattern to the one of Aggregate Real Wage Growth, in Figure 7.

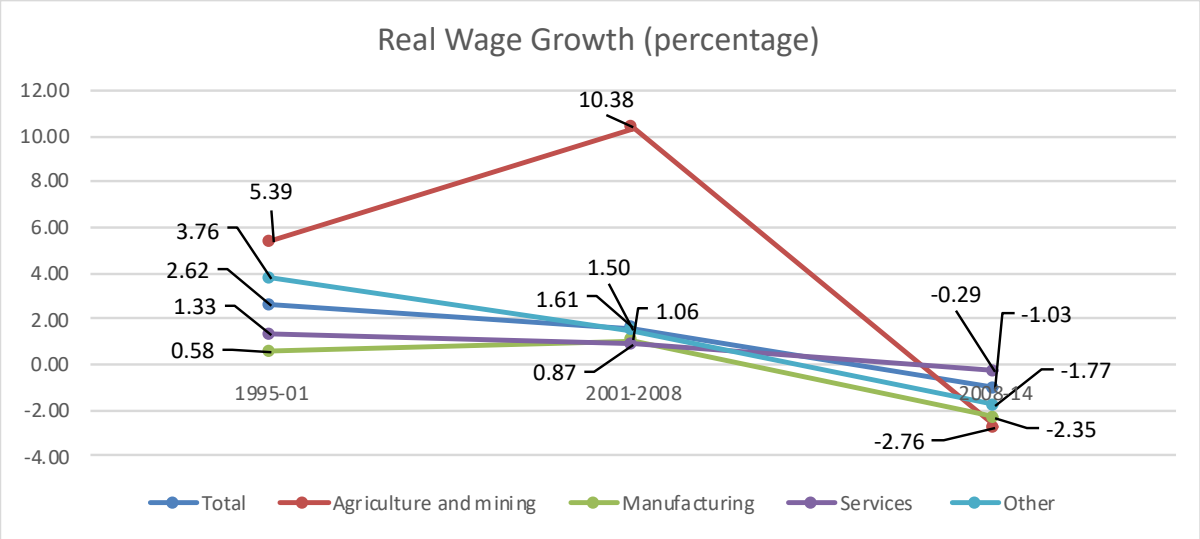


***Figure 5:*** *Real Wage growth in the Greek economy (source: author; based on data from EU KLEMS)*

Before the figure of Final Demand Growth, it is interesting to look carefully into Figure 6, where the graph of Final Demand is presented for the whole of the Greek economy, as calculated by the data from ELSTAT, the Hellenic Statistical Authority, and expressed in millions of euros at constant prices. The time series data ranges from 1995 to 2017, so one can observe the initial high-growth period reaching a peak just before the crisis, and the decline that followed. The interesting part is the one after 2014, where we observe a slight increase in the Final Demand during 2017, the period when SYRIZA was in power and implementing the 3rd bailout agreement program. This is an optimistic finding, that is connected either with the policies implemented by SYRIZA outside the memorandum, or with a change in the policies proposed in the 3rd memorandum in relation with the previous two.

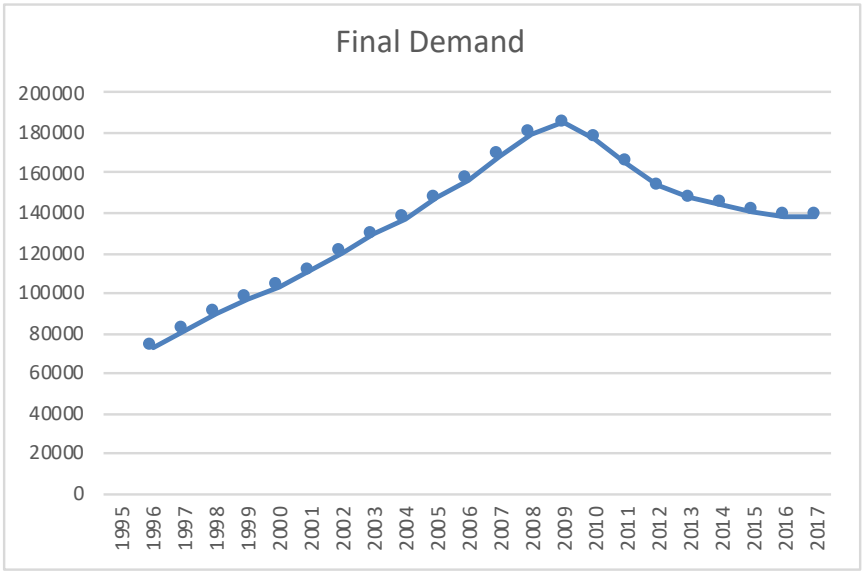


***Figure 6:*** *Final Demand (in constant prices) in the Greek economy (source: author; based on data from ELSTAT)*

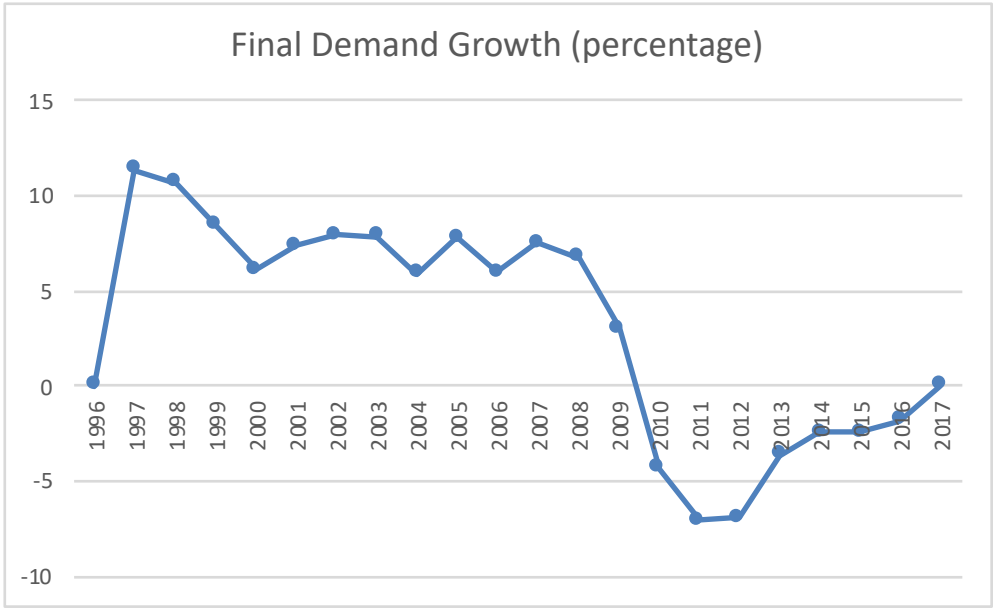


***Figure 7****: Final Demand Growth (percentage) in the Greek economy (source: author; based on data from ELSTAT)*

Regarding the growth of the Final Demand calculated based on constant prices data, Figure 7 gives a clear depiction of the trend, which is similar to the one of Real Wage growth, depicted in Figure 5. There is a clear stagnation during the years before the crisis, when we observe an extraordinary decline until 2012, after the 2nd memorandum started to be implemented, by the New Democracy government. The increase that follows this stagnation is translated into lower Final Demand fall, as we observed in the previous chart, and ends with a slight increase in 2017. *Is this trend connected with our findings regarding TFP growth?*

## 2.5. Chapter Conclusion

In this second chapter, we presented some significant macroeconomic, political, and historical elements concerning the Greek economy in its modern age. Initially, we presented some important events and names that shaped the current state of affairs and then we provided graphs for our calculations on output growth and output

share for the industrial sectors in Greece. Our calculations were based on data from the EU KLEMS project, covering the period from 1995 to 2014. We observed that there is a declining tendency of output growth in the Greek economy, in almost all sectors except Agriculture & Mining. Throughout the next section, we presented similar graphs on Labor productivity growth and Employment Share. We observed stagnation regarding the Manufacturing, Services, and Other sectors, during all three periods. Services showed a slight increase during the crisis period, while it is generally considered as a less dynamic sector because of a lower Labor Productivity Growth. Employment shifts were also observed mainly from the generally dynamic sectors, Agriculture, Mining, and Manufacturing, to the less dynamic Services sectors. Finally, the last section provided the graphs for Final Demand (at constant prices) and its growth during the period from 1995 to 2014, based on data from the Hellenic Statistical Authority. Initially, during a high-growth period Final Demand reached a peak just before the crisis, and dramatic decline followed. After 2012, we observed a slight increase in the Final Demand till 2017, the period when the 2nd and the 3rd bailout agreement program were implemented. However, *is this increasing trend connected with our findings regarding TFP growth?* The next chapter presents the relevant tables and graphs.

# Chapter 3: Secular Stagnation of TFP Growth in the Greek Economy

*"We wanted flying cars, instead we got 140 characters."*

*Peter Thiel*

Previously, we assessed some of the macroeconomic factors that show the deficiencies of the Greek economy. These factors lead to the first part of our research question and methodology, which is the analysis on whether there has been secular stagnation of TFP growth in the Greek economy, and the decomposition of Labor productivity growth. This chapter provides evidence on whether there has been secular stagnation of TFP growth, while the next chapter regards Labor productivity growth. Therefore, at the first section we present a brief literature review on the concept of Secular Stagnation in an economy, and we continue with a literature review on the impact of TFP in Greece. After presenting the theory behind secular stagnation of Total Factor Productivity Growth, we present some basic arithmetic to portray the relation of TFP with Output and Labor Productivity growth, giving three *TFP growth* accountings. Thereafter, we provide the graphs with the results of our calculations based on these three TFP growth accountings and the data from EU KLEMS and we show in a numerical way that there is a long-run decline of TFP growth in the Greek economy. Finally, we conclude that there has been secular stagnation of TFP growth in Greece.

## 3.1. Theoretical foundation: Secular Stagnation in an Economy

*Secular stagnation* is defined as "a condition of negligible or no economic growth in a market-based economy" (Hansen, 1939). After the Great Depression in the U.S., Alvin Hansen (1938) was the first to describe this term in order to illustrate the state of affairs in which there is insignificant Output Growth along with low interest rates and rising unemployment rate. He supported that this economic phenomenon is determined by two elements; extreme savings and a slowdown of population growth. As claimed by Hansen, these two constituents decrease Final Demand and thus Output. Excess savings lead to lower investment, and hence decline of Final Demand. Economists have been debating on the theoretical definitions of secular stagnation. Cherry (1987) defined secular stagnation as a "period of longer and deeper than average recessions, or it stands for a long-cycle downturn, which will be followed, more or less, after some 25 years' duration, by a long-cycle upturn".

70 years later, in 2008, the world witnessed the largest crisis till then, the Global Financial Crisis. Lawrence Summers, senior U.S. Treasury Department official throughout President Clinton's administration and former director of the National Economic Council for President Obama, brought back the term "secular stagnation" to support that the slowdown of GDP growth, interest rates and inflation that were existing after the crisis, were all happening long before (Summers, 2015). Following this extraordinary macroeconomic condition, a number of popular economists created other terms to describe if, such as Krugman and the "Liquidity Trap", Bernanke and the "Saving Glut", and Peter Thiel with "Zero to One". PayPal co-founder and the most prominent Silicon Valley venture capitalist (the first outside investor of Facebook), Thiel, describes current global situation as one with large horizontal progress. By horizontal progress, he means that due to globalization, less advanced economies grow through copying what the more advanced economies did, giving the example of China and U.S., and hence we do not observe vertical progress, from Zero to One, with radical innovations that take humanity to a more advanced quality of life. Globalization of technology leads to horizontal progress, while technological advancements lead to vertical progress (Thiel, 2014). His book, Zero to One (2014), can be considered as a powerful echo of Hansen's proposition, connecting the two eras of economists on the reasons of secular stagnation, but providing different solutions. Thiel argues that: "In a world of scarce resources, globalization without new technology is unsustainable."

Modern Keynesian economists, like Summers, recommended a rise in public spending for infrastructure, but this fiscal stimulus (over a trillion dollars) did not prove to be enough (Wingo, 2015). Policies pertinent to R&D spending to stimulate innovation and the relevant ecosystem can be helpful and complementary, if not necessary. Moreover, it should be noted that many economists claim that secular stagnation is connected with politics, as it strengthens political arguments for rising levels of government debt (Boianovsky, 2015). For this study, the "secular stagnation' concept describes the stagnation of economic growth in Greece, which has been existing long before the Global Financial Crisis and the sovereign debt crisis of the Greek economy. The adjective "secular" marks the long duration of this stagnation. Recent papers of Summers and Gordon (2015), propose the supply-side and demand-side secular stagnation, according to the different perspectives regarding the origin of the situation.

*Supply-side secular stagnation* is generated when expected real growth is over actual real growth (Gordon, 2015). Hansen implied this gap when he argued that about the decreased opportunities for investment due to lack of technological progress, something which Summers did not mention when arguing about slow demand as the cause of economic recession. Gordon (2015) supports that the current output gap indicates the stagnation of economic growth, regarding Working Hours and Labor Productivity, notwithstanding the fact that sluggish demand may have been the cause of the 1938's recession. *Demand-side secular stagnation* is induced by shortage of demand, resulting from higher propensity to save, even though real interest rates may be adequately low (Summers, 2015). The scheme that describes this process initiates with the higher propensity to save income instead of spending it to consume. Hence, demand is decreased and thus growth, leading to deflation. While the supply-side focuses on a gap, the demand-side refers to an imbalance between spending and saving (Summers, 2015).

Servaas Storm argues that the declining TFP growth, which is "the best available measure of the underlying pace of innovation and technological change" (Gordon, 2015), indicates technological stagnation, leading to low investment spending due to decrease of the ROI (Storm, 2017b). Others argue that TFP growth is a delusive indicator, as data for real productivity has not captured the added value of the high-tech products launched in the global market 10 years ago (Syverson, 2017). However, the Chairman of President Obama's Council of Economic Advisors, believes that TFP growth is a critical indicator for a market economy as it "tells us how efficiently and intensely inputs are used", measuring "pure innovation" (Storm, 2017b). As Peter Thiel and Garry Kasparov argued in a Financial Times article on technological progress, declining TFP growth signifies that the impact of innovations in the "world of digits" and biotechnology is not as powerful as the past innovations in the "world of atoms" (Kasparov & Thiel, 2012). So, what is the contribution of TFP growth to the Greek economy?

## 3.2. TFP Growth in Greece – A literature Review

Economic research has continuously manifested that technology is highly important for the economic performance of a nation. As Mokyr (2013) writes, rich nations do not have more money than the poor nations; they produce more because of their better technology and thus utilize natural and human capital more productively (Mokyr, 2013). Leounakis and Sakellaris (2014) gathered time series data from 1960 to 2013 on growth of the Greek economy and decomposed it into the Capital, Labor, and TFP contributions. They concluded that during the recent economic history of Greece, with boom periods succeeding depression periods and vice versa, the most decisive constituent of impact on growth was the Total Factor Productivity, with its contribution to growth varying between 33% to 71% (Leounakis & Sakellaris, 2014). They also showed that the TFP performance was the critical factor of the recession during the 1980s and early 1990s, as well as for the ongoing crisis (Leounakis & Sakellaris, 2014). Nikolaos Vettas, a popular Greek economist, argued during his speech in Athens University of Economics and Business that TFP (calculated based on data from 1970 to 2004) had a dominant role during the 1970s and contributed significantly during the 80s. However, TFP became negative during the 1990s and was not increased or affected by the extensive use of Information Technologies, as it happened in more developed countries, such as the U.S (Vettas, 2016).

Mamuneas and Ketteni provide results, based on which we observe that TFP growth in Greece has been negative after the 2008 crisis, whereas in the Euro area and Cyprus it appears to be almost zero (Mamuneas & Ketteni, 2012). Covering the period from 1996 to 2011 and after decomposing the output data that they provide, they

show that during 2008 to 2011, the period before the results of the 1st bailout agreement started to have impact, TFP contribution declined dramatically (Mamuneas & Ketteni, 2012). Michaelides and Bellegri (2006) utilize the Growth Accounting methodology in order to evaluate technological change in the Greek economy, with time series data ranging from 1988 to 1998. Their conclusion is that technological level, calculated on the basis of TFP growth, "has remained practically unchanged", while its contribution to growth is close to 40% (Belegri-Roboli & Michaelides, 2006). Their findings, TFP growth estimation is 0.39%, agree with those of other researchers during the same period (1988-1998). The Groningen Growth and Development Center published a calculation from 2003 to 2014, on the average rate of growth for TFP in Greece, which equaled 0.43%. Bosworth and Kollintzas (2001) through a similar study with data ranging from 1988 to 1998, calculated the TFP growth rate to be 0.13%, and finally O.E.C.D, for the same period, estimated the TFP growth rate for Greece at about 0.30% (Belegri-Roboli & Michaelides, 2006). All these researches use somewhat different methodologies and produce almost the same results. They all agree that TFP in the Greek economy during this decade "remained practically unchanged".

Bournakis (2012) investigated the factors that decisively affect Productivity Growth, focusing especially to technology transfer from the more to the less advanced countries, e.g. from Germany to Greece, during the period from 1980 to 2003. Technological diffusion is even more important nowadays that we experience a global technological revolution, and results in productivity convergence, the faster the adoption happens (Bournakis, 2012). Supported by his findings, he advocates that autonomous technological transfer contributes significantly to TFP growth. However, his results suggest that technological transfer is very slow, although in the pertinent literature this is not the case. This small speed is claimed to account for the large technological gap between Germany and Greece, while it is mathematically derived that it takes approximately 40 years for an average Greek manufacturing industry to converge technologically and reach half the technical efficiency of its German counterpart (Bournakis, 2012).

Moreover, the relationship of R&D capital and TFP in the Greek economy was investigated by Voutsinas and Tsamadias (2007), during 1981 to 2007. There is a long-term connection of total and public R&D capital to TFP, while this is not the case for private R&D capital. More specifically, a 1% rise in total R&D capital results in 0.038% raise in TFP, whereas the same increase in just the public R&D capital leads to 0.075% increase of TFP (Voutsinas & Tsamadias, 2014). This has clear implications for the Greek government that will be elaborated on the final chapter of this study. Finally, the relation between product market regulations and TFP was studied by Nicoletti and Scarpetta (2003), who suggest that if countries like Germany, Italy and Portugal aligned their product market regulations to those of the UK (the most liberal OECD country), their TFP would raise at a growth rate ranging from 0.4% to 1.1%, with Greece having the highest gain from such a regulation change (Nicoletti & Scarpetta, 2003).

To conclude this literature review, there is a notable number of studies regarding TFP Growth in the Greek economy. Most of these studies focus on similar aspects and some of them make some interesting connections between different macroeconomic factors. Some of the periods studied overlap, giving slightly different results due to different methodologies and sources of data. Our time series data is derived from the EU KLEMS project and apply to the period from 1995 to 2014. In order to answer the research question and understand the Secular Stagnation in the Greek economy, we will use TFP growth as the key diagnostic. Therefore, for the purpose of this study, we will use the definition of Secular Stagnation of TFP Growth as proposed by Storm (2017): "secular stagnation of TFP growth is defined as a state of the slowdown of TFP growth for a long period of time in which it contributes to the slowdown of output growth". Next, we will focus to the practical section of the chapter to answer the question: Has secular stagnation of TFP growth been happening in the Greek economy?

## 3.3. Arithmetic of TFP growth accountings

After presenting the theory behind secular stagnation of Total Factor Productivity Growth, we will present some basic arithmetic to portray the relation of TFP with Output and Labor Productivity growth, based on the study of Servaas Storm (2017). Three *TFP growth* accountings are given. Firstly, *Solow's Residual* describes TFP as a residual factor that cannot be explained. Secondly, TFP growth is defined as the *Weighted Average Factor Productivity Growth* on the basis of the average Labor and Capital productivity. Finally, the third method approaches TFP growth as the *Weighted Average Factor Payment Growth* based on average Wage and Profit

Rate. (Storm, 2017b). It is argued that the second method provides the best description regarding the Secular Stagnation of TFP growth in Greece.

To begin with, we explain how Output Growth is affected by TFP growth. The key variables used are: labor, capital, output, and a factor reflecting the relation of the three. First, we need to define potential output '$x_p$' in terms of TFP growth. For that purpose, we define potential labor supply '$L_p$' as the maximum labor that can contribute to production. Output is expressed in millions of euros and potential labor supply in hours of work. Accordingly, $\lambda_p = x_p / L_p$ is the equation that expresses potential labor productivity per working hour, and by this definition,

(1) $$\lambda_p = x_p / L_p$$

We now logarithmically differentiate equation (1), in order to express it in terms of potential output growth,

(2) $$\hat{x}_p = \hat{L}_p + \hat{\lambda}_p$$

This second equation, where the circumflex portrays the growth rate, depicts output growth as a source of Labor Supply growth and Labor Productivity growth. If we assume that labor supply is unchanged, so as to focus on Labor productivity Growth, eq. (2) takes the following form,

(3) $$\hat{x}_p = \hat{\lambda}_p$$

From eq. (3) it is shown that Output Growth equals Labor Productivity growth. In order to elaborate on this, we utilize the Cobb-Douglas production function, as expressed below (Douglas, 1976),

(4) $$x = AL^{\emptyset}K^{1-\emptyset}$$

Eq. (4) includes produced Output (x) expressed in real value added at factor cost, Labor input (L) expressed in actual number of hours worked, Capital input (K) expressed in constant euros, Labor share in income (φ) and the scale factor (A). According to Storm (2017) and Jones (2015), if we divide both sides of (4) by $x^{\varphi}$ and then solve for productivity per hour of work, that is x/L, we obtain,

(5) $$\lambda = A^{\frac{1}{\emptyset}}\kappa^{\frac{1-\emptyset}{\emptyset}}$$

We now differentiate (5) in order to get the growth term and the above equation is expressed below,

(6) $$\hat{\lambda} = \frac{1}{\phi}\hat{A} + \frac{1-\phi}{\phi}\hat{\kappa}$$

The first term of eq. (6) includes A with circumflex, which represents TFP growth. The other term includes Capital Productivity growth. According to Storm (2017), Capital Productivity growth should be zero, considering the steady state of the neoclassical growth model, where capital-output ratio is constant. Thus,

(7) $$\hat{\lambda}_p = \frac{1}{\phi}\hat{A}$$

If we substitute (7) into (3), we see that Output Growth is dependent on TFP growth, that is the slowdown in the observed Output Growth for the Greek economy, as depicted in the previous chapter, is due to the stagnation of TFP growth. At this point, we should concentrate on finding evidence on the secular stagnation of TFP growth in the Greek economy.

First, we need to see how TFP growth is determined. We start with the "unexplained residual" concept, as put forward by Solow (1957). We recall the Cobb-Douglas production function, and differentiate eq. (4), as shown below,

(8) $$\hat{A} = \hat{x} - \emptyset\hat{L} - (1 - \emptyset)\hat{K}$$

The factor on the left side of the equation, is Solow's Residual TFP growth, representing the "unexplained residual" that influences Output growth along with the inputs of Labor and Capital. According to Storm (2017), it can also be interpreted as Hicks-neutral technological progress (Storm, 2017b). As Abramovitz (1956) calls it, Solow's residual is a "measure of our ignorance", while Jones (2015) argued that it accounts for approximately 80% of the economic growth in the United States throughout 1948-2013.

Next, we substitute $\hat{\lambda} = \hat{x} - \hat{L}$ and $\hat{\kappa} = \hat{x} - \hat{K}$ into equation (8) and we get the following expression,

(9) $$\hat{A} = \emptyset\hat{\lambda} + (1 - \emptyset)\hat{\kappa}$$

which is the definition of TFP growth, as the Weighted Average Factor Productivity (Rada & Taylor, 2006; Storm, 2017b). Based on the NIPA accounting identity, real GDP at factor cost equals to wage income plus capital income,

(10) $$x = wL + rk$$

with w expressing the real wage per working hour and r expressing the profit rate on the capital stock. We now divide the above equation by x and get,

(11) $$1 = \left(\frac{wL}{x}\right) + \left(\frac{rK}{x}\right) = \emptyset + (1 - \emptyset)$$

where φ is labor share in income, as mentioned before, and (1 – φ) represents the capital share. When we turn eq. (11) into the growth rate form, we get the following expression,

(12) $$\hat{x} = [\emptyset\hat{w} + (1 - \emptyset)\hat{r}] + \emptyset\hat{L} + (1 - \emptyset)\hat{K}$$

As explained by Storm (2017) and Felipe and McCombie (2012), the isomorphism between eq. (8) and (12) infers directly that we will not get the right outcome about technological progress. The definition of TFP is only empirically valid in the following form,

(13) $$\hat{A} = \emptyset\hat{w} + (1 - \emptyset)\hat{r}$$

where we see the growth rates of w and r, as these were defined above. That last equation expresses the TFP growth on the basis of the Weight Average Factor Payment (Storm, 2017b). More elaborate description of the above mathematical processes can be found in the Appendix.

To conclude this section, Solow's Residual TFP growth is expressed through eq. (8), and eq. (9) expresses TFP growth as the Weighted Average Factor Productivity. Finally, eq. (13) is the formulation for the Weighted Average Factor Payment. Next, we are going to apply these three accounting methods to show whether secular stagnation of TFP growth has been happening in the Greek economy.

## 3.4. Application of The Three TFP Growth Accountings

Throughout this section, we will provide the results of our calculations based on the previous three growth accounting methodologies, discuss them, and provide evidence on the second sub-research question. As mentioned in the previous section, the elaborate description of the methodology, data sourcing and categorization, as well as variable explanation, are all presented analytically in the appendices.

Starting with the Solow's Residual TFP growth, we recall eq. (8),

(8) $$\hat{A} = \hat{x} - \emptyset\hat{L} - (1 - \emptyset)\hat{K}$$

The term on the right side is TFP growth, and $\hat{x}$ is the Output growth at constant price. The data pertinent to Output in the EU KLEMS database, called Value Added and represented with the VA symbol, is in the current price form. We therefore needed to divide it with the factor price index of the same year, in order to translate it into the real term. As a result, we got Output at constant price. We also calculate Φ, which represents labor income share, as the part of Output (or VA) that is distributed to labor wages. EU KLEMS data is also the source where we obtained the time series data for L and K, from which we also calculated the growth rates, as described in the Appendix. As mentioned, the time series of EU KLEMS range from 1995 to 2014. The results of the TFP growth in terms of Solow's Residual are calculated for each year, and can be observed on the graph in the Figure 8.

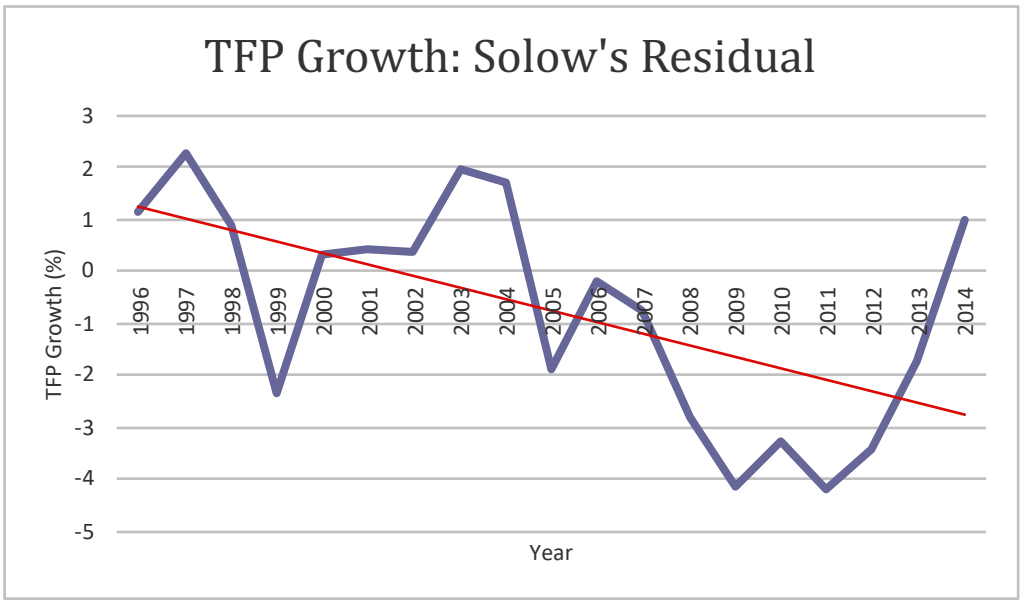


***Figure 8:*** *Solow's Residual TFP growth of the Greek economy (source: author; based on data from EU KLEMS)*

Clearly, the red trendline shows the downward movement tendency of TFP growth during this period. If we look more carefully, we can see the negative peak in 1999, which is a result of the Global Financial Crisis of that year due to the "dotcom" bubble. Another negative peak is in 2005, just after the Olympic Games and the change of government, when New Democracy got into power again and the sovereign debt crisis started to build up. In 2009 and 2011, we observe two more negative peaks, which are probably connected with the two bailout agreements that were signed between Greece, the IMF and the European Union, the following years. After 2011, we observe an extraordinary rise in TFP growth rate, ending almost at where it started in 1996, which is probably a result of the implementation of three memorandums and the policies that were proposed and followed by the European Union and the Greek governments. Before we reach any conclusion, we will compare these results with those of the other two growth accounting methods.

The second method is the Weighted Average Factor Productivity, and for that we recall eq. (9),

(9) $$\hat{A} = \emptyset\hat{\lambda} + (1 - \emptyset)\hat{\kappa}$$

The right side of the equation represents TFP growth as Weighted Average Factor productivity. λ and κ, with the circumflex, represent actual labor and capital productivity growth, as described in the previous section. The time series data utilized for this calculation is also based on the EU KLEMS database and the figure below gives the pertinent results for each year of the period 1996-2014.

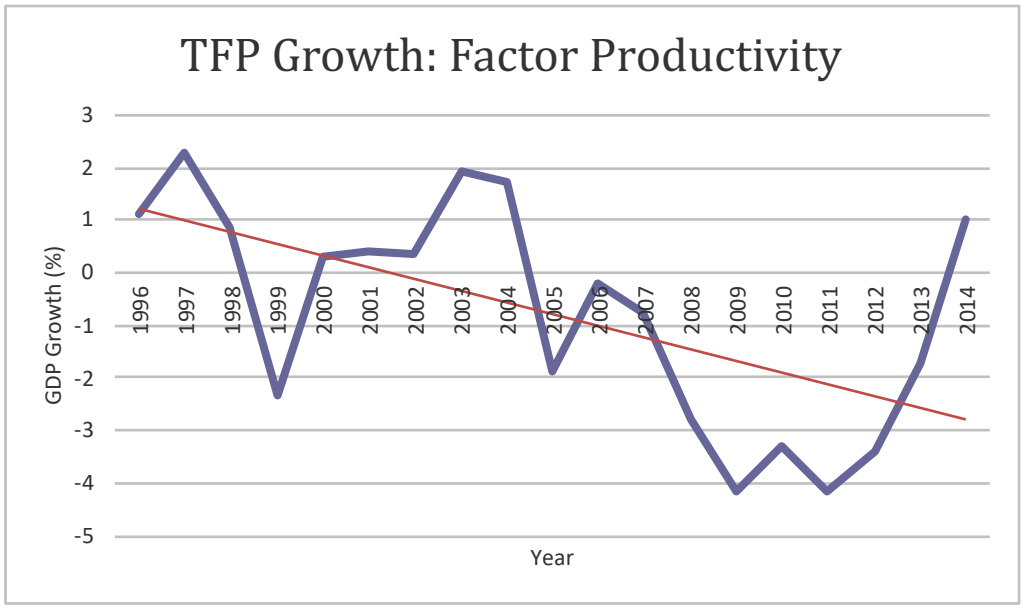


***Figure 10**: Weighted Average Factor Productivity TFP Growth of the Greek economy (source: author; based on data from EU KLEMS)*

The above graph portrays the same trend as the one based on Solow's Residual. We should therefore compare these two results with the third method of TFP growth accounting: Weighted Average Factor Payment. To do so, we recall eq. (13),

(13) $$\hat{A} = \emptyset\hat{w} + (1 - \emptyset)\hat{r}$$

For this growth accounting, we will need to estimate $\hat{w}$ and $\hat{r}$, that is real wage growth per working hour and the profit rate on capital stock, respectively. The former ($\hat{w}$), is derived by the EU KLEMS database, called employee compensation per hours worked, while the latter ($\hat{r}$) is calculated through the division of capital compensation by the real net capital stock for the same year, which are also derived from EU KLEMS. Figure 10 presents the results for each year of this growth accounting method.

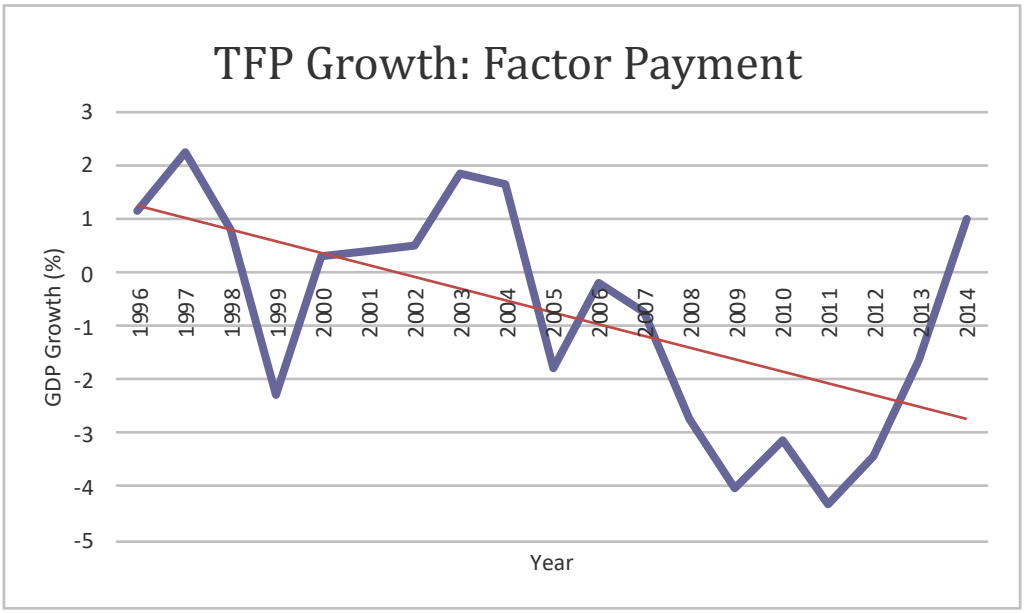


***Figure 11:** Weighted Average Factor Payment TFP growth in the Greek economy (source: author; based on data by EU KLEMS)*

The graph in Figure 10 follows the same trend with the other two growth accounting methods, not only regarding the red trendline but also regarding the positive and negative peaks. We can observe the slowdown in TFP growth from 1995 to 2014, with a notable rise after 2011. Recalling the Labor Productivity growth graph from the previous chapter, that pattern does not seem to be the same because of the way the periods were divided. However, if we carefully look at the numerical results of Labor Productivity Growth, which are presented in the Appendix, we can see that after 2011, there is a rising movement, which is portrayed clearly in these TFP growth graphs. For that reason, we provide the following graph ion Figure 11, in which the results for Labor Productivity Growth in the Greek economy are presented for each year. The declining trend is clear with the negative peaks happening during the same years, as well as the rising tendency after 2011, a pattern very close to the results the TFP growth for all the three growth accountings. At this point, we are ready to answer the first part of our research question.

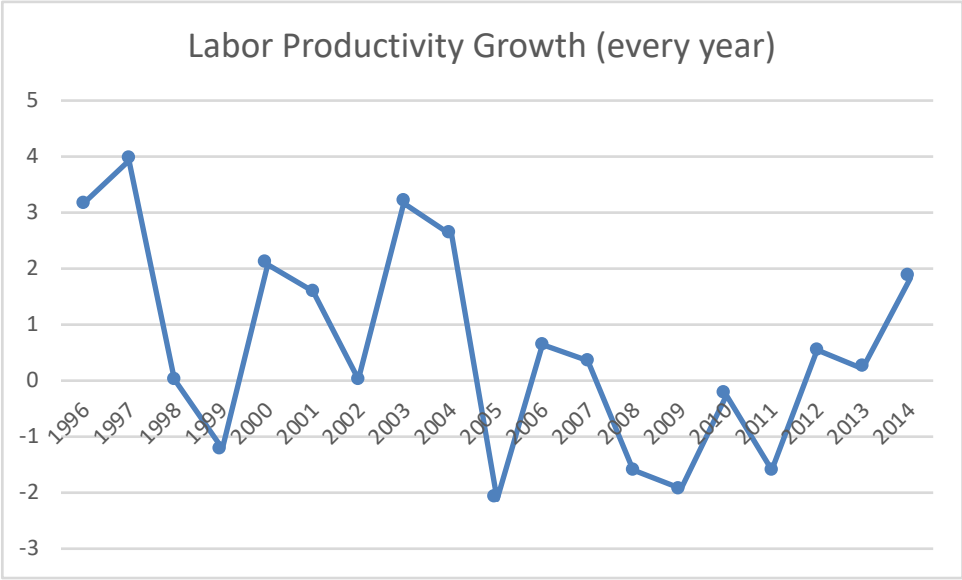


***Figure 12:*** *Aggregate Labor Productivity Growth in the Greek economy for all years (source: author; based on data by EU KLEMS)*

## 3.5. Long-run Decline of TFP Growth in the Greek Economy

If we show that TFP growth has been declining in the Greek economy for a long period of time, especially before the crisis, then we will also show based on the previous analysis that there has been Secular Stagnation of Total Factor Productivity Growth. The previous section provides the three graphs of the pertinent results, that show the same declining pattern. From 1995 to 2014, the red trendline reflects the long-run decline of TFP growth, based on the three growth accountings. Looking closer, we observed the negative peaks in 1999, 2005 and 2011, which can be explained by the "dotcom" bubble-induced Financial crisis that year, the change of government policies and the implementation of the 2nd memorandum, respectively. Labor Productivity growth follows a very similar pattern, which was expected, according to the theoretical foundation by Storm (2017). As mentioned in the literature review, the ICT revolution of the 90s did not boost TFP growth in Greece, as it happened in other technologically advanced countries. The lowest TFP growth rate was observed in 2009, just when the Global Financial Crisis hit the Greek economy, and the sovereign debt crisis became a global news headline. The crisis period was followed by the two bailout agreements, with the second having a significantly positive impact on TFP and Labor productivity growth. It would be interesting to see if that trend continued the following years, when the SYRIZA government signed the 3rd agreement with the IMF and the EU, which ended on August 2018. The table below provides a numerical representation of the above results, for the Aggregate TFP growth and the four industrial categories, as we did on the previous chapter: Manufacturing, Agriculture and Mining, Services, and Other.

***Table 1:*** *TFP Growth (percentage) in the Greek Economy, in terms of a) Solow's Residual, b) Weighted Average Factor Productivity, and c) Weighted Average Factor Payment*

| **TFP GROWTH: SOLOW RESIDUAL** | **1995-01** | **2001-2008** | **2008-14** |
|---|---|---|---|
| *AGRICULTURE AND MINING* | -1,42 | -4,22 | 3,21 |
| *MANUFACTURING* | 0,16 | -0,81 | -2,31 |
| *SERVICES* | -0,64 | -0,17 | -1,03 |
| *OTHER* | -1,28 | -1,07 | -4,74 |
| **TOTAL** | 0,44 | -0,25 | -2,66 |
| **TFP GROWTH: WEIGHTED AVERAGE FACTOR PRODUCTIVITY** | **1995-01** | **2001-2008** | **2008-14** |
| *AGRICULTURE AND MINING* | -1,38 | -4,07 | 3,26 |
| *MANUFACTURING* | 0,23 | -0,80 | -2,37 |
| *SERVICES* | -0,57 | -0,15 | -1,04 |
| *OTHER* | -1,02 | -0,89 | -4,74 |
| **TOTAL** | 0,43 | -0,24 | -2,67 |
| **TFP GROWTH: WEIGHTED AVERAGE FACTOR PAYMENT** | **1995-01** | **2001-2008** | **2008-14** |
| *AGRICULTURE AND MINING* | -1,37 | -3,81 | 3,31 |
| *MANUFACTURING* | 0,005 | -0,75 | -2,52 |
| *SERVICES* | -0,57 | -0,11 | -1,02 |
| *OTHER* | -0,92 | -0,99 | -4,64 |
| **TOTAL** | 0,42 | -0,22 | -2,70 |

First of all, through this numerical representation, we can observe the slight differences between the results of the three accounting methods, as expected. Aggregate TFP growth is 0,43% on average for the first period, just before the introduction of the Euro, a finding that agrees with those of other researchers, as presented in the previous section, who advocated that TFP growth in Greece has remained "practically unchanged". Between the first two periods, we notice a decline to -0,24% on average, which is followed by a larger decline to -2,67 on average between the second and the third period after the crisis. Through these results, we understand the impact of the Global Financial crisis, not only regarding the buildup of the sovereign debt crisis the years before, but also regarding the policies that were followed in response to the crisis. As far as the four sectors are concerned, Manufacturing TFP growth declined significantly during the three periods of observation, from 0,23% to -2,3%. The Services sector scored a slight increase between the first and the second period of observation from -0,57% to -0,15%, while the Agricultural sector experienced an extraordinary increase during the crisis period, a fact that is also portrayed on its Output growth graph in the previous section. The Other sector followed the same pattern as the Aggregate TFP growth rate, declining during all the three periods, a decline that ranged from -0,1% to -4,7%.

**Table 2:** TFP and Labor Productivity Growth in the Greek economy (source: author; based on data from EU KLEMS)

| | **1995-2001** | | **2001-2008** | | **2008-2014** | |
|---|---|---|---|---|---|---|
| | *TFP* | *Labor* | *TFP* | *Labor* | *TFP* | *Labor* |
| **TOTAL** | 0,43 | 1,58 | -0,24 | 0,42 | -2,68 | -0,42 |
| *AGRICULTURE AND MINING* | -1,39 | 2,10 | -4,07 | 11,26 | 3,27 | 2,25 |
| *UTILITIES AND CONSTRUCTION* | 3,18 | 3,11 | -1,83 | -1,45 | -3,88 | 3,40 |
| *MANUFACTURING* | 0,24 | 3,18 | -0,80 | -0,17 | -2,37 | -1,59 |
| *WRT* | -3,47 | 2,60 | -3,67 | 1,44 | -6,06 | -3,75 |
| *INFORMATION* | 4,32 | 7,01 | 3,63 | 4,27 | -6,32 | -5,25 |
| *FIRE* | -0,83 | -0,59 | 1,49 | 2,53 | 0,90 | 7,22 |
| *PBS* | -8,31 | -1,87 | -4,08 | 0,59 | -8,35 | -7,52 |
| *EDUCATIONAL AND HEALTH CARE SERVICES* | -0,81 | 2,19 | -1,78 | -2,30 | -2,60 | -2,22 |
| *ART, ENTERTAINMENT, RECREATION SERVICES* | -1,10 | 0,51 | 1,90 | 1,20 | -2,20 | -0,62 |
| *GOVERNMENT* | 0,17 | 0,52 | -0,58 | -0,44 | 1,66 | 2,03 |

In order to observe the TFP growth for the rest of the Greek economy, apart from the tables given in the Appendix, the table above presents the numerical results for TFP growth as defined by Weighted Average Factor Productivity, as well as the respective results for Labor Productivity growth. WRT stands for Wholesale, Retail and Transportation, FIRE stands for Financial, Investment, and Real Estate, and PBS stands for Professional and Business Services.

Through close observation of the above table, one can see the similar movements of TFP and Labor Productivity growth between the periods of observation, with the exception of Agriculture and Mining. In general, when there is decline in Labor Productivity Growth, there is also decline in TFP growth. However, in Agriculture and Mining, we observe the opposite movements. Another noteworthy finding is the large decline in both TFP and Labor productivity growth for the Information sector, from 4,32% and 7,01% in the first period to -6,32% and -5,25% in the third period. The slight increase observed previously for the TFP growth in the Services sector, between the first and the second period, can be attributed to FIRE, PBS, and Art, entertainment and recreation Services, where we can see that their respective growth rates increased during the transition between these two periods. Finally, the numerical results above justify the TFP growth pattern of the three growth accounting graphs, and describe a tendency in agreement with the red trendline. Therefore, we can conclude that *there has been secular stagnation of Total Factor Productivity growth in the Greek economy.*

## 3.6. Chapter Conclusion

Initially described by Hansen in 1939 and then recalled by Summers who argued in favor of the demand-side as well as Gordon who argued in favor of the supply-side, secular stagnation describes a market economy where negligible or no growth exists. After describing the respective debate and presenting several definitions, we used the concept as described by Storm (2017), according to which secular stagnation is a condition where there is long-run decline of the TFP growth, approximately for a period of 25 years (Cherry, 1987). After that, a literature review regarding the contribution, impact, and relationships of TFP growth in the Greek economy was presented, which was followed by the description of the three growth accounting methodologies. Subsequently, the results of these growth accountings were presented as graphs, in which the red trendline is clearly declining, illustrating the long-run slowdown of TFP growth in the Greek economy. After presenting the numerical results that support the graphs, we observed the decline in a numerical way, and we can conclude that there has been secular stagnation of TFP growth in the Greek economy.

# Chapter 4: Labor Productivity Growth and Baumol's Cost Disease

*"The essence of technology is by no means anything technological."*

*Martin Heidegger*

After presenting the evidence that there has been secular stagnation of TFP growth in the Greek economy, we will now concentrate on the next sub-question and investigate whether the observed stagnation and decline in Labor Productivity growth is due to within-sector productivity slowdown or between-sector employment shifts. To do this, we will decompose Labor productivity growth, using shift-share analysis. Therefore, this chapter starts with a theoretical foundation on the connection between TFP and Labor productivity growth and the pertinent equations. The next section provides the mathematical process through which we will decompose labor productivity growth, through shift-share analysis. After explaining the concept of shift-share analysis, we recall our previous graphs on Labor productivity growth and employment share in the Greek economy, based on calculations with the EU KLEMS data, and eventually we present the results of the shift-share analysis. It is shown that the decline in labor productivity growth, and hence TFP growth, was due to within-sector productivity slowdown in almost all sectors. Finally, we argue and provide evidence that Baumol's second proposition, Baumol's Cost Disease, did not exist in the Greek economy.

## 4.1. Theoretical foundation: TFP Growth and Labor Productivity Growth

As explained in the previous chapter, Capital Productivity growth should be zero, considering the steady state of the neoclassical growth model, where capital-output ratio is constant, according to Storm (2017). Thus, we obtained eq. (7),

(7) $$\hat{\lambda}_p = \frac{1}{\phi}\hat{A}$$

where we see that TFP growth is a determinant of Labor Productivity Growth, but we have not yet shown whether this is two-way relation. Also, in the previous chapter, through this relation we connected Output growth with TFP growth and showed that the long-run slowdown of Greece's Output growth can be explained by the secular stagnation of Total Factor Productivity growth in the Greek economy. In order to show that what equation (7) tells us is valid also from the other way, we resort to Rada and Taylor (2006), as their approach is explained by Storm (2017). They arranged eq. (8) differently, by accepting that $\lambda = x/L$ and $\kappa = x/K$, and obtaining eq. (9), in the following form,

(9) $$\hat{A} = \emptyset\hat{\lambda} + (1 - \emptyset)\hat{\kappa}$$

which is the second interpretation of TFP growth, defined as the Weighted Average Factor Productivity (Rada & Taylor, 2006; Storm, 2017b). This equation demonstrates that TFP growth is determined by Labor Productivity growth, λ, and Capital productivity growth, κ̂. According to Storm (2017), we can assume that the latter can be considered as constant, as explained by Kaldor (1966), as the output-capital ratio has not been varying importantly throughout the decades (Kaldor, 1966). We therefore modify the above into the following form,

(14) $$\hat{A} = \emptyset\hat{\lambda}$$

where we can see that the other way of eq. (7) is valid and be correctly utilized, for the purpose of this study. We can now argue that Labor Productivity Growth is directly related to TFP growth, is a determinant of TFP Growth, and due to the fact that Solow's Residual TFP growth cannot be observed directly because of

measurement reasons, we will now concentrate on labor productivity for the rest of this chapter. Next, we will decompose Labor Productivity growth in the Greek economy into within-sector and between-sector productivity and employment shifts. As a result, we expect a clearer depiction of the country's Labor productivity growth pattern throughout this period, from 1995 to 2014, and consequently a more coherent view of the secular stagnation of TFP growth in the Greek economy.

## 4.2. Decomposition of Labor Productivity Growth in the Greek economy

Considering equation (14) and in order to decompose Labor Productivity growth, we will use Shift-Share analysis, a decomposition method, as described also by Storm (2017). Through this Shift-Share analysis, we will decompose the changes in Labor productivity growth into the two main responsible factors: changes or slowdown in productivity within an industry, and shifts in employment share between different industries, either through transfers from dynamic to less-dynamic sectors, or the other way around. Before we proceed to that, we define aggregate Labor Productivity as the sum of Labor Productivity of each industrial sector (Storm, 2017b), as expressed by the equation below,

(15) $$\lambda_{L,agg} = \frac{X_{agg}}{L_{agg}} = \sum_{j=1}^{n} \frac{X_j}{L_j} \times \frac{L_j}{L_{agg}} = \sum_{j=1}^{n} \lambda_j \times S_j$$

The left side of equation (15) consists of $\lambda_{L,agg}$, expressing aggregate Labor Productivity, while the right side is comprised of $X_{agg}$ which expresses aggregate Output, and $L_{agg}$ expressing the total employment in the economy. In order to decompose into the sectoral terms, we use the symbol j for each industrial sector. $X_j/L_j$ represents labor productivity for industry j ($\lambda_j$) and $L_j/L_{agg}$ expresses the employment share of industry j ($S_j$). The growth formulation of equation (15) is shown below,

(16) $$\hat{\lambda}_{L,agg} = \frac{\lambda^t_{L,agg} - \lambda^0_{L,agg}}{\lambda^0_{L,agg}}$$

which is the principal way of describing growth terms, as the difference of Labor productivity during two observation periods 0 and t, divided by the labor productivity at time 0. Combining these two equations (15 and 16), we can express the decomposed aggregate Labor Productivity growth in the following form (Storm, 2017b),

(17) $$\hat{\lambda}_{L,agg} = \frac{\sum_{j=1}^{n}(\lambda^t_j - \lambda^0_j) \times S^0_j}{\sum_{j=1}^{n} \lambda^0_j} + \frac{\sum_{j=1}^{n}(S^t_j - S^0_j) \times \lambda^0_j}{\sum_{j=1}^{n} \lambda^0_j}$$

The left side of equation (17) is aggregate Labor Productivity growth. On the right side, the two terms reflect the changes within and between the industrial sectors. The first one accounts for the sum of every industry's impact in terms of the change in their Labor productivity from time period 0 to t, reflected by the $(\lambda^t_j - \lambda^0_j)$ term, which expresses the difference in labor productivity for industry j, between two periods of observation, 0 and t. The second one shows the impact on aggregate Labor Productivity growth of the employment share shifts, for industry j, between the two time periods 0 and t. This is reflected in the term $S^t - S^0$ (Storm, 2017b). According to Storm (2017), equation (17) can be articulated in a different form, as shown below,

(18) $$\hat{\lambda}_{L,agg} = \sum_{j=1}^{n} (\hat{\lambda}^p_j - \hat{\lambda}^0_j) \times S^0_j + \sum_{j=1}^{n} (S^p_j - S^0_j) \times \hat{\lambda}^0_j$$

which is the fundamental equation for our Shift-Share analysis. The left side is the same as in equation (17), Labor Productivity growth for the aggregate economy. Again, the right side is comprised by two factors. The first expresses the sum of the within-sector difference of labor productivity in sector j between two periods of observation, calculated for all sectors, while the employment share is constant during that time period. The second term represents the sum of the shift in employment share of industry j during the two periods of observation and while the level of labor productivity is constant, calculated for all industries. Hence, these two terms contribute to our understanding of whether the impact on Labor Productivity growth is due to within-sector change in labor productivity, or a between-sector shift in the employment structure.

In order to calculate the results for the Greek economy, through the Shift-Share analysis based on equation (18), we will use again data obtained by the EU KLEMS database, from which two variables are necessary. First,

GDP at factor cost constant price, defined as Value Added (VA) in the EU KLEMS database, and the working hours for each industry as well as for the aggregate economy. If we divide GDP at constant prices by the worked hours, we obtain Labor Productivity, for each industry but also for the aggregate economy. Then, we make the pertinent calculations, as there are shown in equation (18), and we get the results of the Shift-Share analysis, which are presented in a Table for all industries in the next chapter. At this point, we will provide the relevant analysis and interpretation of the results, in order to answer the third sub-research question: *Considering labor productivity growth as a source of TFP growth, is the decline in sectoral or aggregate labor productivity growth due to a between-sector employment shift or a within-sector slowdown?*

## 4.3. Within-Sector or Between-Sector Impact on Labor productivity Growth

Before diving into the Shift-Share analysis, it is considered important to recall Figure 4, presented in the 2nd chapter, in order to initially analyze the structure of Employment in the Greek economy and the changes that it underwent, from 1995 to 2014, based on EU KLEMS data. As observed from the graph below, there have been employment shifts from the generally dynamic sectors, that is Manufacturing and Agriculture, to the less dynamic (lower productivity growth), such as the Services sector. The Other sector became slightly more important in terms of employment share between the first two periods of observation, whereas it experienced a decline during the crisis period.

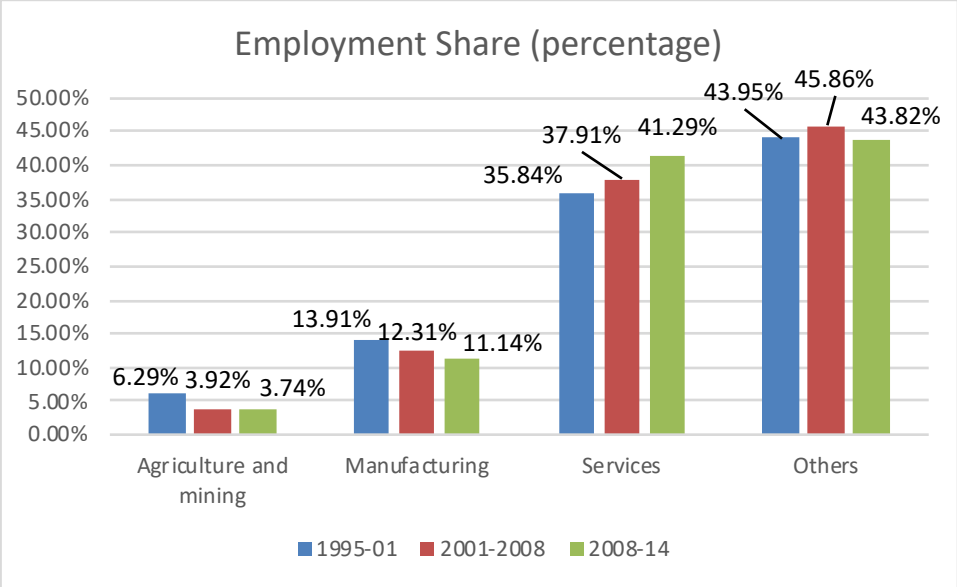


***Figure 13:*** *Employment Share in terms of Hours Worked in the Greek economy (source: author; based on data by EU KLEMS)*

This temporal pattern illustrates the fact that after 1995, workers preferred to leave their villages, farms, or family businesses related to Agriculture and chose to work for the Services industry, resulting in lower importance of the Agriculture sector in terms of employment. On the other side, farmers shifted to more machinery utilization, making Agriculture more capital intensive. Thus, capital and output are increased, whereas labor is decreased, leading to rise in Labor Productivity growth, as shown in the previous chapter for the first two periods of observation, from 1995 to 2008. This shift is not only structural in terms of employment, but also in terms of society, leading to division of families and different ways of societal formulation, and is a result of both technological and cultural changes. On the other hand, even if Labor productivity increases through this transformation of Agriculture, after everything is mechanized and a plateau is reached, growth slows down and it becomes continuously more difficult to achieve higher growth. Moreover, because of the crisis in 2008, a noteworthy number of people return back to working at family farms, not only as a source of income but also as a different way of life. Hence, share of employment goes up and Labor Productivity declines. This process describes the distinct (relative to the others) behavior of the red line, portraying Labor Productivity Growth for Agriculture, in Figure 13.

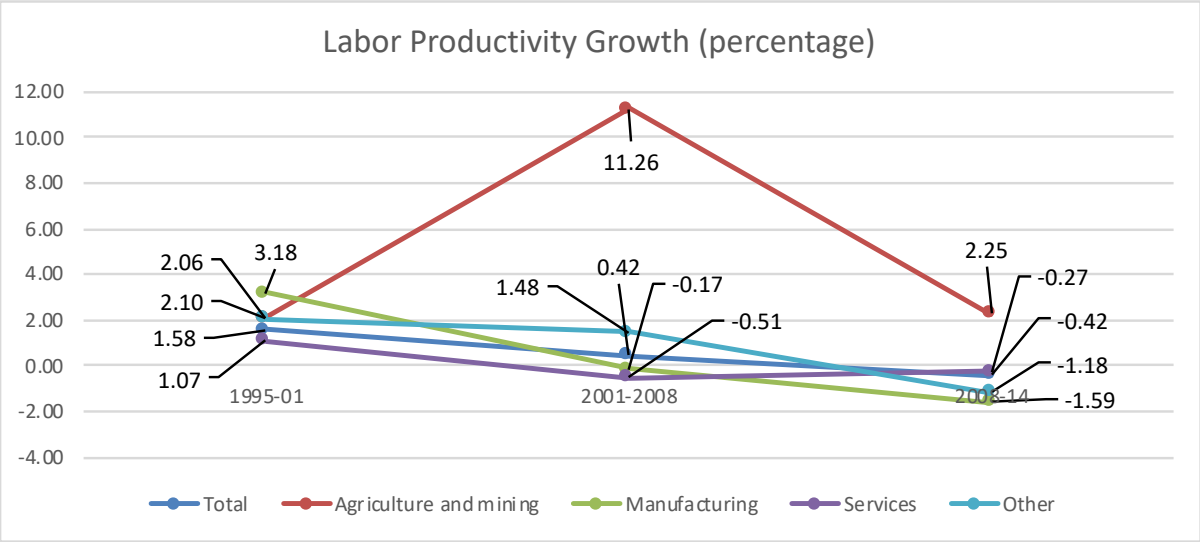


***Figure 14:*** *labor productivity Growth for the Greek economy (source: author; based on data by EU KLEMS)*

Figure 12 shows the changes that happened in the Employment share in the Greek economy, specifically for three big sectors, Agriculture and Mining, Manufacturing, and Services. These shifts show a tendency of employment movement from the more dynamic to the less dynamic sectors of the economy. *Did the impact of these shifts contribute more to the decline of Labor Productivity growth than the contribution of the changes in productivity within a sector?* Shift -Share analysis answers that question for the Greek economy. The table below captures in a numerical way the impact of these two effects. Labor Productivity growth of the ten industries is decomposed into the contribution of within-sector productivity change, and between-sector change in employment share. Data is obtained by the EU KLEMS project and the calculations are based on the equations presented above.

After closely scrutinizing Table 3, we observe that within-sector decline in productivity was more impactful to the aggregate decline than the between-sector employment shifts. Nearly all sectors of the Greek economy, except FIRE, recreation and government services, experienced a decline in their productivity, and hence contributed to the aggregate decline. However, the between-sector contribution is not negligible. From 1995 to 2014, Aggregate Labor Productivity growth declines by -2,94%, with -2,54% coming from the within-sector slowdown in productivity, and -0,39% from the shift between the more and the less dynamic sectors of the Greek economy. More specifically, as far as the Agriculture and mining sector is concerned, the within-sector slowdown, as explained above, contributes to the total decline by -0,40%, a contribution more impactful than the change in its employment structure, which contributed by -0,28%. Bigger difference between these two contributions is observed at the Manufacturing sector, where the within-sector decline in productivity contributed by -0,46% to the aggregate decline, whereas the between-sector contribution was -0,04%.

The largest negative contribution comes from WRT, Wholesale, Retail and Transportation, in which the decline in productivity contributed by -1,47% to the aggregate decline, whereas its between-sector contribution is very low, at -0,0035%. Finally, the Information sector contributes by -0,23% to the aggregate decline in terms of within-sector productivity slowdown, while in terms of between-sector employment shifts the contribution is negligible. To conclude, within-sector changes in productivity contributed to the aggregate decline of Labor Productivity far more than between-sector changes in employment structure. *Taking that into account, was Baumol's Cost Disease present in the Greek economy?*

***Table 3:*** *Shift-Share Analysis for Labor Productivity Growth Decomposition in the Greek economy (source: author; based on data by EU KLEMS)*

| | WITHIN SECTOR | BETWEEN SECTOR | LABOR PRODUCTIVITY | |
|---|---|---|---|---|
| | **Contribution (%)** | **Contribution (%)** | **Growth (%)** | **Weighted** |
| **TOTAL** | -2,5494 | -0,3949 | -2,9444 | 1,0000 |
| *AGRICULTURE AND MINING* | -0,4084 | -0,2875 | -0,6959 | 0,2363 |
| *UTILITIES AND CONSTRUCTION* | -0,0580 | -0,0198 | -0,0779 | 0,0264 |
| *MANUFACTURING* | -0,4634 | -0,0450 | -0,5084 | 0,1727 |
| *WRT* | -1,4758 | -0,0035 | -1,4793 | 0,5024 |
| *INFORMATION* | -0,2373 | -0,0016 | -0,2389 | 0,0811 |
| *FIRE* | 0,1988 | 0,0002 | 0,1990 | -0,0676 |
| *PBS* | -0,1272 | -0,0322 | -0,1594 | 0,0541 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | -0,1431 | -0,0139 | -0,1570 | 0,0533 |
| *ART, ENTERTAINMENT, RECREATION, FOOD SERVICES & OTHER SERVICES* | 0,0080 | 0,0086 | 0,0166 | -0,0056 |
| *GOVERNMENT* | 0,1569 | -0,0003 | 0,1567 | -0,0532 |

## 4.4. Baumol's Cost Disease

Using the example of a Beethoven string quartet, William J. Baumol along with William G. Bowen, described the phenomenon of rising salaries in jobs with low or no growth of Labor productivity, as a response to the increase in salaries in jobs that experienced rise of Labor Productivity growth. Arguing against the classical economics theory, according to which Real Wage growth is linked to Labor productivity growth, Baumol (1966)

asserted that competition for employees with high-salary jobs due to growth in productivity, leads to the wage increase in jobs without any significant productivity growth. Baumol and Bowen showed that despite the productivity of musicians during a live performance has remained practically unchanged, as it is connected with the limitations of the human body, their real wages have increased by a considerable amount since the last century.

The decline we observed previously regarding the Employment Share of Manufacturing and Agriculture and Mining, along the respective rise in the Services sector can be linked to the above diagnosis. Baumol (1966), after analyzing this structural shift from a dynamic to a stagnant sector in terms of technology, suggested two implications. The first was that Aggregate Productivity growth will slow down if this employment change is not stopped. The second, widely known as Baumol's Cost Disease, will exist when the Real Wage in stagnant sectors is the same of higher than the Real Wage in dynamic sectors. We will test this implication in the Greek economy, and show whether Baumol's Cost appeared and influenced the Greek economy. Before we that, we point out that Baumol's first implication is partly correct for the Greek case, as we observed this shift from technologically dynamic sectors (Agriculture and Manufacturing) to technologically less dynamic sectors (Services). Table 4 presents our findings on Real Wage growth for the Greek economy in a numerical way, during three periods of observation. Calculations are based on data from the EU KLEMS project, and the periods are chosen as previously.

***Table 4**: Real Wage Growth (in percentage) in the Greek economy (source: author; based on data from EU KLEMS)*

| | **1995-2001** | **2001-2008** | **2008-2014** |
|---|---|---|---|
| **TOTAL** | 2,62 | 1,61 | -1,03 |
| *AGRICULTURE AND MINING* | 5,39 | 10,38 | -2,76 |
| *UTILITIES AND CONSTRUCTION* | 3,22 | 2,16 | 3,99 |
| *MANUFACTURING* | 0,58 | 1,06 | -2,35 |
| *WRT* | 7,59 | 3,97 | -2,62 |
| *INFORMATION* | 2,91 | 0,48 | -4,71 |
| *FIRE* | 0,16 | 2,11 | -2,92 |
| *PBS* | 4,90 | -1,24 | -2,61 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 2,07 | -1,84 | -1,65 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 1,14 | 4,49 | -1,03 |
| *GOVERNMENT* | 0,78 | -0,02 | 1,80 |

The table above provides a clear picture of the aggregate decline in Real Wage Growth per working hour in Greece, during these three periods, especially after the crisis. As explained, these movements follow the tendency that was observed also in Labor productivity Growth. More specifically, real wage in Agriculture was increased during the first two periods of observation (from 5,39% to 10,38%), as a result of higher productivity and more mechanization, while it fell dramatically after the crisis (-2,76%). Manufacturing followed a similar pattern, although at a lower degree, with an initial rise (0,58% to 1,06%) followed by decline (-2,35%) during the crisis. Regarding the Services sector, Financial, Investment and Real Estate experienced an increase in Real Wage growth from 0,16% to 2,11%, followed by a notable decline after the crisis to -2,92%. Professional and Business Services, however, experienced a decline during all three periods of observation, from 4,90% to -1,24% and then -2,61%. The same trend is observed for the Wholesale, Retail and Transportation sector, in which there was decline during all three periods as well, from 7,49% (the largest growth percentage of the first period) to 3,97%, followed by -2,62% during the crisis years.

In order to test whether Baumol's Cost Disease did exist in the Greek economy, we need to take a closer look to the Real Wage growth, calculated for each year, and its differences between the dynamic and stagnant sectors. For that, in the figure below, the pertinent calculations are presented in a graph, where $W_d$ expresses the Real Wage growth in the dynamic sectors, and $W_s$ the Real Wage growth in the stagnant sectors. Agriculture and Manufacturing are considered generally as the dynamic sectors, while Services is considered as the less dynamic or stagnant sector.

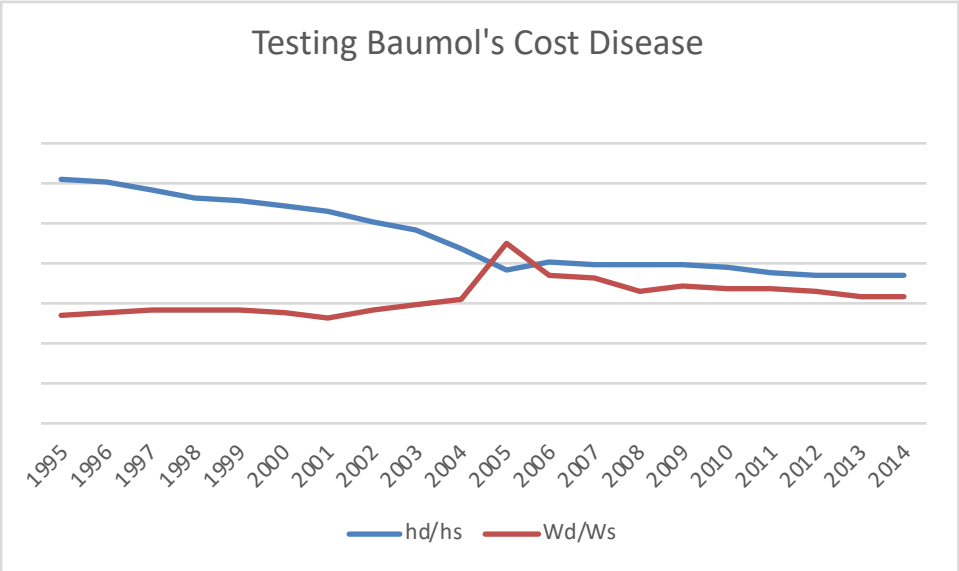


***Figure 15:*** *Testing Baumol's Cost Disease in the Greek economy (source: author; based on data from EU KLEMS): hd= hours worked in dynamic sectors, hs=hours worked in stagnant sectors, Wd= Real Wage growth in dynamic sectors, Ws= Real Wage Growth in stagnant sectors*

In Figure 14, the blue line represents the ratio of working hours between the dynamic and stagnant sectors, which is clearly decreasing, as expected. However, the red line, representing the ratio of Real Wage per working hours between the dynamic and stagnant sectors, is slightly increasing, contrasting Baumol's second implication, according to which we expected the ratio to either be stagnant or declining.

## 4.5. Chapter Conclusion

In this chapter, we focused on the decomposition of Labor Productivity growth in the Greek economy, the determinant of TFP growth. We presented the theoretical foundation for the Shift-Share analysis to support our calculation and findings, and we recalled the graphs presented in the second chapter, regarding Employment Share and Labor Productivity growth, along a numerical table that includes the numerical representation of the Real Wage growth movements during the three periods of observation.

As shown in Table 3, within-sector slowdown of Labor productivity growth was more impactful than the between-sector employment shifts to the aggregate decline of Labor Productivity Growth in Greece throughout 1995 to 2014. The results of the Shift-Share analysis show that the slowdown of TFP growth across almost the whole economy, contributed to the Labor Productivity decline in almost all sectors, contributing more to that decline than the between-sector employment shifts, even though they were still occurring but in lower levels. This finding is in contrast with the first implication by Baumol, according to which the decline results from structural changes in employment between the industrial sectors.

Finally, we tested whether the second implication of Baumol, Baumol's Cost disease, influenced the Greek economy. Our findings show that Real Wage growth in dynamic sectors was slightly higher than in stagnant sectors, leading us to the conclusion that Baumol's Cost Disease did not exist in the Greek economy.

# Chapter 5: Profit Rate Decomposition and Capacity Utilization

*"The difficulty lies not so much in developing new ideas as in escaping from old ones."*

*John Maynard Keynes*

Having discussed the Secular Stagnation of Total Factor productivity growth, the slowdown of Labor productivity growth in almost all sectors of the Greek economy, and the decline in Output before and after the crisis, we can explain the notable decline of Final Demand after 2008. In this chapter, we argue that this decline originates also from lack of technological competitiveness and the increased competition of Greek firms with low-wage countries. Thus, capacity utilization and profit rate are decreased, leading to reduction in investments for innovation and locking the Greek economy into a state of decline. In order to provide evidence for that, we decompose profit rate, particularly for manufacturing firms. After presenting the relevant theoretical foundation and the equations that will be used for this decomposition, we present our findings on the decline of capacity utilization in the Greek economy, resulting from sluggish demand, and leading to lower profit rates, which lock the economy into a state of decline or stagnation. In the next section, we provide the causal scheme, through which the considerably harmful feedback mechanisms trap the Greek economy into this vicious cycle, and we conclude with two main solutions. The first regards demand revival and the second a long-term strategy for sustainable economic growth, through innovation, entrepreneurship and technological competitiveness.

## 5.1. Final Demand and Profit Rate of Greek Firms

In the previous chapters, we discussed the Secular Stagnation of Total Factor productivity growth, the slowdown of Labor productivity growth in almost all sectors of the Greek economy, and the decline in Output before and after the crisis. Subsequently, Final demand experienced a noteworthy decline, after 2008, as shown in Figure 15, on the basis of calculations with data obtained from the Hellenic Statistical Authority, ELSTAT.

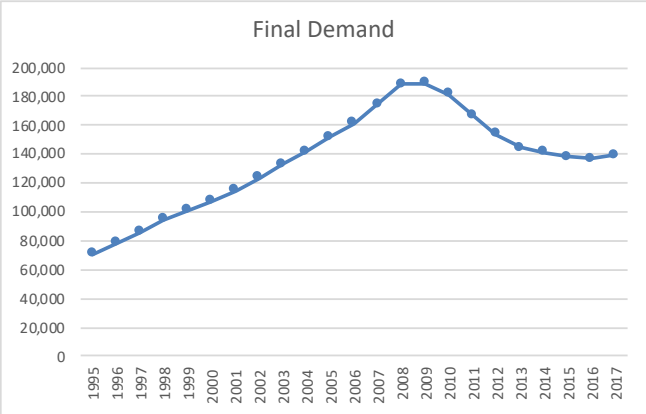


***Figure 16**: Final Demand in the Greek economy (source: author; based on data from ELSTAT)*

As Storm argues in his last paper concerning Italy, sluggish demand was generated from lack of technological competitiveness combined with the reduced ability of Italian companies to preserve their foreign market shares while competing with low-wage countries, such as China (Storm, 2019). We argue that these factors can also explain the situation in the Greek economy, reducing demand, capacity utilization, profit rate, and hence further investment to R&D that leads to innovation. Figure 16 portrays the movements of the Aggregate Profit Rate of Greek firms during the period from 1995 to 2014, based on calculations with data obtained from the EU KLEMS

project. As a result of the above, Greek economy is locked into a declining state, with a continuously weakening of its productive matrix.

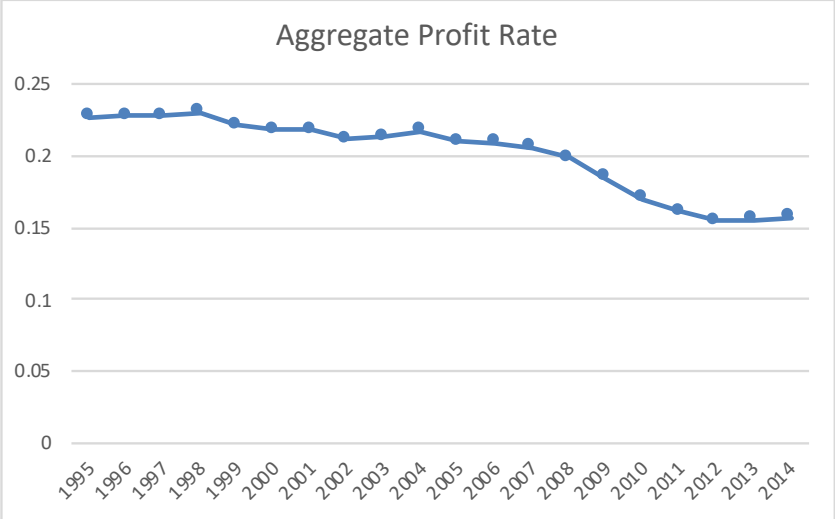


***Figure 17:*** *Aggregate Profit Rate of Greek firms (source: author; based on data from EU KLEMS)*

## 5.2. Theoretical foundation: Profit Rate Decomposition

The profit rate of firms, that is the return on the invested capital, is depressed when capacity utilization is decreased, as a result of lower demand. Next, we will focus on Manufacturing to show how this relation is derived through Profit Rate decomposition, based on the equations presented below. Thus, the profit rate of Manufacturing can be defined in the following form,

(19) $$\rho = \frac{\Pi}{K} = \frac{\Pi}{X} \times \frac{X}{\bar{X}} \times \frac{\bar{X}}{K} = \pi \times u \times \kappa$$

Equation (19) includes $\pi = (\Pi/X)$, reflecting the share of real profits (Π) in the real Manufacturing Output (X), $u = (X/\bar{X})$ that represents capacity utilization, and $\kappa = (\bar{X}/K)$ expressing the "normal" Output-Capital ratio for the Manufacturing sector. According to Storm (2019), we continue under the assumption that κ remains unchanged in the long-run. In order to extend eq. (19), we use the Profit Share equation, as defined by Storm and Naastepad (2012) in the following form (Storm & Naastepad, 2012),

(20) $$\pi = 1 - \theta = 1 - w \times \lambda^{-1}$$

Equation (20) is comprised of θ (wage share), w (real wage per hour of work) and λ (labor productivity per hour worked). The time series data for these variables is obtained from the EU KLEMS project, for the period during 1995 to 2014. We can substitute eq. (20) into eq. (19), in order to obtain the following decomposed formulation of ρ,

(21) $$\rho = (1 - w \times \lambda^{-1}) \times u \times \kappa$$

From equation (21) we conclude that the Profit Rate for Manufacturing firms is determined by three elements: the w, u, and λ, that is the real wage, labor productivity and capacity utilization. Profit rate is decreased when the real wage is increased, and thus the profit share is decreased. Also, the profit rate increases when labor productivity is increased and thus wage share is reduced, resulting to a profit share increase. Finally, a decline in capacity utilization results in profit rate decline, and in some cases even if Profit Share increases. Next, we present our findings on the decline of capacity utilization in the Greek economy, resulting from sluggish demand, and leading to lower profit rates, which lock the economy into a state of decline or stagnation.

## 5.3. Capacity Utilization of Greek Manufacturing Firms

If we solve equation (21) for capacity utilization (u), we observe that u is determined by: Profit Share (Gross profits divided by the Real Output), Profit Rate (return on invested capital) and the constant κ. To begin with, we present the graph of the behavior of Gross Profits (Real Output – Employee Compensation) of the Greek firms operating in the Manufacturing sector. In Figure 17, we observe that Gross profits experienced a rise during the first period of observation (1995 to 2001). The next period following the introduction of the Euro, Gross Profits remained almost constant, and after the crisis, they experienced a large decline, as a result of the decline in Real Output, as shown in the previous chapters. After 2010, when the 1st bailout agreement was being implemented, we observe the end of that decline and the beginning of a continuous rise until 2014, which is a result of the decreased Employee Compensation. The stagnant period, from 2001 to 2008, can be explained by the rise of Employee Compensation, as a result of convergence policies due to Greece's participation in the Eurozone. Figure 18 portrays the movements of Profit Share (Gross Profits per Real Output) for the Greek Manufacturing firms. In Figure 18, we observe a very similar pattern with Gross Profits, but with smaller variations.


***Figure 18:*** *Gross Profits of Greek Manufacturing firms (source: author; based on data from EU KLEMS)*

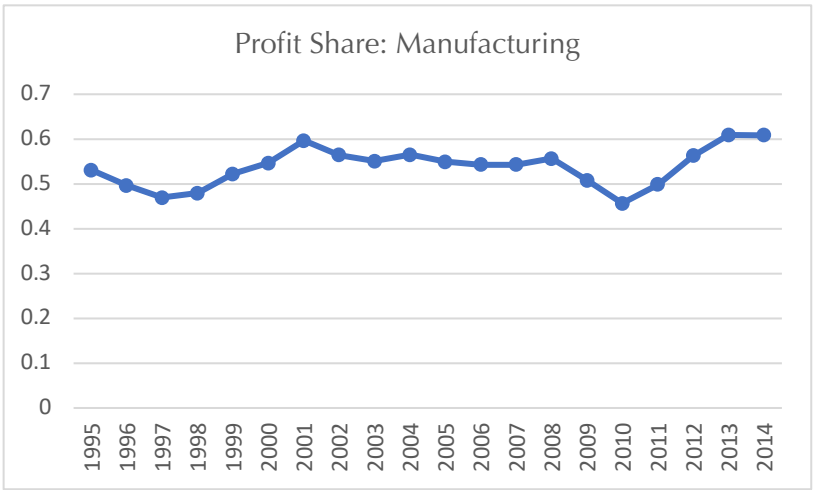


***Figure 19:*** *Profit Share of Greek Manufacturing firms (source: author; based on data from EU KLEMS)*

Figures 17 and 18 illustrate that Gross Profits and Profit Share of the Greek manufacturing firms experienced almost the same movements during 1995 to 2014. Initial rise till 2001, followed by stagnation till 2008, a decline till 2010, and eventually a rise till 2014. These movements are explained by the introduction of the Euro and the policies for convergence that came along, the Global Financial Crisis and sovereign debt crisis that followed, and finally the implementation of the policies proposed by the TROIKA within the 1st bailout agreement.

However, this is not the case with the profit rate. In Figure 19, we observe that although the pattern seems very close to the above, the decline starts earlier. More specifically, after 2005, we observe that Profit Rate of Greek manufacturing firms started to decline, a decline that was follow by a larger one after the crisis. We argue, that this divergence between the Profit Share and the Profit Rate is attributed to the respective changes in Capacity utilization during that same period of observation, in which it is declining after 2005, reducing Profit Rate, although Profit Share did not. Figure 20 shows the movements in Capacity Utilization of Greek manufacturing firms, based on calculations with data obtained from the EU KLEMS project.

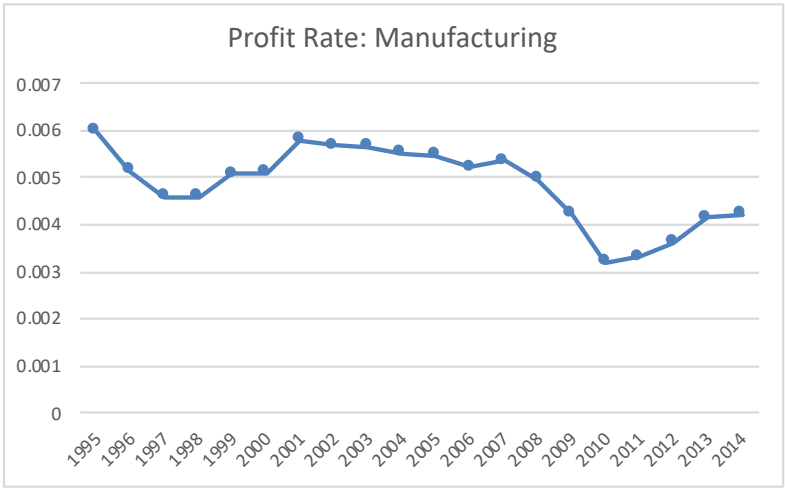


***Figure 20:*** *Profit Rate of Greek manufacturing firms (source: author; based on data from EU KLEMS)*

The fact that Capacity Utilization started to decline after 2005 is interesting, because during that time demand and wages were in an increasing phase. We observe that the negative impact of the decline in Capacity Utilization offsets the positive impact of increased Profit Share, a phenomenon that occurred also in the Italian manufacturing (Storm, 2019). Decline in Capacity Utilization depressed the profitability of firms in terms of the Profit Rate, which in turn hurt investment to innovation because Profit Rate is a more significant factor for investment than Profit Share.

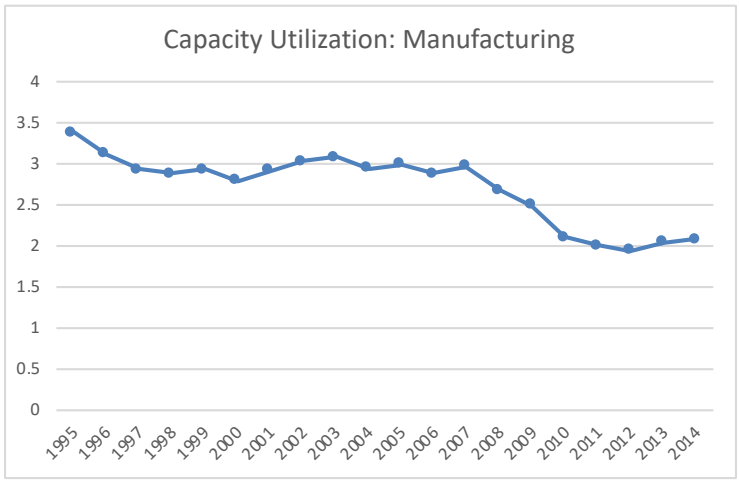


***Figure 21:*** *Capacity Utilization of Greek manufacturing firms (source: author; based on data from EU KLEMS)*

In Figure 21, the same pattern of Capacity Utilization can also be observed in the whole economy, reflecting the locked state in which Greece is trapped in terms of investment. Whereas in the manufacturing sector, we can see a slight increase in Capacity utilization after 2012, this is not the case for the aggregate economy, as shown in Figure 21. As Storm (2019) argues for Italy, demand deficiency is generated from fiscal austerity, wage restraint, and inadequacy of technological competitiveness. As a result, Capacity utilization is decreased, and thus Profit Rate decreases, stalling innovation due to lack of investment. We argue that this is also the case for Greece after 2005, and especially regarding the years after the crisis, when austerity and wage restraints lead to shortage of demand, which through this process, trapped the economy into a state of decline, weakening the productive part of the Greek population and the quality of its exports.

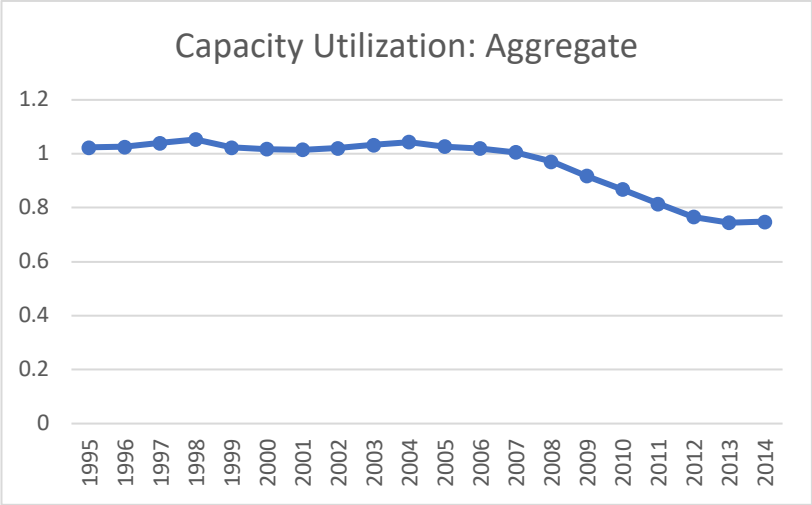


***Figure 22:*** *Capacity Utilization of the Greek economy (source: author; based on data from EU KLEMS)*

## 5.4. Trapped in a State of Decline

As explained in the previous section, due to demand deficiency, capacity utilization is reduced and hence firms' profit rate decline, followed by shortage of investment to innovation. The Greek economy is locked into a state of decline due to several other factors. As we have shown, there is secular stagnation of TFP growth, labor productivity is declining, and wages have been restrained due to austerity. As far as labor productivity is concerned, we have seen in the previous chapter that the major part of its decline comes from within-sector slowdown in productivity, which is the case for almost all the industrial sectors of the Greek economy. The structural changes in the employment share did affect adversely productivity growth, although with much less impact.

Moreover, Greek exports are underperforming, lacking technological competitiveness, combined with an overvalued exchange rate. Greek manufacturing firms are not specialized in high-technology activities, but rather in low- or low-medium. As Storm (2019) explained for Italy, this kind of specialization creates structural weaknesses for a market economy, because "exchange-rate elasticity of export demand is larger for 'traditional' exports than for medium-and high-tech exports" (Storm, 2019). Therefore, we argue that the rise in the value of Euro affects negatively Greek exporters, who export low-tech and "traditional" rather than high-tech and "dynamic" products. Also, we should point out that Greek firms operate and compete in global markets, in which China and other low-wage countries are also operating, hence creating another factor of difficulty to their export performance. Consequently, the countries that specialize in high-tech products, such as Germany and France, are not hurt as much by the growing competition of low-wage countries (e.g. China) as Italy and Greece that specialize in low- and medium-tech goods and services.

That being the case, all the above-mentioned deficiencies, along with the current global state of economic affairs, suggest that the Greek crisis is part of a larger existential crisis, not only for Greece but also Europe. The same is true for Italy, as argued by Storm in his last paper (2019), where he elaborates on the substantial

harmful feedback cycles that trap the Italian economy into a state of permanent decline (Storm, 2019). We argue that a similar scheme can be applied to the Greek case and explain this existential crisis.

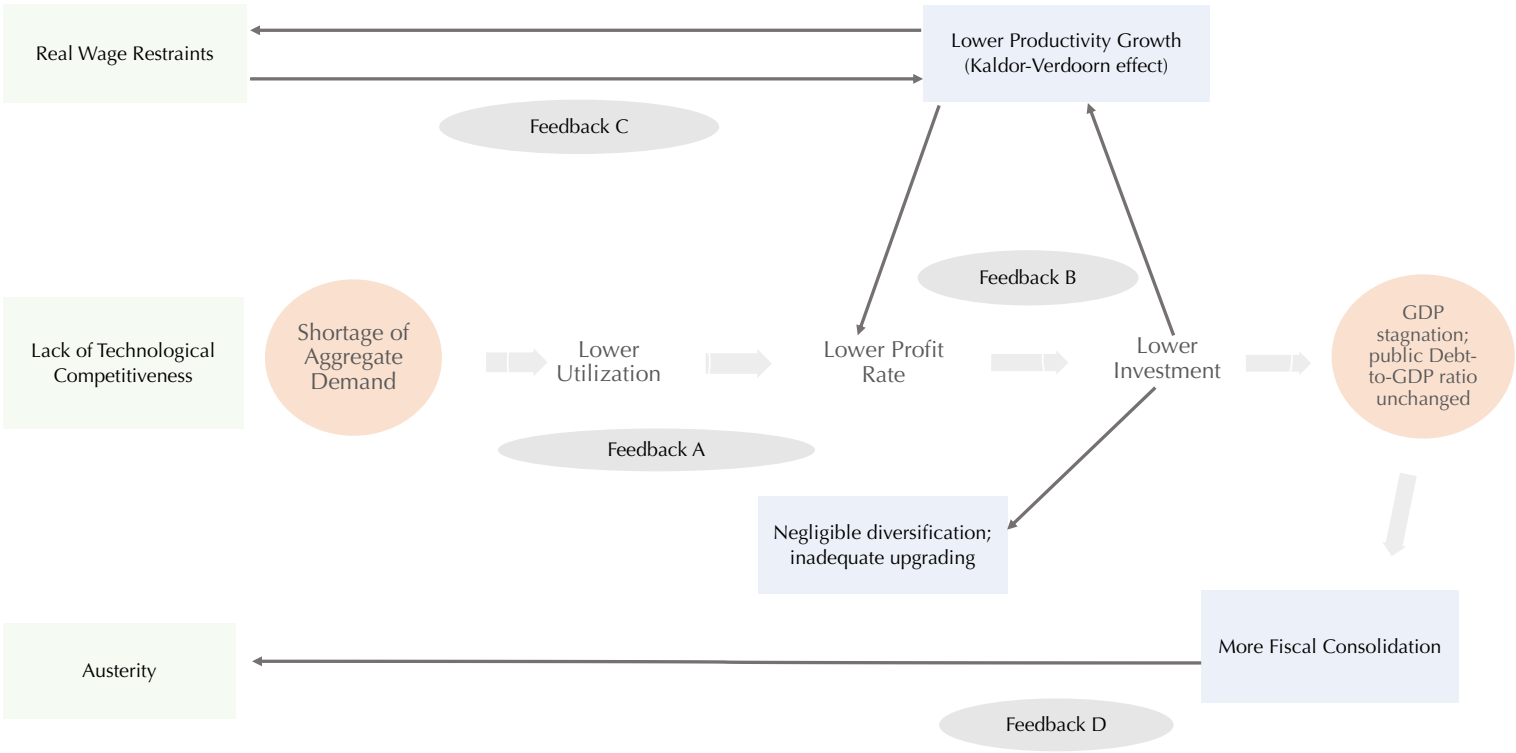


***Figure 23**: Decline Trap Causal Scheme (Storm, 2019)*

Figure 22 presents this scheme, as proposed by Storm (2019). As explained in the literature review regarding the diagnosis of the crisis in the first chapter, the bailout agreements between the Greek governments, the EU and the IMF, included policies that focused on fiscal consolidation and wage restraints. These two factors, in combination with deficient technological competitiveness in the exported goods and services, resulted in structural shortage of aggregate demand. Through the process described in the previous section, this lack of demand lead to lower capacity utilization and hence reduced firm profitability. This results in decline of investment, especially in R&D, and consequently lack of innovation. Stagnation of GDP is the final outcome, which is also reflected in the Secular Stagnation of TFP growth that we showed in the 3rd chapter.

This main causal scheme is augmented by four negative feedback cycles. The first one (A) regards the further weakening of Greek technological competitiveness, through less investment in R&D, that stalls innovation, resulting in negligible product diversification, inadequate upgrades (incremental innovation) and absence of radical innovations. The competition with China and the other low-wage economies will become even more harmful, unless Greek exporters focus on upgrading quality and diversifying into high-tech niches. The second negative feedback loop (B) that augments the main causal scheme initiates again from the reduced investment, which results in stagnating or declining Labor productivity growth through the Kaldor-Verdoorn effect. Lower labor Productivity growth results in lower Profit Rate, as we also explained in the previous section with equation (21). As Storm argues, reduced investment slows down the speed of "technical progress embodied in newly installed capital goods", and restrains "the division of labor", as defined by Adam Smith, through decreasing the "extent of the market" (Storm, 2019). This process results in lower Labor Productivity growth, and is widely recognized as the Kaldor-Verdoorn effect (Storm & Naastepad, 2012). Decline in Labor Productivity adversely affect not only the Profit Rate but also the Profit Share, as shown previously through the Profit Rate decomposition equations, leading to further lowering of investment.

The third feedback loop (C) is active in two directions. The first represents the process, through which lower productivity and thus profit share lead to more wage restraints, in an attempt by firms to keep their profit share unchanged. The second reflects the process, through which wage growth decline allows firms with lower productivity survive in the market, and hence delaying productivity growth even more (Storm & Naastepad, 2012). This feedback mechanism is also known as "Marx-biased technical progress", and it strengthens the negative impacts of the causal scheme (Storm, 2019). Finally, the fourth feedback cycle (D) can be considered as a continuation of the main causal scheme, as it links the GDP stagnation with more fiscal consolidation, due to the fact that public debt-to-GDP ratio remains unchanged or increases. This is particularly the case for Greece as well as Italy, where the EU policies insisted in fiscal surpluses through austerity. A notable number of economists in Greece, as shown in the literature review in the first chapter, agree that austerity increases the debt-to-GDP ratio because it reduces GDP, through this main causal scheme. This was the most important argument that brought SYRIZA into power, in January 2015.

This causal scheme, along with its augmentation with the four negative feedback loops, describes the trap from which the Greek economy needs to escape, leaving stagnation behind, and head towards sustainable economic growth. These feedback mechanisms can be also viewed as vicious cycles, reflecting the "lock-in" situation of Greece. According to the proposals suggested by Storm (2019 regarding Italy, there are solutions, strategies, and policies that the Greek government along with the private sector can implement, in order to get Greece out of this economic stagnation and debt-deflation trap.

## 5.5. Turning the vicious into a virtuous cycle

Storm proposes two main strategies, which should focus on the long-term and avoid easy and short-term measures. Firstly, demand needs to be revived. This can be accomplished through the end of austerity and real wage restraints, policies that can be regarded as short-term and relatively easy to implement. In Greece, the end of austerity has been overwhelmingly discussed, especially after 2014, as a result of the change in government and the SYRIZA proposals for a new economic model. However, after the political and economic turmoil of the first half of 2015, which ended with a referendum and the 3rd bailout agreement, austerity and wage restraints continued to exist in the Greek economy, until August of 2018. That was the month when Greece officially completed all the "structural reforms" asked by the TROIKA, and successfully reached the end of the 3rd bailout agreement. Subsequently, the SYRIZA government attempted to implement new policies, focused on leaving austerity behind and heading towards a new and sustainable economic future. Nevertheless, revival of demand is one part of what is needed.

The second strategy outlined by Storm (2019) is more focused on the long-term sustainable economic growth. It is argued that the Italian exports will become more technologically competitive, as long as Italian exports diversify and upgrade their productive structure and innovative capacity. Innovation, entrepreneurship, and technological competitiveness through public and private investment in R&D, in combination with a focus on high-tech niche activities and "green" economy, will create the necessary conditions for a long-term sustainable future, especially when considering the growing competition from low-wage countries such as China.

We argue that this is also the case for Greece. Technological competitiveness through radical and incremental innovation is the field where the new government, which will be formed after the elections in the 7th of July, should focus their efforts. After August 2018 and the end of memorandum era, Greece has a relative freedom to choose the policies that will drive the country forward and contribute to its survival in this competitive global economic state. The SYRIZA government during these months did try to revive demand through short-run measures of public spending. But the vicious cycles described above will not become virtuous, unless a long-term perspective is adopted. This perspective, this "krisis" framework, is mainly comprised of policies that will create the framework for a new, effective, and sustainable National Innovation System. In the next chapter, we present the pertinent literature review for this framework, constructive proposals by Greek economists, along with our concluding proposals regarding policies for the government and strategies for the private sector.

## 5.6. Chapter Conclusion

In the previous chapters, we focused on the Secular Stagnation of TFP growth, and the slowdown of Labor productivity growth. In this chapter, we argued that the resulting decline in Final Demand is connected with the lack of technological competitiveness and the increased competition of Greek firms with low-wage countries. We also argued that lower demand leads to decreased capacity utilization, and hence depressed profit rate. To show that, we decomposed profit rate for manufacturing firms and we presented our findings regarding the decreased capacity utilization that adversely affects profit rate, and thus reduces R&D investments to innovation that could help the country escape the vicious cycle of decline in which it is trapped. Thereafter, we provided and discussed the causal scheme firstly put forward by Storm (2019), which explains this vicious cycle. Finally, we argued that two main solutions exist to escape this state of decline. Firstly, demand revival should be a priority for the next government. Secondly, the Greek government and all the involved stakeholders, regardless of their political or ideological origins, should cooperate to create a long-term development strategy that will focus on sustainable economic growth, innovation, entrepreneurship, and hence technological competitiveness. This is the subject of the rest of this report. We will now focus on the framework, based on which this strategy should be created, the National Innovation System.

This is the end of the quantitative part of this project. We used macroeconomic equations to show the Secular Stagnation of TFP growth, the within-sector productivity slowdown that resulted in a declined labor productivity growth, and the decreased profit rate, which in combination with the current state of macroeconomic affairs, creates a state of decline in which the Greek economy is trapped. This quantitative analysis will now be followed by a qualitative one, focused on the National Innovation Systems concept, the Triple Helix Model, Innovation Management Notions, and an opening of the black box of the Greek Innovation System. According to OECD, there is no quantitative framework that evaluates or measures the efficiency of a National Innovation System, so our approach will be comprised of a critical literature review and recommendations proposals based on the theoretical foundation and the distinct characteristics, comparative advantages and disadvantages of the Greek Innovation System. The quantitative framework and this qualitative approach are interconnected with the causal scheme mentioned above, through which it becomes clear that innovation leads to higher productivity. Therefore, if the Greek economy manages to escape this decline and increase its innovative capacity, the vicious cycle will become a virtuous one, by rising exports that lead to higher demand, increased utilization, and thus profit rate. Also, as the derived equations illustrate, productivity will raise wages without firm profits being affected, and higher wages will result in higher domestic demand. Therefore, the focus on innovation and productivity can be stepping stone, and reverse the negative feedback scheme. At this point, the development of an effective and sustainable National Innovation System becomes an acute requirement. The two parts of this study are combined through the positive feedback mechanism that will be created, through qualitative changes in institutional, legal, and social dimensions, which will in turn impact the quantitative aspect of the macroeconomic equations utilized in the first chapters.

# Chapter 6: National Innovation Systems and Innovation Management

*"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."*

*Carl Sagan*

Having provided evidence for the secular stagnation of TFP growth, the slowdown of Labor Productivity growth due to almost all industrial sectors of the Greek economy, and the decrease in capacity utilization because of sluggish demand that decrease profit rate and hence investment to R&D and innovation, we argued that not only demand revival is needed, but also a focus on a long-term strategy for innovation, entrepreneurship, and technological competitiveness. For that, the concepts of National Innovation Systems and Innovation Management are critical and have to be considered by the Greek government. This chapter regards the second part of the research question, and presents the theoretical background, before we provide the pertinent characteristics of the Greek economy and the respectively appropriate policies throughout the next chapter. More specifically, the first section, presents the core elements of effective innovation systems in a brief literature review, which follows the evolution of these concepts during the last thirty years. Then, we focus on the part of the literature that regards implementation of these concepts and we explain the limitations. Following that, we present the Triple Helix Model theory and the "Entrepreneurial University" concept, as put forward by Etzkowitz and other researchers. Finally, in order to include all the three parts of an Innovation System, that is the academia, the state, and the market, we conclude with an enterprise perspective on Innovation Management, as it is presented in the relevant and recent literature.

Our approach at this part of the study is qualitative. The transition from the first method, the quantitative analysis based on macroeconomic frameworks, to a qualitative critical literature review and recommendation proposals based on the distinct characteristics of the Greek economy and its comparative advantages and disadvantages, is due to the fact that there is no quantitative framework to evaluate or measure the effectiveness of National Innovation System to the cumulative macroeconomic performance of a country, according to OECD. Hence, we initially dive into the pertinent literature, provide a critical literature review on the notions that have been developed mainly during the last thirty years, in order to provide the reader with the necessary theoretical foundation for the proposals that will follow throughout the next chapter.

## 6.1. Theoretical foundation: Core elements of effective innovation systems

Modern society can be characterized as a network society. This societal feature is strongly demonstrated in the evolution of technology. Pertinent literature suggests that technological innovation is an outcome of the connections between the government, the market, and the scientific community (Etzkowitz & Leydesdorff, 2000). The productive interaction and cooperation of regulation, money, and knowledge is the necessary constituent for sustainable and innovative technological development. More and more, we observe these generative synergies in the production of radical technological innovations, and we have come to understand that innovation is not a successful outcome of an individual, but rather a process that incorporates the fields of policymaking, private and public investment, and knowledge creation and diffusion. Pertinent literature considers these innovation processes as "hybrid" in their nature, existing at the same time across different levels of the institutional environment in a market economy (Avenel, Favier, Ma, Mangematin, & Rieu, 2007; Gibbons, 2000). The activities that are executed for the development of contemporary technology advancements, are not only highly specialized but also involve several actors from different institutional realms (Swierstra & Jelsma, 2006), such as entrepreneurs, scientists, and regulators (Elzen, Enserink, & Smit, 1996). A National Innovation System brings together the scientific and entrepreneurial community, under the auspices and the initiative of the government.

The National Innovation Systems (NIS) concept has been developed, studied, and utilized not only by scholars but also policymakers, during the last thirty years (Watkins, Papaioannou, Mugwagwa, & Kale, 2015). It describes, explains, and suggests the ways in which different institutions in one nation interact and cooperate, aiming to support and facilitate technological advancements along with their diffusion to the market society. Several definitions for innovation have been put forward in the contemporary capitalist economies, and most of them perceive innovation as either the process of recombining existing ideas or generating new ideas and turn them into new products as well as processes (Chris Freeman & Soete, 1997; Gordon & McCann, 2005; Rodríguez-Pose & Crescenzi, 2008). This process of innovation is widely argued that it is closely connected to a country's economic growth. More specifically, its ability to create, obtain, incorporate, and implement new technologies, is embodied in each country's NIS (Metcalfe & Ramlogan, 2008). A widely accepted definition of a National Innovation System is the following: "that set of national institutions which contribute to generation and diffusion of new technologies and which provide the framework within which governments and firms negotiate policies to influence the innovation process" (Metcalfe, 1997). Consequently, the NIS concept is linked to economic growth and technological convergence (Lundvall, 2007).

The various functions of an innovation system are described elaborately in various different ways, in a large part of the relevant literature. Hekkert et al. (2007) provide their distinct description, suggesting seven key functions and elements of an innovation system. First, the role of the entrepreneurial community is critical, because through the appropriate actions the new knowledge is turned into a business opportunity, generating a new advantage for the network and market in which they operate. The second function is knowledge production, typically through Research and Development activities. The third function is about diffusing this knowledge through the appropriate networks. The fourth applies to the long-term policies that will stimulate and guide innovation and research to the most beneficial path. The next function concerns the market, and how will potential new technologies be incorporated into the existing market, and how will they be compatible or complementary to what is already in the hands of the customer. Following, resource mobilization of human and financial capital is essential to the above-mentioned activities. Finally, the seventh function relates to the legitimacy creation, meaning the balancing of the positive and negative impacts of an innovation. As Schumpeter described in his popular work, "Capitalism, Socialism, and Democracy", innovation in a market society can be viewed as 'creative destruction' (Schumpeter, 1942). There is always a stakeholder that loses and hence resists to the introduction of an innovative good or service. This loss needs to be supported somehow, either through the market, the government, or the general public.

In 1841, when Friedrich List published his work "Das nationale System der politischen Ökonomie ", the idea of National Production Systems was first put forward. The concept of NIS was firstly suggested by Freeman in 1982, who aimed to respond to the neoclassical approaches to economic growth (Freeman, 1982), essentially linking the NIS concept to public policy (Sharif, 2006). Inspired by the Schumpeterian theory that intrinsically connected innovation and technological change with economic growth, Freeman (1982, 1987), Lundvall (1992, 2007) and Nelson with Winter (1982), argued against the neoclassical growth models, describing them as insufficient because they disregarded the role of technology and innovation, especially regarding economies where technology and science were the main drivers of growth. Those Schumpeterian economists believed that technological change and innovation were of paramount importance for economic growth (Freeman, 1982; Christopher Freeman, 1987; Lundvall, 1992, 2007; Nelson & Winter, 1982). Moreover, because innovation is not an outcome of an individual inventor or firm, but rather a collaborative venture that requires various types of expertise and resources, every country does not have the same institutional competency in order to innovate either radically or incrementally (Patel & Pavitt, 1994). This is an important realization that contrasts the neoclassical approach to growth, arguing essentially that governments, institutions and other collective actions, can influence positively or negatively, the innovative capacity of a country, and hence its economic growth. The importance of institutional actors is substantial in creating the environment that will facilitate the exchange of knowledge and resources, in order to create new ideas and business opportunities (Chris Freeman & Soete, 1997).

These institutional actors and their systemic interactions have been extensively studied by pertinent literature, especially for OECD countries. Patel and Pavitt (1994) describe elaborately the four core institutional elements of a National Innovation System. The primary institutions that comprise a NIS are firstly governments and associated organizations that provide supportive regulation for innovation, the facilitative environment,

partnerships between the private and private sector, and the research funds. Secondly, industrial sectors that contain firms which experiment, operate R&D activities, improve their existing products, and as a result create commercial innovations. Thirdly, universities play the significant role of training the scientific or technical human capital, while at the same conducting foundational research. Last, the fourth element is comprised of other private or public agencies, which are involved in education-oriented projects (Patel & Pavitt, 1994). The interactions between these institutions are the determinant factor for the success of a NIS. As Lundvall (1992) explained, they need to expedite sharing of information and resources, resulting to increasing knowledge and collaborative learning (Lundvall, 1992). As far as learning is concerned, the focus has been on its constituent that is most important to innovation and institutional aptitude, that is learning by doing, as it was depicted by Arrow (Arrow, 1962). Learning in the pertinent literature is not linear and is an outcome of repetitive processes that are dependable on constructive feedback mechanisms among the actors of the system (Nelson & Winter, 1982).

In the beginning, the NIS theory viewed firms of all sizes as the central node in the system (Patel & Pavitt, 1994), as the principal institution that generated and commercialized innovations. According to this perspective, the other actors had an assisting function, still significant but not determinant. This firm-centered approach to National Innovation Systems considers governments as the provider of the necessary incentives as well as regulatory assistance to firms that innovate. Also, universities and other education-oriented agencies are considered as the area where the cultivation of new knowledge, ideas and thinking, is occurring along with the human capital training that will later contribute to the business ecosystem. This firm-centered approach was later called into question, and the focus of the literature moved to the Mode 2 and Triple Helix Model (Etzkowitz & Leydesdorff, 2000), which will be described in the next section.

## 6.2. Implementing the NIS concept – A literature review

At this point, after describing and explaining the core elements of effective National Innovation Systems along with their history in the literature, we should note that the successful application of these functions and interactions among the institutional actors will potentially lead to the "desired" virtuous cycle of sustainable innovation for a country. On the other hand, any deficiency, lack of some functions or interactions can result in systemic failures in terms of the innovative capacity of a country (Watkins et al., 2015). For example, the abovementioned resistance by incumbent firms to a radical innovation that disrupts the industry in which it operates, may create a "lock-in" situation from which the nation is unable to escape. Consequently, the degree at which these functions, their interactions, and the included actors are related and connected is of utmost importance for the success of such a collaborative network of knowledge production and technological innovation. This success determines a nation's innovative capacity, and hence its economic growth. Central and regional governments play an important role in coordinating these functions. From the R&D activities by public research agencies, universities or firms, to the commercialization of the new technologies through entrepreneurial initiatives, this coordination postulates the respective policies, and vision for the future.

The linkages between the different actors in the innovation system need to have a strong foundation, based on high levels of trust, which is also a governmental responsibility. These linkages are comprised of collaborative research, workforce swapping, cross-patenting, and technological trading or acquisitions (OECD, 1996). For the productive coexistence of these linkages, trust is essential, and initiates from the government, spreading later to the rest of the system. Lastly, differences between nations, regarding their specific social and cultural characteristics, have a significant impact on the quality of their NIS. Therefore, each nation has a distinct NIS in terms of innovation trajectory and technological path, resulting from its comparative advantages and disadvantages, as well as from the perspective of their future (Fromhold-Eisebith, 2007). These differences demonstrate that we cannot accept a best practice universally; we should rather focus on each nation's distinct socio-cultural, geographical, historical, and technological characteristics, while applying the above-mentioned key theoretical elements.

This theoretical foundation on the key elements of effective National Innovation Systems is useful in terms of the direction it can give to policymakers in regards with the systemic failures that can occur within an industry and its innovative capacity. Lack of productive interaction, lack of congruence between basic research and the industrial applications, insufficient technology exchanges, and deficient linkages, can all influence adversely

the innovative capacity of a country. The NIS concept can lead to new policies in order to deal with these failures. These policies range from networking schemes to improving firms' information and technology absorption (OECD, 1996). The improved interaction between the institutions and actors will lead to joint research initiatives, technical partnerships between the private and public sector, workforce transfers and other exchange projects, co-patenting, and co-publication. The core elements of these policies are the flow of knowledge and the reach to technological networks, and therefore it is suggested that the appropriate information technology and infrastructure policies need to be realized. Regarding the improvement of the firms' innovative performance, an improvement in the organizational, managerial and technical abilities is needed through investing in information technology, workforce training, and R&D activities. These policies will aim to enhance not only its innovative performance but also its absorptive capacity, and hence it is significant also for the firms that are not based on technology, but in more "traditional" markets.

The Organization for Economic Co-operation and Development (OECD) has published numerous relevant studies during the last three decades. The most significant issue that it recognizes regarding the NIS concept is the measurement problem (OECD, 1996). Knowledge flow NIS mapping have yet not developed sufficiently, as a result of the nature of the data used to describe them. Number of patents, R&D expenses, and high-tech purchases are typical indicators, and although they can be proved powerful, they cannot give the full picture. Furthermore, it is difficult to depict a NIS because there are no "comparable approaches" among the countries (OECD, 1996). Finally, the ultimate measurement goal is to connect the NIS of a country with its economic performance.

Clearly, improved innovative capacity leads to economic growth, but till now we are not able to measure specifically the degree to which stronger network interactions lead to increase in production output and productivity. The evaluation challenge of National Innovation Systems is due to the multiple and abstract dimensions and variables that affect it, resulting in no consensus regarding their measurement. Lu et al. (2014) attempted to provide a measurement framework for National Innovation Systems, and after presenting their results, they created a decision-making matrix and a performance improvement strategy map to facilitate national policy makers increase their country's innovative capacity. Their results include the Greek National Innovation System and their suggestions are incorporated in the last section of this chapter, along with our other recommendations pertinent to policies for the Greek government and strategies for the Greek private sector.

## 6.3. The Triple Helix Model and the Entrepreneurial University

The interactions between universities, governments and industries, in order to achieve economic growth has been also described by another framework that was put forward after the NIS concept, the Triple Helix Model of innovation (THM). Etzkowitz and Leydesdorff (Etzkowitz & Leydesdorff, 1995) were the first to define it, including the main three elements of a NIS, along with their roles and interactions. Science parks and technology transfer offices were created as a result of the interactions between these three domains. The functions described for the NIS apply also to the THM. As bidirectional linkages between academia, market, and government increase, each constituent transforms in order to absorb attributes of the other institutions, hence creating "hybrid" organizations (Etzkowitz & Leydesdorff, 2000).

As far as the interactions between universities and industry are concerned, they are concentrated on the fundamental role of universities, that is education and basic research. Based on the linear model of innovation, the industry is supposed to absorb the knowledge created through the academic research and commercialize it (Etzkowitz & Leydesdorff, 1995). This transfer of knowledge is mainly occurring in a bilateral way through the transfer of people. However, it has been argued that when faculty members utilize university resources to provide consultation to industries, the principal role of the university is left behind, generating a conflict of interest (Boyer & Lewis, 1984). Despite that, success stories like that of Silicon Valley and Stanford university demonstrate that provision of knowledge and human capital to the industry can create strong dynamics that could have not been otherwise created (Saxenian, 1994). Moreover, Grenoble and Oxford constitute similar European examples of success stories that implemented these policies (Lawton Smith, 2004). According to literature pertinent to NIS, systemic failure can also occur, mainly due to lack of the appropriate agents, problematic interactions between the actors, and missing or deficient institutions (Llerena, Matt, & Avadikyan, 2005). Ooms et al. (2015) in another study tried to answer whether "every region can become a Silicon Valley".

Their findings suggested that the answer is negative, and they emphasized that it should not even be in their interest to do so, but rather they should focus on their comparative advantages (Ooms, Werker, Caniëls, & Bosch, 2015).

The role of universities is particularly important in regions where high-tech entrepreneurship is not developed sufficiently. By providing entrepreneurship education, universities can provide the necessary competences and help students become entrepreneurs by inspiring them and increasing their motivation, as well as by learning them to manage difficult projects through learning-by-doing activities, as was shown by the cases of five universities in Sweden (Rasmussen & Sørheim, 2006). Spin-offs are another example of the "entrepreneurial university". In this case, a graduate, faculty member or researcher becomes an entrepreneur, by commercializing a research outcome. Exploiting commercially knowledge obtained during studies or work at a university is an important element of successful regional, and hence national, innovation system (Benneworth & Charles, 2005; Gunasekara, 2006). All over the world, universities increasingly drive and stimulate entrepreneurship, by providing knowledge and technology as well as by commercializing basic research, and finally by supporting regional firms (startups, spin-offs or bigger enterprises) with the appropriate human capital as interns, graduate or regular employees (Fromhold-Eisebith & Werker, 2013). Finally, the increasing participation of universities in commercial activities through licensing and patenting, blurs the boundaries of their initial role, contributing to the hybridization of the three constituents of the Triple Helix Model (Etzkowitz & Leydesdorff, 2000). The "entrepreneurial university", with MIT as the prominent example, is the most powerful manifestation of this process of hybridization (Etzkowitz, 2008).

Regarding the interactions between the universities and the government, their strength is highly dependent on the governmental policies pertinent to higher education (Etzkowitz & Leydesdorff, 2000). If higher education is mainly public (European universities), governmental impact is stronger, especially because the government provides the necessary research funds, and hence guides the research. If the universities are private (U.S.A), they are more independent in terms of their research orientation. Similar is the case with the interactions between the government and the industry. If the government's approach to the market economy is liberal, its role is restricted when there is a failure; whereas if there is higher involvement, regulatory actions either prevent potential market failures or limit the independence of the market. Usually, specific circumstances create different conditions among different countries regarding the interactions between the government and the industry. The strength of these interactions between the three domains is dependent on which of them predominates in the structure. Etzkowitz (2011) argues that in a statist model, the government is the driving force of these interactions and thus through its policies the linkages can become more powerful (Etzkowitz, 2010). In the laissez-faire model, the market and the enterprises through their actions influence these linkages, resulting usually in weaker connections and less dependent institutions. Nevertheless, in particular cases the strength or weakness of these ties depends on the governmental approach towards each industrial sector.

Henry Etzkowitz, the creator of the 'Entrepreneurial University' and 'Triple Helix' concepts, argues that while our society becomes more and more knowledge-based, the role and value of the university, the producer and distributor of knowledge, is becoming increasingly important. Therefore, all three elements of the model exert similar influence to the system, with none of them having a leading role (Etzkowitz, 2003). According to the THM theory, innovation nowadays encourages hybridization of these institutions, with the "Entrepreneurial University" operating based on an interactive rather than a linear model of innovation, and contributing to the bidirectional flow of knowledge between the industry and academia. The firms on the other side operate with a model similar to the academic one, especially when they increase their technological sophistication and engage in more training and knowledge sharing. Finally, the government behaves as a venture capitalist or public entrepreneur on top of its conventional regulatory character (Etzkowitz, 2003).

Recently, the THM theory has been expanded with the addition of the Quadruple and the Quintuple Helix models. The former adds civil society and the media to the framework (Carayannis & Campbell, 2009), while the latter adds the natural environment as the fifth helix, viewing the natural environment of economy and society as a driver for innovation and knowledge creation (Carayannis, Barth, & Campbell, 2012). Etzkowitz and Leydesdorff argue that THM is a helpful tool for policy making, with successful implementation in countries of the Eastern Europe and Sweden (Etzkowitz & Leydesdorff, 2000), although it can be proven particularly important for developing economies. On the other hand, critics of the model argue that it has been

developed with the focus on developed, Western economies, where the appropriate infrastructure exists along with other specific circumstances. More specifically, the democratic culture, market orientation, protection of intellectual property, and the existence of knowledge-based activities is not granted for every country (Cai, 2013), making the THM not useful for developing economies, where there is lack of one or more of these circumstances.

## 6.4. Innovation Management from an enterprise perspective

Innovation is also a matter of culture. Therefore, managing innovation is principally significant in the current state of affairs, in which it is necessary for survival. As Drucker (1999) wrote, "innovate or die". As a result, Innovation Management theories adopt a normative approach, proposing concepts and ideas to inspire innovation managers create the necessary environment and culture, so as to enhance successful innovation in their firms. During the last forty years, these theories have changed and evolved, creating different innovation generations, depending on the best practice of each period (Rothwell, 1994). Niosi (Niosi, 1999) described these generations in a concise way, starting from the mid-nineteenth century. The first one was mainly comprised of the R&D laboratory, while the second added project management techniques to R&D. The third generation was characterized by internal collaboration among departments of a company, whereas the fourth added procedures and practices, intending to increase flexibility within the R&D department through incorporating user and competitor knowledge (Niosi, 1999). As Roland Ortt and Patrick van der Duin (2008) explained, these "historical bundles" of best practices demonstrate that innovation management generations evolved throughout this period by adapting to the societal changes of their business environment and by overcoming the drawbacks of the previous best practices. Besides that, they proposed an innovative approach to innovation, called *contextual innovation* (Ortt & van der Duin, 2008).

The proposed contextual approach to innovation can be considered as the fifth generation of innovation management, replacing the "traditional" approaches with a portfolio-based innovation management (Ortt & van der Duin, 2008), meaning that decision-making and the pertinent activities will need to adapt to the specific business, cultural, natural, and even political context. More specifically, this contextual framework of innovation should include several levels of detail, permitting changes in decision-making regarding strategy and operational issues. Furthermore, a systematic perspective is essential, one that interrelates the different contextual elements and deals with complementary procedures at the same time. Finally, encouragement of more flexibility is crucial, such as the "trial and error" or the "lean" approach. In the current global state of affairs, the linear model of innovation is too simplistic, as it does not consider the complexities of the economic, social and technological environment. The innovation process is dynamic, and cannot be approached with a one-size-fits-all perspective (Ortt & van der Duin, 2008).

Cees van Beers, Alfred Kleinknecht, Ronald Ortt and Robert Verburg, published a book in 2008, titled: "Determinants of Innovative Behaviour: A Firm's Internal Practices and Its External Environment". It was essentially a thorough overview of the research up till then pertinent to the determinants of innovative behavior, viewed from economic, managerial and psychology perspectives. According to the authors, five company behaviors play a determinant role in the innovative capacity of a company, linking its "internal" with its "external" environment" (Pal, 2010). The first has to do with the *complementary technical knowledge* that is accessed by firms from their *external* environment in order to augment their competencies and leverage their innovation activities. Secondly, *open innovation* is the evolution of the linear model, according to Paul Trott, although its threats and dangers should not be forgotten. Thirdly, the *assimilation of the absorbed knowledge* is critical for the success of an R&D acquisition, especially in the early-stage of the integration. The fourth behavior is global partnerships and *collaboration*, through the utilization of the new communication technologies that facilitate it, leading to enhanced communication *across geographies*. Finally, the fifth behavior pertains to *demand for innovation*, that is the demand expectations compared with the structure of the market and the number of competitors. Low competition usually is beneficial, whereas these benefits are lost as the competition gets more intense (Pal, 2010).

One of the papers included in the abovementioned book, is focused on industry specialization and the efficiency of Regional Innovation Systems (RIS). Before we analyzed the key elements of National Innovation Systems (NIS) and their importance on economic growth and technological progress. Fritsch and Slavtchev (2008)

investigated the impact of regional specialization in specific industrial sectors on the capacity of the RIS in knowledge production. Innovation is a collaborative learning procedure, and when the actors involved are located in the same region, they are part of the same RIS. If that region is specialized in a specific industry, there are positive effects, *localization advantages*, for the innovative capacity of its firms (Fritsch & Slavtchev, 2008). This is due to the increased pool of specialized workforce (Ellison & Glaeser, 1999; Marshall, 1890), more specialized business services or particular infrastructure (Bartelsman, Caballero, & Lyons, 1994), stimulated R&D collaboration and spillovers of tacit and geographically bounded knowledge (Lawson, Lorenz, C, Knowledge, & Studies, 1998; Mowery, Oxley, & Silverman, 1998). On the other hand, if the concentration of specialized companies exceeds a limit, we may observe disadvantages, such as a "lock-in" situation when too much specialization deters the development of other technologies (Fritsch & Slavtchev, 2008).

## 6.5. Chapter Conclusion

This chapter focused on the theoretical foundation of the second part of the research question. After providing the evidence for the secular stagnation of TFP growth, the slowdown of Labor Productivity growth, and the decrease in capacity utilization that reduces profit rate and hence investment to R&D and innovation, we provided the theoretical foundation for escaping the vicious cycle in which the Greek economy is trapped, a foundation crucial for the Greek government and academia. For that, we presented the historical evolution of the National Innovation System theory and the core elements of an effective NIS. After extending this review with the part of the literature that concerns the implementation of a NIS, we directed our attention into the Triple Helix Model theory and the concept of the "Entrepreneurial University", which is part of a global wave that transforms traditional education. Finally, in order to incorporate the third element of a NIS, we focused on Innovation Management from an enterprise perspective, presenting relevant ideas that can be conducive to Greek firms and industrial sectors in their endeavor to increase their innovative capacity and technological competitiveness. In the next chapter, we focus on the Greek Innovation System, its strengths and weaknesses, and the appropriate strategic recommendations for the Greek public and private sector regarding a new, effective, sustainable, and successful National Innovation System that will give long-term escape solutions to a country trapped in a state of decline.

# Chapter 7: The Greek Innovation System

*"The opening up of new markets, foreign or domestic, and the organizational development from the craft shop to such concerns as U.S. Steel illustrate the same process of industrial mutation—if I may use that biological term—that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism."*

*Joseph Schumpeter*

At this point, we have already explored the Secular Stagnation of TFP growth, the slowdown of Labor productivity in most of the Greek industrial sectors, and the profit rate decrease due to sluggish demand and reduced capacity utilization that leads to lower investments in R&D and innovation. This state of affairs created a vicious cycle for the Greek economy, from which the country needs to escape. To do this, we proposed revival of demand, but most importantly a long-term development strategy that focuses on innovation, entrepreneurship, and technological competitiveness. For the latter, we examined the pertinent literature on National Innovation Systems and Innovation Management, and now we will focus on the specific characteristics of the Greek Innovation System, its comparative advantages, strengths and weaknesses, to conclude with policy recommendations.

More specifically, the first section of this chapter presents the industrial environment of the Greek economy in a more elaborate way, highlighting the fields with high growth potential. Then, having explained the important role of education in a NIS and the Triple helix Model, we present the impact of education and research in the Greek economic and TFP growth. Thereafter, we present an assessment of the Greek Innovation system, emphasizing the strengths and weaknesses of the sub-systems it is comprised of. Following that, we focus on the high-tech startup ecosystem in Greece, its recent developments, opportunities and threats. We argue that it is one of the few industrial fields, where optimism still exists. Taking all the previous findings and the presented characteristics into consideration, we conclude with policy recommendations for the Greek government regarding productivity and innovation, and strategic recommendations for all the stakeholders of the Greek Innovation System, focusing on its most significant sub-systems.

## 7.1 Industrial Environment in the Greek Economy

A main weakness of the Greek economy is the lack of diversification regarding its industrial environment. The Services sector contribution to GDP is above the EU levels, mainly due to tourism, transportation, real estate and public administration activities, which account for more than 40% of total Output, while in EU these sectors account for 25% of GDP on average. Moreover, these activities in the Greek economy are not knowledge- but labor-intensive. The Agriculture sector, which is also relied on labor and not knowledge, contributes more than in the EU on average, although still it accounts for just 4% of total Output. As shown in previous chapters, Manufacturing is relatively small, mostly focused on low- and medium-tech activities, such as production of metal, wood, tobacco and food products, characterized by low productivity and labor-intensive jobs (Markatou, 2011). As a result, competition with the EU manufacturing is difficult, turning these industries into the domestic market, limiting the export orientation of the whole economy, and ultimately affecting adversely economic growth.

The low efficiency of the public sector, the slow speed of the justice institution, corruption, tax avoidance, and overregulation are further reasons that create problems for the Greek economy and its growth potential. Greek companies are small-sized, with medium age and divergent export levels to markets geographically close, such as the Balkans, the Middle East, and the European Union. They are specialized providers of capital goods and

traditional intermediate products, such as metals, machine equipment, plastic and fabricated metal products (Markatou, 2011). Additionally, large companies' contribution accounts for about 25% of GDP, lower than the EU average, which is another reason for the fragmentation of exports. Small and Medium-sized Enterprises (SMEs) are more easily formed in Greece due to tax avoidance potential and the problematic public sector, and thus are mostly run by families. Consequently, they do not utilize economies of scale and managerial expertise in order to increase their productivity and technology sophistication, and hence become more export-oriented (McKinsey, 2012). Low skills and technological stagnation suggest the necessity for an effective innovation system, that will lead the Greek economy to high-tech activities, higher salaries, better export performance, and eventually sustainable economic growth.

In spite of the above, there is a small part of the economy with an effective innovation system and industries with growth potential, providing optimism to the current state of affairs. Logistics and the maritime industry have historically been determinant pillars of economic growth in Greece. In addition, shipowners invest in tourism, transportation and energy, providing a much-needed support to the whole economy. The ICT area has also the potential for growth, through the global technology advancements and the pertinent investments. Digitization of the public administration and of the private sector could be proven the most significant determinant of positive change for the Greek economy, by increasing productivity through faster processes and less costs. Another industry with growth potential is the pharmaceutical, because of the skilled employees, its developed R&D and the niche opportunities that exist in the global market. Similarly, medical tourism is another area that is currently being discussed extensively in Greece, due to the comparative advantages of the country because of its experience in tourism. Infrastructure investments and reputation building could extend significantly the tourism season and provide additional output (McKinsey, 2012). Finally, novel tourism and healthcare activities, as well as innovative businesses in agriculture and energy industry can widen the Greek comparative advantage range.

## 7.2. Effect of Education on Greek Economic Growth

As far as the effect of education on economic growth is concerned, in Greece the impact was negative during 1981 to 2009, as shown by the empirical analysis of Tsamadias and Pegkas (Tsamadias & Pegkas, 2012), who applied the model established by Mankiw et al. (Mankiw, Romer, & Weil, 1992). In particular, Benos and Karagiannis (Benos & Karagiannis, 2016) provided evidence regarding the negative effect of elementary education, along with evidence for the positive impact of upper secondary and tertiary education, on Labor Productivity. In contrast, they argued that there was no impact on labor productivity by lower secondary education, concluding that the role of education becomes positive as its level increases. Also, the quality of the education provided is shown to have a determinant impact on economic growth. Their findings agree with pertinent literature on developed economies, in which the effect of education is increased as its level move from elementary to tertiary (Benos & Karagiannis, 2016).

Solaki (Solaki, 2013) investigated the causal relationship of economic growth and education for a longer period, from 1961 to 2006, and utilizing a bi-variate method derived from human capital theory. With her empirical results, she suggested that real GDP per capita is positively affected by the increase of public expenditures in education. More specifically, increasing public expenditure on tertiary education in order to expand the quality and number of students, has a positive effect on economic growth (Solaki, 2013). Voutsinas and Tsamadias (Voutsinas & Tsamadias, 2014) explored the relationship of TFP growth and R&D capital allocation for the Greek economy from 1981 to 2007. Their findings demonstrate that total R&D and public R&D capital are related with TFP in the long-run, in contrast to private R&D that does not have a significant relation with TFP (Voutsinas & Tsamadias, 2014).

The above results from the relevant literature suggest that policy makers should consider the effect of education when designing an effective innovation system. In particular, quality of education and pertinent spillovers affect regional growth (Benos & Karagiannis, 2016). Increase in public expenditure for tertiary education and enlargement of the student number, are policies that have been shown to lead to economic growth (Solaki, 2013). Qualifications and quality of education improvements, development of complementary educational types like vocational and lifelong training, and expansion of tertiary level of education, are also some of the paths that lead to reduction of regional imbalances in terms of labor productivity (Benos & Karagiannis, 2016). Finally,

increased R&D capital allocation, especially public R&D capital, along with the essential structural reforms will, according to Voutsinas and Tsamadias (2014), strenghten the effectiveness of the innovation system. In the next section, we provide an assessment of the Greek Innovation System, based on widely used indicators and focusing on its most important sub-systems.

## 7.3. Assessing the Greek Innovation System - Strengths and Weaknesses

We will provide the assessment of the Greek Innovation System, in terms of the following sub-systems: Education, R&D, Networking, Financing, Regulation, Quality of Governance, Demand for innovation, and Capacity to attract talent (DiaNEOsis, 2016). Before we focus on each subsystem, we present a holistic assessment based on three indicators. First, the Greek ranking in the 2015 Innovation Indicator was 29 among 35 participating countries all over the world (Frietsch et al., 2015). Greece performed poorly in some of the subsystems (quality of governance, R&D, Networking), and better in others (Education, Demand for Innovation), but still all the rankings cannot be considered satisfactory for a developed economy. In the same year, the Global Innovation Index ranked Greece on the 45$^{th}$ position out of 141 countries, with Education demonstrating the highest performance, in contrast to R&D and Networking (Goedhuys et al., 2015). In 2019, the European Innovation Scoreboard categorized Greece as "Moderate Innovator", the same categorization with the previous four years, along with Portugal, Poland and Croatia, performing below average of the 28 EU member states (European Commission, 2019). This below average performance in all three indicators demonstrates the urgent need for the development of an effective National Innovation System.

More specifically, *education* was largely affected by the austerity policies in response to the financial crisis (Dassiou, 2015). Survey results in the Global Competitiveness Report of the World Economic Forum demonstrate that the Greek education system is not producing workforce that can deal with the global competition landscape, with a poor high school student performance (PISA results), and a small number of doctorates who are a principal input element for an innovation system, as they are expected to drive cutting-edge research and lead the economy to greater innovative capacity (Schwab, 2015).

Regarding *R&D activities*, public R&D expenditure accounted for 0.9 % of GDP in 2014, whereas in Sweden or Finland about 3% of their much higher GDP was invested in R&D. Private R&D expenditure was also notably low, limiting the innovative capacity of firms and hence of the whole market. Another weakness in the R&D field is the fact that universities along with research institutes focus mostly on basic research and much less on applied research. Nevertheless, the quality of the executed research among these institutes is of very high quality, a fact that is justified by the number of outstanding scientific publications (DiaNEOsis, 2016). Finally, there is a big imbalance between scientific publications (basic research) and patents (applied research), demonstrating that there is shortage of cooperation between research institutes. Applied research is a fundamental factor for the innovative capacity of an economy, and this output in Greece needs to increase.

As far as *networking* is concerned, Greek research networks are rare and their interactions are, at the present time, weak. Collaboration between public research and industry is inadequate, resulting also from the fact that there is a shortage of big and innovative companies, which will generate innovation or utilize resources from research institutes (European Commission, 2017). Connections between public and private research are also poor, although ideas for research cluster development have been proposed and discussed but not completed (Kanellopoulos, 2013). The integration of Greece into international research networks and its involvement in cutting-edge research is showed through the noteworthy number of international scientific co-publications (DiaNEOsis, 2016). This integration is connected to the big number of exceptional Greek researchers who now work for research institutions and high-tech firms in Europe or the United States. Regarding the European Research Grant, the number of Greek recipients who work in other countries is larger than that of the Greek recipients who work in Greece (Herrmann & Kritikos, 2013). This phenomenon of "brain drain" has an adverse impact on Greece from several perspectives, but it can be overcome if Greek universities and research institutes provide the appropriate motivation for these economic migrants to either return to their home country or cooperate with those based in Greece.

Concerning *financing*, during the most difficult years of the sovereign debt crisis, numerous Greek private investors moved their equity from the Greek banks to other countries (Evans-Pritchard, 2012). As a result, loans and venture capital funds are much more limited for entrepreneurs that want to start a business as well as for established firms that want to expand their product base or just survive in this economic environment. Launching of innovative goods or services and start-up companies would be hampered without the sufficient financing, even if the Greek innovation system was functioning perfectly. Trust in banks needs to be re-established and the private investors need to place their equity back in the Greek economy.

*Regulation* is another important factor on the effective of an innovation system. The Greek regulatory system is highly complicated in most areas and is characterized by high levels of uncertainty as it changes dramatically while governments shift, discouraging entrepreneurs and investors to invest their capital and labor in the Greek economy (Richter, Giudice, & Cozzi, 2015). Adverse regulation, market entry restrictions, and uncertain tax legislation are some of the most important factors that influence negatively the poor performance of the Greek innovation system and its export performance, contributing to the "brain and capital drain" that we observed the last decade. The World Bank "Doing Business" report and the Worldwide Governance Indicators demonstrate that although the situation has been improved since 2010, there is still room for improvement regarding overregulation, which results to corruption, which in turn impedes entrepreneurship and innovation as there is no trust on the institutions that are supposed to protect the intellectual property rights (Audretsch & Feldman, 1996). Consequently, bureaucracy, tax legislation, corruption, and the problematic function of the justice system create uncertainties, which are viewed as higher risks to investors and start-up entrepreneurs, who thus invest or commercialize their innovation outside Greece, in countries where the environment is more supportive.

As far as *quality of governance* is concerned, the political environment in Greece was really unstable throughout its political history after the dictatorship and in particular during the crisis years. Governments were changing every 2 years, cancelling legislation and applying new, creating an unobliging environment for entrepreneurs and investors (DiaNEOsis, 2016). *Demand for innovation* is a crucial indicator that shows whether the pertinent stakeholders are incentivized financially to commercialize basic or applied research. According to the Global Competitiveness Report in 2015, this indicator in Greece was weak, especially when compared with the one of the innovation leaders like Germany and Finland (Schwab, 2015). Finally, the *capacity* of Greece *to attract or retain talent* is also poor. A considerable number of ambitious and capable Greek scientists, researchers, entrepreneurs and investors have relocated or are thinking of doing so, largely because of the above-mentioned uncertainties and deficiencies of its innovation system. In the next section, a summary of the recent developments in the Greek Startup ecosystem is presented, as it is one of the few areas in the Greek economy, where optimism and hope are still the driving forces.

## 7.4. The Greek Startup Ecosystem

Entrepreneurship has traditionally been a part of Greek culture, ever since the establishment of the ancient Greek trading colonies throughout the length of the Mediterranean Sea coast. Nowadays, the country attempts to continue this tradition of encouraging businesses with high growth potential through Equifund. Equifund is the current fund-of-funds scheme, created particularly for the Greek economy, that will invest approximately €500 million into the Greek Startup ecosystem, in high-technology start-up endeavors, ultimately aiming to boost high-tech entrepreneurship and the whole Greek market. It followed the expiration of the Joint European Resources for Micro to Medium Enterprises (JEREMIE programme) and is established by the Greek government in collaboration with the European Investment Fund (EIF). Equifund is a partnership of the public and private sector, with private and public funds that will be supplied by the EU, the Hellenic Republic, the EIF, and the European Investment Bank (EIB) through the European Fund for Strategic Investment (EFSI). €200 million are provided by the Hellenic Republic, €60 million by the EIF and €40 million by the EIB. The residual €200 million are provided by private investors and institutes, such as the Onassis Foundation and National Bank of Greece.

Nine venture capital funds have been created to manage this capital, and they are expected to invest it in companies established or having a branch (mostly R&D) in the Greek territory. SMEs are the target of the biggest percentage of this fund. In particular, small and medium-sized companies developing innovation goods

or services and are at their early stage. The domain of software engineering and development is also the focus of Equifund, and especially state-of-the-art technologies like Virtual Reality, Internet of Things, Artificial Intelligence, and Robotics. Equity financing is going to be the form of investment, and it will come along the pertinent support of investors to the entrepreneurs regarding scale-up strategies, access to knowledge, connections to the ecosystem, and general guidance on achieving the highest potential.

On the positive side, during 2018 and following Barcelona, Amsterdam and Paris, Athens received the award of the European Capital of Innovation from Horizon 2020. Numerous other developments in the ecosystem like the establishment of an R&D center by Tesla and Google's partnership with a start-up from Thessaloniki, indicate that there is some progress happening and a promising path to sustainable growth and technological innovativeness exists. According to Found.ation (2018), Athens climbed 28 ranks in the "Founders' Choice" category of European start-up hubs, even though it is still placed 32$^{nd}$ when every factor is taken into account (Found.ation, 2018). Software as a Service (SaaS) and eCommerce were the industries that include the most successful startups in Athens, in contrast to Financial Technology (Fintech). More specifically, more than €100 million have been invested in Greek startups during 2018, a number that increases every year, especially when one considers the fact that from 2010 to 2016, about €200 million were raised by Greek startups (Found.ation, 2018). This noticeable rise in investments the recent years is a positive sign providing optimism and hope to the Greek Startup Ecosystem.

On the other hand, according to the survey provided by Found.ation (2018), product market regulations are not approved by startup founders (12% approval rate), while foreign investments account for only 27% of the pertinent partnerships (Found.ation, 2018). Moreover, one in two Greek tech-startup founders leave the country, and the results of the EU's Digital Transformation Scoreboard showed that, in 2018, Greece performed below the EU average in six out of the seven variables (European Commission, 2018). Additionally, research has shown that "Fear of Failure" impedes Greek citizens from starting a business (BCG, 2018). This is mostly due to cultural reasons, because entrepreneurship is not deliberately taught in the Greek education system, leading young people to prefer safe careers as societal stigma of failure is considerable. Also, bankruptcy legislation is not conducive and does not provide second chances, hence influencing adversely aspiring entrepreneurs who do not perceive enough opportunities to create a new venture (BCG, 2018).

Turning our attention into the *"Fear of Failure"* issue, we firstly need to mention that it not only a Greek but also a European phenomenon. According to the Global Entrepreneurship Monitor (GEM), it is a fluctuating indicator depending on the location. The lower this indicator, the lower the fear for seizing opportunities and turning ideas into entrepreneurial action. The highest fear of failure was observed in European Union economies (40,7%), with Asia and Oceania following closely (37,5%). Among the EU economies, the highest "Fear of Failure" rate was observed in Greece (61,6%), followed by Poland (51,1%), Belgium (49,4%) and Italy (49,1%) (GEM, 2018). This "Fear of Failure" has been the subject of study by scholars in the field, who concluded that the most usual fears can be categorized in six groups (Martínez, 2016). *Financial, Career Related, Social Perception, and Self-Perception* are the first four categories of the most common fears. The remaining two are comprised by the *Feeling of losing it all, and the Fear of losing personal freedom*. These studies on "Fear of Failure" belong to the scientific domain of sociology and psychology, but they are highly relevant in our attempt to understand the Greek Innovation System.

To conclude, after ten years of sovereign debt crisis, the Greek startup ecosystem is starting to improve with investment initiatives like JEREMIE and Equifund. Also, the cultural aspect is changing, with an increasing number of young Greeks considering entrepreneurship as a career choice (BCG, 2018). This is the time to revive the entrepreneurial ecosystem. However, inadequate collaboration, hostile market conditions and impeding regulatory environment are some of the problematic issues that need to be addressed by a new National Innovation System, an effective, sustainable, and inclusive partnership between the government, the market, and the academia.

## 7.5. Policy Recommendations for Productivity and Innovation

As long as Greece cannot escape its past or change dramatically its present, the focus should shift on creating a better future without destroying the existing positive elements. Combining the current economic system with the high growth potential fields, Markatou (2011) suggests that the Greek government should incentivize particular activities and emerging technologies in the chemical as well as in the basic and fabricated materials industry (Markatou, 2011). These incentives could also be expanded in other fields, expanding the comparative advantage base of Greece, while investing labor and capital into the creation of an export-oriented entrepreneurial productive system (Giotopoulos & Vettas, 2018). Export orientation through new global firms is highly necessary to facilitate growth for the whole economy, and therefore the appropriate conditions for R&D and the following transformation of innovate ideas into commercial products are needed to become a reality by the next government, which will be elected on the 7th of July 2019. Additionally, a strong education system with emphasis on entrepreneurship, the "Entrepreneurial University", needs to be established and supported by the government and industry, in order to facilitate a new growth model, with high quality and income jobs. A wave of entrepreneurship in new technologies, combined with export orientation and the "traditional" comparative advantages, can have a multiplying effect on the whole economy (Giotopoulos & Vettas, 2018).

The Organization for Economic Cooperation and Development (OECD, 2016) argues for Greece that low productivity compounded the crisis impact on the Greek GDP, and suggests that reduction of regulatory and administrative procedures, especially for start-ups is compulsory for improving productivity. In addition, the quality of the education system is also considered of vital importance, along with the establishment of a single institution devoted to productivity, as currently there is no institution in Greece dedicated to providing analyses on productivity (OECD, 2016). Moreover, Lu et al. (Lu, Kweh, & Huang, 2014) suggested a decision-making matrix and a strategy map to provide general recommendations for countries to improve their NIS performance. Greece belongs to the Zone C of this map, along with Australia, the Czech Republic, New Zealand, and other countries that need to improve their economic efficiency while having a sufficient R&D performance. It is recommended that companies in these countries should concentrate on the reduction of operating costs, diversification, marketing communication, channel expansion for the R&D diffusion, and strengthening of the interactions between government, industry, and universities (Lu et al., 2014). Finally, according to Lu et al. (Lu et al., 2014), education is again the main area for improvement, followed by the technical training system, applied science, project management, strategic planning for technology and product commercialization.

Belegri and Michaelides (Belegri-Roboli & Michaelides, 2006), who measured technological change in Greece, recommended that research organizations and production units should be encouraged to collaborate, and technology from abroad should be absorbed more effectively. The R&D institutions should consider restructuring, aiming to reinforce the innovation procedures, and applied research for post-graduates should be governmentally incentivized along with specialization training for new technologies (Belegri-Roboli & Michaelides, 2006). This finding agrees with other studies that suggest increased R&D spending in combination with pertinent structural reforms, in order to enhance the NIS effectiveness and thus the productivity of the whole economy (Voutsinas & Tsamadias, 2014). Regarding foreign technology adoption, anachronistic and rigid organizational and institutional structures, bureaucracy and complicated business legislation, hamper the technological convergence between Greece and innovation leaders, such as Germany (Bournakis, 2012). Consequently, governmental initiative for implementing the relevant institutional improvements and state intervention in labor markets will be beneficial to TFP, as shown by Bournakis (Bournakis, 2012). This governmental initiative is argued to be essential for technological convergence with innovation-driven economies, knowledge spillovers that will improve total productivity, and ultimately for establishing an effective NIS, whose political essence is strongly connected with state intervention and governmental initiatives.

Mariana Mazzucato in her recent book (2013) argues for the *"Entrepreneurial State",* claiming that the economic success of US resulted from mission-oriented public and state funded investments in technology and innovation, and not by free market initiatives supported by a small and powerful state, as it is commonly believed. Her notion of *mission-oriented public investment* by the "Entrepreneurial State" is interesting in the case of Greece, and especially where the acute need for a National Innovation System is realized. She argues that we need to change our perception of the government as a bureaucratic machine that stalls innovative

activities and perceive it as "the lead risk taker" as far as investments to innovation are concerned. More specifically, at this specific point in time, mission-oriented public investments should focus mostly on green energy (Mazzucato & Wray, 2015), a field in which Greece owns unequivocal comparative advantages due to its climate and geographical location. The public sector should invest in the green economy, an area of high technological risk and capital intensity that threatens private sector entrepreneurs. Tax incentives are not enough, as firms look for high growth opportunities, making the state involvement essential on long-term growth (Mazzucato & Wray, 2015). Consequently, the "Entrepreneurial State" should not just illustrate a change of perception, but play an active role in high-risk, green energy investments, benefiting from the Greek climate and location, and contributing to a long-term, sustainable growth of the Greek energy sector.

The "Entrepreneurial University" wave, defined by Henry Etzkowitz in his papers and talks, is wave that should not be missed by the Greek public and private sector, especially when applying the Triple Helix Model theory for the regional and national innovation systems, as described in the previous chapter. The entrepreneurship boost to the Greek economy needs to start from the education system, so as to result in multiplied effects to the rest of the economy. Graduates and young entrepreneurs, inventors and innovators, will benefit from the right function of the Triple Helix of innovation, and combined with pertinent management theories like Contextual Innovation will take advantage of the Greek comparative advantages, such as climate, "traditional" goods and services, tourism experience, history and culture. Nation branding should be part of this new context in the innovation procedure, and the Greeks need to remind the rest of the world what their country was and should be known for, leaving the really harmful bad publicity of the last decade in the past. If the Greek government implements this Triple, Quadruple, or Quintuple Helix model aiming to revive its NIS, it should not exclude the alignment of the financial environment with the NIS, which is primarily a governmental responsibility (Kapetaniou, Samdanis, & Lee, 2018).

Aligning the financial environment with the NIS is crucial, because early stage funding for research by SMEs is critical for their survival due to the high risk of their activities (Kapetaniou et al., 2018). Consultants or other intermediaries like agencies developed by the state can serve by connecting investors and entrepreneurs and bridge the gap between research and the market. Additionally, R&D tax benefits and other pertinent incentives could contribute to the increase of investment in R&D by firms. The venture capital and angel investor market has been shown to be positively affected by spatial proximity (Mason & Harrison, 2002), and therefore this is another factor to be taken into consideration when creating a well-designed NIS, aligned with the financial environment. Another important funding instrument not only for high-tech but also for low- or medium-tech products, which has been very popular since the invention of the Internet, is crowdfunding (Kapetaniou et al., 2018). As a consequence, the role of government is vital, particularly if we consider the utilization of media in order to create awareness about the importance of innovation for growth, the available funding instruments, the foreign funding opportunities, and the role of entrepreneurs.

A developed and strong National Innovation System with the appropriate institutions and strategies is a determinant factor to a country's response to a dramatic economic decline and its capacity to overcome quickly such a downturn. Underdeveloped National Innovation Systems trigger several challenges for innovation during periods of crisis, such as obstacles to funds for innovation and reduction of public funding due to austerity policies (Filippetti & Archibugi, 2011), as also described in the previous chapter. Consequently, governments can upgrade a problematic NIS by improving the financial environment and aligning both of them. However, risk-averseness especially regarding science and technology is observed during an economic crisis (Kapetaniou et al., 2018). At this point, the role of European Union and of national governments is to provide and maintain stable economic conditions, mitigating the harm and promoting innovation. The "healthy core" and the "sick periphery" will continue to demonstrate an unhealthy division in Europe, unless stability of the EU economies and promotion of radical innovations take place.

## 7.6. Strategic Recommendations for the Greek Innovation System

Our previous findings, along with an amalgam of the recommendations found in the pertinent literature and proposal from Greek think tanks, all agree that a long-term strategic development of a National Innovation System is crucial for economic growth and stability in the Greek economy. To begin with, a permanent nationwide consensus, including every stakeholder, should be the goal of the Greek policy makers in order to

create a prosperous ecosystem, which cannot be developed with either just public funding or just government initiatives. The inclusive, conducive, and long-term strategy for a Greek Innovation System is necessary to avoid pitfalls or unexpected shocks, like the Global Financial Crisis. A governmental change from one party to another should not affect this area. A new approach, collaborative and continuous, with policies either from the left or from the right, is needed for a sustainable, strong, and effective National Innovation System. For a nationwide agreement like this, pertinent stakeholders need to be aware and sufficiently informed, the Greek society needs to understand the importance of such an endeavor, and therefore governmental initiatives with information campaigns would be helpful, as well as a Greek Innovation Conference including agents from academia, state, and the market. More specifically, we present some strategic recommendations on each sub-system of the Greek Innovation System, as it was presented in the previous section for the assessment of the strengths and weaknesses of the Greek NIS.

As far as *regulation* is concerned, it is recommended that the next Greek government should improve the overregulated business environment, simplify the pertinent legislation for starting and operating a company, reduce corruption through powerful institutions, provide a stable macroeconomic setting especially for investors, protect intellectual property, and digitize the processes of the state, reducing costs while improving the quality of the services provided. These are the reforms the public administration needs and not further tax increases or wage and pension restraints. The tax legislation is important to be stable in order for investors to be able to predict the outcomes of their investments in a market friendly environment, where corruption is not the rule but the exception. Greece needs foreign investors with respect to the institutions and the law, and not investors who try to benefit from the complicated and deficient regulatory context.

Regarding *Research and Development*, the public as well as the private expenditures need to be increased, along with a long-term strategic approach to R&D. Considering the national comparative advantages, the developments in specific Greek industries with growth potential, and the global state of technological affairs, the Greek government in cooperation with the market and the academia, needs to develop a longstanding strategy for R&D, accompanied with increased public and private investments. Additionally, the establishment of agencies for research and innovation is already being realized, such as Hellenic Foundation for Research and Innovation (HFRI), and we recommend that it should be complemented with other relevant institutions that promote and support the transition to a knowledge-based economy. These new institutions should concentrate on conducting and combining basic and applied research, specializing in the fields with strategic relevance and potential for the Greek economy. Strong connections of these research agencies need to be set, in forms of clusters comprised of them, universities, start-ups and bigger firms. Finally, the Greek researchers who leave the country should be motivated and encouraged to stay in Greece and stop the "brain drain". For that, policy makers need to remove the regulatory barriers to conduct high-quality independent research, and provide higher salaries, competitive to those provided by the institutes in innovation-driven economies in Europe and the United States.

*Education* is the foundation for a prosperous future in any country. For Greece, reforming education should mean a focus on technical training, STEM (Science, Technology, Engineering and Mathematics) and practical occupations, in order to increase the effectiveness of its connection with the market and what it needs at its current state. Technical skills will be conducive not only to filling market gaps, but also to turning technology into business. Entrepreneurship needs to be introduced from the primary level of education, aiming for a big cultural change, and in the tertiary level, Greece needs to catch up with the "Entrepreneurial University" wave that has been occurring the last decade in many advanced economies. Finally, high-tech start-ups need to be developed, supported, and promoted by the university, which in turn will remain connected with the talented workforce, and collaborate in research projects.

With respect to *financing*, funding access and instruments were poor in the Greek economy during these difficult crisis years. However, it remains the most important element for supporting the innovative research or commercialization projects of prospective innovators and entrepreneurs. Increased R&D investments and foreign venture capital are necessary to strengthen the funding environment of the Greek Innovation System and increase the available instruments. This will be realized through the appropriate legislative interventions, which concern the complication and effect of the tax system, the speed of the justice system, and the stability of the political environment. Research grants, tax guarantees for startups, high absorption of European grants,

and tax incentives for companies to conduct R&D activities are some of the policies that could be implemented to enhance financing for the Greek NIS. Finally, regarding the venture capital market, the Equifund project needs to be more successful than the JEREMIE project, in order to support startups not only financially but also in other fields, such as networking, experienced workforce transferring, and commercialization strategies. The Greek NIS will advance in partnership with the Greek venture capital market, and therefore attraction of foreign experience in this field could be decisive, particularly from the Greek diaspora in London and Silicon Valley.

In order to benefit from the Greek diaspora at the highest possible extend, the *networking* activities of the Greek NIS should be enhanced inside and outside the country. Firstly, inside the Greek territory, the cluster development as explained above requires relocation of research organizations, development of new institutes of basic and applied research, and strong communication between them for greater knowledge spillover and sharing. In addition, the development of research institutes that will give access to SMEs in order to translate basic research into applied research, or commercial and marketable products. Intermediaries like consultant agencies, incubators or accelerators, and national contact points, can contribute to the stronger interaction between the three "helixes". Universities, firms, and the government have to collaborate in a supportive and inclusive environment.

Last but not least, *society* is the context in which the NIS will prosper or fail. The general societal attitude towards entrepreneurship, innovation, and science, is a significant element for the success of a NIS, and in Greece this attitude is not conducive. This is due to many historical, cultural, and geographical reasons that have shaped and changed Greek society during the last 2500 years, especially the last five centuries during the Ottoman empire, and thus difficult to experience a quick change. However, policy makers along with pertinent societal actors can create and diffuse to the whole society a new vision for the future of Greece, a different perspective on science-based entrepreneurship and innovation. Consequently, a supportive environment to innovative entrepreneurship will be created, "brain gain" may become the new normal, and new foreign talent may be attracted that can accelerate the transition to an innovation-driven economy. In turn, this process can lead to attraction of foreign capital investments into innovative projects, ultimately creating economic growth. Finally, "fear of failure" and risk-aversion should be fought by the government, through reducing the actual cost of failure in a start-up and changing the societal attitude towards failure, embracing the Silicon Valley concepts on failure like "fail fast" and "second chance".

As explained previously, "Fear of Failure" is not only a Greek phenomenon, but also a European one. Therefore, the Greek government should align its pertinent policies with the EU initiatives, such as FACE (Failure Aversion Change in Europe) and the "LIFE" project (Learning Incrementally from Failed Entrepreneurship). The FACE campaign, managed by the Spanish firm Secuoya Group, actively encourages mostly ICT entrepreneurship by dealing with the emotional side of starting a business, through sharing stories of founders who succeeded after facing several failures during their journey. As most of them have argued so far, fear is normal, but it should be understood, embraced, and overcome by perceiving failure as a learning process that facilitates future success (Martínez, 2016). The "LIFE" project is supported by a consortium of 15 EU organizations, such as Tech.eu, aiming to change the perception we, Europeans, have on failure, and transform a taboo to an understood normality, utilizing the power of storytelling. In Europe, we should witness a change of paradigm regarding failure and ambition, through the promotion of the appropriate role models. Robin Klein, the pioneer of early-stage tech investments in Europe, stated in one of his articles in TechCrunch: "It has often been said that Silicon Valley is not a place, rather a state of mind; a state of mind that celebrates ambitious innovation, coupled with a healthy disregard for fear of failure". And to conclude with a phrase from Winston Churchill: "Success is not final, failure is not fatal; it is the courage to continue that counts".

## 7.7. Chapter Conclusion

After providing evidence for the Secular Stagnation of TFP growth, the slowdown of Labor productivity, and the profit rate reduction due to sluggish demand and decreased capacity utilization that leads to lower investments in R&D and innovation, we focused on the development of an effective National innovation System for Greece. In the previous chapter, we presented a brief literature review on the concepts, and throughout this

chapter the pertinent characteristics of the Greek economy and innovation system. Initially, we focused on the industrial environment and the industries with growth potential, as well as the effect of education and research on economic and TFP growth. Then, we presented an assessment of the Greek Innovation system, by exploring the strengths and weaknesses of its sub-systems. We observed the problematic issues that need to be solved and then we directed our attention towards an optimistic part of this system, the Greek high-tech Startup ecosystem.

After presenting the current situation and the future potential, we concluded with policy recommendations for the Greek government on productivity and innovation, as well as strategic recommendations for the Greek Innovation system. More specifically, we suggested that the Greek government should incentivize activities and technologies in particular fields, such as basic and fabricated materials, expand the comparative advantage base of the country, invest labor and capital into creating an export-oriented entrepreneurial productive system, a strong education system emphasizing on entrepreneurship, reduce regulatory and administrative procedures, establish a single institution dedicated to productivity, and align the financial environment with the NIS. For the Greek Innovation system, we strongly recommended a permanent national consensus on the future strategy, including every stakeholder. Regarding the particular subsystems, we recommended improvement and simplification of the overregulated business environment and legislation, increase in public and private R&D investments along with the appropriate for Greece long-term R&D strategy, focus of education on technical training, STEM fields and support of entrepreneurship, strengthening of the financing environment (R&D investments and venture capital) through simplifying the tax and justice system as well as stabilizing the political environment, enhancement of networking activities especially for the diaspora, and eventually creation of a supportive society to innovative entrepreneurship through fighting risk-aversion and “fear of failure”.

If the Greek economy manages to escape the current state of decline and increase its innovative capacity, the vicious cycle of decline in which it is trapped will become a virtuous one, by rising exports that lead to higher demand, increased utilization, and thus profit rate. Also, as the derived equations in the previous chapters illustrate, productivity will raise wages without firm profits being adversely influenced, and higher wages will lead to higher domestic demand. Therefore, the focus on innovation and productivity will be stepping stone, and reverse the negative feedback scheme. The two parts of this study are interconnected through the positive feedback mechanism that will be created, through qualitative changes in institutional, legal, and social dimensions, which will in turn influence the quantitative aspect of the macroeconomic equations utilized in the first chapters.

# Chapter 8: Conclusion

*"The line it is drawn*
*The curse it is cast*
*The slow one now*
*Will later be fast*
*As the present now*
*Will later be past*
*The order is*
*Rapidly fadin'*
*And the first one now*
*Will later be last*
*For the times they are a-changin'"*

*Bob Dylan*

## 8.1. Conclusion and Discussion

Following the collapse of the U.S. financial system due to the housing market bubble, the Global Financial Crisis hit Europe, and still the economies of the "sick periphery" have not been able to totally recover. Especially Greece, is trapped into this crisis for more than a decade, and after three adjustment programmes and €293 billion in financial assistance, is still trying to recover and reach its economic condition before 2008. However, the political, media, and economic environment was not conducive to this recovery, and the decline in output also before the crisis demonstrates that we need to investigate signs of long-term stagnation, secular stagnation. Total Factor productivity is a source of output growth, and therefore we concentrated the purpose of this project onto providing evidence on whether there has been secular stagnation of TFP growth in the Greek economy.

Initially, in the 2nd chapter, we provided some important macroeconomic, historical, and political factors for the modern Greek economy. Decisive events and significant names that created the basis for the current difficult situation were presented, along with graphs for output growth, and output share for the Greek industrial sectors, after the appropriate classification. All the calculations were based on data from EU KLEMS, which covered the period from 1995 to 2014. *Output growth has been declining* since then in almost all sectors, except Agriculture and Mining. Graphs with similar declining tendencies were presented next, regarding labor productivity growth and employment share. *Long-term stagnation of productivity* was observed in the Manufacturing, Services, and Other sectors, whereas changes in employment share between sectors were noticed, mostly from the generally dynamic to the less dynamic sectors. Thereafter, we demonstrated the movements of Final Demand, focusing on its dramatic decline after the crisis and the peak it had reached in 2007. During 2012 to 2017, when the 2nd and 3rd bailout agreement programs were implemented, a slightly increasing tendency was observed. With these findings, we then focused on investigating whether secular stagnation of TFP growth exists in the Greek economy.

After presenting the respective debate and presenting several definitions on secular stagnation in an economy, we utilized the concept as described by Storm, based on which secular stagnation is a state in which there is long-run slowdown of TFP growth, roughly for a period of 25 years. We showed that TFP growth can be defined as (i) Solow's Residual, (ii) Weighted Average Factor Productivity growth, and (iii) Weighted Average Factor

payment growth. Then, we provided a literature review on the contribution of TFP growth in the Greek economy, we explained the three growth accounting methodologies, and eventually we presented our results with graphs, in which the red trendline is evidently declining, providing evidence for the long-run slowdown of TFP growth in Greece. The numerical results, given thereafter, provide a more elaborate explanation for the graphs, and lead us to conclude that *there has been secular stagnation of TFP growth in the Greek economy.*

Moreover, Labor Productivity growth is a source of TFP growth, and therefore we focused on its slowdown. Changes in Labor Productivity growth can be decomposed into two components; the within- and between-sector shifts that impact Labor Productivity growth. In the fourth chapter, we focused on this decomposition of Labor Productivity growth in the Greek economy, the determinant of TFP growth. We provided the theoretical background for the Shift-Share analysis to support our findings, and we recalled our findings regarding shifts in Employment Share and the decline in Labor Productivity growth. After presenting the table with our findings, based on calculation with data from EU KLEMS, from 1995 to 2014, we concluded that the *decline in labor productivity growth was due to within-sector productivity slowdown in almost all sectors*, although employment shifts between sectors were also impactful, but with negligible effect on the total decline. We discussed that this outcome is in contrast to the first Baumol implication, based on which the slowdown is a result of employment shifts between sectors. At the end of this fourth chapter, we executed a test on the existence of Baumol's Cost Disease in the Greek economy. After presenting the pertinent data on Real Wage growth, we observed that in the dynamic sectors it was moderately higher than in stagnant, and we concluded that there is *no evidence the "Cost Disease" did occur in the Greek economy.*

Throughout the next chapter, we argued that the observed decline in Final Demand results from lack of technological competitiveness and the increased competition with low-wage countries, such as China. As a result, capacity utilization is decreased and hence the profit rate of Greek firms, which in turn invest less on R&D and innovation to increase their technological competitiveness. This process creates a state of decline, a vicious cycle, from which the Greek economy needs to escape. To provide evidence for this argument, we decomposed the profit rate, especially for manufacturing, after presenting the pertinent equations that support this decomposition. The outcomes of our calculations, presented in the relevant graphs, show that the decreased capacity utilization follows a similar pattern with the profit rate movements. So, *sluggish demand leads to lower capacity utilization, decreased profit rate, and hence reduction of investments in R&D and innovation*. We then presented and discussed the causal scheme that explains this vicious cycle and we concluded with the solutions to escape from this state of decline. The next Greek government should not only revive demand with the appropriate fiscal measures, but also develop *a nationwide, long-term, development strategy for economic growth through innovative entrepreneurship and technological competitiveness*. On this basis, the focus should shift on creating an effective *National Innovation System*.

We therefore directed our attention into the concepts of *National Innovation System and Innovation Management*, which also need to be scrutinized by the next Greek government. In the sixth chapter, we described the conceptual evolution of National Innovation system theory and the key elements of an efficient NIS. We also added a brief literature review on their implementation, observing some limitations regarding their quantified outcomes. We then scrutinized the concepts of the *Triple Helix Model theory and the "Entrepreneurial University"*, which comprise the state-of-the-art, as far as the global transformation of traditional education is concerned. Both the National Innovation System and Triple helix Model theories include consist of the universities, the government, and the firms. Having discussed the former two, we presented an enterprise perspective on Innovation Management, in order to provide the Greek private sector with the necessary theoretical tools to enhance their technological competitiveness and innovation activities. This theoretical chapter gave us the necessary foundation to dive into the Greek Innovation System, its strengths and weaknesses, opportunities and threats, and provide the respective policy-makers with the appropriate policy recommendations for a new, efficient, and sustainable National Innovation System, taking the country away from the vicious cycle of decline, in which it is trapped.

Subsequently, the final chapter regarded *the Greek innovation System*. Firstly, we briefly described the industrial environment as well as the sectors with growth potential at the current situation, and we explored the effect of education and research on economic and TFP growth in the pertinent literature, mostly by Greek researchers. With these initial demonstrations, we dived into the Greek Innovation System, and assessed the strengths and

weaknesses of its sub-systems. Numerous weaknesses along with comparative advantages were observed, and then we focused on its part that gathers the largest share of optimism, the Greek high-tech Startup ecosystem. Having obtained the necessary foundation, we concluded this chapter with *policy recommendations for the Greek government regarding enhancement of productivity and innovative capacity, as well as strategic recommendations regarding the deficiencies of the Greek Innovation system*. Particularly, we recommended that the Greek government should motivate activities and technologies in fields with national comparative advantage or growth potential, such as basic and fabricated materials, and enlarge the comparative advantage base of Greece, by investing labor and capital into the creation of an export-oriented entrepreneurial productive ecosystem. In addition, the education system should be strengthened and support entrepreneurship from the earliest possible levels. Finally, the Greek government should simplify and digitize regulatory and administrative processes, create a single institution dedicated to productivity, and align the financial institutions and stakeholders with the NIS. As far as the Greek Innovation system is concerned, we highly recommended a long-term, nationwide consensus on the future strategy, including every stakeholder, and not being affected by a change in government or other sudden political and economic shocks. In respect of the specific subsystems and their weaknesses, we recommended increase in public and private R&D investments along with a long-term and Greece-oriented R&D strategy, priority of education on technical training, STEM fields and entrepreneurship, encouragement of the funding environment (R&D investments and venture capital) through tax system simplifications and justice system acceleration. Further, the political environment should be stabilized and that is a responsibility for all political parties. The networking activities should also be strengthened to create powerful interactions between the stakeholders, especially including the diaspora. Lastly, the Greek wider public and society in general need to become more supportive to entrepreneurship, more risk-tolerant, and overcome their "fear of failure".

## 8.2. Reflections and Consideration for Future Studies

At this point, we can claim that the four initial objectives of this project were met, and our findings answered the first part of the research question, as well as our theoretical approach answered the second part of it. We argued that the long-term decline of Output growth in Greece was a result of the *secular stagnation of Total Factor Productivity growth in the Greek economy*. Also, the slowdown in Labor productivity growth was due to within-sector decline in the labor productivity of almost all sectors of the Greek economy, and the decrease in capacity utilization due to reduced final demand lead to depressed profit, which in turn adversely affected investments to R&D and innovation. This vicious cycle can be overcome if a long-term strategy regarding the development of an effective National Innovation System is implemented in a nationwide basis. Specific policy recommendations were given in respect of this framework.

Two different approaches were followed. A quantitative and a qualitative one. The former was based on the pertinent macroeconomic equations, while the second on a critical review of the pertinent literature and proposals based on the distinct characteristics and comparative advantages of the Greek Innovation System. There were not any trade-offs between these two approaches, as there is not currently any way to evaluate or measure quantitively the effectiveness of a National Innovation System, according to OECD. However, the qualitative framework is interconnected with the quantitative equations through the causal scheme, presented in the fifth chapter, through which it becomes clear that innovation leads to higher productivity. If the Greek economy becomes successful in the attempt to escape this decline and increase its innovative capacity, the vicious cycle will become a virtuous one, by rising exports that lead to higher demand, increased utilization, and thus profit rate. Also, as the derived equations illustrate, productivity will raise wages without firm profits being affected, and higher wages will result in higher domestic demand. Therefore, the focus on innovation and productivity is the stepping stone, that reverses the negative feedback scheme. The two parts of this study are combined through the positive feedback mechanism that will be created, through qualitative changes in institutional, legal, and social dimensions, which will in turn impact the quantitative aspect of the macroeconomic equations utilized in the first chapters.

However, several limitations were faced during the execution of this project, whose incorporation in future studies pertinent to the same field of study could give more elaborate and justified results. Firstly, the time series data utilized is obtained mostly from the EU KLEMS project and is covering the period from 1995 to 2014. Notwithstanding the fact that there was no particular problem with its data regarding the specific industrial

sectors and its variety, we were limited by the fact that it covered the period after 1995 and not before. As mentioned in the second chapter, the period after the dictatorship in 1974 was characterized by significant changes in the structure of the Greek economy, its innovative capacity, the public debt, and the real wage growth. In order to have a better understanding on the factors that lead Greece to the current situation, a similar analysis starting from 1974 would be really conducive, even though some Greek economists have already presented relevant findings, but with different methodologies as it was observed in our pertinent literature review. Moreover, apart from going further into the past, we could not investigate what happened after 2014, when the 2nd bailout agreement ended, SYRIZA got the power, a political and economic turmoil followed for the first half of 2015, leading to the 3rd memorandum, which lasted for the next three years. This three-year period is essential for our understanding of the memorandum effect in the Greek economy, because we have observed a slight increase in labor productivity at the end of the 2nd memorandum. If this tendency was continued, that would have several implications for the policies suggested to the Greek government by the IMF and the European Union. Although we can still argue on the effectiveness of these programmes, we cannot have the holistic picture of the situation. Future studies could incorporate this data to enrich their results, if provided by EU KLEMS. This is the case not only for the calculation on TFP growth, but also for Labor productivity growth and the decomposition of the profit rate.

In addition, a similar to the above issue was faced with the data regarding Final Demand, that was obtained from the Hellenic Statistical Authority. It covered the period from 1995 to 2014, giving us no insights on the situation during the 1980s and early 1990s, as well as during the implementation of the third memorandum. Furthermore, for our calculations we needed the data for GDP, Final Demand, and Employee Compensation at constant prices, which was not the case with EU KLEMS and the Hellenic Statistical Authority. We had to divide the current price with the price level time series data, which was also obtained from the EU KLEMS database. In addition to the partial completeness of this database, we suggest that more factors and methodologies could be utilized to investigate the productivity and output decline of the Greek economy, as it a complicated field with aspects not only in macroeconomics, but also in political and geopolitical sciences, and of course sociology. As it can be realized by our literature review previously, numerous economists have focused their research on the Greek case, and especially the impact of TFP growth, but there is no study following these three growth accountings as well as covering the whole decade after the crisis, during which three different bailout agreement programmes were implemented, and the Greek economy and society experienced extraordinary changes.

Moreover, the demographic problem is currently the most significant issue the Greek society is facing and should not be ignored by policy-makers. The country is aging, “brain drain” is adversely influencing its productivity, innovative capacity and technological competitiveness, and another vicious cycle is being created, from which it will be even more difficult to escape. Studies on the relation of Labor productivity growth with the aging population could be conducive to scholars and policy-makers researching this field. There have been similar studies, but we suggest that future studies could focus on this phenomenon in Southern Europe, the “sick periphery”. As far as the literature on National Innovation Systems is concerned, the Organization for Economic Co-operation and Development (OECD) has published pertinent studies since the beginnings of this conceptual framework. As mentioned earlier however, OECD argues that there is a measurement problem regarding the development of a NIS, due to the complication and abstraction of the nature of the data needed to measure its implementation and success. R&D expenditure, number of patents, and high technology goods or services could be representative indicators, hut they are not enough. In addition, there is a lack of “comparable approaches” among the countries (OECD, 1996). As a measurement objective, future studies should consider connecting the National Innovation System of a country with its economic performance.

Further, our methodology has been followed also for the Italian economy, providing comparable results. It would be interesting and conducive for the European Union and the national governments to conduct similar studies for countries of the Mediterranean Sea, such as Spain, Portugal, and Cyprus, as well as Ireland, a country strongly hit by the crisis but with a quick and extraordinary recovery to the previous state. Utilization of *System Dynamics, regression analysis,* or other macroeconomic frameworks could also be helpful to a more holistic understanding of the secular stagnation of TFP growth in these economies, as well as through incorporating more impactful factors and dynamic behaviors, such as tax evasion, employment protection legislation, and other social factors. Regression analysis could serve in exploring the relationships between important variables,

and the impact of specific policies. In our case, these methods could serve to investigate the impact of the TROIKA policies during the three bailout programmes, the macroeconomic impact of the frequent changes in government, and numerical estimations on the impact of the Greek Innovation system to the general economic performance. Finally, the increasing competition from low-wage countries has been oftentimes mentioned as a factor for the decrease of final demand in the Greek economy, which is specialized in medium-and low-tech products. China and South Korea are two countries that have recently advanced to gain considerable share of this market, threatening economies with characteristics like the Greek one. They focus on lower prices rather than quality, which is the most important characteristic of the Greek expensive products, and hence adversely affect the Greek export performance. Future studies on this field could be conducive, if not necessary, for European and in particular Mediterranean policy-makers.

A significant consideration on the policy proposals we suggested in the previous chapter should be the way in which these policies will be aligned with the economic and technological environment, in which the analysis was executed. We should recognize the larger environment and accept that the EU factor and context ultimately determines the success or failure of these policies and strategies. More specifically, recovery of demand, development of an effective National Innovation System, investments in education and research, are policies that need to be aligned with the EU financial environment. Taking into consideration the austerity programmes that were implemented in the recent years, and are still being advocated by various proponents in several member states, we should be conscious of the difficulties that will arise, when the new Greek government reaches the negotiation table. However, the EU creditors and pertinent institutions will be persuaded to fund such policies, as long as they realize that the New Democracy government is honestly eager to pursue the long-desired and highly necessary reforms, that will lead to less bureaucracy, and a convergence of the Greek state with the rest of the advanced EU member states. The constraints on Greek public spending may become looser, as long as the Greek stakeholders take initiatives to change, without the need of a memorandum program.

As far as the alignment with the EU context is concerned, a Green New Deal for Europe could provide a determinant foundation for "mission-oriented public investment" in the Greek economy as well. This idea is not new, even though through the last European elections, it was once again brought forward in a powerful way. In the 1930s, the original New Deal was brought into effect by President Franklin D. Roosevelt, aiming to recover the American economy following the Great Depression. It was based on the "3Rs": Reform of the financial system, Relief for the poor, and recovery of the economy. As modern European proponents claim: "we're trying to marry that language with existing programs to kick-start the economy and address the climate emergency". The Green New Deal for Europe could be viewed as the continuation of the "Juncker Plan" of 2015, known as the European Fund for Strategic Investments (EFSI). In particular, this Green New Deal suggests that 5% of the European GDP to be invested in emission-free transportation infrastructure, renewable energy and other pertinent innovative technologies, while at the same time creating jobs for highly educated individuals as well as contributing to the transition of Europe into a zero-emission economy without raising taxes. The Green New Deal for Europe provides member states with one solution to the economic pressure created by the past decade of austerity, and is closely linked with the Greek economy, due to its significant comparative advantages stemming from its climate and geographical location. Political will and a mature society are the prerequisites for such an ambitious task to fight climate change and transform the dangerous anger towards the EU establishment into a creative endeavor that will facilitate further economic and political convergence.

Regarding the permanent nationwide consensus that is necessary for the establishment of an effective and sustainable NIS, we should recognize the difficulties that will arise due to the current state of affairs in the Greek society and political scene. The society is divided, and polarization is high, especially since the tumultuous summer of 2015. Since the late 1970s, the party-based polarization of PASOK and New Democracy was the main axis of political rivalry in the Greek political system(Andreadis & Stavrakakis, 2019). This lasted till the end of last decade, when the crisis hit the country. In 2009, polarization retreated due to an ideological convergence between these two parties towards the center, and the emergence of a new political terrain, comprised of radical actors, such as the right-wing Golden Dawn, and the Coalition of the Radical Left, SYRIZA, which eventually gained power in 2015. Political debate is still intense and polarization high, but the development of the National Innovation System should be perceived in a similar way with the National Defense, and hence not become polarized. The national strategy on technology and innovation should be a politically

polarized issue. Scholars and thought leaders in the field of political polarization have proposed a non-exhaustive list of solutions to this problem, with the most relevant to the Greek case being the following: Reform of the election process, proportional representation, increased voter turnout, improved voter knowledge, and encouragement of voter respect for differing perspectives through the necessary communication activities (Persily, 2015).

Finally, as far as the definitions we utilized to estimate TFP growth are concerned, we will now take a closer look at the second and third definitions, as they are more relevant because they are measurable. We observe that TFP Growth is defined as Factor Productivity Growth or as Factor Payments Growth. Both of these definitions describe actually what economists call TFP growth, because we can actually directly measure TFP growth through labor and capital productivity, real wages and profits. Consequently, when we show that there is a slowdown in TFP growth as it is the case for the Greek economy, it is labor productivity that actually goes down as well as the growth of real wages goes down. Therefore, two factors are driving down TFP growth, and these two factors must be related, creating a long-standing debate in economics. Why are these two factors going down, influencing also TFP growth, at the same time?

The standard neoclassical assumption suggests that technological change is exogenous, and hence any change in labor productivity is exogenous. As a result, real wages adjust. When labor productivity goes down, real wages in profit-maximizing firms should go down, and this is how real wages are determined based on the neoclassical assumptions. On the other view that was firstly put forward by Marx, if wages increase through union initiative, firms will respond by cutting labor input, and increased productivity, a theory known as Marx-biased technical change. In this perspective, wages are exogenous and determined in a wage bargaining process between the unions and the firms. So, real wage growth is determined through this process. There is an interesting question regarding this topic, and the honest answer is probably that both explanations are correct. If wages increase, firms will respond, and if productivity increases the same will occur.

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# Appendix A: Classification of Industrial Sectors

KLEMS is an acronym comprised of K-capital, L-labor, E-energy, M-materials, and S-services. It is a European Union funded project, aiming to build a database on economic growth, technological change, capital formation, productivity, and employment creation at the industry level for all EU members since 1970. It is consisted of input measures on capital, labor, energy, material and service. For Greece, provided starts from 1995 and ends in 2014. We used this data for the Greek economy, to calculate TFP growth based on the three growth accounting methods, labor productivity Growth, and other pertinent growth rates. The industrial sectors included are the following:

1. Agriculture, Hunting, Forestry, and Fishing
2. Mining and Quarrying
3. Manufacturing (Total)
4. Electricity, Gas, and Water Supply (Utility)
5. Construction
6. Wholesale and Retail Trade
7. Hotels and Restaurant
8. Transport, Storage, and Communication
    - Transport and Storage
    - Post and Telecommunication
9. Financial Intermediation
10. Real Estate, Renting, and Business Activities
    - Real Estate Activities
    - Renting and Other Business Activities
11. Community, Social, and Personal Services
    - Public Administration, Defense, and Compulsory Social Security
    - Education
    - Health and Social Work
    - Other Community, Social, and Personal Services
    - Private Households with Employed Person
    - Extra-Territorial Organizations and Bodies

We classified these industrial sectors for the Greek economy, based on the classification by the U.S. Bureau of Economic Analysis (BEA), because we followed its method regarding the growth accounting. The ten classified industrial sectors are the following:

1. Agriculture and Mining
2. Utilities and Construction
3. Manufacturing
4. Wholesale, Retail, and Transportation (WRT)
5. Information
6. Finance Intermediation and Real Estate (FIRE)
7. Professional Business Services (PBS)
8. Educational Services, Healthcare, and Social Assistance
9. Art, Entertainment, Recreation, Food Services, and Other Services
10. Government

Utilizing the BEA classification, we can better concentrate on the industries that had the most significant changes and influence on the Greek economy since 1995. Below, the table presents this classification process.

| KLEMS Classification | BEA Classification | Adjusted KLEMS Classification |
|---|---|---|
| *Agriculture, Hunting, Forestry, and Fishing* | Agriculture and Mining | Agriculture: Agriculture, Hunting, Forestry, and Fishing<br>Mining: Mining and Quarrying |
| *Mining and Quarrying* | Utilities and Construction | Utilities: Electricity, Gas, and Water Supply<br>Construction: Construction |
| *Manufacturing (Total)* | Manufacturing | Manufacturing (Total) |
| *Electricity, Gas, and Water Supply (Utility)* | Wholesale, Retail, and Transportation (WRT) | Wholesale, Retail, and Transportation (WRT) |
| *Construction* | Information | Post and Telecommunication |
| *Wholesale and Retail Trade* | Finance Intermediation and Real Estate (FIRE) | Finance Intermediation and Real Estate (FIRE) |
| *Hotels and Restaurant* | Professional Business Services (PBS) | Professional Business Services (PBS) |
| *Transport, Storage, and Communication* | Educational Services, Healthcare, and Social Assistance | Educational Services, Healthcare, and Social Assistance: Education Health and Social Work |

| KLEMS Classification | BEA Classification | Adjusted KLEMS Classification |
|---|---|---|
| *Financial Intermediation* | Art, Entertainment, Recreation, Food Services, and Other Services | Art, Entertainment, Recreation, Food Services, and Other Services: Hotels and Restaurant Other Community, Social, and Personal Services, Private Households with Employed Person, Extra-Territorial Organizations and Bodies |
| *Real Estate, Renting, and Business Activities, Real Estate Activities Renting and Other Business Activities* | Government | Government<br>Public Administration, Defense, and Compulsory Social Security |

# Appendix B: TFP Growth Accounting Method and Results

Based on the three growth accounting methods we used for the purpose of this study, we used the time series data from the EU KLEMS project concerning the Greek economy, from 1995 to 2014. The three methods that we used to answer whether secular stagnation of TFP growth existed in the Greek economy are *Solow's Residual, Weighted Average Factor Productivity, and Weighted Average Factor Payment*. The necessary input measures for these calculations are the following and are described below the table:

| INPUT MEASURES | UNITS | EU KLEMS ABBREVIATION |
|---|---|---|
| *GDP AT FACTOR COST CURRENT PRICE* | Millions (Euro) | VA |
| *GDP AT FACTOR COST CONSTANT PRICE* | Millions (Euro) | - |
| *COMPENSATION OF EMPLOYEES* | Millions (Euro) | COMP |
| *HOURS WORKED* | Thousands (Hours) | H_EMPE |
| *NUMBER OF EMPLOYEES* | Thousands (People) | EMPE |
| *NET REAL CAPITAL STOCK* | Billions (Euro) | Kq_GFCF |

The definition of *GDP at Factor Cost* by Eurostat is "the gross income from operating activities after adjusting for operating subsidies and indirect taxes". *VA (Value Added)* is the EU KLEMS abbreviation and is used to express GDP as the total gross value added, including capitalized production, asset turnover, stock movements minus acquisitions of products and deductive taxes. For this project, we used the VA data from EU KLEMS, ranging from 1995 to 2014, measured in millions of Euro. We also translated *Current Price to Constant Price*, that is the value observed when considering inflation to the value observed if inflation is not considered. Regarding the *Compensation of Employees, or COMP* as expressed in the EU KLEMS database, it is defined by ESA 2010 as "the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter during the accounting period". It is calculated by the wages and salaries, along with

the social contributions of the employer. We used the data for Greece provided by EU KLEMS, ranging from 1995 to 2014, and measured in millions of Euro.

*Hours Worked* is defined by Eurostat as "the number of hours actually worked, the sum of all periods spent on direct and ancillary activities to produce goods and services". We used the pertinent data for Greece from the EU KLEMS project, ranging from 1995 to 2014, and measured in thousands of hours. The *Number of Employees* is defined by Eurostat as "the number of people engaged in productive activities in an economy and includes both employees and the self-employed". The data for Greece is also obtained from the EU KLEMS project, ranging from 1995 to 2014, and measured in thousands of people. Finally, the *Net Real Capital Stock* is defined by Eurostat as "the value of all fixed assets still in use, including produced assets that are used repeatedly or continuously in the production process for more than a year". For our calculations, we obtained the relevant data for the Greek economy from EU KLEMS, ranging from 1995 to 2014, and measured in billions of Euros. Using the time series of these variables, we calculated the growth rates for the variables needed to calculate TFP growth, based on the three following equations, as explained in the respective chapter. The table below presents the numerical results.

(8) $$\hat{A} = \hat{x} - \emptyset\hat{L} - (1 - \emptyset)\hat{K}$$

(9) $$\hat{A} = \emptyset\hat{\lambda} + (1 - \emptyset)\hat{\kappa}$$

(13) $$\hat{A} = \emptyset\hat{w} + (1 - \emptyset)\hat{r}$$

*TFP Growth Based on Solow's Residual (percentage)*

*Part 1*

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 1,14 | 2,27 | 0,87 | -2,34 | 0,32 | 0,40 | 0,38 | 1,94 | 1,71 | -1,87 |
| *AGRICULTURE AND MINING* | -2,33 | -1,74 | 1,35 | -0,58 | -2,82 | -2,35 | -2,80 | -0,71 | 1,20 | 12,28 |
| *UTILITIES AND CONSTRUCTION* | 3,28 | 3,46 | 3,50 | 8,52 | 1,95 | -1,15 | 0,19 | 19,39 | 7,48 | -16,39 |
| *MANUFACTURING* | -5,62 | -1,00 | 0,04 | 3,48 | -0,52 | 5,52 | 4,31 | 2,63 | -2,33 | -1,80 |
| *WRT* | -0,95 | -0,22 | -8,46 | -4,97 | 3,42 | -11,76 | -8,02 | 1,98 | 1,88 | -4,46 |
| *INFORMATION* | -0,52 | 11,35 | 0,57 | 11,81 | 0,84 | 2,06 | 3,74 | 0,29 | 6,03 | 2,65 |
| *FIRE* | 2,80 | 0,45 | 2,05 | -7,99 | -0,71 | -1,50 | 3,09 | -5,70 | 1,45 | 2,27 |
| *PBS* | -3,43 | -6,86 | -10,56 | -8,98 | -17,58 | -9,51 | 2,04 | -0,33 | -5,76 | -16,83 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | -1,77 | -3,47 | 4,64 | -10,95 | -1,79 | 8,85 | -2,19 | -4,26 | -4,42 | -5,86 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | -0,84 | 0,65 | 0,37 | -8,30 | -3,02 | 4,54 | 1,90 | -2,90 | 1,83 | 8,21 |
| *GOVERNMENT* | 0,00 | 4,96 | -0,79 | -0,59 | -1,27 | -1,35 | -6,37 | 6,17 | -1,18 | -2,84 |

*TFP Growth Based on Solow's Residual (percentage)*

*Part 2*

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | -0,21 | -0,78 | -2,80 | -4,14 | -3,28 | -4,18 | -3,41 | -1,73 | 1,00 |
| *AGRICULTURE AND MINING* | -31,45 | -13,89 | -3,36 | 1,82 | 3,56 | 0,46 | 13,38 | -4,93 | 4,91 |
| *UTILITIES AND CONSTRUCTION* | 26,64 | -15,26 | -24,93 | 7,32 | -5,16 | -1,57 | 8,94 | -28,66 | -9,85 |
| *MANUFACTURING* | -1,28 | 3,02 | -10,00 | -3,61 | -8,94 | -1,26 | -3,13 | 5,06 | 0,11 |
| *WRT* | -11,76 | -3,76 | -4,12 | -10,68 | -3,69 | -8,81 | -12,23 | -7,28 | 9,03 |
| *INFORMATION* | 10,20 | 3,42 | -0,17 | 1,32 | -10,72 | -9,78 | -11,44 | 5,90 | -11,28 |
| *FIRE* | -6,71 | 8,73 | 8,73 | 0,04 | 7,86 | -5,44 | -0,84 | 1,79 | 2,01 |
| *PBS* | 7,17 | -6,71 | -12,54 | -11,08 | -18,91 | -4,05 | -4,74 | -7,99 | -4,25 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,39 | 2,52 | -0,02 | -7,31 | 3,09 | 1,04 | -12,84 | -1,66 | 3,01 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 1,70 | 0,17 | 2,67 | -10,43 | -15,86 | -8,58 | 6,31 | 17,24 | -0,08 |
| *GOVERNMENT* | 0,69 | 1,15 | -1,53 | 3,16 | 1,01 | 1,86 | 5,10 | -3,61 | 2,01 |

*TFP Growth Based on Weighted Average Factor Productivity (percentage)*

*Part 1*

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 1,14 | 2,27 | 0,87 | -2,34 | 0,32 | 0,40 | 0,38 | 1,94 | 1,71 | -1,87 |
| *AGRICULTURE AND MINING* | -2,33 | -1,74 | 1,35 | -0,58 | -2,82 | -2,35 | -2,80 | -0,71 | 1,20 | 12,28 |
| *UTILITIES AND CONSTRUCTION* | 3,28 | 3,46 | 3,50 | 8,52 | 1,95 | -1,15 | 0,19 | 19,39 | 7,48 | -16,39 |
| *MANUFACTURING* | -5,62 | -1,00 | 0,04 | 3,48 | -0,52 | 5,52 | 4,31 | 2,63 | -2,33 | -1,80 |
| *WRT* | -0,95 | -0,22 | -8,46 | -4,97 | 3,42 | -11,76 | -8,02 | 1,98 | 1,88 | -4,46 |
| *INFORMATION* | -0,52 | 11,35 | 0,57 | 11,81 | 0,84 | 2,06 | 3,74 | 0,29 | 6,03 | 2,65 |
| *FIRE* | 2,80 | 0,45 | 2,05 | -7,99 | -0,71 | -1,50 | 3,09 | -5,70 | 1,45 | 2,27 |
| *PBS* | -3,43 | -6,86 | -10,56 | -8,98 | -17,58 | -9,51 | 2,04 | -0,33 | -5,76 | -16,83 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | -1,77 | -3,47 | 4,64 | -10,95 | -1,79 | 8,85 | -2,19 | -4,26 | -4,42 | -5,86 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | -0,84 | 0,65 | 0,37 | -8,30 | -3,02 | 4,54 | 1,90 | -2,90 | 1,83 | 8,21 |
| *GOVERNMENT* | 0,00 | 4,96 | -0,79 | -0,59 | -1,27 | -1,35 | -6,37 | 6,17 | -1,18 | -2,84 |

*TFP Growth Based on Weighted Average Factor Productivity (percentage)*

*Part 2*

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | -0,21 | -0,78 | -2,80 | -4,14 | -3,28 | -4,18 | -3,41 | -1,73 | 1,00 |
| *AGRICULTURE AND MINING* | -31,45 | -13,89 | -3,36 | 1,82 | 3,56 | 0,46 | 13,38 | -4,93 | 4,91 |
| *UTILITIES AND CONSTRUCTION* | 26,64 | -15,26 | -24,93 | 7,32 | -5,16 | -1,57 | 8,94 | -28,66 | -9,85 |
| *MANUFACTURING* | -1,28 | 3,02 | -10,00 | -3,61 | -8,94 | -1,26 | -3,13 | 5,06 | 0,11 |
| *WRT* | -11,76 | -3,76 | -4,12 | -10,68 | -3,69 | -8,81 | -12,23 | -7,28 | 9,03 |
| *INFORMATION* | 10,20 | 3,42 | -0,17 | 1,32 | -10,72 | -9,78 | -11,44 | 5,90 | -11,28 |
| *FIRE* | -6,71 | 8,73 | 8,73 | 0,04 | 7,86 | -5,44 | -0,84 | 1,79 | 2,01 |
| *PBS* | 7,17 | -6,71 | -12,54 | -11,08 | -18,91 | -4,05 | -4,74 | -7,99 | -4,25 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,39 | 2,52 | -0,02 | -7,31 | 3,09 | 1,04 | -12,84 | -1,66 | 3,01 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 1,70 | 0,17 | 2,67 | -10,43 | -15,86 | -8,58 | 6,31 | 17,24 | -0,08 |
| *GOVERNMENT* | 0,69 | 1,15 | -1,53 | 3,16 | 1,01 | 1,86 | 5,10 | -3,61 | 2,01 |

*TFP Growth Based on Weighted Average Factor Payment (percentage)*

*Part 1*

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 1,15 | 2,24 | 0,83 | -2,25 | 0,33 | 0,39 | 0,50 | 1,88 | 1,68 | -1,79 |
| *AGRICULTURE AND MINING* | -2,20 | -1,64 | 1,35 | -0,45 | -2,69 | -2,10 | -2,34 | -0,54 | 1,78 | 23,86 |
| *UTILITIES AND CONSTRUCTION* | 3,24 | 3,43 | 3,43 | 8,40 | 1,95 | -1,08 | 0,73 | 20,99 | 7,50 | -13,05 |
| *MANUFACTURING* | -4,87 | -0,22 | 0,08 | 3,90 | -0,29 | 6,24 | 4,76 | 2,74 | -2,26 | -1,63 |
| *WRT* | -0,77 | -0,06 | -7,01 | -4,15 | 3,60 | -9,93 | -6,22 | 1,99 | 1,85 | -3,85 |
| *INFORMATION* | 1,14 | 11,37 | 0,53 | 13,58 | 1,48 | 2,34 | 4,04 | 1,07 | 6,20 | 2,85 |
| *FIRE* | 2,96 | 0,56 | 2,03 | -7,60 | -0,63 | -1,45 | 3,13 | -5,46 | 1,44 | 2,21 |
| *PBS* | -2,52 | -5,79 | -8,97 | -7,95 | -15,07 | -6,60 | 1,93 | 0,59 | -5,05 | -14,62 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | -1,59 | -2,16 | 4,71 | -9,72 | -1,27 | 9,47 | -1,97 | -3,79 | -3,93 | -4,96 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | -0,79 | 0,66 | 0,38 | -7,74 | -2,63 | 4,73 | 3,33 | -2,81 | 1,80 | 8,25 |
| *GOVERNMENT* | 0,05 | 5,32 | -0,77 | -0,52 | -1,08 | -1,31 | -6,16 | 6,16 | -1,04 | -2,78 |

*TFP Growth Based on Weighted Average Factor Payment (percentage)*

*Part 2*

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | -0,19 | -0,74 | -2,71 | -4,01 | -3,12 | -4,35 | -3,41 | -1,62 | 1,01 |
| *AGRICULTURE AND MINING* | -23,54 | -13,50 | -3,17 | 2,03 | 3,98 | 0,50 | 14,43 | -4,89 | 5,06 |
| *UTILITIES AND CONSTRUCTION* | 28,05 | -13,44 | -21,61 | 8,84 | -3,63 | 0,06 | 12,95 | -23,13 | -9,25 |
| *MANUFACTURING* | -1,15 | 2,97 | -9,56 | -2,27 | -7,41 | -0,80 | -1,71 | 6,33 | 0,14 |
| *WRT* | -10,17 | -3,33 | -3,85 | -9,98 | -2,62 | -9,10 | -12,72 | -7,30 | 9,73 |
| *INFORMATION* | 18,03 | 3,63 | 0,04 | 1,95 | -8,20 | -9,80 | -9,64 | 6,48 | -11,17 |
| *FIRE* | -6,28 | 8,34 | 8,60 | 0,06 | 8,68 | -5,51 | -0,56 | 1,84 | 2,17 |
| *PBS* | 7,04 | -5,28 | -10,59 | -10,22 | -4,68 | -3,65 | -4,67 | -8,16 | -2,96 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,43 | 2,52 | 0,00 | -7,30 | 3,56 | 1,10 | -12,41 | -1,67 | 3,06 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 1,69 | 0,31 | 2,58 | -9,12 | -15,42 | -8,71 | 6,78 | 19,60 | 0,08 |
| *GOVERNMENT* | 0,66 | 1,13 | -1,48 | 3,45 | 1,48 | 2,00 | 5,46 | -3,54 | 2,25 |

# Appendix C: EU KLEMS Time Series Data after Classification

*GDP at Factor Cost Current Price in Millions (source: EU KLEMS)*

*Part 1*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 135470,7 | 145797,4 | 160513,3 | 174773,1 | 178820,5 | 193047 | 205266,8 | 213818,9 | 212390,9 | 199643,7 |
| *AGRICULTURE AND MINING* | 7251,7 | 7215,4 | 7631,8 | 7949,5 | 8197,3 | 8257,3 | 8525,9 | 8809,6 | 9687,6 | 9067,7 |
| *UTILITIES AND CONSTRUCTION* | 7644,6 | 8620,5 | 9683,3 | 11061 | 12371,1 | 12492,3 | 13688,8 | 15039,2 | 19585,8 | 21681,3 |
| *MANUFACTURING* | 10222,1 | 10387,2 | 10417,3 | 11259,9 | 12759 | 13408,1 | 15126,8 | 16077,9 | 16378,4 | 16942,7 |
| *WRT* | 18505,8 | 21026,7 | 23260,2 | 24535,4 | 25928 | 28491,4 | 28060,9 | 29101,5 | 33093,3 | 35757,7 |
| *INFORMATION* | 3198,1 | 3667,8 | 4444,7 | 4988,2 | 5731 | 5447 | 6024,6 | 6659,8 | 6630,5 | 7234 |
| *FIRE* | 13136,1 | 15258,3 | 16947,6 | 18796,9 | 18316,7 | 19714,9 | 20233,2 | 22697,8 | 23679,1 | 26292,1 |
| *PBS* | 3978 | 4332,2 | 4904,5 | 5501,4 | 6110 | 6070,9 | 6549,7 | 7655,5 | 8862,3 | 9942,2 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 7103,6 | 7793 | 9019,3 | 10621,5 | 10993,9 | 11407,2 | 13478,4 | 15328,9 | 16135,7 | 18269,5 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 7014,4 | 8044,9 | 9103,1 | 10075,9 | 10178,5 | 10708 | 12841,2 | 12740,7 | 13573,6 | 14930,7 |
| *GOVERNMENT* | 6624,8 | 6930,1 | 8025,3 | 8634 | 9375,2 | 10184,3 | 10941,2 | 11686,5 | 12887 | 14655,2 |

*GDP at Factor Cost Current Price in Millions (source: EU KLEMS)*

*Part 2*

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 77427,5 | 86060,7 | 95805,3 | 105474,2 | 111763,4 | 117924,1 | 126944,8 | 136987,8 | 150825,7 | 165705,4 |
| *AGRICULTURE AND MINING* | 9378,8 | 7790,8 | 7966,4 | 7610,1 | 7439,8 | 7381,5 | 6960 | 6885,6 | 6613,4 | 6691 |
| *UTILITIES AND CONSTRUCTION* | 17523,3 | 24300,8 | 21287,4 | 16500 | 17451,2 | 14036,4 | 11299,9 | 11320,1 | 10421,3 | 9262,1 |
| *MANUFACTURING* | 17107,9 | 18427,2 | 19695 | 20578,3 | 18146,4 | 16356,1 | 16175,2 | 15376,7 | 15250,9 | 14938,5 |
| *WRT* | 36063,3 | 37026,1 | 41107,8 | 44302,9 | 40577,1 | 38935,9 | 35240 | 28994,4 | 26533 | 27721 |
| *INFORMATION* | 7584,1 | 8554,8 | 9027 | 8879 | 9344,9 | 8333,4 | 6926,1 | 5980,6 | 6139,2 | 5639,4 |
| *FIRE* | 29272,3 | 29128,5 | 33544,1 | 37699,3 | 39318,9 | 43137,7 | 40018,6 | 40720,1 | 38624,8 | 36442,5 |
| *PBS* | 10184,8 | 12059,2 | 13341,1 | 13649,1 | 13463,1 | 10593 | 9570,3 | 8682,8 | 7649 | 7558,1 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 19828,1 | 21314,9 | 22754,8 | 24811,9 | 24894,4 | 23238,8 | 21970,1 | 18402,4 | 16690,6 | 17094,3 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 16915,7 | 18103,3 | 18937,9 | 20632 | 19933,8 | 17632,2 | 15316,8 | 15098,7 | 16146,6 | 15889,6 |
| *GOVERNMENT* | 14962,2 | 16341,4 | 17605,3 | 19156,3 | 21821,3 | 19998,7 | 18432,4 | 17517,5 | 16168 | 15950,9 |

*GDP at Factor Cost Constant Price in Millions (source: author; based on EU KLEMS data)*

*Part 1*

| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 2628,86 | 2669,46 | 2777,27 | 2860,83 | 2875,09 | 2768,07 | 2605,13 | 2392,07 | 2243,85 | 2207,03 |
| *AGRICULTURE AND MINING* | 82,80 | 81,39 | 82,39 | 84,12 | 85,60 | 84,22 | 83,81 | 82,41 | 82,83 | 84,65 |
| *UTILITIES AND CONSTRUCTION* | 107,95 | 112,70 | 118,17 | 126,68 | 139,75 | 145,25 | 149,59 | 154,92 | 189,36 | 205,71 |
| *MANUFACTURING* | 153,26 | 146,57 | 147,63 | 153,47 | 168,43 | 172,97 | 189,95 | 200,05 | 204,48 | 199,48 |
| *WRT* | 264,31 | 277,33 | 294,63 | 304,40 | 313,96 | 342,85 | 343,41 | 354,21 | 396,33 | 428,09 |
| *INFORMATION* | 34,94 | 36,97 | 42,74 | 46,20 | 53,04 | 56,12 | 62,19 | 70,79 | 71,82 | 77,77 |
| *FIRE* | 268,38 | 277,31 | 286,36 | 299,35 | 283,54 | 293,67 | 292,13 | 301,83 | 295,90 | 310,95 |
| *PBS* | 83,15 | 89,07 | 93,87 | 97,84 | 98,95 | 92,96 | 94,76 | 102,80 | 112,55 | 120,59 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 167,67 | 174,94 | 177,12 | 198,00 | 188,72 | 190,66 | 214,54 | 222,75 | 222,39 | 234,39 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 139,29 | 142,46 | 149,12 | 157,54 | 151,50 | 152,93 | 162,34 | 174,90 | 174,98 | 183,16 |
| *GOVERNMENT* | 148,09 | 150,01 | 156,39 | 155,96 | 157,28 | 165,75 | 165,23 | 160,05 | 173,03 | 183,27 |

*GDP at Factor Cost Constant Price in Millions (source: author; based on EU KLEMS data)*

*Part 2*

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 1259,09 | 1294,65 | 1347,86 | 1412,76 | 1415,43 | 1467,90 | 1524,56 | 1587,38 | 1651,49 | 1737,70 |
| *AGRICULTURE AND MINING* | 88,29 | 77,20 | 68,46 | 68,13 | 70,38 | 73,82 | 71,35 | 76,58 | 73,31 | 75,85 |
| *UTILITIES AND CONSTRUCTION* | 179,11 | 231,23 | 204,22 | 156,20 | 164,54 | 140,36 | 118,23 | 114,12 | 98,87 | 87,37 |
| *MANUFACTURING* | 201,05 | 200,62 | 210,26 | 197,37 | 188,78 | 163,56 | 152,89 | 141,50 | 140,78 | 135,90 |
| *WRT* | 427,55 | 422,76 | 444,54 | 453,90 | 409,65 | 389,36 | 340,92 | 275,88 | 247,95 | 261,33 |
| *INFORMATION* | 81,52 | 92,93 | 96,17 | 95,99 | 96,86 | 83,33 | 68,26 | 59,94 | 62,65 | 55,70 |
| *FIRE* | 332,49 | 318,15 | 361,34 | 402,05 | 406,30 | 431,38 | 393,89 | 406,60 | 410,79 | 417,42 |
| *PBS* | 118,07 | 135,31 | 143,28 | 143,31 | 135,23 | 105,93 | 95,12 | 87,37 | 76,14 | 73,50 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 244,59 | 252,82 | 260,75 | 261,82 | 242,32 | 232,39 | 222,69 | 188,44 | 180,40 | 186,98 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 197,39 | 205,04 | 207,97 | 221,77 | 205,32 | 176,32 | 158,54 | 160,96 | 180,89 | 181,33 |
| *GOVERNMENT* | 178,71 | 191,68 | 197,56 | 195,48 | 200,52 | 199,99 | 194,48 | 191,52 | 186,98 | 185,56 |

*Labor Income Share (source: author; based on EU KLEMS data)*

*Part 1*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,32 | 0,32 | 0,33 | 0,33 | 0,34 | 0,34 | 0,35 | 0,37 | 0,37 | 0,37 |
| *AGRICULTURE AND MINING* | 0,11 | 0,12 | 0,11 | 0,11 | 0,12 | 0,12 | 0,13 | 0,15 | 0,16 | 0,17 |
| *UTILITIES AND CONSTRUCTION* | 0,28 | 0,28 | 0,27 | 0,28 | 0,27 | 0,27 | 0,28 | 0,32 | 0,26 | 0,24 |
| *MANUFACTURING* | 0,47 | 0,50 | 0,53 | 0,52 | 0,48 | 0,45 | 0,40 | 0,44 | 0,45 | 0,44 |
| *WRT* | 0,22 | 0,22 | 0,22 | 0,25 | 0,27 | 0,28 | 0,30 | 0,33 | 0,33 | 0,32 |
| *INFORMATION* | 0,63 | 0,57 | 0,53 | 0,53 | 0,46 | 0,49 | 0,51 | 0,55 | 0,59 | 0,56 |
| *FIRE* | 0,15 | 0,15 | 0,15 | 0,15 | 0,16 | 0,15 | 0,16 | 0,16 | 0,17 | 0,16 |
| *PBS* | 0,23 | 0,23 | 0,23 | 0,25 | 0,26 | 0,28 | 0,34 | 0,35 | 0,38 | 0,37 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,55 | 0,55 | 0,59 | 0,56 | 0,59 | 0,61 | 0,56 | 0,57 | 0,59 | 0,59 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,27 | 0,26 | 0,26 | 0,27 | 0,29 | 0,30 | 0,28 | 0,35 | 0,34 | 0,34 |
| *GOVERNMENT* | 0,70 | 0,69 | 0,71 | 0,71 | 0,71 | 0,71 | 0,71 | 0,71 | 0,71 | 0,73 |

*Labor Income Share (source: author; based on EU KLEMS data)*

*Part 2*

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,38 | 0,38 | 0,38 | 0,39 | 0,40 | 0,41 | 0,40 | 0,39 | 0,37 | 0,37 |
| *AGRICULTURE AND MINING* | 0,18 | 0,23 | 0,23 | 0,22 | 0,21 | 0,20 | 0,20 | 0,18 | 0,18 | 0,17 |
| *UTILITIES AND CONSTRUCTION* | 0,33 | 0,27 | 0,33 | 0,42 | 0,36 | 0,38 | 0,40 | 0,31 | 0,31 | 0,34 |
| *MANUFACTURING* | 0,45 | 0,46 | 0,46 | 0,44 | 0,49 | 0,54 | 0,50 | 0,44 | 0,39 | 0,39 |
| *WRT* | 0,34 | 0,36 | 0,36 | 0,36 | 0,39 | 0,43 | 0,42 | 0,45 | 0,43 | 0,40 |
| *INFORMATION* | 0,54 | 0,40 | 0,37 | 0,39 | 0,36 | 0,44 | 0,38 | 0,46 | 0,43 | 0,44 |
| *FIRE* | 0,15 | 0,17 | 0,16 | 0,15 | 0,15 | 0,12 | 0,12 | 0,11 | 0,10 | 0,09 |
| *PBS* | 0,38 | 0,35 | 0,31 | 0,31 | 0,31 | 0,50 | 0,46 | 0,45 | 0,46 | 0,46 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,59 | 0,58 | 0,57 | 0,58 | 0,58 | 0,59 | 0,59 | 0,64 | 0,63 | 0,62 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,34 | 0,34 | 0,36 | 0,36 | 0,40 | 0,42 | 0,42 | 0,42 | 0,37 | 0,37 |
| *GOVERNMENT* | 0,72 | 0,73 | 0,73 | 0,74 | 0,75 | 0,72 | 0,71 | 0,71 | 0,70 | 0,71 |

*Net Capital Stock Growth Rate in percentage (source: author; based on EU KLEMS data)*

*Part 1*

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 2,47 | 2,54 | 3,56 | 3,95 | 4,05 | 3,81 | 3,20 | 4,25 | 4,28 | 2,69 |
| *AGRICULTURE AND MINING* | 0,85 | 3,75 | 0,58 | 3,19 | 1,18 | 2,98 | 1,94 | 1,79 | 3,38 | 1,67 |
| *UTILITIES AND CONSTRUCTION* | 1,27 | 2,41 | 2,09 | 3,01 | 0,59 | 4,25 | 3,17 | 2,03 | 1,38 | -1,66 |
| *MANUFACTURING* | 3,83 | 6,83 | 5,87 | 8,18 | 7,34 | 5,36 | 1,44 | 0,38 | 2,33 | -0,96 |
| *WRT* | 8,16 | 7,81 | 13,78 | 9,19 | 8,63 | 15,75 | 15,72 | 13,11 | 8,41 | 6,33 |
| *INFORMATION* | 8,13 | 7,30 | 7,81 | 7,56 | 6,73 | 13,52 | 6,67 | 3,77 | 4,37 | 1,43 |
| *FIRE* | 1,84 | 1,36 | 2,32 | 2,42 | 4,04 | 1,69 | 0,84 | 2,99 | 4,02 | 4,33 |
| *PBS* | 14,76 | 15,63 | 14,89 | 12,07 | 15,79 | 12,01 | 5,56 | 13,64 | 14,28 | 13,34 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 9,60 | 9,84 | 9,49 | 10,14 | 8,94 | 7,41 | 5,56 | 7,22 | 5,33 | 3,00 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 4,21 | 5,34 | 4,34 | 5,47 | 5,52 | 1,31 | 2,56 | 2,50 | 3,28 | -0,63 |
| *GOVERNMENT* | 0,93 | 1,07 | 3,02 | 4,70 | 0,99 | 3,96 | 5,57 | 5,81 | 3,90 | -2,20 |

*Net Capital Stock Growth Rate in percentage (source: author; based on EU KLEMS data)*

*Part 2*

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 4,57 | 4,60 | 3,59 | 2,14 | -0,43 | -3,03 | -0,33 | 0,29 | -0,40 |
| *AGRICULTURE AND MINING* | 2,62 | 3,61 | 4,80 | 0,54 | -1,90 | -3,04 | -4,82 | 0,15 | -1,67 |
| *UTILITIES AND CONSTRUCTION* | 3,93 | 1,29 | 2,46 | -0,50 | -1,26 | -6,72 | -8,16 | 26,25 | 0,34 |
| *MANUFACTURING* | 3,52 | 2,00 | 3,76 | 2,80 | 2,37 | -1,62 | -4,16 | -5,87 | -5,04 |
| *WRT* | 14,33 | 11,66 | 7,77 | 2,79 | 1,83 | -1,68 | -4,90 | -3,65 | -4,09 |
| *INFORMATION* | 4,55 | 0,90 | 1,00 | -1,47 | -1,60 | -4,52 | -3,75 | -2,23 | -2,77 |
| *FIRE* | 2,98 | 5,13 | 2,81 | 1,75 | -0,69 | -2,29 | 4,43 | -0,12 | 0,09 |
| *PBS* | 12,25 | 16,39 | 17,97 | 9,29 | -0,47 | -6,40 | -6,51 | -0,89 | -10,49 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 5,49 | 0,55 | 0,08 | -1,71 | -3,39 | -5,33 | -4,74 | -3,78 | -0,37 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 3,03 | 1,10 | 3,71 | 4,01 | -2,58 | -0,88 | -2,81 | -6,16 | 3,38 |
| *GOVERNMENT* | 4,86 | 1,49 | 3,34 | 4,40 | 0,13 | -5,33 | -7,13 | 2,79 | 2,26 |

*Hours Worked Growth Rate percentage (source: author; based on EU KLEMS data)*

*Part 1*

| | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | -0,45 | 0,07 | 4,86 | 2,33 | 1,36 | 1,96 | 3,79 | 2,18 | 2,75 | 3,22 |
| *AGRICULTURE AND MINING* | -1,02 | -3,31 | 2,03 | -4,14 | 1,32 | -5,45 | -3,45 | -1,66 | -10,36 | -52,06 |
| *UTILITIES AND CONSTRUCTION* | 0,75 | -1,32 | 7,89 | -1,44 | 5,68 | 3,86 | 3,81 | 5,22 | 0,47 | 13,80 |
| *MANUFACTURING* | -1,28 | -2,80 | 2,12 | 4,17 | -1,77 | 2,72 | 0,44 | -1,38 | -3,28 | 6,91 |
| *WRT* | -2,40 | 1,79 | 5,71 | 5,23 | -1,42 | 3,05 | 1,82 | 3,38 | 1,33 | 0,54 |
| *INFORMATION* | 4,92 | 1,59 | 7,31 | -2,49 | 3,17 | 4,14 | 12,85 | -0,62 | 0,58 | 2,80 |
| *FIRE* | -6,82 | 10,98 | 3,42 | 4,21 | 5,56 | -2,91 | -3,00 | 7,46 | 1,56 | 6,46 |
| *PBS* | -3,49 | 0,99 | 14,50 | 4,63 | 0,58 | 10,37 | 8,08 | 3,54 | 10,54 | 17,03 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 3,28 | 1,22 | 5,32 | 3,59 | -1,14 | 0,69 | 6,35 | 1,95 | 12,87 | 15,23 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,08 | 0,32 | 7,80 | 1,95 | 0,44 | 2,38 | 12,05 | 3,78 | 1,98 | -0,06 |
| *GOVERNMENT* | 1,46 | -1,42 | -0,53 | 0,10 | 8,96 | -0,14 | 2,27 | 0,39 | 8,30 | 1,33 |

*Hours Worked Growth Rate percentage (source: author; based on EU KLEMS data)*

*Part 2*

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 3,21 | 2,81 | 1,73 | -1,53 | -5,56 | -7,53 | -6,74 | -2,80 | -1,66 |
| *AGRICULTURE AND MINING* | 74,69 | -0,93 | -3,90 | 5,07 | 14,18 | -6,86 | -11,64 | 2,96 | -0,29 |
| *UTILITIES AND CONSTRUCTION* | -1,60 | 8,29 | -0,04 | -4,66 | -23,22 | -25,47 | -21,86 | -9,12 | -5,82 |
| *MANUFACTURING* | -1,85 | 1,52 | 4,02 | -4,40 | -10,12 | -8,90 | -4,53 | -5,09 | -1,30 |
| *WRT* | 4,14 | 4,13 | 3,48 | -1,93 | -5,31 | -6,28 | -9,24 | -1,77 | -2,94 |
| *INFORMATION* | 2,66 | -1,29 | -1,61 | 1,49 | -5,33 | -14,40 | 2,77 | -0,25 | 3,86 |
| *FIRE* | -0,49 | 3,43 | 1,05 | -3,09 | -9,08 | -10,16 | 0,99 | -6,51 | -5,45 |
| *PBS* | -1,39 | 4,05 | 0,58 | -3,07 | -5,01 | -5,88 | 0,35 | -9,57 | 13,84 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 1,15 | 0,67 | 0,68 | 1,02 | -9,86 | -5,14 | -1,29 | -1,93 | 1,25 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,51 | 1,53 | 4,43 | 1,54 | 7,68 | -2,37 | -7,45 | -2,71 | -4,81 |
| *GOVERNMENT* | 7,20 | 2,07 | -0,55 | -2,25 | -1,83 | -4,32 | -6,42 | 0,59 | -4,84 |

*Real Wage Growth per Hour Worked in percentage (source: author; based on EU KLEMS data)*

*Part 1*

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 2,71 | 6,63 | 0,30 | 1,29 | 3,54 | 1,36 | 6,12 | 4,22 | 0,90 | 0,95 |
| *AGRICULTURE AND MINING* | 7,71 | -1,76 | -0,69 | 10,75 | 5,40 | 11,70 | 15,88 | 10,11 | 22,26 | 124,12 |
| *UTILITIES AND CONSTRUCTION* | 3,77 | 4,81 | 0,26 | 9,57 | -0,65 | 1,88 | 11,65 | -5,66 | 2,01 | 4,87 |
| *MANUFACTURING* | 4,02 | 9,18 | -0,15 | -3,29 | -0,83 | -4,83 | 13,25 | 6,75 | -2,23 | -2,31 |
| *WRT* | 3,34 | 8,47 | 8,00 | 7,92 | 15,09 | 3,15 | 10,27 | 8,39 | 4,43 | 6,42 |
| *INFORMATION* | -9,52 | 6,34 | 0,83 | 0,57 | 10,67 | 9,99 | 9,72 | 9,11 | 2,33 | -2,19 |
| *FIRE* | 14,50 | -7,48 | -2,30 | 1,10 | -6,18 | 2,83 | 8,97 | -4,71 | -1,52 | -2,84 |
| *PBS* | 12,70 | 4,69 | -0,73 | 0,80 | -0,36 | 13,31 | 1,96 | 14,84 | -6,31 | -13,28 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,60 | 7,61 | 0,21 | -2,99 | 4,96 | 2,35 | 0,53 | 1,26 | -6,20 | -10,22 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | -0,29 | 3,25 | 1,35 | 0,05 | 6,63 | -3,83 | 17,49 | -3,88 | 0,59 | 7,28 |
| *GOVERNMENT* | -1,62 | 9,23 | -0,42 | 1,23 | -3,15 | -0,13 | -5,57 | 8,60 | -0,34 | -4,31 |

*Real Wage Growth per Hour Worked in percentage (source: author; based on EU KLEMS data)*

*Part 2*

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,00 | 0,83 | -1,57 | 0,22 | 3,75 | -3,16 | -2,36 | -4,58 | 0,16 |
| *AGRICULTURE AND MINING* | -37,03 | -9,64 | 0,36 | -8,48 | -10,33 | 2,78 | 10,14 | -7,21 | -1,94 |
| *UTILITIES AND CONSTRUCTION* | 5,66 | -0,02 | -2,44 | -5,38 | 17,27 | 19,56 | -3,69 | -5,02 | 4,20 |
| *MANUFACTURING* | 3,08 | 3,25 | -12,40 | 10,87 | 6,47 | -5,29 | -15,44 | -6,34 | -2,05 |
| *WRT* | -0,16 | 1,49 | -2,43 | 0,40 | 10,93 | -9,04 | -5,27 | -12,68 | 1,74 |
| *INFORMATION* | -17,53 | -1,62 | 6,42 | -9,24 | 11,44 | -16,59 | 2,76 | -2,31 | -11,57 |
| *FIRE* | 6,41 | 6,77 | 2,53 | 2,95 | -7,82 | 4,59 | -12,58 | 3,47 | -6,75 |
| *PBS* | 8,18 | -11,66 | 0,81 | -2,45 | 33,31 | -12,34 | -10,62 | -2,52 | -14,10 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,18 | 1,45 | 0,77 | -8,65 | 8,23 | 1,00 | -7,00 | -3,29 | 0,79 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 4,37 | 5,28 | 1,52 | 3,36 | -16,89 | -8,79 | 12,06 | 1,81 | 5,11 |
| *GOVERNMENT* | 0,61 | 1,46 | -0,01 | 6,90 | -2,62 | 0,50 | 5,52 | -4,21 | 5,26 |

# Appendix D: Profit Rate Decomposition Time Series Data

*Gross Profits in Millions of Euro (source: author; based on EU KLEMS data)*

*Part 1*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 964,82 | 992,81 | 1019,24 | 1067,01 | 1063,94 | 1092,01 | 1132,34 | 1135,63 | 1189,89 | 1267,32 |
| *AGRICULTURE AND MINING* | 73,76 | 71,76 | 73,24 | 74,84 | 75,76 | 73,70 | 72,71 | 69,98 | 69,38 | 69,91 |
| *UTILITIES AND CONSTRUCTION* | 77,91 | 81,30 | 85,68 | 91,54 | 101,80 | 105,41 | 107,42 | 106,05 | 140,85 | 156,00 |
| *MANUFACTURING* | 81,35 | 72,73 | 69,27 | 73,58 | 87,94 | 94,56 | 113,30 | 112,86 | 112,69 | 112,68 |
| *WRT* | 204,88 | 217,39 | 228,45 | 228,85 | 228,16 | 245,50 | 239,93 | 238,03 | 266,15 | 290,33 |
| *INFORMATION* | 12,77 | 15,91 | 19,99 | 21,59 | 28,90 | 28,57 | 30,63 | 31,71 | 29,45 | 34,16 |
| *FIRE* | 228,98 | 235,27 | 243,19 | 255,73 | 237,59 | 248,16 | 246,70 | 253,80 | 246,73 | 261,77 |
| *PBS* | 64,30 | 68,57 | 72,20 | 73,21 | 72,97 | 66,92 | 62,20 | 66,92 | 69,88 | 76,41 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 74,70 | 78,35 | 71,91 | 86,96 | 77,13 | 74,87 | 95,20 | 95,16 | 90,67 | 94,94 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 101,48 | 104,73 | 110,04 | 114,84 | 107,95 | 106,29 | 116,42 | 114,44 | 114,67 | 121,29 |
| *GOVERNMENT* | 44,69 | 46,79 | 45,26 | 45,88 | 45,74 | 48,03 | 47,84 | 46,67 | 49,41 | 49,84 |

*Gross Profits in Millions of Euro (source: author; based on EU KLEMS data)*

*Part 2*

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 1256,03 | 1309,51 | 1346,35 | 1346,70 | 1281,69 | 1175,13 | 1080,87 | 1033,20 | 1037,60 | 1049,09 |
| *AGRICULTURE AND MINING* | 72,46 | 59,78 | 52,86 | 53,09 | 55,91 | 59,01 | 57,18 | 62,79 | 60,13 | 62,96 |
| *UTILITIES AND CONSTRUCTION* | 119,77 | 169,54 | 137,43 | 91,07 | 105,78 | 87,46 | 71,09 | 78,64 | 68,25 | 57,32 |
| *MANUFACTURING* | 110,41 | 108,90 | 114,12 | 109,77 | 95,93 | 74,71 | 76,23 | 79,61 | 85,77 | 82,71 |
| *WRT* | 280,15 | 269,50 | 282,56 | 290,36 | 248,63 | 220,21 | 196,71 | 151,90 | 141,59 | 156,31 |
| *INFORMATION* | 37,67 | 55,81 | 60,13 | 58,24 | 62,09 | 46,65 | 42,07 | 32,29 | 35,70 | 30,95 |
| *FIRE* | 281,61 | 264,28 | 301,85 | 340,41 | 344,81 | 379,84 | 345,46 | 363,85 | 369,43 | 380,96 |
| *PBS* | 73,23 | 87,47 | 99,31 | 98,73 | 93,07 | 52,55 | 51,07 | 47,87 | 41,32 | 39,45 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 100,32 | 106,63 | 111,44 | 110,34 | 102,53 | 96,03 | 92,04 | 68,50 | 66,64 | 70,90 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 131,06 | 135,45 | 133,59 | 142,92 | 122,57 | 102,26 | 92,59 | 92,57 | 113,14 | 113,54 |
| *GOVERNMENT* | 49,34 | 52,15 | 53,05 | 51,78 | 50,35 | 56,43 | 56,43 | 55,20 | 55,64 | 53,99 |

*Profit Share in percentage (source: author; based on EU KLEMS data)*

*Part 1*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,67 | 0,67 | 0,66 | 0,66 | 0,65 | 0,64 | 0,64 | 0,62 | 0,62 | 0,62 |
| *AGRICULTURE AND MINING* | 0,89 | 0,88 | 0,89 | 0,89 | 0,88 | 0,88 | 0,87 | 0,85 | 0,84 | 0,83 |
| *UTILITIES AND CONSTRUCTION* | 0,72 | 0,72 | 0,73 | 0,72 | 0,73 | 0,73 | 0,72 | 0,68 | 0,74 | 0,76 |
| *MANUFACTURING* | 0,53 | 0,50 | 0,47 | 0,48 | 0,52 | 0,55 | 0,60 | 0,56 | 0,55 | 0,56 |
| *WRT* | 0,78 | 0,78 | 0,78 | 0,75 | 0,73 | 0,72 | 0,70 | 0,67 | 0,67 | 0,68 |
| *INFORMATION* | 0,37 | 0,43 | 0,47 | 0,47 | 0,54 | 0,51 | 0,49 | 0,45 | 0,41 | 0,44 |
| *FIRE* | 0,85 | 0,85 | 0,85 | 0,85 | 0,84 | 0,85 | 0,84 | 0,84 | 0,83 | 0,84 |
| *PBS* | 0,77 | 0,77 | 0,77 | 0,75 | 0,74 | 0,72 | 0,66 | 0,65 | 0,62 | 0,63 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,45 | 0,45 | 0,41 | 0,44 | 0,41 | 0,39 | 0,44 | 0,43 | 0,41 | 0,41 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,73 | 0,74 | 0,74 | 0,73 | 0,71 | 0,70 | 0,72 | 0,65 | 0,66 | 0,66 |
| *GOVERNMENT* | 0,30 | 0,31 | 0,29 | 0,29 | 0,29 | 0,29 | 0,29 | 0,29 | 0,29 | 0,27 |

*Profit Share in percentage (source: author; based on EU KLEMS data)*

*Part 2*

| | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,61 | 0,62 | 0,61 | 0,61 | 0,60 | 0,59 | 0,60 | 0,61 | 0,63 | 0,63 |
| *AGRICULTURE AND MINING* | 0,82 | 0,77 | 0,77 | 0,78 | 0,79 | 0,80 | 0,80 | 0,82 | 0,82 | 0,83 |
| *UTILITIES AND CONSTRUCTION* | 0,67 | 0,73 | 0,67 | 0,58 | 0,64 | 0,62 | 0,60 | 0,69 | 0,69 | 0,66 |
| *MANUFACTURING* | 0,55 | 0,54 | 0,54 | 0,56 | 0,51 | 0,46 | 0,50 | 0,56 | 0,61 | 0,61 |
| *WRT* | 0,66 | 0,64 | 0,64 | 0,64 | 0,61 | 0,57 | 0,58 | 0,55 | 0,57 | 0,60 |
| *INFORMATION* | 0,46 | 0,60 | 0,63 | 0,61 | 0,64 | 0,56 | 0,62 | 0,54 | 0,57 | 0,56 |
| *FIRE* | 0,85 | 0,83 | 0,84 | 0,85 | 0,85 | 0,88 | 0,88 | 0,89 | 0,90 | 0,91 |
| *PBS* | 0,62 | 0,65 | 0,69 | 0,69 | 0,69 | 0,50 | 0,54 | 0,55 | 0,54 | 0,54 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,41 | 0,42 | 0,43 | 0,42 | 0,42 | 0,41 | 0,41 | 0,36 | 0,37 | 0,38 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,66 | 0,66 | 0,64 | 0,64 | 0,60 | 0,58 | 0,58 | 0,58 | 0,63 | 0,63 |
| *GOVERNMENT* | 0,28 | 0,27 | 0,27 | 0,26 | 0,25 | 0,28 | 0,29 | 0,29 | 0,30 | 0,29 |

*Profit Rate in percentage (source: author; based on EU KLEMS data)*

*Part 1*

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,00227 | 0,00228 | 0,00228 | 0,00231 | 0,00221 | 0,00218 | 0,00218 | 0,00212 | 0,00213 | 0,00218 |
| *AGRICULTURE AND MINING* | 0,00475 | 0,00458 | 0,00451 | 0,00458 | 0,00449 | 0,00432 | 0,00414 | 0,00391 | 0,00380 | 0,00371 |
| *UTILITIES AND CONSTRUCTION* | 0,00345 | 0,00355 | 0,00366 | 0,00383 | 0,00413 | 0,00425 | 0,00416 | 0,00398 | 0,00518 | 0,00566 |
| *MANUFACTURING* | 0,00598 | 0,00515 | 0,00459 | 0,00460 | 0,00509 | 0,00509 | 0,00579 | 0,00569 | 0,00566 | 0,00553 |
| *WRT* | 0,01053 | 0,01033 | 0,01007 | 0,00886 | 0,00809 | 0,00801 | 0,00677 | 0,00580 | 0,00574 | 0,00577 |
| *INFORMATION* | 0,00112 | 0,00129 | 0,00152 | 0,00152 | 0,00189 | 0,00175 | 0,00165 | 0,00160 | 0,00144 | 0,00160 |
| *FIRE* | 0,00093 | 0,00093 | 0,00095 | 0,00098 | 0,00089 | 0,00089 | 0,00087 | 0,00089 | 0,00084 | 0,00086 |
| *PBS* | 0,03007 | 0,02795 | 0,02545 | 0,02246 | 0,01998 | 0,01582 | 0,01313 | 0,01338 | 0,01230 | 0,01176 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,00833 | 0,00797 | 0,00666 | 0,00735 | 0,00592 | 0,00528 | 0,00625 | 0,00592 | 0,00526 | 0,00523 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,00601 | 0,00595 | 0,00594 | 0,00594 | 0,00529 | 0,00494 | 0,00534 | 0,00512 | 0,00500 | 0,00512 |
| *GOVERNMENT* | 0,00067 | 0,00069 | 0,00066 | 0,00065 | 0,00062 | 0,00064 | 0,00062 | 0,00057 | 0,00057 | 0,00055 |

*Profit Rate in percentage (source: author; based on EU KLEMS data)*

*Part 2*

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL** | 0,00210 | 0,00209 | 0,00206 | 0,00199 | 0,00185 | 0,00170 | 0,00162 | 0,00155 | 0,00155 | 0,00158 |
| *AGRICULTURE AND MINING* | 0,00378 | 0,00304 | 0,00259 | 0,00249 | 0,00260 | 0,00280 | 0,00280 | 0,00323 | 0,00309 | 0,00329 |
| *UTILITIES AND CONSTRUCTION* | 0,00442 | 0,00602 | 0,00482 | 0,00311 | 0,00364 | 0,00304 | 0,00265 | 0,00320 | 0,00220 | 0,00184 |
| *MANUFACTURING* | 0,00547 | 0,00521 | 0,00536 | 0,00497 | 0,00422 | 0,00321 | 0,00333 | 0,00363 | 0,00415 | 0,00422 |
| *WRT* | 0,00524 | 0,00441 | 0,00414 | 0,00395 | 0,00329 | 0,00286 | 0,00260 | 0,00211 | 0,00204 | 0,00235 |
| *INFORMATION* | 0,00173 | 0,00246 | 0,00262 | 0,00252 | 0,00272 | 0,00208 | 0,00196 | 0,00157 | 0,00177 | 0,00158 |
| *FIRE* | 0,00088 | 0,00080 | 0,00087 | 0,00096 | 0,00095 | 0,00106 | 0,00098 | 0,00099 | 0,00101 | 0,00104 |
| *PBS* | 0,00995 | 0,01059 | 0,01033 | 0,00870 | 0,00751 | 0,00426 | 0,00442 | 0,00443 | 0,00386 | 0,00412 |
| *EDUCATIONAL SERVICES, HEALTH CARE AND SOCIAL ASSISTANCE* | 0,00536 | 0,00540 | 0,00562 | 0,00555 | 0,00525 | 0,00509 | 0,00515 | 0,00403 | 0,00407 | 0,00435 |
| *ART, ENTERTAINMENT, RECREATION AND FOOD SERVICES & OTHER SERVICES* | 0,00557 | 0,00559 | 0,00545 | 0,00562 | 0,00464 | 0,00397 | 0,00363 | 0,00373 | 0,00486 | 0,00472 |
| *GOVERNMENT* | 0,00056 | 0,00057 | 0,00057 | 0,00054 | 0,00050 | 0,00056 | 0,00059 | 0,00062 | 0,00061 | 0,00058 |