

**MASTER**  
IN ECONOMICS OF BUSINESS AND STRATEGY

# **Productivity Levels in Portugal: Capital-Intensive Industries vs. Labor- Intensive Industries**

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**M**

2024



FACULDADE DE ECONOMIA



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**PRODUCTIVITY LEVELS IN PORTUGAL: CAPITAL-INTENSIVE  
INDUSTRIES VS. LABOR-INTENSIVE INDUSTRIES**

**José Mário Cabral Fernandes**

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Dissertation  
Master in Economics of Business and Strategy

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Supervised by  
**Pedro Luís Marques Correia da Silva**

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2024

*“A história não é benevolente com quem não reconhece a sua evolução e se mantém refém do passado.”*

– José Maria Pedroto (1928-1985)

## Acknowledgements

I am a person who finds in words the ideal complement to actions. I rely on them when I feel that the actions have not managed to leave their abstract field. I hope, therefore, that all those to whom I dedicate them at this precise moment will receive them as the complement that I intend them to be. But, above all, I hope you receive them, even if, eventually, I do not have the necessary courage to get them to you. Although this brief text does not allow me to thank all the people who, in one way or another, contributed to charting the path that brought me here, I am fully convinced that none of the truly important people were forgotten in the paragraphs that follow.

Firstly, I would like to say a word of appreciation to the Faculty of Economics of the University of Porto and to all the professors with whom I had the pleasure of meeting along the way. A particular word of gratitude to my supervisor for this dissertation, Professor Pedro Luís Silva, with whom I had the privilege and, above all, the pleasure of working.

Thank you, too, to those who, although separated by an ocean, never refrained from showing all their support. I hope that these words of mine are received by you with the same affection as your “And how is everything going in Porto?” have been received by me over these two years. I am sure that you will never let this achievement be just mine, but ours.

I extend this gratitude (and I intensify it because it is something that is justified in this case) to a friend in particular who, despite the physical distance, never stopped making herself feel present. You are, perhaps, the most regular listener of this more affectionate “lyrical self” of mine because I know perfectly well the value you place on it. Well, not just for that. The truth is that I constantly feel the need to reinforce the affection I have for you. And, constantly, you give me more reasons to reinforce it. There will never be too many, believe me.

I could not fail to express my enormous gratitude to the friends I made here, being certain that this entire journey was much more enriching from the moment they managed to accomplish the herculean task of entering my life. Rest assured that I would not change a single line of the script that served to unite us. Looking back, I would never have dared to take such a risk; essentially, the risk of being unable to look back with an unconscious smile.

As paradoxical as it may sound, I still feel “obliged” to say “thank you” to those who, for one reason or another, I did not have the privilege of getting to know – in the literal sense

of the word – during these two years. There were wonderful conversations that insisted on not leaving the draft, jokes that will be waiting for laughter, and links that never really intertwined. Perhaps these could be words that, in the future, will only serve to describe the past; but, if not, I will be forever grateful that everything was at least superficial.

On the other hand, I could never forget those who joined me in writing such a “book of honor of unparalleled victories”. With you, I saw dreams materialize that I once considered unreal. Dreams that connected us even before destiny had decided to do so. It was in your company that I experienced most of the highlights of my time in Porto. It was also in that same company that I lived the moments that I would easily classify as the toughest ones. I assure you that both the highs and the lows will remain in my memory forever. I assure you that those who spent them with me will remain in my heart forever.

Finally, definitely the most important. If I write these words today, I write them fully aware that this would never be possible without you. If, today, there is someone who deserves the credit for something, I am far from being that person. If, today, people want to point out any merit to me, point it out to those who enable me to be the privileged person that I am day after day. I could try to continue infinitely, but I fear that words would run out long before they would be able to reach the real dimension of your effort. Therefore, I make a point of repaying you in the only way I can: doing everything in my power to make sure this is just the beginning.

Funding for this research was provided by FCT – Foundation for Science and Technology (Portugal) under the project Ref. <https://doi.org/10.54499/2022.01269.PTDC>.

## Agradecimentos

Sou alguém que encontra nas palavras o complemento ideal para as ações em si. É nelas que me refugio quando sinto que as ações não conseguiram sair da sua vertente abstrata. Espero, portanto, que todos aqueles a quem as dedico neste preciso momento as recebam como o complemento que pretendo que sejam; mas, acima de tudo, espero que as recebam, ainda que, eventualmente, não reúna em mim o desembaraço necessário para vos fazer chegá-las. Embora este breve texto não me permita agradecer a todas as pessoas que, de uma forma ou de outra, contribuíram para que traçasse o caminho que me trouxe até aqui, fico feliz por estar plenamente convicto de que nenhuma das pessoas verdadeiramente importantes foi esquecida nos parágrafos que se seguem.

Em primeiro lugar, deixar uma palavra de apreço à Faculdade de Economia da Universidade do Porto e a todos os docentes com os quais tive a felicidade de me cruzar. Uma particular palavra de agradecimento ao meu orientador na presente dissertação, o Professor Doutor Pedro Luís Silva, com quem tive o privilégio e, sobretudo, o prazer de trabalhar.

Agradecer, também, àqueles que, embora separados por um oceano de distância, nunca se abstiveram de demonstrar todo o seu apoio. Torço para que estas minhas palavras sejam recebidas por vocês com o mesmo carinho que os vossos “E como é que está a correr lá no Porto?” foram por mim recebidos ao longo destes dois anos. Estou certo de que jamais deixarão que esta conquista seja apenas minha, mas sim nossa.

Estendo este agradecimento (e intensifico-o, porque é algo que se justifica neste caso) a uma amiga em particular que, não obstante a distância física, nunca deixou de se fazer sentir presente. És, porventura, a ouvinte mais assídua deste meu “eu lírico” mais afetuoso porque sei perfeitamente o valor que lhe dás. Bem, não só por isso. A verdade é que sinto constantemente a necessidade de reforçar o carinho que tenho por “si”. E, constantemente, “você” dá-me mais motivos para o reforçar. Nunca serão demais, acredita.

Não poderia deixar de expressar também a minha enorme gratidão aos amigos que por aqui fiz, estando certo de que todo este percurso foi muito mais agregador a partir do momento em que conseguiram cumprir a hercúlea tarefa que é entrar na minha vida. Tenham a certeza de que não alteraria uma única linha do guião que serviu para nos unir. Olhando

em retrospecto, jamais me atreveria a correr tamanho risco; essencialmente, o risco de ser incapaz de olhar em retrospecto com um sorriso inconsciente.

Por mais paradoxal que possa soar, sinto-me, ainda, no dever de deixar um “obrigado” a quem, por um ou outro motivo, não tive o privilégio de conhecer – no sentido literal da palavra – durante estes dois anos. Foram belas conversas que teimaram em não sair do rascunho, piadas que ficarão à espera do riso, elos que nunca se entrelaçaram. Porventura, estas poderão ser palavras que, no futuro, sirvam apenas para descrever o passado; mas, se assim não for, serei para sempre grato por tudo ter sido, pelo menos, superficial.

Por outro lado, jamais poderia esquecer aqueles que se juntaram a mim para escrever um belíssimo “livro de honra de vitórias sem igual”. Convosco, vi materializarem-se sonhos que outrora considerei irrealis. Sonhos que nos ligavam ainda antes de o destino se ter encarregado de o fazer. Foi na vossa companhia que vivi grande parte dos momentos mais altos da minha passagem pelo Porto. Foi também nessa mesma companhia que vivi aqueles que facilmente elegeria como os mais duros. Garanto-vos que, quer os altos, quer os baixos, permanecerão para sempre na minha memória. Garanto-vos que, quem os passou comigo, permanecerá para sempre no meu coração.

Por fim, definitivamente, o mais importante. Se, hoje, escrevo estas palavras, escrevo-as plenamente consciente de que tal jamais seria possível sem vocês. Se, hoje, há alguém que merece os louros por seja lá o que for, estou longe de ser essa pessoa. Se, hoje, me querem apontar qualquer mérito, apontem-no àqueles que me possibilitam ser o privilegiado que sou dia após dia. Podia (tentar) continuar infinitamente, mas temo que as palavras se esgotariam muito antes de estas serem capazes de atingir a real dimensão do vosso esforço. Por isso, faço questão de retribuir-vos da única forma que consigo: fazer de tudo para que isto seja apenas o começo.

O financiamento para esta investigação foi concedido pela FCT – Fundação para a Ciência e a Tecnologia (Portugal) no âmbito do projeto Ref.

<https://doi.org/10.54499/2022.01269.PTDC>.

## **Abstract**

Labor productivity has been one of the main sources for the Portuguese economy's underperformance in comparison to European standards. Throughout the last decades – and even today – this reality is closely followed by a diminished intensity in the use of capital during the production process, resulting in a predominantly labor-intensive economy. Hence, this study aims to determine whether the capital intensity ratio has played an important role on the levels of labor productivity observed across the Portuguese economic sectors in recent years (2004-2022). In addition, to generate a more detailed diagnostic of the aspects that influence the most labor productivity, other variables, namely the weight of exports, the financial debt, operating subsidies, investment rate, and labor productivity adjusted wage, were also considered. The combination of these independent variables resulted in a weighted least squares, log transformed model, whose results pointed out to a strong, positive relationship between labor productivity and three of those predictor variables – capital intensity, exports, and adjusted wage. On the contrary, it was also found a negative, strong connection between the dependent variable and subsidies.

**Keywords:** Capital Intensity; Capital-Intensive Industries; Economic Sectors; Labor-Intensive Industries; Labor Productivity; Portuguese Economy.

**JEL Codes:** D24; E24; J24; L60.

## Resumo

A produtividade do fator trabalho tem sido uma das principais causas do fraco desempenho da economia portuguesa comparativamente a outros países europeus. Ao longo das últimas décadas – e ainda nos dias que correm – esta realidade é acompanhada de perto por uma utilização reduzida do fator capital durante o processo produtivo, o que resulta numa economia predominantemente intensiva em mão de obra. Assim, este estudo pretende determinar se o rácio de intensidade de capital desempenha um papel relevante nos níveis de produtividade do trabalho observados nos setores económicos nacionais nos últimos anos (2004-2022). Além disso, de modo a alcançar um diagnóstico mais detalhado dos aspetos que mais influenciam a produtividade do trabalho, foram também consideradas outras variáveis, nomeadamente o peso das exportações e do endividamento das empresas, os subsídios à exploração, a taxa de investimento e o salário ajustado à produtividade do trabalho. A combinação destas variáveis independentes resultou num modelo de regressão linear ponderada e com transformação logarítmica, cujos resultados apontaram para uma forte relação positiva entre a produtividade do trabalho e três dessas variáveis independentes – a intensidade de utilização de capital, as exportações e o salário ajustado à produtividade do trabalho. Pelo contrário, também foi encontrada uma forte ligação negativa entre a variável dependente e os subsídios à exploração.

**Palavras-Chave:** Economia Portuguesa; Indústrias Intensivas em Capital; Indústrias Intensivas em Trabalho; Intensidade de Capital; Produtividade do Trabalho; Setores Económicos.

**Códigos JEL:** D24; E24; J24; L60.

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## Abbreviations

|            |                                                                        |
|------------|------------------------------------------------------------------------|
| 12WE       | 12 Western European Countries mentioned in Maddison (2001)             |
| AIC        | Akaike Information Criterion                                           |
| CAE Rev. 3 | Third Revision of the Portuguese Classification of Economic Activities |
| EFTA       | European Free Trade Association                                        |
| EU         | European Union                                                         |
| EU2004     | Countries that joined the European Union in 2004                       |
| EU2007     | Countries that joined the European Union in 2007                       |
| EU27       | Countries that form the European Union since 2020                      |
| GDP        | Gross Domestic Product                                                 |
| GVA        | Gross Value Added                                                      |
| IBAS       | Integrated Business Accounts System                                    |
| IMF        | International Monetary Fund                                            |
| log        | Logarithmic                                                            |
| MLR        | Multiple Linear Regression                                             |
| OECD       | Organisation for Economic Co-operation and Development                 |
| OLS        | Ordinary Least Squares                                                 |
| PPP        | Purchasing Power Parity                                                |
| R&D        | Research and Development                                               |
| TFP        | Total-Factor Productivity                                              |
| UK         | United Kingdom                                                         |
| USA        | United States of America                                               |
| VIF        | Variance Inflation Factor                                              |
| WLS        | Weighted Least Squares                                                 |

## 1. Introduction

Throughout the last few decades (and even centuries), Portugal has often stood out negatively from its “European neighbors” in regard to multiple economic topics. Such a reality ends up being particularly true in relation to productivity-related aspects, namely labor productivity. Recent data from OECD (2024b) places Portugal among the worst-performing nations in the European Union (EU) in terms of labor productivity. Nevertheless, it is important to bear in mind that this tendency is not recent – the Portuguese economy’s level of labor productivity has constantly been far behind that of the most developed European countries (Reis, 2000; Foreman-Peck & Lains, 2000; Lains, 2002a; Lains et al., 2013). What can be perceived as even more concerning than the gap by itself is the fact that Portugal has struggled over the years to close – at least, partly – this same gap (Maddison, 2001; Amaral, 2009; OECD, 2024b). In fact, the historical periods where Portugal was capable of continuously overperforming the most developed nations of the continent are rather scarce, with the most significant one occurring during the “Golden Age” period (1950-1973). This “Golden Age” coincided with the (late) beginning of the national industrialization process, enabled by the large external aid provided by the Americans through the Marshall Plan (Rollo, 1994).

This brief description of the Portuguese labor productivity evolution enlightens how the country has underperformed in this topic. The main implications of this reality will appear in the form of slower salary and purchasing power growth and loss of competitiveness in the international markets (Alcalá & Ciccone, 2004; Felbermayr et al., 2011; Yi & Chan, 2014). Those constraints combined, can deeply hamper the country’s economic growth and, consequently, lead to an intensification of the emigration flows, mainly of highly skilled labor, entrepreneurs, and researchers. This tendency intensifies the difficulties of stimulating the economy towards higher growth rates, which can be perceived as a snowball effect (Banco de Portugal, 2019).

Another aspect that appears to be playing an important, yet negative role in the Portuguese labor productivity level is its economy’s low capital intensity. As a matter of fact, the country’s late industrialization for European standards can be seen as the tip of the iceberg on this matter. The national economy has always been characterized by researchers over the 19<sup>th</sup> and 20<sup>th</sup> centuries as resource-poor and significantly dependent on labor – a labor market mostly composed of workers with low levels of skills and literacy – and on the

primary sector – especially agriculture (Reis, 1993; Reis, 2000; Foreman-Peck & Lains, 2000; Lains, 2002a; Lains et al., 2013). Agriculture – the most important component of the country's Gross Domestic Product (GDP) during a large part of the 20<sup>th</sup> century – and industry – mostly composed of small-sized enterprises during the first half of the 20<sup>th</sup> century – presented poor levels of labor productivity, particularly before the large American aid that arrived after World War II (Lains, 2006). Also, imports, namely capital assets, suffered some restrictions from the end of the 19<sup>th</sup> century up to the mid-20<sup>th</sup> century, which definitely contributed to the country's lack of industrialization (Lains, 2002a).

Currently available literature commonly demonstrates this connection between the low capital intensity of the country and its underperformance in terms of labor productivity. Examples that support this claim may be found, for instance, in Reis (1993), Lains (2002a), Lains (2006), Amaral (2009), and Silva et al. (2016). Despite these connections to this thesis's topic and goal, past studies – such as the aforementioned – tend to touch on more historical data, describing with an interesting level of detail how the country's sectors related to labor productivity throughout the end of the 19<sup>th</sup> century and the entirety of the 20<sup>th</sup> century. Based on that, by focusing on a relatively recent time period (2004-2022), this study aims to contribute to this literature section by providing a complement to the studies mentioned above.

The fact that this thesis might be perceived as an add-on is also based on how some characteristics of the Portuguese economy observed throughout past decades are confirmed in the current study for the 21<sup>st</sup> century. Some of these “similar” findings include the overall low level of labor productivity, the predominance of labor-intensive sectors, and the positive and statistically relevant impact that the capital intensity ratio has on labor productivity.

Moreover, in order to come up with a more complete diagnostic of the labor productivity issue in the national economy, it was also estimated the impact of other variables – the weight of exports, financial debt, operating subsidies, investment rate, and labor productivity adjusted wage – in labor productivity. Such an approach led to the conclusion that, despite being intrinsically related to labor productivity, the capital intensity ratio is surpassed by exports, subsidies, and adjusted wage in terms of strong relationships with this dependent variable.

This thesis will be divided as follows. In section 2, the focus will be on providing a brief review of what currently available literature expresses regarding the two topics of most

interest in this study – labor productivity and capital-/labor-intensive industries. Section 3 aims to describe past tendencies of labor productivity – both in Portugal and in the international scene – since the transition from the 19<sup>th</sup> to the 20<sup>th</sup> century to the current days. Section 4 is reserved for descriptive statistics and data description and treatment. Section 5 provides the thesis’s methodology, where the final model is designed and transformed. Section 6 focuses on the interpretation of the findings that resulted from the model established in the previous section. Finally, Section 7 addresses the main conclusions from this study, as well as the directions for eventual future research.

## **2. Literature Review**

### **2.1. Labor Productivity**

The evolution of labor productivity has been a topic that has received a significant amount of attention from researchers in the economics field throughout the last decades. That has to do, in part, with how economists often perceive labor productivity as a key element in understanding and explaining, for instance, the internal levels of competitiveness and quality of life of national economies worldwide (Heil, 2018; Kornieieva et al., 2022; Krugman, 1994). Indeed, according to Yi & Chan (2014), higher levels of labor productivity are often related to increases in terms of salaries, purchasing power – namely, as a consequence of lower production costs – and inflation control.

From a wider perspective, one could define “productivity” as the level of efficiency associated with a certain firm’s capacity to transform inputs into outputs (Syverson, 2011). In other words, productivity might be perceived as an output-input ratio, in the sense that enhancements in productivity must derive either from diminishments in inputs or increases in outputs (or both, simultaneously) (Giutini & Gaudette, 2003).

This concept is usually divided into two main categories: total-factor productivity (TFP) – also called multifactor productivity – and labor productivity. On the one hand, TFP considers the impact of the different types of inputs inserted in the production process – e.g., capital, labor, and intermediate inputs (Baily & Montalbano, 2016) –, reflecting the total level of efficiency with which these inputs are utilized during the production process (OECD, 2024c). On the other hand, labor productivity exclusively focuses on the contribution that, on average, labor has regarding the production and provision of both goods and services within a given economy (Burda, 2018). In a nutshell, labor productivity measures the level of output per hour worked (Baily & Montalbano, 2016). Nonetheless, it is important to underline that these two metrics often significantly differ, which might derive from the evolution of the level of capital stock (Marques, 2019).

Indeed, the latter concept tends to stand out when analyzing a certain economy’s level of productivity (Goldin et al., 2022). In part, that has to do with how this indicator possesses the ability to encompass other inputs’ efficiency, as labor productivity is intrinsically connected to the remaining factors of production (GEE, 2019). In that sense,

Roth (2019) states that, for a unit of production to improve labor productivity, it must necessarily increase its hourly output as a result of a more efficient use of one or more inputs.

Neoclassical economists often decompose labor productivity into three main components: i) labor quality, that is, how aspects such as age and demographic distribution of the workforce affect its productivity; ii) capital deepening, which is related to the enhancement of the capital-labor ratio by increasing the amount of capital stock for each labor's working hour; iii) finally, multifactor productivity (Owyang & Shell, 2018).

Additionally, multiple economists throughout the years have established a bond between the observed variations in labor productivity and the different stages of the business cycle. In other words, evidence from past decades points to higher levels of average labor productivity during economic expansions and to the opposite scenario during contractions. Economic contractions tend to feature significant decreases in GDP growth rates and aggregate demand, which tends to negatively impact labor productivity (Baily et al., 2001; Erber et al., 2017). Such a scenario might also be in line with higher long-run unemployment rates, impacting labor's skills and, ultimately, productivity. Such occurs because, when reintroduced in the production process, workers who come from long periods of unemployment often demonstrate difficulties in "catching up" (Dosi et al., 2018). Nevertheless, it is important to note that other factors impact labor productivity, namely the innovation process, technological enhancements, private and public investment, and the level of competitiveness within a certain sector or economy (Baily et al., 2005; Erber et al., 2017).

In line with that, Hopenhayn & Rogerson (1993) claim that significant barriers to labor reallocation within an economy might end up reducing productivity. Even the companies' internal barriers might end up playing a similar role from this perspective. Giroud & Mueller (2015), for example, affirm that productivity tends to increase when management decides to reallocate some of the company's resources (e.g., labor and capital) from a lower-return plant to a more profitable one.

From an international point of view, trade liberalization impacts the labor market and, ultimately, labor productivity. Felbermayr et al. (2011) suggest that trade liberalization helps to enhance an efficient firm's position in the market, while "pushing out" inefficient firms. With this so-called "selection effect", unemployment decreases, while real wages increase; the combination of these two main effects is in line with enhancements in terms of labor productivity. These enhancements mostly derive from the diminished international

trade costs and by the arise of new trading countries. In addition, other empirical studies, namely the one by Alcalá & Ciccone (2004), also found a highly significant impact of international trade on labor productivity in recent decades.

## **2.2. Capital-Intensive and Labor-Intensive Industries**

To understand the concept of “capital-intensive industry”, it is key to consider the idea of capital intensity. Based on this assumption, the level of capital intensity of a given industry is associated with its ratio of capital to labor. Capital intensity can be measured by comparing the company’s investment/expenses in capital and labor. Thus, capital-intensive industries tend to present substantial capital to labor ratios, given that the firms inserted in these industries heavily depend on investing in capital to enable their production process. Moreover, capital intensity might also be perceived as the number of assets necessary to produce a euro of sales, that is, the ratio between a company’s total assets and its revenues (Harris, 1988). On the contrary, labor-intensive industries often demand significantly high levels of labor for their production process. Therefore, such a scenario is commonly in line with a substantially lower capital to labor ratio when compared to firms that operate in capital-intensive sectors (Shahidul & Shazali, 2010).

Hence, one would be led to believe that, especially regarding companies operating in capital-intensive industries, higher levels of the capital to labor ratio might end up being related to enhanced labor productivity. As a matter of fact, Bergeaud et al. (2016) demonstrate a positive relation between the overall level of capital intensity in a certain country and its labor productivity. In the international scene, there is a tendency for capital flows to be directed to countries highly specialized in capital-intensive industries (Jin, 2012). As aforementioned, public and private investment are important enhancers of labor productivity. This may lead one to believe that economies that specialize in capital-intensive industries would ultimately improve their labor productivity levels.

In line with that, Chen (2020) suggests that the existing labor productivity gap between the goods and services sectors in the United States of America (USA) can be partly explained by the fact that capital intensity increased faster in the goods sector. Such has to do with capital's ability to substitute low-skilled labor and boost skilled labor productivity. This process tends to be accelerated when capital costs diminish, leading to a cheaper enhancement of the capital-labor ratio (Greenwood et al., 1997). Such an enhancement

would then originate an increase in terms of labor productivity, as capital deepening tends to be closely tied to labor productivity improvements (Owyang & Shell, 2018).

The capital-labor ratio might also end up reflecting the different stages of the business cycle. In fact, during periods of expansion, which usually feature a significant growth regarding private investment, the amount of capital stock per hour of work increases, ultimately boosting the capital-labor ratio. Nevertheless, in the ten years that followed the 2007-2008 financial crisis, the capital deepening growth was well below expectations in the USA, for instance. That might help to explain why this country's economy is currently operating below the expected level of productivity. Similarly, in the 12 countries that adopted the euro in 1999, capital deepening accounted for, approximately, 40% of labor productivity growth, from 1995 to 2019 (Owyang & Shell, 2018). However, the fact that the increases in the capital stock have been mostly soft in recent years has negatively impacted labor productivity growth in European nations, ultimately contributing to its stagnation (Lopez-Garcia & Szörfi, 2021).

Overall, the existing literature tends to associate capital deepening with increases in terms of labor productivity, meaning that countries with higher internal capital-labor ratios would be more prone to possess highly productive labor (Owyang & Shell, 2018). However, that does not have necessarily to be accomplished by raising the weight of capital-intensive industries in a given country's GDP. Indeed, capital deepening in labor-intensive industries might boost the economy's productivity as a whole as a result of substituting low-skilled workers' duties and complementing highly-skilled labor (Chen, 2020). A brief summary of the literature review may be found in Table A1.

### **3. Labor Productivity: Main Historical Global and National Trends**

#### **3.1. The Transition from the 19<sup>th</sup> to the 20<sup>th</sup> Century**

The 20<sup>th</sup> century is commonly perceived as a period that featured significant modifications in terms of both the labor market and this factor's productivity. Several aspects of labor's "daily life" were deeply modified throughout these 100 years – especially in more developed economies –, ultimately resulting in substantial gains in relation to the labor's hourly real wage and a decrease in the overall number of hours of work. In addition to that, it was during this century that employees became eligible for a whole new range of benefits that aimed to safeguard them from possible unemployment, sickness, and injury scenarios (Goldin, 2000).

Another important aspect fostering these changes in the labor market was the increasing importance of unionism, in the sense that this phenomenon contributed to the achievement of some of the aforementioned labor benefits, alongside stronger workers' bargaining power. This was particularly true in Western Europe, in opposition to other nations such as the USA or the United Kingdom (UK) (Goldin, 2000; Brody et al., 2024).

The 20<sup>th</sup> century was also the period where the USA established itself as the global leader in terms of labor productivity as a consequence of multiple factors. These include the country's vast territory, accessibility to natural resources, its geographical location – away from the main battlefields of the two World Wars – and, ultimately, the outcome of these two conflicts (Bayoumi, 1995; Broadberry & O'Mahony, 2007). Accordingly, authors such as Habakkuk (1962), Ames & Rosenberg (1968), and Broadberry & O'Mahony (2007) highlight how the abundance of land and raw materials was key to accelerating and enhancing the process of substituting labor for capital on American soil, which stimulated the labor-saving technical progress.

As a result of that transition, as demonstrated in Table 1, the level of hourly GDP in the USA surpassed that of more developed European economies – for example, the UK – during the transition from the 19<sup>th</sup> to the 20<sup>th</sup> century. In the decades that followed – and throughout the entire century –, the Americans managed to keep their position as global labor productivity leaders.

**Table 1:** GDP per hour of work, in 1990 international \$

|         | 1870 | 1913 | 1950  | 1973  | 1990  | 1998  |
|---------|------|------|-------|-------|-------|-------|
| USA     | 2.25 | 5.12 | 12.65 | 23.72 | 30.10 | 34.55 |
| UK      | 2.55 | 4.31 | 7.93  | 15.97 | 21.42 | 27.45 |
| Germany | 1.55 | 3.03 | 3.99  | 14.76 | 21.94 | 26.56 |
| France  | 1.38 | 2.88 | 5.82  | 18.02 | 29.47 | 33.72 |

Source: Maddison (2001)

European nations, on the other hand, could not replicate the formula used by the Americans to boost labor productivity on the other side of the Atlantic. There were two major reasons behind this inability – the “natural resource scarcity and skilled labor abundance” (Broadberry & O’Mahony, 2007). Yet, in Portugal, this scenario was even more challenging. Not only was the scarcity of natural resources – namely, strategic minerals such as coal and iron – more severe but also skilled labor was far from being abundant (Reis, 1993). In fact, it is possible to find in Reis (2000), Foreman-Peck & Lains (2000), and Lains (2002a), for example, clues leading to the conclusion that Portugal – alongside the Balkan countries – were already well behind the rest of Europe in terms of economic development since the transition from the 19<sup>th</sup> to the 20<sup>th</sup> century. During this period, Portugal did not follow the Balkans when it comes to opening its economy to foreign trade and capital imports. One could argue that this option turned out to be decisive to the aforementioned gap, however countries such as Bulgaria, Serbia, and Romania did not manage to initiate a convergence trend with the most-developed European nations, thus casting doubt around the effectiveness of this strategy (Lains, 2002a).

Another “symptom” of the national economic underdevelopment in the early 20<sup>th</sup> century was how agriculture – or the primary sector as a whole – gathered a large part of employees. As an example, in 1911, 61% of employment was absorbed by the primary sector, while the remaining was almost equally divided between Industry and Services (21.7% and 17.3%, respectively). However, these roughly two-thirds of workers in agriculture contributed to little more than one-third of that year’s GDP – 37.1%, to be more precise (Lains, 2006). This reflects the idea that, besides an agriculture-based economy, Portuguese reality relied on diminished levels of labor productivity. This is in line with the words Lains et al. (2013) used to describe the state of the national economy during this period – “(...) a backward, resource-poor, labor-abundant agrarian economy (...)”.

### 3.2. The Two World Wars and the “Golden Age”

As it would be expected, in the years ahead of World War I (1914-1918), while the USA was investing in a model that prioritized mass production, due to its machinery-based industries, Europe’s most developed nations were opting for a less standardized model. Indeed, European countries resorted to skilled labor as an alternative to the American process of production, which allowed them to provide more customized products when compared to that of the USA (Broadberry & O’Mahony, 2007).

After World War II (1939-1945), some European nations that were directly affected by this conflict – for instance, the UK, France, and West Germany – were able to stimulate their internal levels of labor productivity, as demonstrated in Maddison (2001). Interestingly, this trend managed to persist until the late 90s, which allowed these European countries to converge with the USA in terms of labor productivity, given that their annual growth rates always surpassed – or, at least, matched – the American’s, as can be perceived in the last three columns of Table 2.

**Table 2:** Annual growth rates of GDP per hour worked

|                      | 1870-1913 | 1913-1929 | 1929-1938 | 1938-1950 | 1950-1973 | 1973-1990 | 1990-1998 |
|----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| USA                  | 1.9       | 2.4       | 1.5       | 3.2       | 2.7       | 1.4       | 1.7       |
| UK                   | 1.2       | 1.5       | 0.9       | 2.3       | 3.1       | 1.7       | 3.1       |
| Germany <sup>1</sup> | 1.8       | 1.4       | 1.1       | -0.8      | 5.1       | 2.9       | 1.7       |
| France               | 1.7       | 2.4       | 2.9       | 0.5       | 7.7       | 3.0       | 2.1       |

Source: Broadberry & O’Mahony (2007)

In Portugal, the 30s, 40s and 50s also brought gains in terms of labor productivity. However, given the less-developed, agrarian economy the country presented at that time, the aforementioned enhancements did not mostly derive from improvements in the industrial sector. On the contrary, labor productivity in manufacturing was, in some districts, lower than the level verified in agriculture. Such might find a justification in the fact that a significant part of the Portuguese factories was very small-sized (Lains, 2006). Notwithstanding, the overall picture placed the secondary sector above agriculture regarding

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<sup>1</sup> After 1950, only West Germany was considered.

labor productivity, as Table A2 shows. Even if we were to widen the period of analysis – as Aguiar & Martins (2005) did – then it would be possible to find out that industry contributed more than agriculture to the total growth of labor productivity, between 1910 and 1950 (35.5% and 23.9%, respectively). However, if the object of analysis was growth rates, then agriculture would have evolved more rapidly than manufacturing (Table A2). This had a positive impact on the country's overall labor productivity, given that in 1930, 1940, and 1950 agriculture was the leading sector in terms of output (see Table A3).

As aforementioned, after World War II, the times were considerably different from the previous decades filled with uncertainty. Such a scenario might be explained by the staggering postwar economic growth (1950-1973, the “Golden Age”), which ended up “affecting” not only more developed Western nations but also the developing ones. For instance, the weighted average of labor productivity among twelve Western European countries<sup>2</sup> almost tripled during the Golden Age (Maddison, 2001). Nevertheless, it is important to note that not all countries were able to embark on this postwar economic recovery at the same time; for instance, while this recovery on American soil began almost immediately after the end of the conflict – in part, because the USA had not been attacked in its mainland – in Southern European this economic boom was delayed for a few years, more precisely until the late 50s (Bayoumi, 1995; O'Neill, 2022).

In the Portuguese case, both Reis (1993) and Silva et al. (2016) argue that the aforementioned “Golden Age” was particularly golden. This claim can be justified considering that Portugal overperformed, economically speaking, the rest of Western Europe from the 50s up to the 70s, a scenario that had rarely been observed since 1850. Ultimately, that contributed to the persistently large gap between Portugal and the rest of Europe in terms of development. It is worth mentioning that, during the decades mentioned above, the Portuguese economy widely benefited from a favorable external economic climate. This enabled easier access to international markets, increased international trade, foreign investment, and the acquisition of technical know-how, thus fostering the modernization and industrialization of the national economy.

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<sup>2</sup> The 12 countries considered in Maddison (2001) were Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. From now on, these will be referred to as “12WE”.

In line with that modernization of the Portuguese economy is the introduction of the Marshall Plan in Europe. Its main goal was to support the recovery of the western part of the continent after World War II based on the assumption that Europe, by itself, would not have the necessary amount of resources to enable such a recovery. Therefore, a large external aid was required, a support that could only be provided by the American government (O'Neill, 2022). Despite the initial skepticism of important Portuguese leaders concerning the Marshall Plan, namely the dictator, António de Oliveira Salazar, and his Minister of Finance, João Pinto da Costa Leite, Portugal ended up receiving over 54 million dollars of direct financial aid from the USA, which allowed the beginning of the industrialization process in the country (Rollo, 1994). It is, nonetheless, worth mentioning that this process began with a significant delay in Portugal, if compared to other nations from the Organisation for Economic Co-operation and Development (OECD) (Feinstein, 1999).

Simultaneously, a set of policies was put into practice by the Portuguese government aiming to prepare the ground for the implementation of the industrialization plan. Hence, in 1953, the First Development Plan was launched, whose primary goal was to stimulate the secondary sector's growth within the national economy. Some protectionist measures, namely focusing on discouraging imports of substitute goods, were also adopted at the time (Lains et al, 2013). This approach would eventually be altered due to Portugal's adherence to the European Free Trade Association (EFTA), in 1959 (Lains, 2006).

As a result, in the following decades (1950-1970), there was a significant shift in terms of employment as the number of people working in the primary sector – mostly, agriculture – diminished. These workers were then largely absorbed by the industry sector, which started gaining a bigger role in the Portuguese economy, as illustrated in Table 3.

**Table 3:** Composition of the Portuguese GDP in the 20<sup>th</sup> century (in %)

|             | 1900 | 1910 | 1920 | 1930 | 1940 | 1950 | 1960 | 1970 | 1980 | 1990 |
|-------------|------|------|------|------|------|------|------|------|------|------|
| Agriculture | 40.1 | 37.1 | 30.4 | 31.5 | 30.6 | 32.1 | 27.2 | 15.3 | 10.5 | 10.4 |
| Industry    | 24.7 | 27.1 | 25.8 | 28.0 | 28.7 | 30.3 | 37.0 | 48.8 | 48.8 | 44.6 |
| Services    | 35.3 | 35.8 | 43.9 | 40.5 | 40.6 | 37.6 | 35.7 | 35.9 | 40.7 | 45.0 |

Source: Lains (2009)

Simultaneously, the country's level of labor productivity continuously increased at a quick pace, especially during the 60s and the early 70s – interestingly, the final years of the Portuguese dictatorial regime (Amaral, 2009). Yet, an important element that did not follow such an upward trend at all was education. As referred by Mitchell (1998) and Lains et al. (2013), Portuguese children and young adults, when “gifted” with the possibility of going to school, would often have access exclusively to primary education. Around 85% of students in Portuguese educational institutions in 1960 and 1970 were enrolled in primary school. Also, it is key to reinforce that the use of the word “gifted” above was not just a mere figure of speech. Having access to education remained throughout these decades as something that did not cover most of the national population aged between 5 and 24 years (see Table A4).

Lains et al. (2013) underline that this pattern in Portuguese education contributed to low literacy rates compared to the European reality. In Tortella (1994), for instance, it is referred that Portuguese literacy levels were only 62% in 1960, which nonetheless may be seen as an improvement, given the reality that existed in 1930 (41% of literacy rate). This late improvement can be perceived as a consequence of the late investment that the Portuguese government conducted in human capital during the 50s and 60s, namely via the improvement of legislation that allowed access to primary school to all children aged between 6 and 12 (Lains et al., 2013). Unfortunately, as data from Table A4 demonstrate, this was not enough to motivate all Portuguese parents to enroll their children in educational facilities.

### **3.3. The Beginning of the “Great Moderation” Period**

After the fruitful period explored in the previous subchapter, the world – at least, the “developed half” of it – entered a new stage of its economic history – the so-called “Great Moderation”. This epoch ended up being better known for its overall macroeconomic stability, effective monetary policies, relatively steady economic growth, and reduced levels of inflation, among other factors that contributed to this classification. Regarding the beginning of this period, some authors tend to present conflicting information. In Hakkio (2013) – whose work's focus is on the USA – the mid-80s is pointed out as the beginning of everything, more precisely the year 1982. Bean (2010) agrees with the mid-80s suggestion, however clarifying that this stability tendency only got to the rest of the developed world around 1992/93. On the other hand, Giannone et al. (2008) clearly establish 1984 as the starting point of the “Great Moderation”, not only in the USA but also in some OECD

countries. Still, in one aspect authors tend to agree: this epoch came to an end as a result of the 2007-09 financial crisis and subsequent recession.

Yet, for the sake of this study, it would be interesting to start this subchapter's analysis in the mid-70s – at least, when focusing on the Portuguese reality – as major changes occurred in the country over this decade. To begin with, the dictatorial regime that ruled the country for more than four decades had come to an end, as a result of the Carnation Revolution of 1974, more commonly known as the “25<sup>th</sup> of April”. Notwithstanding the positive impacts that it brought to the Portuguese people in the long run, in the short run – more precisely, during the years immediately following the revolution – the country underwent a period of instability. Aspects such as the multiple attempts to conduct a new coup, the successive government falls, the decolonization process, and the wave of nationalizations are among the contributing factors to such political, social, and economic unsteadiness (Comissão Comemorativa 50 Anos 25 Abril, 2022).

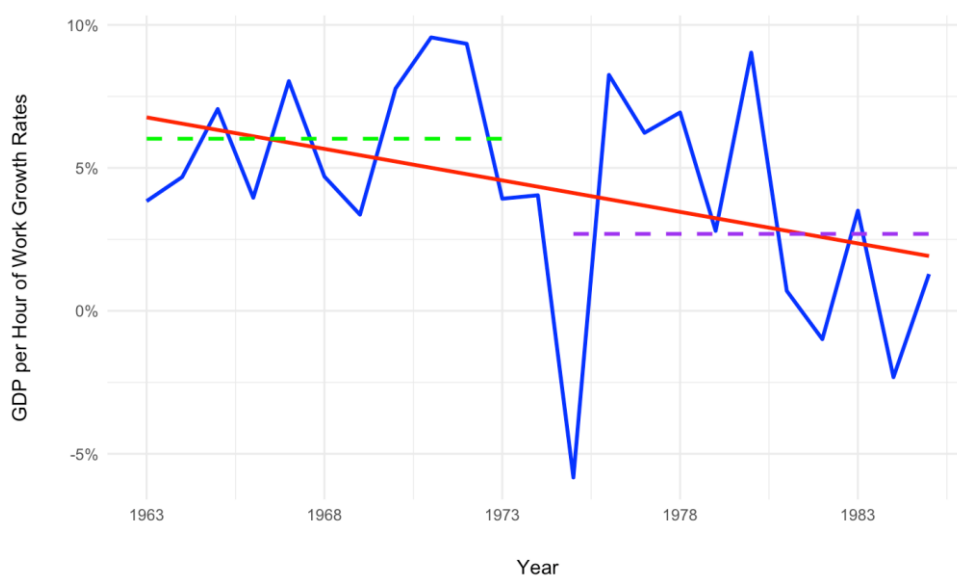
In fact, Lains (2002b) emphasizes the impact of the decolonization after 1974 on Portuguese labor productivity. The wave of immigration from the former colonies (as they declared independence from Portugal) led to a substantial increase in the working population. As this process occurred in simultaneity with the introduction of employment protection legislation, the author relates the colonies' independence with the decrease in labor productivity during this period. This was particularly worrying because, despite the convergence tendency presented towards the most developed European economies during the previous decades, the gap separating Portugal from these countries was still considerable. For example, after presenting an average annual growth rate of 6.09% in terms of GDP per hour of work between 1960 and 1973, the Portuguese labor productivity represented only 45.8% of the weighted average of the 12WE (Maddison, 2001; Amaral, 2009).

Data from Amaral (2009) strengthen the idea that the period following the revolution of 1974 was not prone to significant improvements in labor productivity compared to the previous years. To ensure a proper analysis, in Figure 1, both the eleven years prior- (1963-1973) and post-1974 (1975-1985) were considered with the aim of comparing labor productivity annual gains during these two periods. The main motivation for selecting a time window of eleven years lies in the fact that it allows us to consider the two interventions

from the International Monetary Fund (IMF) (1978-1979 and 1983-1985)<sup>3</sup> and, consequently, to measure how those impacted productivity.

The outcomes from Figure 1 are more than expected. Labor productivity achieved significantly higher annual growth rates between 1963 and 1973 than during the 1975-1985 period. The hourly GDP increased at an average annual rate of, approximately, 6.02% over the first period; regarding the eleven years following the 1974 revolution, the annual growth rate diminished to an average value around 2.69%. Additionally, in three out of the eleven years composing this second period (1975, 1982, and 1984), it was registered a decrease in labor productivity in comparison to the previous year. Overall, this deacceleration of the annual growth pace is attested by the negative slope of the trend line presented in the plot.

**Figure 1:** GDP per hour of work annual growth rates in Portugal (1963-1985)



Source: adapted from Amaral (2009)

Even when the economic situation in Portugal stabilized, after the IMF “departure”, the country’s labor productivity never went back to the staggering growth rates observed in

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<sup>3</sup> Some authors, namely Zorrinho (2018) and Amaral et al. (2020), contest this conventional approach regarding the IMF’s interventions in Portugal during the 70s and 80s. Zorrinho (2018) suggests that the IMF intervention lasted eleven years (from 1975 to 1985), while Amaral et al. (2020) accept the division into two separate interventions, however arguing that the first assistance from the IMF began in 1975, rather than 1978. Nevertheless, given that in Figure 1 the second period comprises all those hypotheses, it is safe to say that it is somewhat irrelevant for the context of this study which approach is more accurate.

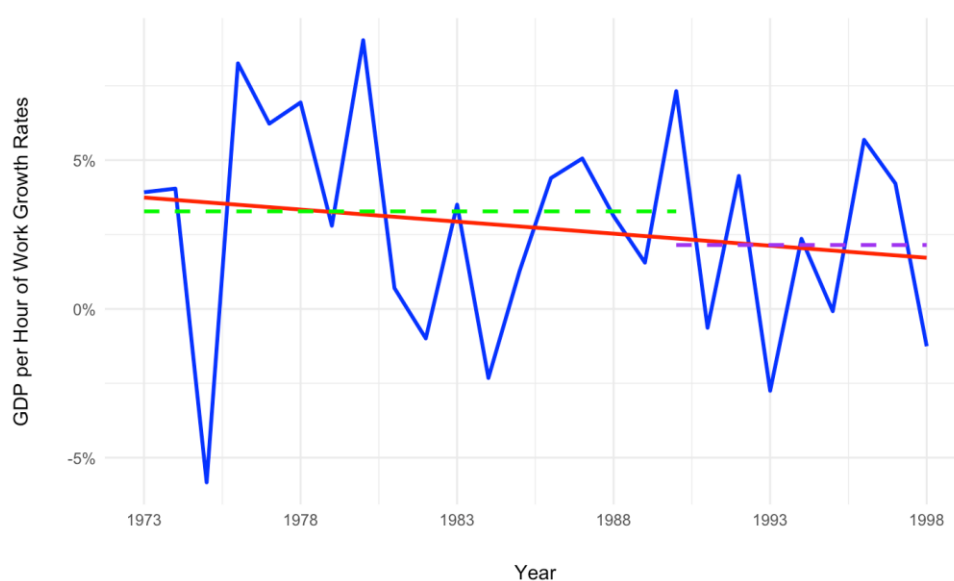
the “Golden Age” (Amaral, 2009). Up until the end of the millennium, the rates of growth kept a similar pace to the ones registered between 1975 and 1985 (see Table A5). As Table 4 demonstrates, such was not enough to significantly reduce the productivity gap between Portugal and some of the most developed nations in Europe. In addition, over the 90s, the deacceleration that had been felt regarding the growth of labor productivity was intensified, as shown in Figure 2. Consequently, the relative enhancements between 1973 and 1990 – even if not very significative – had been partly erased in 1998 due to this decrease in Portuguese labor productivity performance (Table 4). The country would, thus, enter the new millennium with a level of labor productivity two times lower than the one registered in most Western European nations (Maddison, 2001; Amaral, 2009).

**Table 4:** Portuguese hourly GDP in comparison with that of other European countries

|                      | 1973   | 1990   | 1998   |
|----------------------|--------|--------|--------|
| Portugal/France      | 41.18% | 42.79% | 41.99% |
| Portugal/Germany     | 50.27% | 57.47% | 53.31% |
| Portugal/Netherlands | 38.07% | 41.82% | 46.24% |
| Portugal/Belgium     | 43.93% | 45.95% | 42.18% |
| Portugal/12 WE       | 45.77% | 52.41% | 49.63% |

Source: Maddison (2001); Amaral (2009)

**Figure 2:** GDP per hour of work annual growth rates in Portugal (1973-1998)



Source: adapted from Amaral (2009)

During the period analyzed above, labor productivity started to lose its positive influence on TFP which had been demonstrated during the previous decades. This occurred mainly in the services sector, which, as observed in Table 3, had an increasingly larger weight on the Portuguese economy throughout the last three decades of the century (Lains, 2002b). Notwithstanding, this tendency was also extended to part of the industry sector (responsible for the other half of 90% of the Portuguese GDP). This was particularly true concerning some of the sectors where Portugal historically had competitive advantages – textiles, wearing apparel, leather and footwear, wood products, paper, and electrical appliances (Lopes, 1994). Other authors, such as Barbosa et al. (1999), suggest that the relative gains of the aforementioned sectors were precisely one of the main causes for the decrease in the overall labor productivity in the industry sector. Despite presenting comparative advantages in these industries in relation to other European economies (the UK, for instance), their labor productivity was below the average of the Portuguese industry sector. These sectors had a huge potential for exportation and, therefore, benefited from the country's integration into the European community. However, the relatively high growth rates achieved by these “traditional” parts of the Portuguese industry ended up harming the country's labor productivity.

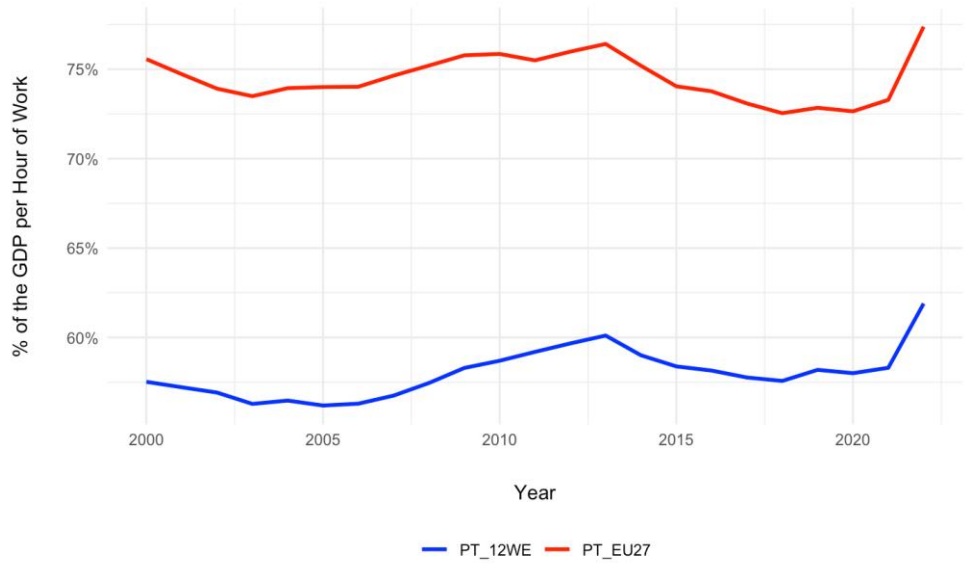
### **3.4. The New Millennium and the Current Scenario**

The truth is that the new millennium did not provide significant alterations to what had been the overall tendency over the last decades of the 20<sup>th</sup> century. Portugal kept struggling to close – or, at least, narrow down – the labor productivity gap separating the country from the “more developed half” of the European continent from 2000 onwards (see Figure A1 and Table A6). When comparing the country's labor productivity with the mean value of the 27 countries that form the EU since February 2020 (EU27) throughout these 23 years – see Figure 3 and Table A7 – it is noticeable that Portugal did not get even close to gaining ground in relation to the EU. A slightly more positive reality might be observed in Figure 3 with regard to the 12WE. In 2022, when compared to 2000, Portugal was able to diminish the labor productivity gap to the 12WE by only 4.4 percentual points; regarding the EU27, the gap narrowed only by 1.8 percentual points during the course of 23 years.

The reason why Portugal performed better in comparison to the 12WE than to the EU27 can be easily explained by looking at the labor productivity growth rates presented by

some of the countries that joined the EU in 2004 (EU2004), 2007 (EU2007), and 2013. But this raises a new concern: while Portuguese productivity seems to have stagnated in the 21<sup>st</sup> century, in emerging European economies – namely those that entered the EU in the last three enlargements<sup>4</sup> – labor productivity has been rapidly progressing.

**Figure 3:** Evolution of the Portuguese GDP per hour of work as a percentage of the average of the 12WE and EU27 (2000-2022)



Source: OECD (2024a)

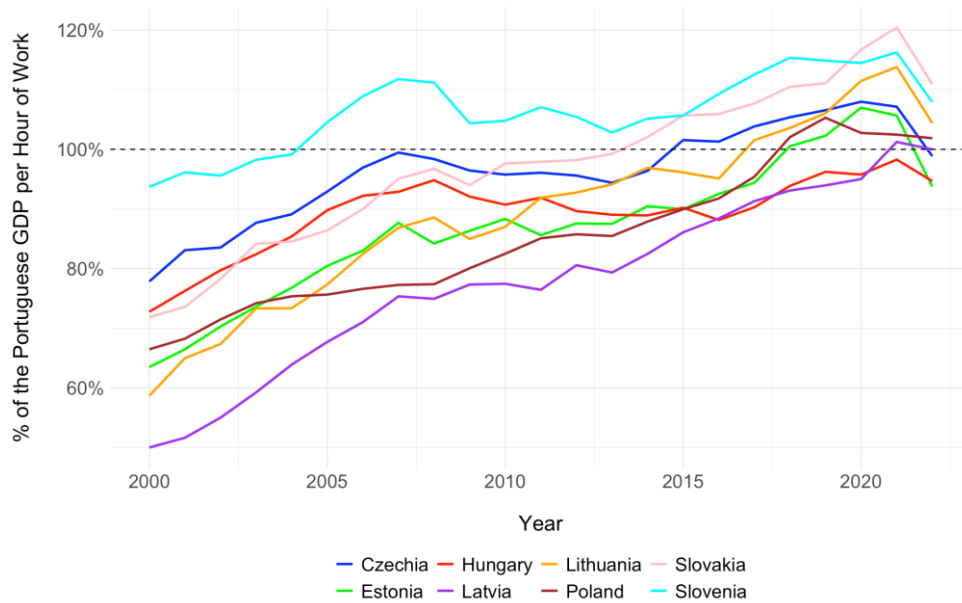
By analyzing Figures 4 and 5, it is possible to conclude that these nations’ growth rates surpassed that of Portugal by the simple fact that their labor productivity – measured as a percentage of the level presented in Portuguese territory (see Table A8) – massively increased over the period being considered. Such a reality is particularly true in regard to EU2004<sup>5</sup>. Of the eight countries here considered, only Hungary was not capable of surpassing the Portuguese level of productivity at some point during the period 2000-2022. Moreover, in 2022, five of those new members of the EU – Latvia, Lithuania, Poland,

<sup>4</sup> The last three enlargements of the EU took place in 2004 (Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia), 2007 (Romania and Bulgaria), and 2013 (Croatia).

<sup>5</sup> OECD (2024a) does not provide data on the labor productivity of Cyprus and Malta, countries that joined the EU in 2004 as well. Hence, these will not be considered in Figures 4, A3, and A4 and Tables A6 and A8. Yet, ILO (2024) gathers information regarding the evolution of these nations’ labor productivity between 2005 and 2024 (see Table A9 and Figure A2).

Slovakia, and Slovenia – were ahead of Portugal in this field. This situation starts to gain an even larger proportion when all these countries – except Slovenia – entered the new millennium with a labor productivity of less than 80% of that registered in Portugal.

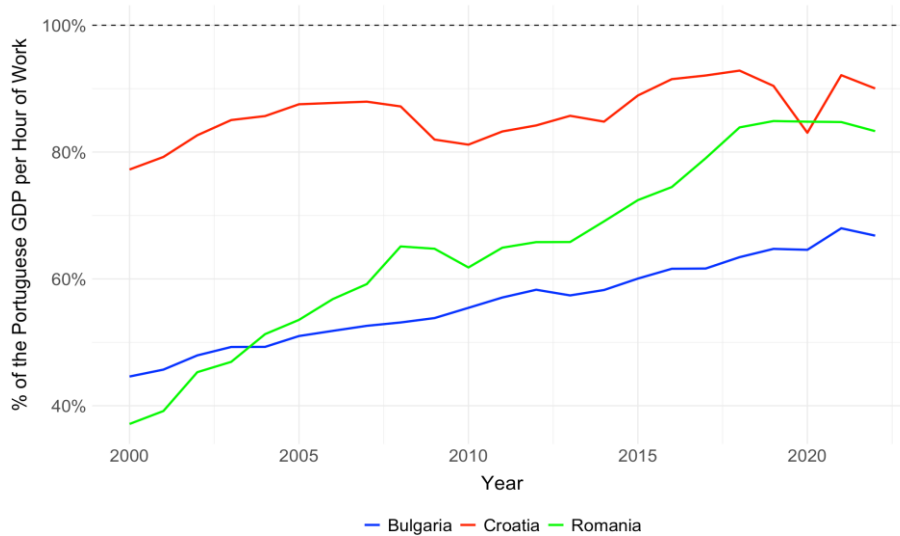
**Figure 4:** Evolution of the GDP per hour of work of 8 countries that joined the EU in 2004 as a percentage of Portugal's (2000-2022)



Source: OECD (2024a)

If the focus goes toward the countries that joined the EU after 2004 (EU2007 and Croatia), one would be able to argue that the Portuguese position is not as unfavorable as when compared to the EU2004. However, it is important to bear in mind that these economies possessed a very low labor productivity at the beginning of the millennium – especially Bulgaria and Romania – as seen in Figure 5. To put things in perspective, the distance that used to separate Bulgaria and Romania from Portugal back then was larger than the gap between Portugal and the 12WE in 2000. Yet, up until 2022, Bulgaria and, mainly, Romania accomplished what Portugal could not: to draw near the more developed European economies. In fact, as illustrated in Figures A3 and A4, the new entrants in the EU could always gain more ground in relation to the EU27 and 12WE than Portugal after they joined the EU.

**Figure 5:** Evolution of the hourly GDP of the 3 countries that joined the EU after 2004 as a percentage of Portugal's (2000-2022)



Source: OECD (2024a)

It is clear that some of the concerns that existed throughout the 20<sup>th</sup> century with respect to Portuguese labor productivity are still major barriers to the country's economic development. The fact that workers produce less than in other European nations restrains the national levels of investment and wages. These two realities combined enhance the country's chances of losing skilled labor, entrepreneurs, and researchers, which will compromise the growth of labor productivity in the future (Banco de Portugal, 2019). In line with that, Correia (2022) claims that the country's labor productivity growth is currently being restricted by its low levels of gross fixed capital formation and expenses in Research and Development (R&D) for the euro area patterns.

Evidently, one cannot ignore the impact of negative external shocks throughout the first 22 years of the new millennium on the Portuguese economy – the 2008 global economic and financial crisis, the euro area sovereign debt crisis, the COVID-19 pandemic and the war in Ukraine –, as these were all huge shocks that guided global economy into some of the sharpest recessions observed since World War II (Amador et al., 2019; Salimova et al., 2022). However, after realizing how the country has constantly underperformed over the past few decades, it would be misleading to focus on these external shocks instead of studying the causes behind the country's inability to close the gap which has been separating it from the most developed nations for centuries.

## 4. Data and Descriptive Statistics

### 4.1. Data Description

The main sources of data for this thesis were the Integrated Business Accounts System (IBAS) from Statistics Portugal and, in a second stage, the BPstat, the Banco de Portugal statistical website, and PORDATA, a statistical platform provided by Fundação Francisco Manuel dos Santos. The choice for these databases lies mainly on their overall reliability and suitability for this study, as they provide data series for most of the variables being analyzed here.

First of all, in terms of measuring labor productivity, IBAS provides the Gross Value Added (GVA) for a total of 17 different Portuguese industries/economic activities between 2004 and 2022. This division of the national economy into sectors is accomplished based on the third revision of the Portuguese Classification of Economic Activities (CAE – Rev. 3) (see Table A10) (INE, 2007). From the total of 21 economic activities defined by this methodology, only 17 will be considered for this study, as they're the ones whose data are available at Statistics Portugal. For that reason, the following four industries included in the CAE-Rev. 3 will not be analyzed from now on – financial and insurance activities (K); public administration and defense, compulsory social security (O); activities of households as employers and undifferentiated goods- and services-producing activities of households for own use (I); activities of extraterritorial organizations and bodies (U). The level of labor productivity of each of the considered industries derives from dividing their GVA by the total number of people employed in the enterprises that form each economic activity. This metric will exclude all the inputs utilized and exclusively consider the actual contribution to the national GDP of labor's intervention in the production process.

During this stage of data collection and primary analysis, one aspect that came to attention was the existence of a clear outlier among the Portuguese economic activities in terms of labor productivity – the economic sector entitled “Electricity, gas, steam, cold and hot water and cold air” (D). While the average values of productivity of the remaining 16 industries ranged from 7,182€ to 63,984€, the aforementioned activity reached 349,816€ (see Table A11). It is worth mentioning that this huge disparity has been common in Portugal throughout the decades (see Table A2). Hence, in order to prevent any undesirable impacts on this study's results, the final decision was to disregard this sector. The idea that sustains such a call is that this economic activity gathered, on average, only 2,195 out of the 1,201,136

enterprises that existed in the country every year between 2004 and 2022 – a weight of approximately 0.183% (see Table A11). Based on that, one could argue that not only does this industry have a relatively low weight on the overall number of Portuguese companies – the third lowest weight on average, to be more precise – but also possesses several specificities that differentiate it from the global reality of the national economy.

Another key pillar is to separate capital-intensive from labor-intensive industries. As aforementioned, the level of capital intensity might ultimately be measured following different approaches and methodologies. With that being said, the measurement of the capital intensity across Portuguese industries will be conducted based on the formula suggested by some authors in currently available literature – e.g., Harris (1988) –, which is dividing the company's total assets by its sales. Nevertheless, in this case, it is important to note that the amount of revenues resulting from sales will be replaced by the value of the overall production. This occurs mostly due to the inexistence of data regarding the Portuguese economic sectors' total sales for the whole 2004-2022 period, a scenario that forces the use of this proxy. The main implication coming from this approach might be considering that all goods and/or services produced in a given year will be sold during that same year. Despite some inconsistencies with the “real world”, the adoption of this variable seems to be a satisfactory option as one could argue that the value of the products being kept in stock to be sold in the following year might end up being counterbalanced by the production that has been carried over from the previous year.

Then, it was conducted a preliminary analysis aiming to find out whether it was possible to perceive a relationship between these variables in the Portuguese economy. Therefore, the average values of the 16 economic activities were plotted on a scatter graph, where the x-axis corresponds to the average annual value of labor productivity and the y-axis to the average annual level of capital intensity (see Figure A5). From this plot, it is possible to conclude that there is not a strong positive relationship between these two variables. Such a deduction comes from the fact that the data points are spread out and considerably distant from the trend line. This idea is supported by their correlation coefficient – 0.226 – which suggests a relatively weak linear relationship. Nevertheless, this positive correlation, although a weak one, should not be ignored in the sense that it still reveals the tendency that exists for these two variables to evolve in the “same direction”. Additionally, this weak correlation might even imply that other variables besides capital intensity possess a stronger influence

on global Portuguese productivity. Hence, some additional variables were considered for this estimation, namely:

- **Exports as a percentage of total sales:** as mentioned before, international trade can impact a country's internal level of labor productivity (Alcalá & Ciccone, 2004; Felbermayr et al., 2011). Given that Portugal is inserted in economic blocks – the EU and the Schengen Space – that do not restrict exchanges of goods/services, it would be expected that economic sectors that export a larger parcel of their total annual production possess competitive advantages comparatively to other European countries – namely, in terms of labor productivity. Yet, the competitive advantages from exporting sectors do not necessarily have a positive influence in the country's labor productivity (Barbosa et al., 1999). Throughout the last decades, some of the most competitive Portuguese sectors presented a below-average rate of labor productivity. Hence, it is key to find out whether this tendency still holds up or not. The source for this variable is the BPstat, with data available from 2006 to 2022.
- **Financial debt as a percentage of total assets:** financial debt illustrates how accessible funding is in each sector. As labor productivity enhancements are often related to enterprises' degree of investment – e.g., in capital stock (Bergeaud et al., 2016; Owyang & Shell, 2018), in improving workers' skills (Gouveia et al., 2017; Chen, 2020) – it would be interesting to investigate if easier access to financing enables more improvements regarding labor productivity. The source for this variable is the BPstat, with data available from 2006 to 2022.
- **Operating subsidies as a percentage of total production:** it is also relevant to consider how public subsidies – here, in the form of operating subsidies – stimulate each sector's labor productivity. As referred by Baily et al. (2015) and Erber et al., (2017), public investment might be perceived as a key element to improve labor productivity. This indicator might also transmit how dependent Portuguese economic sectors are on public support to become more competitive. The source for this variable is IBAS, with data available from 2004 to 2022.
- **Investment rate (%):** this variable corresponds to the ratio between the gross fixed capital formation and GVA. Such will allow us to realize each sector's patterns regarding their investment in fixed capital. Additionally, by putting this

value as a percentage of GVA, it will be possible to make this variable more comparable between sectors. The importance of this variable mostly lies in the fact that investment in capital tends to enhance labor productivity, mainly when it comes to highly skilled workers (Owyang & Shell, 2018; Chen, 2020). In addition, Chen (2020) argues that this line of thought can be applied to both capital-intensive and labor-intensive industries, which underlines the importance of including this variable in this study. The source for this variable is IBAS, with data available from 2004 to 2022.

- **Labor productivity adjusted wage (%):** this variable consists of measuring the contribution of labor for the enterprise's GVA for each euro spent on personnel expenses. Thus, higher values will correspond to industries where the GVA by workers is proportionally higher than the expenses companies have regarding their workers. This metric can also be an accurate way to verify the impact of companies "returning" a higher part of the employee's productivity to him in the form of their personnel expenses, from a motivational perspective. The inclusion of this variable reflects the tendency in current literature to consider the relationship between wages and labor productivity – e.g., Gričar et al. (2021). The source for this variable is IBAS, with data available from 2004 to 2022.

Table 5 presented below compiles all the variables that will be utilized in the study, as well as the nomenclatures that were adopted to identify them throughout the estimation.

**Table 5:** Variables and their identifications utilized on the estimation

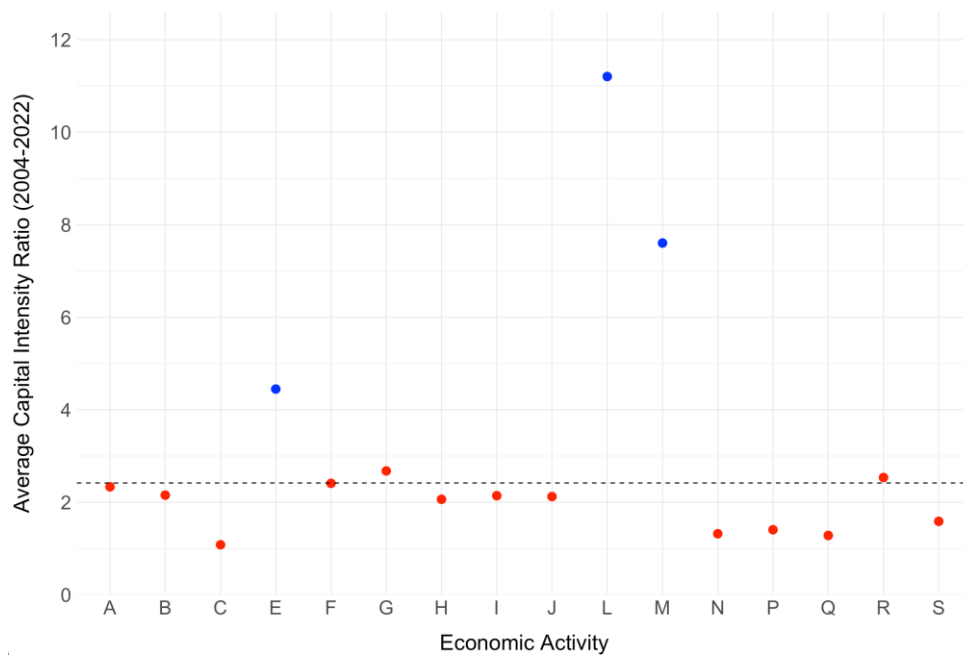
| Variable                                                | Identification in the Estimation |
|---------------------------------------------------------|----------------------------------|
| Labor Productivity                                      | <i>Labor_Productivity</i>        |
| Capital Intensity Ratio                                 | <i>Capital_Intensity</i>         |
| Exports as a percentage of total sales                  | <i>Exports</i>                   |
| Financial debt as a percentage of total assets          | <i>Financial_Debt</i>            |
| Operating subsidies as a percentage of total production | <i>Subsidies</i>                 |
| Investment rate (%)                                     | <i>Investment_Rate</i>           |
| Labor productivity adjusted wage (%)                    | <i>Adjusted_Wage</i>             |

## 4.2. Data Treatment

### *Differentiation Between Capital-Intensive and Labor-Intensive Industries*

To establish a division between capital-intensive and labor-intensive industries, one will resort to the capital intensity ratio to fundament the allocation of each sector to one of the two groups mentioned above. This allocation process will be based on data that has already been gathered in Table A11, as it compiles the average value for each sector's capital intensity ratio between 2004 and 2022. Aiming to ensure an easier visualization of the distribution of this ratio among the Portuguese economic activities, Figure 6 was generated.

**Figure 6:** Distribution of the average capital intensity ratio for Portuguese economic activities (2004-2022)



Source: adapted from INE (2023)

One conclusion that immediately stands out from Figure 6 is the strong predominance of industries with low levels of capital intensity. Such can be perceived by the fact that the country's total capital intensity ratio in this period was, on average, 2.417 (dotted line in the graph). This reveals how much closer the Portuguese economy as a unit is to the most labor-intensive industry (C – 1.082) than to the most capital-intensive one (L – 11.204). Therefore, it was decided that all the industries presenting a capital intensity ratio below the

national average – A, B, C, F, H, I, J, N, P, Q, and S – would make suitable “applicants” for the labor-intensive classification. Nevertheless, it would not be reasonable to automatically consider the remaining six activities capital-intensive ones. For instance, industries G and R also have relatively low capital intensity ratios, despite being above the national average. Thus, given that these two industries are so close to the national average, the final decision was to include them in the labor-intensive category as well. This would then leave us with three capital-intensive industries – E, L, and M – and thirteen labor-intensive sectors – A, B, C, F, G, H, I, J, N, P, Q, R, and S.

### ***Missing Values***

Given the restrictions in terms of time extension from the two variables taken from BPstat – they would only go as far as 2006 –, what was being anticipated was, therefore, a total of 64 missing values<sup>6</sup> in the new dataset that combined the labor-intensive and capital-intensive datasets. As demonstrated by Table A12, this expectation would end up corresponding to reality. Now that it was confirmed that there were no more missing values throughout the combined dataset, the focus would have to go towards the validity of the use of both these variables. In other words, it was now necessary to ensure that the two years of data that were missing would not impact the study’s results.

First of all, a crucial aspect to clarify is that the missing values correspond to, approximately, 10.5% of the aforementioned variables. Keeping that in mind, two paths emerged: either to disregard the years 2004 and 2005 – meaning that the analysis would only cover the period 2006-2022 – or to replace these missing values with estimates. If one was to go with this latter option, it would be wise to get to know better how these two variables were composed. Hence, the primary focus was to understand how distributed the values from both these variables were. For that purpose, the first step was to calculate the standard deviation for the period 2006-2022, where data was fully available. The aim was to be able to identify how close those values were to the mean. Assuming that the standard deviation was low for *Exports* and *Financial\_Debt*, then it would be accurate to estimate that the 2004 and 2005 values would be similar to the mean, allowing for data imputation to occur. In

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<sup>6</sup> These 64 missing values derive from two years of missing data (2004 and 2005) for two variables (*Exports* and *Financial\_Debt*) for all 16 economic sectors considered.

order to ensure that the specificities of each economic sector were contemplated, the analysis of the standard deviation was conducted individually.

Therefore, the first step was to gather exclusively the data that went from 2006 to 2022, the range that would be analyzed since it possessed no missing values. The next step consisted of calculating the standard deviation and mean values (see Table A13) for the aforementioned two variables, aiming ultimately to determine the ratio between them (that is, the coefficient of variation), as this would be a valid form of putting these results into perspective. Those results might be found in Table 6.

**Table 6:** Coefficient of variation for the Portuguese economic sectors considered (2006-2022)

| Economic Activity<br>(Division – CAE Rev. 3) | <i>Exports</i> | <i>Financial_Debt</i> |
|----------------------------------------------|----------------|-----------------------|
| A                                            | 0.18198785     | 0.03877946            |
| B                                            | 0.08947237     | 0.19538025            |
| C                                            | 0.09987304     | 0.08310414            |
| E                                            | 0.23786888     | 0.11212361            |
| F                                            | 0.35022866     | 0.14459314            |
| G                                            | 0.19838149     | 0.09017382            |
| H                                            | 0.10960512     | 0.09260241            |
| I                                            | 0.27164596     | 0.09269016            |
| J                                            | 0.47762918     | 0.19568433            |
| L                                            | 0.35697285     | 0.10609691            |
| M                                            | 0.26785288     | 0.12683977            |
| N                                            | 0.31087542     | 0.06328179            |
| P                                            | 0.24734158     | 0.08281701            |
| Q                                            | 0.33192469     | 0.08611329            |
| R                                            | 0.59304749     | 0.12028544            |
| S                                            | 0.47404168     | 0.07156388            |

Source: adapted from Banco de Portugal (2024a); Banco de Portugal (2024b)

An aspect that immediately comes out is that these two variables do not share the same pattern in terms of data distribution, in the sense that the coefficient of variation is significantly lower in *Financial\_Debt* rather than in *Exports*. In fact, the *Financial\_Debt* coefficient of variation never surpasses the 20% mark, as only two sectors – B and J – exhibit

a standard deviation above 15% of their mean. Such might be translated into the following: while the mean might be a relatively accurate estimate for the missing values regarding the *Financial\_Debt* variable, such a line of thought cannot be applied to *Exports*, given that data is considerably spread and distant from the mean value in most sectors. This reality implies that, although a suitable replacement has been found for the missing values in *Financial\_Debt*, some extra work will be necessary with the aim of replacing these missing values in *Exports*.

This extra work will come in the form of analyzing the weight of each sector's exports in the country's total volume of exports of goods and services (see Table A14). It is worth mentioning that the country's overall volume of exports was based on data from PORDATA (2024a) and PORDATA (2024b). The goal is to observe if the distribution of Portuguese exports among the industries considered was stable between 2006 and 2022. If so, it is safe to assume that one would be able to obtain a close estimate of the ratio between the sector's exports and that of the entire country for 2004 and 2005. However, as Table A15 illustrates, the coefficient of variation for a significant part of the sectors is high, indicating that the standard deviation has a larger weight on the mean than what would be desirable.

Nevertheless, it must not be ignored that this ratio tends to be higher in samples that possess smaller values. This occurs because, in some cases, the standard deviation does not diminish proportionally to the mean when a sample with smaller values is compared with others with larger values. A clear example of that can be seen precisely in Table A14. Sector C gathers the largest cut of the country's overall exports – on average, almost 51% of Portuguese exports derive from this sector – and, at the same time, presents the lower coefficient of variation in Table A15. The same could be said about sectors G and H, the second and third most important ones in the country's total volume of exports, respectively. On the contrary, the five industries with the highest coefficients of variation weight, on average, less than 1% on overall exports.

It is key to confirm that these weights did not suffer significant alterations during the 2006-2022 time interval. For that matter, Table 7 compiles each sector's average weight on total sales, the difference between their highest and lowest value (in percentage points), and their average annual change rate (also in percentage points). Perhaps, the most important note to retrieve from the table below is that average annual changes are very close to zero, i.e., the weights have been stable throughout those 17 years. And, if we keep in mind that

the period of analysis encompasses 17 years, then the difference between the maximum and minimum values cannot be characterized as being significant.

**Table 7:** Average value, the difference between maximum and minimum values, and average annual change of each sector's weight in the country's overall exports (2006-2022)

| Economic Activity<br>(Division – CAE Rev. 3) | Average Value | Max – Min | Average Annual<br>Change |
|----------------------------------------------|---------------|-----------|--------------------------|
| A                                            | 0.68%         | 0.62      | 0.030                    |
| B                                            | 1.21%         | 2.34      | -0.101                   |
| C                                            | 50.98%        | 6.84      | -0.363                   |
| E                                            | 0.27%         | 0.28      | 0.004                    |
| F                                            | 5.23%         | 6.36      | -0.094                   |
| G                                            | 15.60%        | 4.81      | 0.063                    |
| H                                            | 9.00%         | 3.09      | 0.023                    |
| I                                            | 0.46%         | 0.53      | 0.012                    |
| J                                            | 2.97%         | 3.72      | 0.176                    |
| L                                            | 0.19%         | 0.33      | 0.003                    |
| M                                            | 4.10%         | 3.50      | -0.069                   |
| N                                            | 1.77%         | 1.24      | 0.071                    |
| P                                            | 0.05%         | 0.03      | 0.001                    |
| Q                                            | 0.05%         | 0.05      | 0.003                    |
| R                                            | 0.16%         | 0.27      | 0.017                    |
| S                                            | 0.05%         | 0.06      | 0.003                    |

Source: adapted from Banco de Portugal (2024a); PORDATA (2024a); PORDATA (2024b)

Hence, even though the first approach was to replace the missing values of the sectors' volume of exports with their respective average value, the final choice will be to estimate the missing values through the average annual change. The option for this latter approach lies in the results of the coefficient of variation analysis, although its significance was attenuated by the fact that samples were mostly composed of small values. Nevertheless, it was considered to be more cautious to opt for the retroactive application of the average annual change to get to the 2004 and 2005 numbers. Also, this option, in opposition to the utilization of the mean, reinforces the tendency of steadiness which is the main feature of this variable.

Still concerning the *Exports* variable, because it considers the weight of each industry's exports in total sales, if one's objective is to estimate this ratio for 2004 and 2005, it becomes mandatory to determine a proxy for the missing values of sales as well. In this case, it will be considered that the annual growth rates of sales in each economic sector will be identical to those from their production, a variable retrieved from IBAS. This decision is supported by Table A16, where it is noticeable how deeply correlated these two variables are. The sole exception ends up being sector Q; yet, as the annual variations of sales and production are, by definition, closely connected – in fact, when determining the capital intensity ratio, production was utilized as a proxy for sales –, the option of applying the production growth rates to sales stands as an adequate one in this scenario. Finally, with no more missing values, the shape of the dataset is now in line with what's shown in Table A17.

### 4.3. Descriptive Statistics

The missing value imputation process described above also allows us to determine the descriptive statistics for the variables that were picked for this study. Table 8 presents the summary statistics of the variables considered.

**Table 8:** Descriptive statistics for the combined dataset (2004-2022)

| Variable           | N   | Mean  | Std. Dev. | Min     | Pctl. 25 | Pctl. 75 | Max   |
|--------------------|-----|-------|-----------|---------|----------|----------|-------|
| Labor_Productivity | 304 | 25918 | 15893     | 6312    | 13008    | 37756    | 77827 |
| Capital_Intensity  | 304 | 3     | 2.8       | 0.97    | 1.5      | 2.7      | 16    |
| Exports            | 304 | 0.15  | 0.16      | 0.0021  | 0.035    | 0.23     | 0.65  |
| Financial_Debt     | 304 | 0.34  | 0.089     | 0.12    | 0.27     | 0.42     | 0.56  |
| Subsidies          | 304 | 0.032 | 0.054     | 0.00047 | 0.0022   | 0.018    | 0.24  |
| Investment_Rate    | 304 | 0.26  | 0.19      | 0.016   | 0.13     | 0.32     | 1.1   |
| Adjusted_Wage      | 304 | 1.3   | 0.51      | 0.59    | 0.97     | 1.7      | 2.8   |

Table 8 illustrates how both labor productivity and the capital intensity ratio tend to be much closer to the minimum value than to the maximum. In fact, not only is the mean of these variables closer to their lowest value rather than to their highest one but also the same

can be said about the 75<sup>th</sup> percentile. The latter implies that 75% of the observations are considerably distant from translating either highly productive or capital-intensive scenarios.

On the contrary, variables such as *Exports* and *Subsidies* stand out for having dispersed values, a reality that ends up being translated by presenting a standard deviation higher than the mean – hence, a significative coefficient of variation. Therefore, one could expect to verify severe discrepancies among the Portuguese economic activities on these two matters.

*Investment\_Rate* follows a similar pattern to the one found in *Labor\_Productivity* and *Capital\_Intensity*. They all possess the 75<sup>th</sup> percentile significantly closer to the lowest observation than to the maximum value. Thus, in line with what was concluded from the descriptive statistics of *Labor\_Productivity* and *Capital\_Intensity*, the rate of investment can be classified as low in the overall economy. This enhances the image of an underperforming country with respect to labor productivity that had already been drawn in Chapter 3.

Finally, both *Financial\_Debt* and *Adjusted\_Wage* have lower coefficients of variation, which reveals that observations present the tendency to converge to the mean. In regard to *Financial\_Debt*, this is particularly true, given that the 25<sup>th</sup> and 75<sup>th</sup> percentiles are almost equidistant to the minimum and maximum, respectively. In addition to that, the mean is placed right between the lowest and highest observed values, which definitely reinforces the idea of a very balanced data distribution in this variable.

It is also relevant for this study to observe the descriptive statistics for the capital-intensive and labor-intensive industries separately (see Tables 9 and 10). Below, Table 9, whose focus is exclusively on labor-intensive industries, and Table 10, focusing on capital-intensive industries. As it would be expected, the average values for labor productivity, capital intensity, and investment rate are significantly higher among the industries classified as intensive in capital. Yet, the highest value of labor productivity observed between 2004 and 2022 in Portugal was in a labor-intensive industry – more precisely, in sector J. *Adjusted\_Wage* mean is also larger in capital-intensive industries, although, once again, the highest value is observed in a labor-intensive sector – this time, in industry B.

On the contrary, exports appear to have a higher preponderance in labor-intensive industries – on average, five percentage points above capital-intensive sectors' mean value. Operating subsidies also have a larger weight on this type of industry's production. To put things in perspective, the highest value registered for *Subsidies* among capital-intensive industries is lower than labor-intensive sectors' mean. In terms of *Financial\_Debt*, the scenario

is similar in both types of sector. This indicates that there appears to be no major distinction between labor-intensive and capital-intensive industries regarding access to funding.

**Table 9:** Descriptive statistics for the labor-intensive industries (2004-2022)

| Variable           | N   | Mean  | Std. Dev. | Min     | Pctl. 25 | Pctl. 75 | Max   |
|--------------------|-----|-------|-----------|---------|----------|----------|-------|
| Labor_Productivity | 247 | 24007 | 16485     | 6312    | 12364    | 29504    | 77827 |
| Capital_Intensity  | 247 | 1.9   | 0.6       | 0.97    | 1.4      | 2.4      | 3.5   |
| Exports            | 247 | 0.16  | 0.17      | 0.0021  | 0.036    | 0.24     | 0.65  |
| Financial_Debt     | 247 | 0.34  | 0.09      | 0.12    | 0.27     | 0.42     | 0.56  |
| Subsidies          | 247 | 0.037 | 0.059     | 0.00047 | 0.0022   | 0.037    | 0.24  |
| Investment_Rate    | 247 | 0.22  | 0.12      | 0.016   | 0.13     | 0.29     | 0.68  |
| Adjusted_Wage      | 247 | 1.3   | 0.45      | 0.59    | 0.93     | 1.5      | 2.8   |

**Table 10:** Descriptive statistics for the capital-intensive industries (2004-2022)

| Variable           | N  | Mean   | Std. Dev. | Min    | Pctl. 25 | Pctl. 75 | Max   |
|--------------------|----|--------|-----------|--------|----------|----------|-------|
| Labor_Productivity | 57 | 34196  | 9328      | 19315  | 24054    | 42702    | 48015 |
| Capital_Intensity  | 57 | 7.8    | 3.8       | 1.5    | 4.6      | 10       | 16    |
| Exports            | 57 | 0.11   | 0.11      | 0.01   | 0.029    | 0.22     | 0.37  |
| Financial_Debt     | 57 | 0.35   | 0.084     | 0.23   | 0.27     | 0.42     | 0.5   |
| Subsidies          | 57 | 0.0081 | 0.0054    | 0.0007 | 0.0021   | 0.011    | 0.019 |
| Investment_Rate    | 57 | 0.44   | 0.3       | 0.073  | 0.14     | 0.7      | 1.1   |
| Adjusted_Wage      | 57 | 1.7    | 0.58      | 0.92   | 1        | 2.2      | 2.6   |

## 5. Methodology

Considering the composition of the dataset – featuring a dependent variable and six independent variables –, the primary option to be analyzed regarding the model to be adopted is the Multiple Linear Regression (MLR). Such an approach would allow predicting the outcome of the response variable – in this case, labor productivity – through multiple explanatory variables, which is precisely the main goal here. Thus, the model would have the following shape:

$$y = \beta_0 + X_i\beta_i + \epsilon_i$$

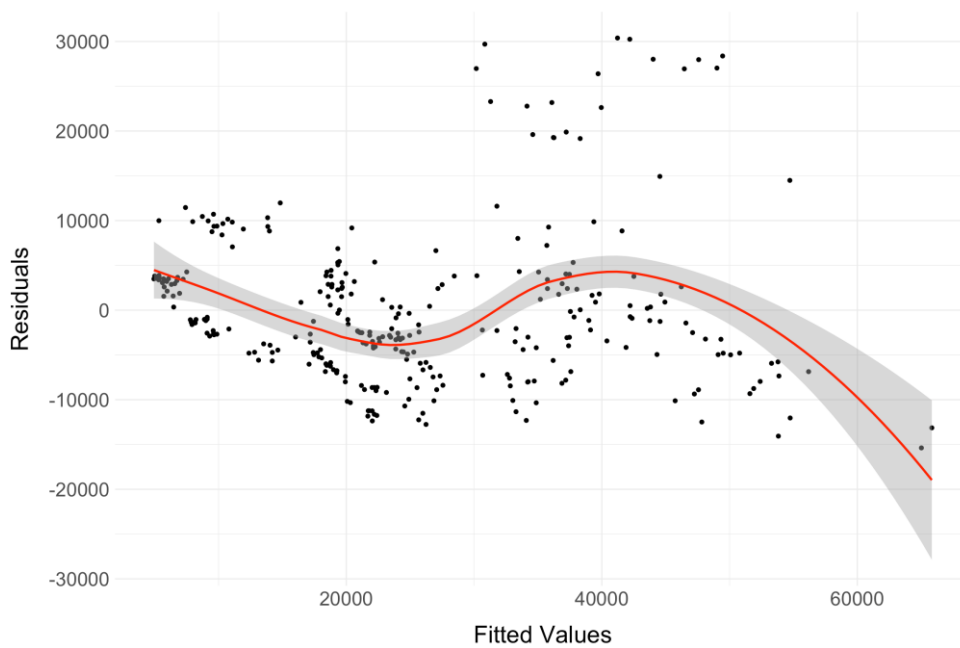
In this case,  $y$  would represent the predicted value;  $\beta_0$  stands for the y-intercept, i.e., the value assumed by the dependent variable in the case of all independent variables being set to zero; these independent variables and their respective coefficients are represented by  $X_i\beta_i$ ; lastly,  $\epsilon_i$  will quantify how much variation exists in the estimation of *Labor\_Productivity*, expressing, therefore, the model error.

Regarding the estimation method to be adopted, in the context of the MLR model, the first option would be the Ordinary Least Squares (OLS). Yet, it is key to perceive whether this method provides an adequate approach for the specificities of this dataset. Based on that, the first test of the validity of this model is to check for any clues of heteroscedasticity. In Figure 7, it is presented this model's residuals vs. fitted values plot, a useful and widely utilized tool to detect aspects such as non-linearity and asymmetrical error variances. Its utilization, in this study's context, has the objective of understanding some of the existing patterns in this dataset in relation to linearity, spread of residuals, and outliers.

With that being considered, it is possible to observe that this plot's trend line does not only possess clear curves but also ends up getting distant from  $y = 0$ . Two major conclusions may be taken from these two characteristics of the plot. First, the curved trend line reveals that picking a linear approach via the MLR might not capture entirely the impact of the independent variables on *Labor\_Productivity*, since this trend line indicates that the relationship between them might not be linear. Second, the spread of residuals among the plot reveals a rather heterogeneous pattern, especially for fitted values above 30,000. In this second half of the plot, some residuals are located far distant from the  $y = 0$  line, suggesting that the difference between the actual results and the values predicted by this regression model is significant. This inconsistency in the distribution of residuals throughout Figure 7

is a clear sign of the existence of heteroscedasticity. This suspicion is sustained by the results obtained from the Breusch-Pagan test, where the p-value is  $1.294\text{e-}08$  – less than 5%. This test indicates that the null hypothesis of homoscedasticity – i.e., the hypothesis that assumes that residuals are distributed with the same variance throughout the dependent variable – should be rejected.

**Figure 7:** Residuals vs. fitted values plot for the MLR model



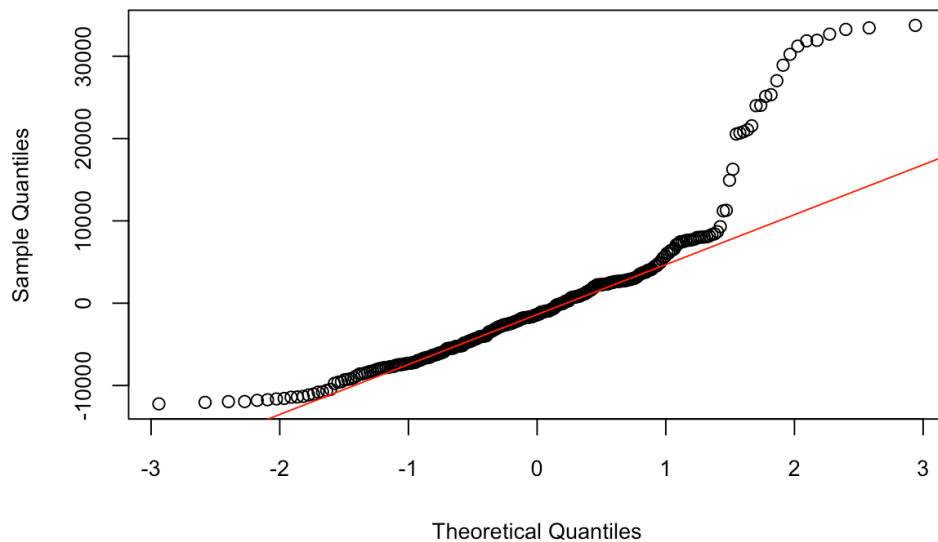
In a scenario like this, it is fundamental to eliminate the heteroscedasticity issue, in order to preserve the reliability of this estimation's results. A possible solution might come from resorting to a Weighted Least Squares (WLS) regression, instead of an OLS regression. A WLS regression often comes in handy when one is dealing with a dataset that violates the homoscedasticity assumption. That is due to the fact that this regression method attributes a larger weight to the observations that present smaller levels of error variance, as these transmit more useful information than the ones with a more significant error variance (Bobbitt, 2020).

To perform a WLS regression, the first step is to define the weights. Hence, these were calculated as the inverse of the squared fitted values from a secondary regression of the absolute residuals against the fitted values from the initial model. This adaptation in the

model led to a significant improvement regarding the Breusch-Pagan test's results. The p-value was now 1, which undoubtedly indicates that the heteroscedasticity issue had been addressed and the homoscedasticity assumption could finally be validated.

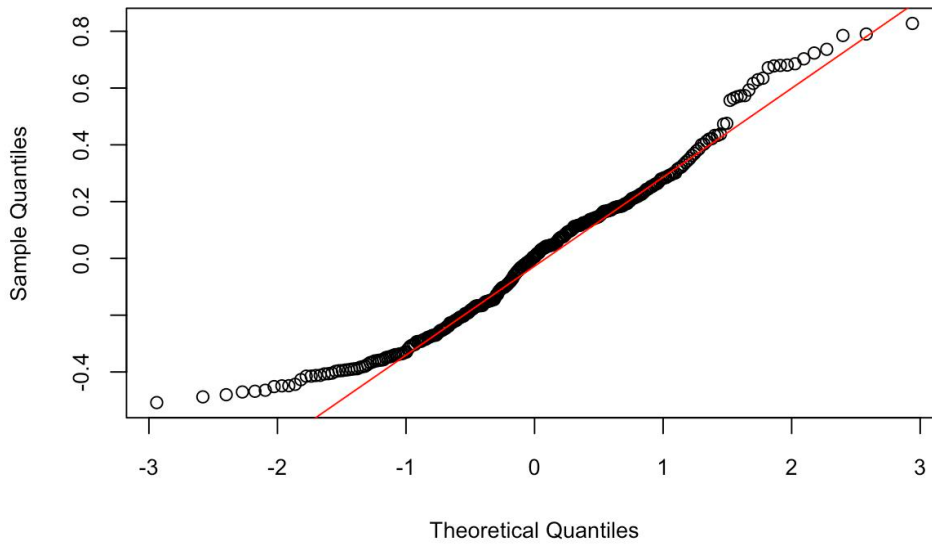
Nevertheless, one aspect that remained unsolved was the existence of outliers among the residuals – a reality that was already perceivable in Figure 7; also, they did not appear to be normally distributed. These two concerns are supported by Figure 8, where the Q-Q plot demonstrates that the residuals did not follow a normal distribution, mainly in the extremities of the plot, due to the presence of the aforementioned outliers.

**Figure 8:** Q-Q plot for the residuals of the WLS model



Based on this scenario, aiming to diminish the impact of these outliers and improve the levels of normality in the residuals' distribution, it was decided to perform a logarithmic (log) transformation to the WLS model. As Figure 9 demonstrates, this transformation significantly improved the distribution of the residuals, as it is visible that the points in the plot are closer to the diagonal line, namely those located closer to the edges. This means that the impact of the outliers – that were creating those deviations in Figure 8 – has dropped, ultimately enhancing the model's robustness and reliability.

**Figure 9:** Q-Q plot for the residuals of the WLS log model



Despite such an enhancement in terms of normality being visible by comparing Figures 8 and 9, it would be prudent to conduct an actual test to determine if the levels of normality ended up increasing after the log transformation. In this context, it became necessary to resort to the Shapiro-Wilk test, a commonly used method to test whether a given sample is normally distributed. The results presented in Table 11 are consistent with the perception obtained from analyzing the two previous Q-Q plots. The log transformation assumed a key role in enhancing the residuals' normality and such might be concluded by observing the significant upgrade in relation to the W statistic (or simply W). Given that W's value ranges between zero and one – where the closer you get from one, the closer you're from a normal distribution –, the WLS log model reaches a very satisfactory result.

**Table 11:** Shapiro-Walk test's results for the WLS and WLS log models

| Model         | W       | p-value   |
|---------------|---------|-----------|
| WLS Model     | 0.83699 | < 2.2e-16 |
| WLS Log Model | 0.96789 | 2.755e-06 |

Yet, on the contrary, the p-value, despite the massive improvement, is still considerably below the significance level of 0.05. This might suggest that, notwithstanding

the positive impact that the log transformation had, the residuals do not have a totally normal distribution. Nonetheless, the log transformation appears to have been effective in mitigating a large parcel of the negative impacts that could come from here regarding the results. Consequently, the assumption is that this transformation provides a proper and acceptable enhancement, not jeopardizing the overall validity of the model's findings.

Another important aspect lies in multicollinearity, in the sense that independent variables should not be highly correlated with each other. This condition – not being highly correlated – aims to prevent major complications when analyzing the model's results, as significant intercorrelations often result in wider confidence intervals and less accuracy in the estimation of the independent variables' impact on the model (Bobbitt, 2019; Hayes, 2024). Therefore, the Variance Inflation Factor (VIF) will be used to determine whether this model's independent variables show signs of multicollinearity. As referred by Bobbitt (2019) and Simon et al. (2018), VIF helps to better quantify how inflated the variance is, that is, how impactful the intercorrelation between independent variables is regarding the results of a given multiple regression model.

Authors tend to agree on the value of 5 as the line that separates acceptable values from more concerning ones regarding VIF – although Simon et al. (2018) refer that VIFs above 4 already demand further investigation. Either way, in Table 12 it is possible to verify that the VIFs are far from providing indications that there would be a multicollinearity issue in this set of independent variables. Hence, it is safe to state that the use of these predictor variables will not compromise the study's results from a multicollinearity point of view.

**Table 12:** VIF values for the independent variables for the WLS log model

| Capital_Intensity | Exports  | Financial_Debt | Subsidies | Investment_Rate | Adjusted_Wage |
|-------------------|----------|----------------|-----------|-----------------|---------------|
| 1.191062          | 1.404770 | 1.365405       | 2.105350  | 1.506093        | 2.125500      |

Despite not exhibiting strong evidence of multicollinearity, it is still important to ensure whether including all the independent variables that were considered at first generates the most suitable model or not. To conduct such an analysis, the option was to resort to the *stepAIC()* function to perform a stepwise regression. In this case, a stepwise regression could be useful as it both adds and removes predictor variables from the model, aiming to form

the most suitable set of independent variables (Bobbitt, 2023). Hence, in this case, the first model, whose results are presented in the left-hand side of Table 13, includes all six candidates to predictor variables that were considered throughout this study. Considering that, for this first model, the starting Akaike Information Criterion (AIC) was -5991.02, the assumption was that the AIC would be recalculated for different scenarios where each independent variable would be removed from the model. If the AIC's value improved, then the new reduced model would be better suited for the context of this estimation. That is precisely what happens when the *Investment\_Rate* variable is removed from the model presented in Table 13. Despite the enhancement not being very significant (the AIC's value goes to -5991.6, in comparison to the initial value of -5991.02), the two columns on the right-hand side of the table indicate that this new reduced model without *Investment\_Rate* is the best option, given that disregarding any other variable from this reduced model would not result in a more solid AIC.

**Table 13:** Stepwise regression for the complete and reduced models

| Complete Model      |         | Reduced Model       |         |
|---------------------|---------|---------------------|---------|
| Variable            | AIC     | Variable            | AIC     |
| - Investment_Rate   | -5991.6 | <none>              | -5991.6 |
| <none>              | -5991.0 | + Investment_Rate   | -5991.0 |
| - Financial_Debt    | -5989.6 | - Financial_Debt    | -5991.0 |
| - Capital_Intensity | -5982.1 | - Capital_Intensity | -5984.0 |
| - Exports           | -5973.8 | - Exports           | -5970.8 |
| - Subsidies         | -5937.2 | - Subsidies         | -5936.6 |
| - Adjusted_Wage     | -5866.6 | - Adjusted_Wage     | -5856.1 |

Finally, after calculating the respective coefficients, the combination of all transformations described in this chapter leads to the following model's equation regarding the Portuguese economy's labor productivity:

$$\log(\text{Labor Productivity}) = 8.8340 + 0.0225 \times \text{Capital Intensity} + 0.7434 \times \text{Exports} + \\ + 0.3722 \times \text{Financial Debt} - 2.6894 \times \text{Subsidies} + 0.6793 \times \text{Adjusted Wage} + \epsilon$$

## 6. Results

After determining the most fitting model for this study in the previous section, its main results are presented below in Table 14. It is worth mentioning that, after all the transformation it ended up going through, the model is capable of explaining a large portion of the variance in the log-transformed variable of labor productivity. The Multiple R-Squared and the Adjusted R-Squared – whose values are 0.7582 and 0.7541, respectively – support such a claim. These two statistical measures transmit the idea that more than 75% of the dependent variable's variance is explained by the set of independent variables established in this model.

This model's suitability and significance are also reinforced by the value of the F-statistic (186.9) and the p-value ( $< 2.2e-16$ ). In addition to that, the values of the weighted residuals (Table 15) – especially, the minimum and maximum values – suggest a symmetrical distribution around zero, eliminating, therefore, any possible biases.

**Table 14:** Results of the final WLS log model for the Portuguese economy

|                   | Estimate  | Std. Error | t value | Pr(> t )  |
|-------------------|-----------|------------|---------|-----------|
| (Intercept)       | 8.834023  | 0.117085   | 75.450  | $< 2e-16$ |
| Capital_Intensity | 0.022495  | 0.007275   | 3.092   | 0.00218   |
| Exports           | 0.743422  | 0.154106   | 4.824   | 2.25e-06  |
| Financial_Debt    | 0.372224  | 0.231868   | 1.605   | 0.10948   |
| Subsidies         | -2.689361 | 0.342902   | -7.843  | 7.91e-14  |
| Adjusted_Wage     | 0.679347  | 0.052041   | 13.054  | $< 2e-16$ |

**Table 15:** Weighted residuals distribution in the WLS log model

| Min        | 1Q         | Median    | 3Q        | Max       |
|------------|------------|-----------|-----------|-----------|
| -1.154e-04 | -3.349e-05 | 2.252e-06 | 3.150e-05 | 1.179e-04 |

Additionally, if one was to compare the Table 14's results with those of the models mentioned over the previous section – MLR, WLS, and initial WLS log models (Tables A18, A19, and A20, respectively) – it would be possible to conclude that the reduced WLS log model is the one that better meets the specificities of this dataset. To begin, the first two

models, as mentioned above, presented issues in terms of heteroscedasticity and in the residuals' distribution. Moreover, when comparing the initial and final WLS log models, the exclusion of the *Investment\_Rate* variable is based on the AIC test presented in Table 13 and reinforced by its low statistic relevance. Such leads to a reduced model that performs as well as the initial one, which, for simplicity and in order to avoid overfitting, appears as the most adequate model in this scenario.

Three independent variables have a very significant relationship concerning labor productivity – *Exports*, *Adjusted\_Wage* (both a positive relationship), and *Subsidies* (a negative one). These variables exhibit a p-value significantly lower than any common significance level. As a consequence of that, it is plausible to assume that these are the predictor variables that have a stronger connection to the level of labor productivity in the Portuguese economy. For instance, a one-unit increase in *Exports* will be associated with an increase of 101.31% in labor productivity, while, regarding *Adjusted\_Wage*, a one-unit increase can be linked to a 97.26% variation of the dependent variable. On the contrary, a unitary increase in *Subsidies* is bonded to a negative variation of 93.21% in labor productivity (see Table A21).

From a theoretical point of view, some of those results seem to be in line with currently available literature about this topic. First, the fact that the weight of exports on total sales is positively related to labor productivity indicates that international markets tend to “force” national industries to enhance their levels of competitiveness and productivity in order to avoid being “pushed out” of those same markets. Second, the negative relationship between the proportional amount of subsidies attributed to each economic sector and their labor productivity can also be perceived as a clue that subsidies are directed to industries that struggle in terms of labor productivity, for example. However, given that this study encompasses data from 2004 to 2022, it is important to ask, based on these results, whether the subsidies have been actively enabling these sectors to boost their levels of labor productivity or not.

On the contrary, the positive relationship between *Adjusted\_Wage* and labor productivity is somewhat counterintuitive. That ends up being particularly true when considering what was the main point of adding this variable into the model – to measure the impact of companies returning a larger cut of workers' productivity to them. However, higher values in *Adjusted\_Wage* – which are related to higher levels of labor productivity – translate a larger disparity between a given enterprise's GVA and the expenses they have with

its employees. Such a scenario may reinforce the idea that sectors that have proportionally less expenses associated with labor – thus, less labor-intensive ones – tend to present higher levels of labor productivity.

This latter hypothesis is backed up by the positive and also statistically significant relationship between the capital intensity ratio and labor productivity. In this case, a unitary variation in *Capital\_Intensity* is associated with a 2.27% enhancement in terms of labor productivity (see Table A21). This finding is aligned with the literature, in the sense that capital investment often leads to enhancements in labor's efficiency and productivity levels, particularly in regard to skilled labor.

Finally, *Financial\_Debt* also has a positive connection with labor productivity, based on this model's findings. However, considering the 0.05 significance level, this relationship does not stand as a statistically significant one, as this predictor variable's p-value is larger than the aforementioned significance level.

## 7. Conclusion

Labor productivity continues to be a huge headache for Portuguese decision-makers. While multiple nations that joined the EU almost two decades after Portugal were successful in closing this labor productivity gap in relation to the most developed nations in recent years, Portugal somehow does not manage to do so. In fact, the national economy has not presented significant progress in this regard in the past few decades, a clear sign of stabilization – or, at best, slow growth – of the country's labor productivity.

The capital intensity ratio appears to be closely connected with the labor productivity of the national economic sectors. Also, other aspects, namely the weight of exports, the attribution of subsidies, and the labor productivity adjusted wage, present a strong relation with the dependent variable – even stronger than the one established with the capital intensity ratio. This is particularly relevant in the sense that this thesis's findings do not just corroborate other studies' results, but also go beyond and identify other important variables that should be taken into consideration when analyzing labor productivity.

Those same results also raise some questions in relation to the effectiveness of operating subsidies that were attributed over the last two decades. If, on the one hand, the negative strong relationship between this variable and labor productivity might indicate that the subsidies are being attributed to the sectors more in need, on the other hand, it may also point out that those have not been fulfilling one of its main goals – to stimulate labor productivity growth. Thus, this may open the door for future studies on the operating subsidies' impact and effectiveness on labor productivity.

Another relevant aspect has to do with the importance of exports to a given sector's labor productivity. This indicates that there is a close bond between the percentage of production exported by a given company and its internal level of labor productivity. Hence, this relationship should be considered when defining policies and measures to increase the country's exports' competitiveness in the international markets. In addition, this thesis also prepares the field for future comparisons between European nations' labor productivity at the economic sector level. This would better situate these results in the European context and, therefore, to observe in which sectors Portugal presents competitive advantages. Such would implicate a more accurate perception of the real shortfall of the country in relation to the countries that are simultaneously its trade partners and competitors.

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## Annexes

**Table A1:** Brief summary of the literature review

|                                                                                                                                                                                                                                                                                | <b>Labor Productivity</b>                                                                                                                           | <b>Capital-Intensive and Labor-Intensive Industries</b>                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>General Concepts</b>                                                                                                                                                                                                                                                        | Labor productivity measures the level of output per hour worked (Baily & Montalbano, 2016)                                                          | Capital-intensive industries present substantial capital-to-labor ratios; the opposite is true for labor-intensive industries (Harris, 1988; Shahidul & Shazali, 2010) |
| <b>Economic Cycles</b>                                                                                                                                                                                                                                                         | Higher levels of labor productivity during expansions; lower levels during contractions (Baily et al., 2001; Erber et al., 2017)                    | Capital-to-labor ratio tends to increase during expansions; lower levels during contractions (Owyang & Shell, 2018; Lopez-Garcia & Szörfi, 2021)                       |
| <b>International Perspective</b>                                                                                                                                                                                                                                               | International trade liberalization enhances labor productivity (Alcalá & Ciccone, 2004; Felbermayr et al., 2011)                                    | Countries specialized in capital-intensive industries attract international capital flows (Jin, 2012)                                                                  |
| <b>Productivity Enhancements</b>                                                                                                                                                                                                                                               | To improve labor productivity, it is necessary to increase the hourly output as a result of a more efficient use of one or more inputs (Roth, 2019) | Higher internal capital-to-labor ratios tend to be in line with more productive labor (Owyang & Shell, 2018)                                                           |
| The enhancement of the capital-to-labor ratio tends to foster labor productivity due to capital's ability to replace low-skilled labor and boost highly skilled labor's efficiency both in capital-intensive and labor-intensive industries (Owyang & Shell, 2018; Chen, 2020) |                                                                                                                                                     |                                                                                                                                                                        |

**Table A2:** Labor productivity in Portugal, in *Contos* per worker (1930-1958)

|                                     | 1930 | 1940 | 1950 | 1958 |
|-------------------------------------|------|------|------|------|
| Agriculture, foresting, and fishing | 7.1  | 7.4  | 9.1  | 10.6 |
| Mining and quarrying                | 9.3  | 11.1 | 11.2 | 12.3 |
| Manufacturing                       | 20.0 | 18.0 | 19.2 | 23.8 |
| Construction                        | 4.0  | 6.8  | 10.3 | 11.8 |
| Electricity, gas, and water         | 27.3 | 45.1 | 51.3 | 90.5 |
| Trade, finance, and rents           | 30.7 | 29.4 | 29.8 | 32.3 |
| Transport, communications           | 14.6 | 15.3 | 18.1 | 24.9 |
| Services                            | 9.8  | 13.2 | 14.9 | 16.6 |
| Total                               | 10.9 | 11.8 | 14.0 | 17.2 |

Source: adapted from Lains (2006)

**Table A3:** Distribution of the output among the Portuguese sectors (1930-1958) (in %)

|                                     | 1930 | 1940 | 1950 | 1958 |
|-------------------------------------|------|------|------|------|
| Agriculture, foresting, and fishing | 33.1 | 33.0 | 32.0 | 26.8 |
| Mining and quarrying                | 0.4  | 0.7  | 0.6  | 0.6  |
| Manufacturing                       | 24.6 | 23.8 | 25.4 | 28.8 |
| Construction                        | 1.8  | 2.6  | 3.6  | 4.7  |
| Electricity, gas, and water         | 0.6  | 0.8  | 1.1  | 2.3  |
| Trade, finance, and rents           | 16.3 | 17.0 | 17.0 | 17.5 |
| Transport, communications           | 3.8  | 3.9  | 4.3  | 5.3  |
| Services                            | 19.4 | 18.3 | 16.0 | 14.0 |

Source: Lains (2006)

**Table A4:** Portuguese population from 5 to 24 years enrolled in schools and its distribution among primary, secondary, and tertiary education (in %)

|      | People enrolled<br>(5-24 years) | Primary School | Secondary School | Tertiary School |
|------|---------------------------------|----------------|------------------|-----------------|
| 1930 | 16.1                            | 94.6           | 4.1              | 1.3             |
| 1940 | 20.8                            | 93.5           | 5.1              | 1.4             |
| 1950 | 21.9                            | 91.1           | 7.0              | 1.9             |
| 1960 | 35.1                            | 86.7           | 10.9             | 2.3             |
| 1970 | 39.0                            | 84.2           | 11.6             | 4.2             |
| 1981 | 44.4                            | 63.2           | 31.0             | 5.8             |

Source: Mitchell (1998)

**Table A5:** GDP per hour of work (in 1990 international \$ at Purchasing Power Parity – PPP) and its annual growth rates in Portugal (1956-2007)

| Year | GDP per Hour of Work | Annual Change | Year | GDP per Hour of Work | Annual Change |
|------|----------------------|---------------|------|----------------------|---------------|
| 1956 | 3.15                 | –             | 1982 | 9.99                 | -0.99%        |
| 1957 | 3.20                 | 1.59%         | 1983 | 10.34                | 3.50%         |
| 1958 | 3.29                 | 2.81%         | 1984 | 10.10                | -2.32%        |
| 1959 | 3.45                 | 4.86%         | 1985 | 10.23                | 1.29%         |
| 1960 | 3.45                 | 0.00%         | 1986 | 10.68                | 4.40%         |
| 1961 | 3.60                 | 4.35%         | 1987 | 11.22                | 5.06%         |
| 1962 | 3.91                 | 8.61%         | 1988 | 11.57                | 3.12%         |
| 1963 | 4.06                 | 3.84%         | 1989 | 11.75                | 1.56%         |
| 1964 | 4.25                 | 4.68%         | 1990 | 12.61                | 7.32%         |
| 1965 | 4.55                 | 7.06%         | 1991 | 12.53                | -0.63%        |
| 1966 | 4.73                 | 3.96%         | 1992 | 13.09                | 4.47%         |
| 1967 | 5.11                 | 8.03%         | 1993 | 12.73                | -2.75%        |
| 1968 | 5.35                 | 4.70%         | 1994 | 13.03                | 2.36%         |
| 1969 | 5.53                 | 3.36%         | 1995 | 13.02                | -0.08%        |
| 1970 | 5.96                 | 7.78%         | 1996 | 13.76                | 5.68%         |
| 1971 | 6.53                 | 9.56%         | 1997 | 14.34                | 4.22%         |
| 1972 | 7.14                 | 9.34%         | 1998 | 14.16                | -1.26%        |
| 1973 | 7.42                 | 3.92%         | 1999 | 14.40                | 1.69%         |
| 1974 | 7.72                 | 4.04%         | 2000 | 15.03                | 4.37%         |
| 1975 | 7.27                 | -5.83%        | 2001 | 15.02                | -0.07%        |
| 1976 | 7.87                 | 8.25%         | 2002 | 15.08                | 0.40%         |
| 1977 | 8.36                 | 6.23%         | 2003 | 15.23                | 0.99%         |
| 1978 | 8.94                 | 6.94%         | 2004 | 15.26                | 0.20%         |
| 1979 | 9.19                 | 2.80%         | 2005 | 15.50                | 1.57%         |
| 1980 | 10.02                | 9.03%         | 2006 | 15.62                | 0.77%         |
| 1981 | 10.09                | 0.70%         | 2007 | 15.94                | 2.05%         |

Source: adapted from Amaral (2009)

**Table A6:** GDP per hour of work (in constant prices 2010 \$ at PPP) (2000-2022)

| Year | 12WE | Austria | Belgium | Bulgaria | Croatia | Czechia | Denmark | Estonia | EU2004 | EU2007 | EU27 |
|------|------|---------|---------|----------|---------|---------|---------|---------|--------|--------|------|
| 2000 | 58.1 | 55.8    | 63.1    | 14.9     | 25.8    | 26      | 60      | 21.2    | 23.16  | 13.65  | 44.2 |
| 2001 | 58.9 | 56.5    | 63.2    | 15.4     | 26.7    | 28      | 59.7    | 22.4    | 24.45  | 14.30  | 45.1 |
| 2002 | 59.7 | 57.6    | 63.7    | 16.3     | 28.1    | 28.4    | 60.2    | 23.9    | 25.55  | 15.85  | 46   |
| 2003 | 60.6 | 58.1    | 64.2    | 16.8     | 29      | 29.9    | 61.2    | 25.1    | 26.98  | 16.40  | 46.4 |
| 2004 | 61.8 | 59.2    | 66.3    | 17.2     | 29.9    | 31.1    | 63.2    | 26.8    | 28.25  | 17.55  | 47.2 |
| 2005 | 62.8 | 60.6    | 67.3    | 18       | 30.9    | 32.8    | 64      | 28.4    | 29.78  | 18.45  | 47.7 |
| 2006 | 63.8 | 62.2    | 67.6    | 18.6     | 31.5    | 34.8    | 64.9    | 29.8    | 31.46  | 19.50  | 48.5 |
| 2007 | 64.3 | 63.8    | 68.9    | 19.2     | 32.1    | 36.3    | 65      | 32      | 33.14  | 20.40  | 48.9 |
| 2008 | 63.9 | 63.8    | 68.5    | 19.5     | 32      | 36.1    | 64      | 30.9    | 33.31  | 21.70  | 48.8 |
| 2009 | 62.8 | 63.4    | 68      | 19.7     | 30      | 35.3    | 63.5    | 31.6    | 32.74  | 21.70  | 48.3 |
| 2010 | 64.2 | 64.3    | 69.1    | 20.9     | 30.6    | 36.1    | 65.9    | 33.3    | 34.13  | 22.10  | 49.7 |
| 2011 | 64.5 | 64.9    | 68.6    | 21.8     | 31.8    | 36.7    | 66.2    | 32.7    | 34.95  | 23.30  | 50.6 |
| 2012 | 64.7 | 65.7    | 68.9    | 22.5     | 32.5    | 36.9    | 67.4    | 33.8    | 35.49  | 23.95  | 50.8 |
| 2013 | 65.2 | 66.1    | 69.5    | 22.5     | 33.6    | 37      | 68      | 34.3    | 35.86  | 24.15  | 51.3 |
| 2014 | 65.8 | 66.3    | 70.5    | 22.6     | 32.9    | 37.4    | 69      | 35.1    | 36.39  | 24.70  | 51.6 |
| 2015 | 66.5 | 67.3    | 71.6    | 23.3     | 34.5    | 39.4    | 70      | 34.9    | 37.11  | 25.70  | 52.4 |
| 2016 | 66.7 | 67.2    | 71.7    | 23.9     | 35.5    | 39.3    | 70.9    | 35.9    | 37.46  | 26.40  | 52.6 |
| 2017 | 67.7 | 68      | 71.5    | 24.1     | 36      | 40.6    | 72.2    | 36.9    | 38.95  | 27.50  | 53.5 |
| 2018 | 67.9 | 68.3    | 71.7    | 24.8     | 36.3    | 41.2    | 73.8    | 39.3    | 40.29  | 28.80  | 53.9 |
| 2019 | 68.2 | 68.2    | 72.3    | 25.7     | 35.9    | 42.3    | 74.3    | 40.6    | 41.50  | 29.70  | 54.5 |
| 2020 | 69.1 | 69.8    | 74.6    | 25.9     | 33.3    | 43.3    | 74.7    | 42.9    | 42.66  | 29.95  | 55.2 |
| 2021 | 69.6 | 69.4    | 73.9    | 27.6     | 37.4    | 43.5    | 75.3    | 42.9    | 43.91  | 31.00  | 55.4 |
| 2022 | 69.6 | 70.6    | 72.9    | 28.8     | 38.8    | 42.6    | 74.3    | 40.4    | 43.76  | 32.35  | 55.7 |

Source: OECD (2024b)

| Year | Finland | France | Germany | Hungary | Italy | Latvia | Lithuania | Netherlands | Norway | Poland | Portugal |
|------|---------|--------|---------|---------|-------|--------|-----------|-------------|--------|--------|----------|
| 2000 | 51.3    | 57.2   | 56.1    | 24.3    | 52.8  | 16.7   | 19.6      | 59.7        | 73.8   | 22.2   | 33.4     |
| 2001 | 52.3    | 58.2   | 57.5    | 25.7    | 53.1  | 17.4   | 21.9      | 60.3        | 76.5   | 23     | 33.7     |
| 2002 | 52.8    | 59.9   | 58      | 27.1    | 52.7  | 18.7   | 22.9      | 60.7        | 78.2   | 24.3   | 34       |
| 2003 | 53.9    | 60.3   | 58.4    | 28.1    | 52.3  | 20.2   | 25        | 61.5        | 80.7   | 25.3   | 34.1     |
| 2004 | 55.7    | 60.9   | 59      | 29.8    | 52.8  | 22.3   | 25.6      | 62.6        | 82.4   | 26.3   | 34.9     |
| 2005 | 56.8    | 61.5   | 59.9    | 31.7    | 53    | 23.9   | 27.3      | 64.1        | 83.3   | 26.7   | 35.3     |
| 2006 | 58.1    | 63     | 60.9    | 33.1    | 52.9  | 25.5   | 29.6      | 65.1        | 82.8   | 27.5   | 35.9     |
| 2007 | 60      | 62.7   | 61.6    | 33.9    | 52.8  | 27.5   | 31.7      | 65.6        | 81.3   | 28.2   | 36.5     |
| 2008 | 59.3    | 62.3   | 61.6    | 34.8    | 52.5  | 27.5   | 32.5      | 66          | 78.9   | 28.4   | 36.7     |
| 2009 | 56.7    | 61.7   | 59.7    | 33.7    | 51.5  | 28.3   | 31.1      | 64.5        | 78.8   | 29.3   | 36.6     |
| 2010 | 58.7    | 62.5   | 61.1    | 34.2    | 52.7  | 29.2   | 32.8      | 65.9        | 79.2   | 31.1   | 37.7     |
| 2011 | 59.5    | 63.1   | 62.7    | 35.1    | 53    | 29.2   | 35.1      | 66.3        | 78.7   | 32.5   | 38.2     |
| 2012 | 58.5    | 63.3   | 63.1    | 34.6    | 52.7  | 31.1   | 35.8      | 66.2        | 79.4   | 33.1   | 38.6     |
| 2013 | 58.7    | 64.2   | 63.4    | 34.9    | 53.1  | 31.1   | 36.9      | 66.7        | 79.8   | 33.5   | 39.2     |
| 2014 | 58.9    | 64.8   | 64      | 34.5    | 53.2  | 32     | 37.6      | 67.2        | 80.5   | 34.1   | 38.8     |
| 2015 | 59.3    | 65.3   | 64.4    | 35      | 53.2  | 33.4   | 37.3      | 67.8        | 81.5   | 34.9   | 38.8     |
| 2016 | 60.7    | 65.5   | 65.2    | 34.2    | 53.1  | 34.3   | 36.9      | 67.7        | 82.1   | 35.6   | 38.8     |
| 2017 | 62.3    | 66.9   | 66.4    | 35.3    | 53.4  | 35.7   | 39.7      | 68.1        | 83.8   | 37.3   | 39.1     |
| 2018 | 61.5    | 67.2   | 66.5    | 36.7    | 53.4  | 36.4   | 40.5      | 67.9        | 83.1   | 39.9   | 39.1     |
| 2019 | 61.7    | 67.4   | 67      | 38.2    | 53.7  | 37.3   | 42.1      | 67.4        | 82.8   | 41.8   | 39.7     |
| 2020 | 61.8    | 67.6   | 67.8    | 38.4    | 55.3  | 38.1   | 44.7      | 67.5        | 83.5   | 41.2   | 40.1     |
| 2021 | 62.6    | 66.4   | 68.2    | 39.9    | 54.4  | 41.1   | 46.2      | 69.4        | 84.8   | 41.6   | 40.6     |
| 2022 | 62.9    | 65.2   | 68.5    | 40.8    | 54.2  | 43.1   | 45        | 69.7        | 84.3   | 43.9   | 43.1     |

| Year | Romania | Slovakia | Slovenia | Sweden | Switzerland | UK   |
|------|---------|----------|----------|--------|-------------|------|
| 2000 | 12.4    | 24       | 31.3     | 55     | 61.4        | 50.6 |
| 2001 | 13.2    | 24.8     | 32.4     | 55.4   | 62.8        | 51.3 |
| 2002 | 15.4    | 26.6     | 32.5     | 57.4   | 63.2        | 52.4 |
| 2003 | 16      | 28.7     | 33.5     | 59.6   | 62.9        | 53.9 |
| 2004 | 17.9    | 29.5     | 34.6     | 61.7   | 63.2        | 54.6 |
| 2005 | 18.9    | 30.5     | 36.9     | 63.5   | 64.7        | 55.1 |
| 2006 | 20.4    | 32.3     | 39.1     | 65.3   | 66.3        | 56.1 |
| 2007 | 21.6    | 34.7     | 40.8     | 65.5   | 67.6        | 57   |
| 2008 | 23.9    | 35.5     | 40.8     | 64.3   | 68.3        | 57   |
| 2009 | 23.7    | 34.4     | 38.2     | 63.4   | 66.7        | 55.5 |
| 2010 | 23.3    | 36.8     | 39.5     | 65.7   | 68.6        | 57   |
| 2011 | 24.8    | 37.4     | 40.9     | 66.2   | 68.2        | 57   |
| 2012 | 25.4    | 37.9     | 40.7     | 65.9   | 68.5        | 56.7 |
| 2013 | 25.8    | 38.9     | 40.3     | 66.4   | 69.8        | 56.9 |
| 2014 | 26.8    | 39.6     | 40.8     | 67.2   | 70.4        | 57.1 |
| 2015 | 28.1    | 41       | 41       | 69.1   | 70          | 58   |
| 2016 | 28.9    | 41.1     | 42.4     | 68.6   | 70.4        | 57.6 |
| 2017 | 30.9    | 42.1     | 44       | 69.3   | 71.6        | 58.8 |
| 2018 | 32.8    | 43.2     | 45.1     | 69.5   | 73.2        | 58.9 |
| 2019 | 33.7    | 44.1     | 45.6     | 71.1   | 73.6        | 59.2 |
| 2020 | 34      | 46.8     | 45.9     | 71.9   | 74.8        | 60.3 |
| 2021 | 34.4    | 48.9     | 47.2     | 74.4   | 76.9        | 59.9 |
| 2022 | 35.9    | 47.8     | 46.5     | 74.8   | 77.7        | 60.5 |

**Table A7:** Portuguese GDP per hour of work as a percentage of that of 12WE and EU27 (2000-2022)

| Year | 12WE  | Austria | Belgium | Denmark | EU27  | Finland | France | Germany | Italy | Netherlands | Norway |
|------|-------|---------|---------|---------|-------|---------|--------|---------|-------|-------------|--------|
| 2000 | 57.5% | 59.9%   | 52.9%   | 55.7%   | 75.6% | 65.1%   | 58.4%  | 59.5%   | 63.3% | 55.9%       | 45.3%  |
| 2001 | 57.2% | 59.6%   | 53.3%   | 56.4%   | 74.7% | 64.4%   | 57.9%  | 58.6%   | 63.5% | 55.9%       | 44.1%  |
| 2002 | 56.9% | 59.0%   | 53.4%   | 56.5%   | 73.9% | 64.4%   | 56.8%  | 58.6%   | 64.5% | 56.0%       | 43.5%  |
| 2003 | 56.3% | 58.7%   | 53.1%   | 55.7%   | 73.5% | 63.3%   | 56.6%  | 58.4%   | 65.2% | 55.4%       | 42.3%  |
| 2004 | 56.5% | 59.0%   | 52.6%   | 55.2%   | 73.9% | 62.7%   | 57.3%  | 59.2%   | 66.1% | 55.8%       | 42.4%  |
| 2005 | 56.2% | 58.3%   | 52.5%   | 55.2%   | 74.0% | 62.1%   | 57.4%  | 58.9%   | 66.6% | 55.1%       | 42.4%  |
| 2006 | 56.3% | 57.7%   | 53.1%   | 55.3%   | 74.0% | 61.8%   | 57.0%  | 58.9%   | 67.9% | 55.1%       | 43.4%  |
| 2007 | 56.8% | 57.2%   | 53.0%   | 56.2%   | 74.6% | 60.8%   | 58.2%  | 59.3%   | 69.1% | 55.6%       | 44.9%  |
| 2008 | 57.5% | 57.5%   | 53.6%   | 57.3%   | 75.2% | 61.9%   | 58.9%  | 59.6%   | 69.9% | 55.6%       | 46.5%  |
| 2009 | 58.3% | 57.7%   | 53.8%   | 57.6%   | 75.8% | 64.6%   | 59.3%  | 61.3%   | 71.1% | 56.7%       | 46.4%  |
| 2010 | 58.7% | 58.6%   | 54.6%   | 57.2%   | 75.9% | 64.2%   | 60.3%  | 61.7%   | 71.5% | 57.2%       | 47.6%  |
| 2011 | 59.2% | 58.9%   | 55.7%   | 57.7%   | 75.5% | 64.2%   | 60.5%  | 60.9%   | 72.1% | 57.6%       | 48.5%  |
| 2012 | 59.7% | 58.8%   | 56.0%   | 57.3%   | 76.0% | 66.0%   | 61.0%  | 61.2%   | 73.2% | 58.3%       | 48.6%  |
| 2013 | 60.1% | 59.3%   | 56.4%   | 57.6%   | 76.4% | 66.8%   | 61.1%  | 61.8%   | 73.8% | 58.8%       | 49.1%  |
| 2014 | 59.0% | 58.5%   | 55.0%   | 56.2%   | 75.2% | 65.9%   | 59.9%  | 60.6%   | 72.9% | 57.7%       | 48.2%  |
| 2015 | 58.4% | 57.7%   | 54.2%   | 55.4%   | 74.0% | 65.4%   | 59.4%  | 60.2%   | 72.9% | 57.2%       | 47.6%  |
| 2016 | 58.1% | 57.7%   | 54.1%   | 54.7%   | 73.8% | 63.9%   | 59.2%  | 59.5%   | 73.1% | 57.3%       | 47.3%  |
| 2017 | 57.8% | 57.5%   | 54.7%   | 54.2%   | 73.1% | 62.8%   | 58.4%  | 58.9%   | 73.2% | 57.4%       | 46.7%  |
| 2018 | 57.6% | 57.2%   | 54.5%   | 53.0%   | 72.5% | 63.6%   | 58.2%  | 58.8%   | 73.2% | 57.6%       | 47.1%  |
| 2019 | 58.2% | 58.2%   | 54.9%   | 53.4%   | 72.8% | 64.3%   | 58.9%  | 59.3%   | 73.9% | 58.9%       | 47.9%  |
| 2020 | 58.0% | 57.4%   | 53.8%   | 53.7%   | 72.6% | 64.9%   | 59.3%  | 59.1%   | 72.5% | 59.4%       | 48.0%  |
| 2021 | 58.3% | 58.5%   | 54.9%   | 53.9%   | 73.3% | 64.9%   | 61.1%  | 59.5%   | 74.6% | 58.5%       | 47.9%  |
| 2022 | 61.9% | 61.0%   | 59.1%   | 58.0%   | 77.4% | 68.5%   | 66.1%  | 62.9%   | 79.5% | 61.8%       | 51.1%  |

Source: adapted from OECD (2024b)

| Year | Sweden | Switzerland | UK    |
|------|--------|-------------|-------|
| 2000 | 60.7%  | 54.4%       | 66.0% |
| 2001 | 60.8%  | 53.7%       | 65.7% |
| 2002 | 59.2%  | 53.8%       | 64.9% |
| 2003 | 57.2%  | 54.2%       | 63.3% |
| 2004 | 56.6%  | 55.2%       | 63.9% |
| 2005 | 55.6%  | 54.6%       | 64.1% |
| 2006 | 55.0%  | 54.1%       | 64.0% |
| 2007 | 55.7%  | 54.0%       | 64.0% |
| 2008 | 57.1%  | 53.7%       | 64.4% |
| 2009 | 57.7%  | 54.9%       | 65.9% |
| 2010 | 57.4%  | 55.0%       | 66.1% |
| 2011 | 57.7%  | 56.0%       | 67.0% |
| 2012 | 58.6%  | 56.4%       | 68.1% |
| 2013 | 59.0%  | 56.2%       | 68.9% |
| 2014 | 57.7%  | 55.1%       | 68.0% |
| 2015 | 56.2%  | 55.4%       | 66.9% |
| 2016 | 56.6%  | 55.1%       | 67.4% |
| 2017 | 56.4%  | 54.6%       | 66.5% |
| 2018 | 56.3%  | 53.4%       | 66.4% |
| 2019 | 55.8%  | 53.9%       | 67.1% |
| 2020 | 55.8%  | 53.6%       | 66.5% |
| 2021 | 54.6%  | 52.8%       | 67.8% |
| 2022 | 57.6%  | 55.5%       | 71.2% |

**Table A8:** EU2004, EU2007, and Croatia's GDP per hour of work as a percentage of that of Portugal (2000-2022)

| Year | Bulgaria | Croatia | Czechia | Estonia | EU2004 | EU2007 | Hungary | Latvia | Lithuania | Poland | Romania | Slovakia | Slovenia |
|------|----------|---------|---------|---------|--------|--------|---------|--------|-----------|--------|---------|----------|----------|
| 2000 | 44.6%    | 77.2%   | 77.8%   | 63.5%   | 69.3%  | 40.9%  | 72.8%   | 50.0%  | 58.7%     | 66.5%  | 37.1%   | 71.9%    | 93.7%    |
| 2001 | 45.7%    | 79.2%   | 83.1%   | 66.5%   | 72.6%  | 42.4%  | 76.3%   | 51.6%  | 65.0%     | 68.2%  | 39.2%   | 73.6%    | 96.1%    |
| 2002 | 47.9%    | 82.6%   | 83.5%   | 70.3%   | 75.1%  | 46.6%  | 79.7%   | 55.0%  | 67.4%     | 71.5%  | 45.3%   | 78.2%    | 95.6%    |
| 2003 | 49.3%    | 85.0%   | 87.7%   | 73.6%   | 79.1%  | 48.1%  | 82.4%   | 59.2%  | 73.3%     | 74.2%  | 46.9%   | 84.2%    | 98.2%    |
| 2004 | 49.3%    | 85.7%   | 89.1%   | 76.8%   | 80.9%  | 50.3%  | 85.4%   | 63.9%  | 73.4%     | 75.4%  | 51.3%   | 84.5%    | 99.1%    |
| 2005 | 51.0%    | 87.5%   | 92.9%   | 80.5%   | 84.3%  | 52.3%  | 89.8%   | 67.7%  | 77.3%     | 75.6%  | 53.5%   | 86.4%    | 104.5%   |
| 2006 | 51.8%    | 87.7%   | 96.9%   | 83.0%   | 87.6%  | 54.3%  | 92.2%   | 71.0%  | 82.5%     | 76.6%  | 56.8%   | 90.0%    | 108.9%   |
| 2007 | 52.6%    | 87.9%   | 99.5%   | 87.7%   | 90.8%  | 55.9%  | 92.9%   | 75.3%  | 86.8%     | 77.3%  | 59.2%   | 95.1%    | 111.8%   |
| 2008 | 53.1%    | 87.2%   | 98.4%   | 84.2%   | 90.8%  | 59.1%  | 94.8%   | 74.9%  | 88.6%     | 77.4%  | 65.1%   | 96.7%    | 111.2%   |
| 2009 | 53.8%    | 82.0%   | 96.4%   | 86.3%   | 89.4%  | 59.3%  | 92.1%   | 77.3%  | 85.0%     | 80.1%  | 64.8%   | 94.0%    | 104.4%   |
| 2010 | 55.4%    | 81.2%   | 95.8%   | 88.3%   | 90.5%  | 58.6%  | 90.7%   | 77.5%  | 87.0%     | 82.5%  | 61.8%   | 97.6%    | 104.8%   |
| 2011 | 57.1%    | 83.2%   | 96.1%   | 85.6%   | 91.5%  | 61.0%  | 91.9%   | 76.4%  | 91.9%     | 85.1%  | 64.9%   | 97.9%    | 107.1%   |
| 2012 | 58.3%    | 84.2%   | 95.6%   | 87.6%   | 91.9%  | 62.0%  | 89.6%   | 80.6%  | 92.7%     | 85.8%  | 65.8%   | 98.2%    | 105.4%   |
| 2013 | 57.4%    | 85.7%   | 94.4%   | 87.5%   | 91.5%  | 61.6%  | 89.0%   | 79.3%  | 94.1%     | 85.5%  | 65.8%   | 99.2%    | 102.8%   |
| 2014 | 58.2%    | 84.8%   | 96.4%   | 90.5%   | 93.8%  | 63.7%  | 88.9%   | 82.5%  | 96.9%     | 87.9%  | 69.1%   | 102.1%   | 105.2%   |
| 2015 | 60.1%    | 88.9%   | 101.5%  | 89.9%   | 95.7%  | 66.2%  | 90.2%   | 86.1%  | 96.1%     | 89.9%  | 72.4%   | 105.7%   | 105.7%   |
| 2016 | 61.6%    | 91.5%   | 101.3%  | 92.5%   | 96.6%  | 68.0%  | 88.1%   | 88.4%  | 95.1%     | 91.8%  | 74.5%   | 105.9%   | 109.3%   |
| 2017 | 61.6%    | 92.1%   | 103.8%  | 94.4%   | 99.6%  | 70.3%  | 90.3%   | 91.3%  | 101.5%    | 95.4%  | 79.0%   | 107.7%   | 112.5%   |
| 2018 | 63.4%    | 92.8%   | 105.4%  | 100.5%  | 103.0% | 73.7%  | 93.9%   | 93.1%  | 103.6%    | 102.0% | 83.9%   | 110.5%   | 115.3%   |
| 2019 | 64.7%    | 90.4%   | 106.5%  | 102.3%  | 104.5% | 74.8%  | 96.2%   | 94.0%  | 106.0%    | 105.3% | 84.9%   | 111.1%   | 114.9%   |
| 2020 | 64.6%    | 83.0%   | 108.0%  | 107.0%  | 106.4% | 74.7%  | 95.8%   | 95.0%  | 111.5%    | 102.7% | 84.8%   | 116.7%   | 114.5%   |
| 2021 | 68.0%    | 92.1%   | 107.1%  | 105.7%  | 108.2% | 76.4%  | 98.3%   | 101.2% | 113.8%    | 102.5% | 84.7%   | 120.4%   | 116.3%   |
| 2022 | 66.8%    | 90.0%   | 98.8%   | 93.7%   | 101.5% | 75.1%  | 94.7%   | 100.0% | 104.4%    | 101.9% | 83.3%   | 110.9%   | 107.9%   |

Source: adapted from OECD (2024b)

**Table A9:** Output per hour of work and annual change rates for Cyprus, Malta, and Portugal  
(in constant 2017 international \$ at PPP) (2005-2024)

| Year | Cyprus                  |               | Malta                   |               | Portugal                |               |
|------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|
|      | Output per Hour of Work | Annual Change | Output per Hour of Work | Annual Change | Output per Hour of Work | Annual Change |
| 2005 | 29.9                    | —             | 39                      | —             | 34.5                    | —             |
| 2006 | 30.1                    | 0.7%          | 39.6                    | 1.7%          | 35                      | 1.3%          |
| 2007 | 30.2                    | 0.6%          | 40.5                    | 2.1%          | 36.2                    | 3.6%          |
| 2008 | 30.7                    | 1.4%          | 42                      | 3.6%          | 36.2                    | 0.0%          |
| 2009 | 30.6                    | -0.2%         | 41.4                    | -1.3%         | 36.2                    | 0.1%          |
| 2010 | 30.4                    | -0.6%         | 43.3                    | 4.7%          | 37.3                    | 2.8%          |
| 2011 | 31                      | 1.7%          | 43.3                    | -0.1%         | 38.6                    | 3.5%          |
| 2012 | 30.6                    | -1.2%         | 42.9                    | -0.9%         | 38.8                    | 0.6%          |
| 2013 | 30.6                    | 0.0%          | 43                      | 0.3%          | 39.3                    | 1.4%          |
| 2014 | 29.6                    | -3.3%         | 44.6                    | 3.7%          | 38.8                    | -1.3%         |
| 2015 | 30.6                    | 3.2%          | 47.1                    | 5.5%          | 38.9                    | 0.3%          |
| 2016 | 31.7                    | 3.7%          | 44.9                    | -4.8%         | 39.9                    | 2.4%          |
| 2017 | 32.3                    | 2.1%          | 47.8                    | 6.5%          | 39.9                    | 0.0%          |
| 2018 | 32.5                    | 0.4%          | 47.5                    | -0.6%         | 40.2                    | 0.7%          |
| 2019 | 33.6                    | 3.4%          | 47.2                    | -0.5%         | 40.9                    | 1.8%          |
| 2020 | 35.2                    | 4.9%          | 45.7                    | -3.3%         | 42.1                    | 2.9%          |
| 2021 | 34.6                    | -1.8%         | 48.5                    | 6.2%          | 42.7                    | 1.5%          |
| 2022 | 34.8                    | 0.6%          | 50.1                    | 3.3%          | 43.5                    | 1.9%          |
| 2023 | 34.7                    | -0.3%         | 50.7                    | 1.2%          | 43.7                    | 0.5%          |
| 2024 | 35.3                    | 1.6%          | 51.7                    | 2.0%          | 44.7                    | 2.2%          |

Source: ILO (2024)

**Table A10:** Portuguese economic sectors and their designation according to CAE – Rev. 3

| CAE – Rev. 3<br>Designation | Economic Sector                                                                                                               |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| A                           | Agriculture, farming of animals, hunting and forestry                                                                         |
| B                           | Mining and quarrying                                                                                                          |
| C                           | Manufacturing                                                                                                                 |
| D                           | Electricity, gas, steam, cold and hot water and cold air                                                                      |
| E                           | Water collection, treatment and distribution; sewerage, waste management and remediation activities                           |
| F                           | Construction                                                                                                                  |
| G                           | Wholesale and retail trade; repair of motor vehicles and motorcycles                                                          |
| H                           | Transportation and storage                                                                                                    |
| I                           | Accommodation and food service activities                                                                                     |
| J                           | Information and communication activities                                                                                      |
| K                           | Financial and insurance activities                                                                                            |
| L                           | Real estate activities                                                                                                        |
| M                           | Consultancy, scientific and technical activities                                                                              |
| N                           | Administrative and support service activities                                                                                 |
| O                           | Public administration and defense, compulsory social security                                                                 |
| P                           | Education                                                                                                                     |
| Q                           | Human health and social work activities                                                                                       |
| R                           | Arts, entertainment, sports and recreation activities                                                                         |
| S                           | Other service activities                                                                                                      |
| T                           | Activities of households as employers and undifferentiated goods- and services-producing activities of households for own use |
| U                           | Activities of extraterritorial organizations and bodies                                                                       |

Source: INE (2007)

**Table A11:** Average annual values for the Portuguese economic activities (2004-2022)

| Economic Activity<br>(Division - CAE Rev. 3) | Enterprises (No.) | Persons Employed in Enterprises (No.) | Personnel Expenses of Enterprises (€) | Production of Enterprises (€) | GVA of Enterprises (€) | Assets of Enterprises (€) | Capital Intensity Ratio | Labor Productivity (€) |
|----------------------------------------------|-------------------|---------------------------------------|---------------------------------------|-------------------------------|------------------------|---------------------------|-------------------------|------------------------|
| Total                                        | 1 201 136         | 3 837 729                             | 51 651 527 259                        | 242 847 630 206               | 88 388 247 546         | 586 111 504 597           | 2.417                   | 22 918                 |
| A                                            | 93 473            | 153 833                               | 882 662 460                           | 5 685 397 305                 | 1 506 363 670          | 13 455 485 120            | 2.334                   | 9 846                  |
| B                                            | 1 223             | 11 112                                | 224 365 467                           | 1 183 104 104                 | 521 224 503            | 2 525 156 909             | 2.154                   | 47 365                 |
| C                                            | 72 875            | 725 321                               | 11 907 080 285                        | 80 455 373 662                | 19 763 644 387         | 86 580 129 992            | 1.082                   | 27 340                 |
| D                                            | 2 195             | 11 305                                | 483 126 193                           | 11 402 473 576                | 3 825 837 403          | 53 941 978 329            | 4.764                   | 349 816                |
| E                                            | 1 138             | 30 487                                | 591 650 230                           | 2 812 433 711                 | 1 329 016 380          | 12 383 492 612            | 4.448                   | 43 272                 |
| F                                            | 100 152           | 395 781                               | 5 208 293 007                         | 26 028 995 931                | 7 830 588 522          | 60 085 579 601            | 2.410                   | 19 720                 |
| G                                            | 241 059           | 792 784                               | 10 977 731 278                        | 33 914 467 071                | 17 328 401 809         | 90 679 305 535            | 2.678                   | 21 835                 |
| H                                            | 26 723            | 167 145                               | 3 949 984 571                         | 18 530 599 333                | 6 362 918 307          | 37 013 297 014            | 2.065                   | 38 112                 |
| I                                            | 95 881            | 313 606                               | 2 892 775 341                         | 10 235 117 587                | 4 461 581 740          | 21 807 701 854            | 2.143                   | 14 033                 |
| J                                            | 17 159            | 95 249                                | 2 962 924 331                         | 12 860 373 716                | 5 950 276 579          | 26 987 542 344            | 2.124                   | 63 984                 |
| L                                            | 35 917            | 60 090                                | 596 190 536                           | 5 371 008 656                 | 2 238 577 454          | 56 919 881 997            | 11.204                  | 36 509                 |
| M                                            | 123 245           | 241 594                               | 3 509 192 387                         | 11 797 543 523                | 5 583 863 441          | 91 219 537 687            | 7.605                   | 22 807                 |
| N                                            | 152 367           | 427 766                               | 3 754 095 649                         | 10 391 660 539                | 5 604 404 886          | 13 787 318 872            | 1.320                   | 12 995                 |
| P                                            | 57 698            | 96 749                                | 819 303 821                           | 1 577 126 955                 | 897 393 947            | 2 233 769 187             | 1.407                   | 9 236                  |
| Q                                            | 86 676            | 171 506                               | 1 809 937 545                         | 7 088 622 611                 | 3 482 050 517          | 9 081 103 298             | 1.283                   | 20 250                 |
| R                                            | 31 851            | 50 567                                | 582 035 768                           | 2 054 552 967                 | 1 033 753 362          | 5 107 112 883             | 2.535                   | 20 193                 |
| S                                            | 61 504            | 92 834                                | 500 178 388                           | 1 458 778 959                 | 668 350 637            | 2 303 111 362             | 1.588                   | 7 183                  |

Source: adapted from INE (2023)

**Table A12:** Missing values in the combined dataset

| Year_Sector | Labor_Productivity | Capital_Intensity | Exports | Financial_Debt | Subsidies    | Investment_Rate | Adjusted_Wage |
|-------------|--------------------|-------------------|---------|----------------|--------------|-----------------|---------------|
| 2004_A      | 9,846.323          | 1.917381          |         |                | 0.0907222647 | 0.2848          | 1.2537        |
| 2004_B      | 35,334.834         | 2.116724          |         |                | 0.0009771104 | 0.3000          | 2.0486        |
| 2004_C      | 21,774.489         | 1.049549          |         |                | 0.0016252263 | 0.1327          | 1.5566        |
| 2004_E      | 36,901.109         | 4.447997          |         |                | 0.0105482124 | 0.8365          | 2.0529        |
| 2004_F      | 18,190.507         | 1.853852          |         |                | 0.0005725782 | 0.2072          | 1.3897        |
| 2004_G      | 19,329.369         | 2.546630          |         |                | 0.0042271357 | 0.1232          | 1.3434        |
| 2004_H      | 30,345.528         | 3.004533          |         |                | 0.0154838593 | 0.5340          | 1.4049        |
| 2004_I      | 13,476.188         | 1.600952          |         |                | 0.0030205669 | 0.2736          | 1.3856        |
| 2004_J      | 77,827.236         | 1.459540          |         |                | 0.0030867596 | 0.2594          | 2.3074        |
| 2004_L      | 35,618.619         | 7.026639          |         |                | 0.0016195780 | 0.6565          | 2.2517        |
| 2004_M      | 19,315.270         | 1.509603          |         |                | 0.0106597458 | 0.0923          | 0.9869        |
| 2004_N      | 12,767.778         | 1.199255          |         |                | 0.0039336804 | 0.1585          | 1.1394        |
| 2004_P      | 8,023.409          | 1.182372          |         |                | 0.2374736742 | 0.1208          | 0.7039        |
| 2004_Q      | 23,863.890         | 1.020156          |         |                | 0.0289170845 | 0.1361          | 1.2787        |
| 2004_R      | 20,308.238         | 2.318641          |         |                | 0.0230061239 | 0.4315          | 0.7797        |
| 2004_S      | 6,499.302          | 1.429170          |         |                | 0.1534331905 | 0.3170          | 0.7697        |
| 2005_A      | 9,659.083          | 2.003793          |         |                | 0.0968759766 | 0.2799          | 1.2674        |
| 2005_B      | 39,751.328         | 1.782654          |         |                | 0.0007049708 | 0.2540          | 2.3044        |
| 2005_C      | 21,937.704         | 1.044898          |         |                | 0.0015077194 | 0.1719          | 1.5369        |
| 2005_E      | 37,830.631         | 4.666650          |         |                | 0.0191729927 | 0.9157          | 2.0739        |
| 2005_F      | 19,169.010         | 1.862946          |         |                | 0.0006516548 | 0.1659          | 1.3999        |
| 2005_G      | 19,219.404         | 2.666823          |         |                | 0.0044492965 | 0.1530          | 1.2999        |
| 2005_H      | 32,254.878         | 2.997654          |         |                | 0.0173504673 | 0.5378          | 1.4517        |
| 2005_I      | 13,414.606         | 1.686067          |         |                | 0.0029993373 | 0.2383          | 1.3526        |
| 2005_J      | 76,035.458         | 1.507527          |         |                | 0.0019307643 | 0.2354          | 2.2798        |
| 2005_L      | 37,880.791         | 7.182011          |         |                | 0.0021350592 | 0.6184          | 2.3025        |
| 2005_M      | 20,002.407         | 1.629630          |         |                | 0.0105368692 | 0.1424          | 0.9721        |
| 2005_N      | 12,521.008         | 1.261821          |         |                | 0.0043659287 | 0.2057          | 1.1015        |
| 2005_P      | 8,097.103          | 1.194335          |         |                | 0.2306456533 | 0.1027          | 0.6765        |
| 2005_Q      | 24,004.372         | 1.017374          |         |                | 0.0429369422 | 0.1490          | 1.2610        |
| 2005_R      | 18,863.216         | 2.589563          |         |                | 0.0208114176 | 0.6828          | 0.7539        |
| 2005_S      | 6,744.073          | 1.409994          |         |                | 0.1522897591 | 0.3619          | 0.7930        |

**Table A13:** Standard deviation and mean values for variables *Exports* and *Financial\_Debt* (2006-2022)

| Sector | sd_Exports  | sd_Financial_Debt | mean_Exports | mean_Financial_Debt |
|--------|-------------|-------------------|--------------|---------------------|
| A      | 0.020457947 | 0.01203463        | 0.112413808  | 0.3103353           |
| B      | 0.048964860 | 0.04442832        | 0.547262342  | 0.2273941           |
| C      | 0.043346096 | 0.02403225        | 0.434011961  | 0.2891824           |
| E      | 0.013894705 | 0.03479130        | 0.058413293  | 0.3102941           |
| F      | 0.053498446 | 0.05758294        | 0.152752904  | 0.3982412           |
| G      | 0.017302475 | 0.02214085        | 0.087218195  | 0.2455353           |
| H      | 0.038174402 | 0.04719237        | 0.348290312  | 0.5096235           |
| I      | 0.009737959 | 0.03912342        | 0.035847979  | 0.4220882           |
| J      | 0.078767777 | 0.06639799        | 0.164914082  | 0.3393118           |
| L      | 0.007938967 | 0.04786968        | 0.022239695  | 0.4511882           |
| M      | 0.068632291 | 0.03556662        | 0.256231302  | 0.2804059           |
| N      | 0.038765317 | 0.02729269        | 0.124697272  | 0.4312882           |
| P      | 0.007357971 | 0.02399452        | 0.029748216  | 0.2897294           |
| Q      | 0.002314297 | 0.02718191        | 0.006972356  | 0.3156529           |
| R      | 0.039167111 | 0.04923212        | 0.066043802  | 0.4092941           |
| S      | 0.019166414 | 0.01761692        | 0.040431916  | 0.2461706           |

Source: adapted from Banco de Portugal (2024a); Banco de Portugal (2024b)

**Table A14:** Weight of each economic sector on the overall volume of Portuguese exports (in %) (2006-2022)<sup>7</sup>

|   | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  | 2020  | 2021  | 2022  |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| A | 0,42  | 0,41  | 0,48  | 0,57  | 0,57  | 0,57  | 0,61  | 0,61  | 0,63  | 0,69  | 0,78  | 0,73  | 0,76  | 0,82  | 1,02  | 1,03  | 0,91  |
| B | 2,29  | 2,63  | 2,84  | 2,96  | 0,99  | 0,93  | 0,91  | 0,78  | 0,75  | 0,69  | 0,62  | 0,65  | 0,69  | 0,63  | 0,67  | 0,90  | 0,67  |
| C | 54,90 | 53,77 | 52,04 | 50,78 | 51,56 | 52,00 | 50,63 | 50,03 | 50,32 | 50,13 | 49,00 | 48,07 | 48,33 | 48,06 | 53,91 | 54,08 | 49,09 |
| E | 0,19  | 0,26  | 0,31  | 0,29  | 0,43  | 0,42  | 0,45  | 0,36  | 0,29  | 0,24  | 0,20  | 0,20  | 0,18  | 0,17  | 0,19  | 0,22  | 0,26  |
| F | 4,32  | 5,82  | 7,47  | 9,18  | 7,28  | 6,10  | 6,54  | 6,50  | 6,15  | 5,34  | 4,51  | 3,92  | 3,30  | 3,18  | 3,30  | 3,17  | 2,82  |
| G | 14,83 | 12,74 | 13,31 | 15,42 | 16,10 | 17,45 | 17,55 | 17,05 | 17,06 | 15,31 | 14,36 | 15,42 | 14,64 | 14,78 | 16,89 | 16,37 | 15,84 |
| H | 8,36  | 8,80  | 9,16  | 9,76  | 10,56 | 9,95  | 9,69  | 9,28  | 9,64  | 9,09  | 8,67  | 8,65  | 8,71  | 8,73  | 7,47  | 7,72  | 8,73  |
| I | 0,45  | 0,46  | 0,43  | 0,35  | 0,32  | 0,32  | 0,25  | 0,31  | 0,34  | 0,50  | 0,59  | 0,64  | 0,68  | 0,78  | 0,38  | 0,44  | 0,64  |
| J | 2,26  | 2,15  | 1,91  | 2,06  | 2,08  | 2,00  | 2,12  | 2,18  | 2,37  | 2,64  | 2,98  | 3,17  | 3,15  | 3,42  | 5,25  | 5,63  | 5,07  |
| L | 0,38  | 0,21  | 0,17  | 0,12  | 0,14  | 0,20  | 0,11  | 0,13  | 0,16  | 0,12  | 0,14  | 0,19  | 0,18  | 0,20  | 0,20  | 0,20  | 0,44  |
| M | 4,84  | 2,36  | 2,69  | 2,99  | 4,80  | 4,83  | 5,29  | 4,92  | 5,87  | 5,00  | 4,06  | 3,64  | 3,57  | 3,51  | 3,66  | 3,99  | 3,74  |
| N | 1,34  | 1,45  | 1,36  | 1,47  | 1,46  | 1,23  | 1,53  | 1,72  | 1,82  | 1,83  | 1,91  | 1,98  | 2,17  | 2,23  | 2,00  | 2,12  | 2,48  |
| P | 0,03  | 0,04  | 0,04  | 0,06  | 0,05  | 0,04  | 0,05  | 0,05  | 0,06  | 0,04  | 0,04  | 0,05  | 0,05  | 0,05  | 0,06  | 0,06  | 0,05  |
| Q | 0,02  | 0,02  | 0,02  | 0,04  | 0,04  | 0,06  | 0,07  | 0,06  | 0,06  | 0,06  | 0,05  | 0,05  | 0,06  | 0,07  | 0,07  | 0,07  | 0,06  |
| R | 0,06  | 0,07  | 0,09  | 0,12  | 0,10  | 0,09  | 0,11  | 0,10  | 0,09  | 0,14  | 0,12  | 0,20  | 0,30  | 0,28  | 0,33  | 0,27  | 0,33  |
| S | 0,03  | 0,03  | 0,03  | 0,04  | 0,04  | 0,04  | 0,04  | 0,04  | 0,06  | 0,06  | 0,05  | 0,06  | 0,06  | 0,06  | 0,09  | 0,09  | 0,07  |

Source: adapted from Banco de Portugal (2024a); PORDATA (2024a); PORDATA (2024b)

<sup>7</sup> It is important to bear in mind that the sum of the weights is never 100% because not all economic sectors were considered in this study.

**Table A15:** Coefficients of variation of each sector's weight on the country's exports (2006-2022)

| Sector | CV         |
|--------|------------|
| A      | 0.27281863 |
| B      | 0.70593977 |
| C      | 0.04320698 |
| E      | 0.33270439 |
| F      | 0.35417448 |
| G      | 0.08972833 |
| H      | 0.08696151 |
| I      | 0.33029814 |
| J      | 0.40961979 |
| L      | 0.45703112 |
| M      | 0.23595035 |
| N      | 0.20487043 |
| P      | 0.18055430 |
| Q      | 0.33105890 |
| R      | 0.59127928 |
| S      | 0.38535941 |

Source: adapted from Banco de Portugal (2024a); PORDATA (2024a); PORDATA (2024b)

**Table A16:** Correlation coefficients between production and sales growth rates for each economic sector (2007-2022)

| Sector | Correlation |
|--------|-------------|
| A      | 0.9184338   |
| B      | 0.5257717   |
| C      | 0.9938432   |
| E      | 0.9324021   |
| F      | 0.9708685   |
| G      | 0.9510713   |
| H      | 0.9841247   |
| I      | 0.9962048   |
| J      | 0.9541834   |
| L      | 0.9072088   |
| M      | 0.6599923   |
| N      | 0.9935068   |
| P      | 0.9039056   |
| Q      | 0.2955324   |
| R      | 0.9628029   |
| S      | 0.8555419   |

Source: adapted from INE (2023); Banco de Portugal (2024c)

**Table A17:** New combined dataset after the imputation of the missing values

| Year_Sector | Labor_Productivity | Capital_Intensity | Exports     | Financial_Debt | Subsidies    | Investment_Rate | Adjusted_Wage |
|-------------|--------------------|-------------------|-------------|----------------|--------------|-----------------|---------------|
| 2004_A      | 9,846.323          | 1.917381          | 0.063488072 | 0.3103353      | 0.0907222647 | 0.2848          | 1.2537        |
| 2004_B      | 35,334.834         | 2.116724          | 0.646023859 | 0.2273941      | 0.0009771104 | 0.3000          | 2.0486        |
| 2004_C      | 21,774.489         | 1.049549          | 0.357627625 | 0.2891824      | 0.0016252263 | 0.1327          | 1.5566        |
| 2004_E      | 36,901.109         | 4.447997          | 0.045668179 | 0.3102941      | 0.0105482124 | 0.8365          | 2.0529        |
| 2004_F      | 18,190.507         | 1.853852          | 0.063257057 | 0.3982412      | 0.0005725782 | 0.2072          | 1.3897        |
| 2004_G      | 19,329.369         | 2.546630          | 0.055706663 | 0.2455353      | 0.0042271357 | 0.1232          | 1.3434        |
| 2004_H      | 30,345.528         | 3.004533          | 0.287505826 | 0.5096235      | 0.0154838593 | 0.5340          | 1.4049        |
| 2004_I      | 13,476.188         | 1.600952          | 0.029615087 | 0.4220882      | 0.0030205669 | 0.2736          | 1.3856        |
| 2004_J      | 77,827.236         | 1.459540          | 0.065391371 | 0.3393118      | 0.0030867596 | 0.2594          | 2.3074        |
| 2004_L      | 35,618.619         | 7.026639          | 0.028584381 | 0.4511882      | 0.0016195780 | 0.6565          | 2.2517        |
| 2004_M      | 19,315.270         | 1.509603          | 0.219912456 | 0.2804059      | 0.0106597458 | 0.0923          | 0.9869        |
| 2004_N      | 12,767.778         | 1.199255          | 0.067387928 | 0.4312882      | 0.0039336804 | 0.1585          | 1.1394        |
| 2004_P      | 8,023.409          | 1.182372          | 0.015650598 | 0.2897294      | 0.2374736742 | 0.1208          | 0.7039        |
| 2004_Q      | 23,863.890         | 1.020156          | 0.002106206 | 0.3156529      | 0.0289170845 | 0.1361          | 1.2787        |
| 2004_R      | 20,308.238         | 2.318641          | 0.008071582 | 0.4092941      | 0.0230061239 | 0.4315          | 0.7797        |
| 2004_S      | 6,499.302          | 1.429170          | 0.013557677 | 0.2461706      | 0.1534331905 | 0.3170          | 0.7697        |
| 2005_A      | 9,659.083          | 2.003793          | 0.069453973 | 0.3102250      | 0.0968759766 | 0.2799          | 1.2674        |
| 2005_B      | 39,751.328         | 1.782654          | 0.569988924 | 0.2336500      | 0.0007049708 | 0.2540          | 2.3044        |
| 2005_C      | 21,937.704         | 1.044898          | 0.350925338 | 0.2910250      | 0.0015077194 | 0.1719          | 1.5369        |
| 2005_E      | 37,830.631         | 4.666650          | 0.042973594 | 0.3102941      | 0.0191729927 | 0.9157          | 2.0739        |
| 2005_F      | 19,169.010         | 1.862946          | 0.059345799 | 0.3963875      | 0.0006516548 | 0.1659          | 1.3999        |
| 2005_G      | 19,219.404         | 2.666823          | 0.055918835 | 0.2449562      | 0.0044492965 | 0.1530          | 1.2999        |
| 2005_H      | 32,254.878         | 2.997654          | 0.269595757 | 0.5090125      | 0.0173504673 | 0.5378          | 1.4517        |
| 2005_I      | 13,414.606         | 1.686067          | 0.030053850 | 0.4253375      | 0.0029993373 | 0.2383          | 1.3526        |
| 2005_J      | 76,035.458         | 1.507527          | 0.071064287 | 0.3453375      | 0.0019307643 | 0.2354          | 2.2798        |
| 2005_L      | 37,880.791         | 7.182011          | 0.026638348 | 0.4511882      | 0.0021350592 | 0.6184          | 2.3025        |
| 2005_M      | 20,002.407         | 1.629630          | 0.207280708 | 0.2835125      | 0.0105368692 | 0.1424          | 0.9721        |
| 2005_N      | 12,521.008         | 1.261821          | 0.068093965 | 0.4304438      | 0.0043659287 | 0.2057          | 1.1015        |
| 2005_P      | 8,097.103          | 1.194335          | 0.015448652 | 0.2891750      | 0.2306456533 | 0.1027          | 0.6765        |
| 2005_Q      | 24,004.372         | 1.017374          | 0.002406006 | 0.3167687      | 0.0429369422 | 0.1490          | 1.2610        |
| 2005_R      | 18,863.216         | 2.589563          | 0.014902393 | 0.4083438      | 0.0208114176 | 0.6828          | 0.7539        |
| 2005_S      | 6,744.073          | 1.409994          | 0.014884368 | 0.2456812      | 0.1522897591 | 0.3619          | 0.7930        |

**Table A18:** Results of the MLR model for the Portuguese economy

|                   | Estimate | Std. Error | t value | Pr(> t ) |
|-------------------|----------|------------|---------|----------|
| (Intercept)       | -7962.4  | 3283.0     | -2.425  | 0.0159   |
| Capital_Intensity | 57.3     | 204.0      | 0.281   | 0.7790   |
| Exports           | 9160.8   | 3703.1     | 2.474   | 0.0139   |
| Financial_Debt    | 2562.3   | 6395.5     | 0.401   | 0.6890   |
| Subsidies         | -14011.9 | 12315.0    | -1.138  | 0.2561   |
| Investment_Rate   | -6581.5  | 3638.7     | -1.809  | 0.0715   |
| Adjusted_Wage     | 24969.3  | 1484.1     | 16.824  | < 2e-16  |

**Table A19:** Results of the WLS model for the Portuguese economy

|                   | Estimate | Std. Error | t value | Pr(> t ) |
|-------------------|----------|------------|---------|----------|
| (Intercept)       | -6525.0  | 2893.5     | -2.255  | 0.024859 |
| Capital_Intensity | 262.9    | 183.8      | 1.430   | 0.153648 |
| Exports           | 15250.1  | 3877.3     | 3.933   | 0.000104 |
| Financial_Debt    | 4858.1   | 5823.9     | 0.834   | 0.404861 |
| Subsidies         | -11937.0 | 8400.2     | -1.421  | 0.156353 |
| Investment_Rate   | -1616.0  | 3100.0     | -0.521  | 0.602560 |
| Adjusted_Wage     | 21026.6  | 1396.0     | 15.062  | < 2e-16  |

**Table A20:** Results of the initial WLS log model for the Portuguese economy

|                   | Estimate  | Std. Error | t value | Pr(> t ) |
|-------------------|-----------|------------|---------|----------|
| (Intercept)       | 8.812962  | 0.118387   | 74.442  | < 2e-16  |
| Capital_Intensity | 0.024741  | 0.007519   | 3.290   | 0.00112  |
| Exports           | 0.698895  | 0.158638   | 4.406   | 1.47e-05 |
| Financial_Debt    | 0.437215  | 0.238282   | 1.835   | 0.06753  |
| Subsidies         | -2.658704 | 0.343689   | -7.736  | 1.61e-13 |
| Investment_Rate   | -0.148478 | 0.126836   | -1.171  | 0.24269  |
| Adjusted_Wage     | 0.706987  | 0.057117   | 12.378  | < 2e-16  |

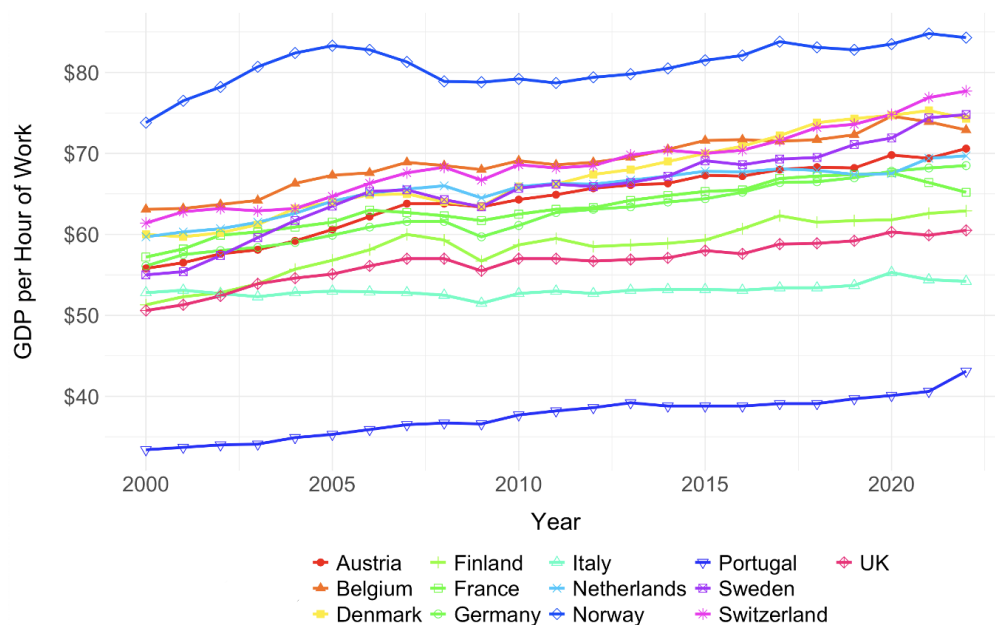
**Table A21:** Estimation of the impact on the dependent variable of a one-unit variation of each independent variable

| Variable          | WLS Log Model Coefficient | Impact on Labor_Productivity of a One-Unit Variation <sup>8</sup> |
|-------------------|---------------------------|-------------------------------------------------------------------|
| Capital_Intensity | 0.022495                  | 2.27%                                                             |
| Exports           | 0.743422                  | 110.31%                                                           |
| Financial_Debt    | 0.372224                  | 45.10%                                                            |
| Subsidies         | -2.689361                 | - 93.21%                                                          |
| Adjusted_Wage     | 0.679347                  | 97.26%                                                            |

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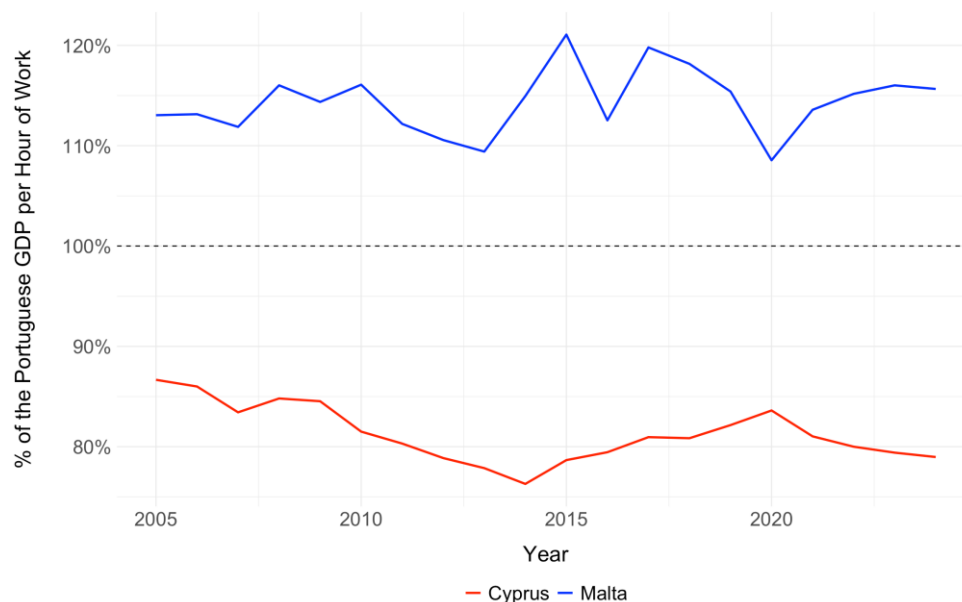
<sup>8</sup> The variation was calculated in accordance with the following:  $Variance = e^{coefficient} - 1$ .

**Figure A1:** GDP per Hour of Work, in US \$ (constant prices 2010 and PPPs), in Portugal and 12WE (2000-2022)



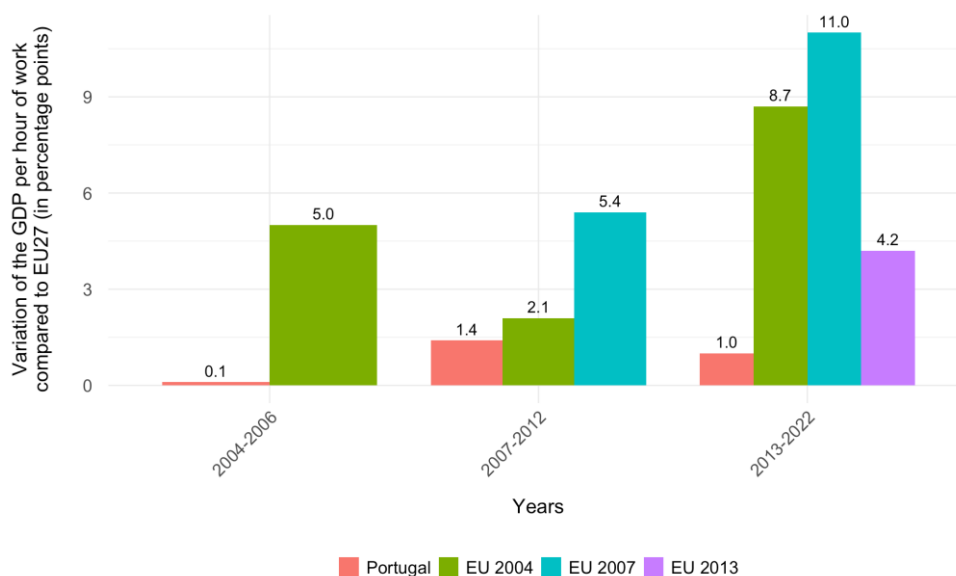
Source: adapted from OECD (2024b)

**Figure A2:** Evolution of the GDP per hour of work of Cyprus and Malta as a percentage of Portugal's (2005-2024)



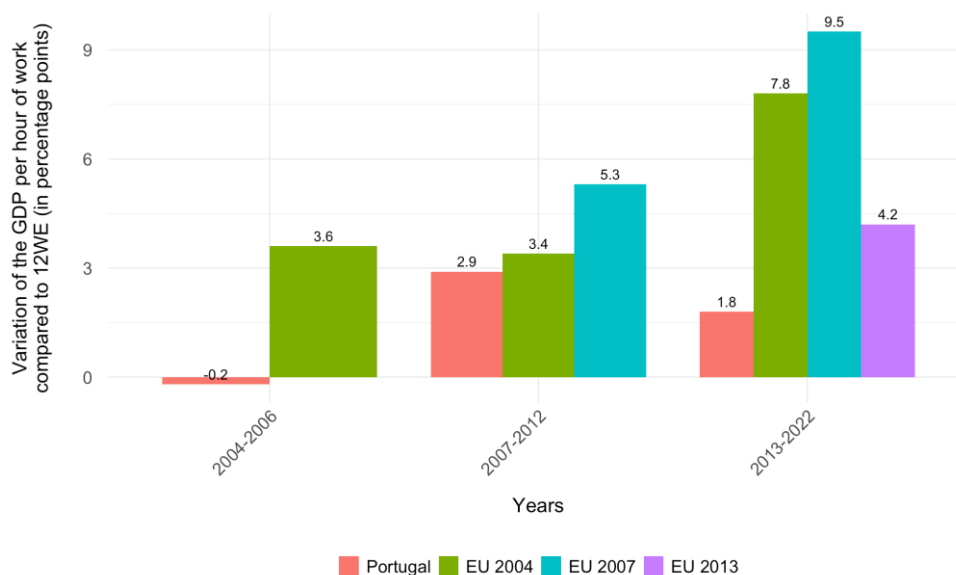
Source: adapted from ILO (2024)

**Figure A3:** Variation of the GDP per hour of work, in percentage points, compared to EU27 (2004-2022)



Source: adapted from OECD (2024b)

**Figure A4:** Variation of the GDP per hour of work, in percentage points, compared to 12WE (2004-2022)



Source: adapted from OECD (2024b)

**Figure A5:** Relationship between capital intensity and labor productivity in Portugal

