Charles University

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

The Stagnation of Productivity in the Czech Republic: Does the Country Suffer from Baumol's Cost Disease?

Author: **Bc. Jakub Blaha**

Supervisor: **Petr Pleticha, MSc.**

Academic Year: **2019/2020**

Declaration of Authorship

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Prague, December 27, 2019

Signature

Acknowledgments

Firstly, I would like to express my sincere gratitude to my supervisor Petr Pleticha for his patience, motivation, and expert knowledge. His guidance helped during the whole duration of writing this thesis.

Besides my supervisor, I would like to thank my parents, Renata and Stanislav, and the rest of my family for the continuous mental and financial support.

Abstract

This thesis examines the impact of diverging productivity gains across industries in the Czech Republic and identifies their effect on other economic indicators. Using methods standard in the literature about Baumol's model, we analyze yearly sectoral data in the Czech Republic for the period 1995-2015 and examine the presence of Baumol's diseases. Using the econometric concept of fixed effects model, our findings are in line with the predictions of Baumol (1967) as relative prices decline in progressive sectors; and sectoral growth of wages is rather independent of the productivity growth. Additionally, sectoral growth of labour productivity is accompanied by a diminishing share of working hours. Opposite to what Baumol's model suggests, we rejected the hypothesis of the 'constant real share' as productivity growth tend to raise real output. And because the volume of this effect is relatively stronger than the decline in the prices, technological advancement has resulted in nominal output growth. Finally, we have demonstrated that sectoral shifts towards stagnating industries have tended to lower aggregate labour productivity growth. Although the results of our study show the presence of Baumol's cost and growth diseases in the Czech Republic, their magnitude differs considerably from the current literature.

JEL Classification	O41, 047, D24, E24, J24, C12
Keywords	Labour productivity, total factor productivity, Baumol's effect, cost disease, gross value added

Author's e-mail	kubablaha@seznam.cz
Supervisor's e-mail	petr.pleticha@cerge-ei.cz

Abstrakt

Tato diplomová práce zkoumá dopad odlišných nárustů produktivity napříč průmyslovými odvětvími v České republice a identifikuje jejich vliv na další ekonomické ukazatele. Za použití standardních metod v literatuře o Baumolově modelu, analyzujeme roční sektorová data v České republice za období 1995–2015 a ověřujeme přítomnost Baumolových chorob. Při použití ekonometrického modelu fixních efektů jsou naše zjištění v souladu s predikcemi Baumola (1967), jelikož jsme zaregistrovali relativní pokles cen v progresivních odvětvích; a také jsme ukázali, že odvětvový růst mezd byl do značné míry nezávislý na růstu produktivity. Sektorový růst produktivity práce byl navíc doprovázen klesajícím podílem pracovní doby. Na rozdíl od toho, co naznačuje Baumolův model, jsme zamítli hypotézu „stálého reálného podílu", protože růst produktivity má tendenci zvyšovat skutečnou produkci. A protože rozsah tohoto efektu je relativně silnější než velikost poklesu cen, technologický pokrok vedl k růstu nominální produkce. Nakonec jsme prokázali, že sektorové posuny směrem k stagnujícím odvětvím mají tendenci snižovat celkový růst produktivity práce. I když výsledky naší studie prokazují přítomnost Baumolovy nákladové a růstové choroby v České republice, její rozsah se značně liší od současné literatury.

Klasifikace JEL O41, 047, D24, E24, J24, C12
Klíčová slova Produktivita práce, celková produktivita faktorů, Baumolův efekt, nákladová choroba, hrubá přidaná hodnota

E-mail autora kubablaha@seznam.cz
E-mail vedoucího práce petr.pleticha@cerge-ei.cz

Contents

List of Tables

List of Figures

Acronyms

OECD Organisation for Economic Co-operation and Development

GDP Gross Domestic Product

GVA Gross Value Added

TFP Total Factor Productivity

CZSO Czech Statistical Office

FTE Full-time Equivalent

LP Labour Productivity

Master's Thesis Proposal

Author	Bc. Jakub Blaha
Supervisor	Petr Pleticha, MSc.
Proposed topic	The Stagnation of Productivity in the Czech Republic: Does the Country Suffer from Baumol's Cost Disease?

Motivation: Lately, the Czech economy has been experiencing a huge success. "Strong economic growth, low unemployment, healthy public finances and high levels of well-being," commented Mr. Gurría, the Secretary-General of the Organisation for Economic Co-operation and Development (OECD 2016), at the occasion of releasing the OECD Economic Survey of the Czech Republic in 2016. Nevertheless, the research emphasizes that productivity growth has slowed considerably in the latest years. After this fact has been stated, one might raise a question of what has made the Czech productivity growth rate slow down from its previous pace, while other peer countries from Central and Eastern Europe belonged to the top OECD performers in terms of productivity progress. Furthermore, we might be interested in knowing the impacts of this economic situation.

Hypotheses: In our thesis, we would like to examine the sources and consequences of slower labour productivity and total factor productivity (TFP) growths as well as to test whether Baumol's cost disease has accompanied the productivity slowdown. It can be described as an effect arising from increasing salaries in jobs that have experienced no or a very weak rise in productivity in order to compete with salaries from other industries of the economy with higher productivity increase. However, other syndromes might arise from different rates of productivity growth across industries, and therefore, we incorporate different forms of total factor and labour productivity models into the analysis to answer the following research questions:

Hypothesis #1: Has low productivity growth led to the cost disease?

Hypothesis #2: Have technologically progressive sectors of the economy experienced a drop in the share of nominal gross value added?

Hypothesis #3: Have the shares of real output between progressive and stagnant sectors remained the same?

Hypothesis #4: Do sectors with faster productivity growth tend to have a declining relative proportion of employment and hours?

Hypothesis #5: Was there a difference between the growth rates of wages between stagnant and progressive industries?

Hypothesis #6: Has the economy experienced a shock resulting from the growth disease?

Methodology: In the first step of the data analysis, we collect a complete dataset of industry accounts from the Czech economy. The majority of the data will be from EU KLEMS, which is a database on measures of economic growth, productivity, capital formation, or technological change. The data is appropriate for our thesis as it is at the industry level for all EU members from 1970 onwards. Most importantly, the EU KLEMS database includes the US economy, and hence, our findings will be comparable to the research written by Hartwig (2011b), who used the very same database to investigate Baumol's diseases both in the European Union and the United States. To provide graphs with the most recent data, we also collected data from the Czech Statistical Office (CZSO). Even though the EU KLEMS is more complex as far as the Czech industry data is concerned, it is not as often updated as the data from CZSO. The final data panel will consist of several economic variables, including real and nominal gross values added, compensations, industry prices or, for example, the number of hours worked. Such a dataset will enable us to construct an index of labour productivity, and its main advantage will be a highly consistent form ensured by using only one source for the regression analysis.

Concerning the analytical framework, this thesis will use an econometric tool that is called the fixed effects model, which is conducted on time series from individual sectors. More specifically, we will introduce a system of reduced-form equations where the various explained variables, such as real output, prices, wages, and others, are determined mainly by explanatory technological improvement. To reach stationarity, the coefficients variables will be estimated in growth terms.

Regarding the data about output, we opted for nominal and real gross value added instead of gross or real GDP since, according to the existing literature, the value-added approach is more appropriate as this technique will allow us to focus more intuitively on the primary sources of technological changes (Cobbold 2003). Also, it prevents estimates from being distorted, and it explains the structure of commodity output in a better way as it avoids a bias resulting from the output of highly frequent companies.

Expected Contribution: The study will aim to investigate a series of hypotheses concerning the impacts of productivity changes on economic, price, or wage growths. Each of the hypothesis lies on the assumptions of W. Baumol, who have analyzed the effect of different productivity growths throughout the overall economy, claiming that stagnating (those, whose productivity-growth levels are below average) industries are typical for above-average cost and price increases. At the same time, they take an increasing share in national output. Although his economic theory was presented in 1963, no researcher has examined Baumol's conjecture on the Czech data, yet. Therefore, we will be the first to investigate if the Czech Republic's economy also suffers from the so-called Baumol diseases, which might be one of the explanations of slower aggregate productivity growth. The survey will be conducted on data from various sectors; the results will be for the overall economy, however. Hence, the ultimate goal of our research is to contribute to the current knowledge about this economic phenomenon, provide statistical proof based on econometric analysis, and finally, enclose whether technologically stagnating industries in the Czech Republic tend to have rising relative prices and decreasing relative real outputs. If the hypotheses of William Baumol were confirmed, our thesis could become a valuable material for future studies as well as for government policy.

Outline

1. Introduction: There are several studies concerning the lower productivity growth in recent years; however, none of them has taken into consideration the Baumol's diseases while working with the Czech data. This fact ensures the uniqueness of the thesis.

2. Productivity: This part consists of various sections. In the first section, the conceptual framework is introduced. It is followed by a brief introduction to Baumol's diseases, and finally, the last part presents the most recent studies concerning the topic, together with their results.

3. Data: In this section, we will describe the data collection together with the primary sources of the dataset, and we will also present various descriptive statistics depicted in the form of tables or graphs so that the potential reader has a better understanding of the data.

4. Modeling: This chapter will describe the models that will deal with the Baumol's diseases, and their derivation will be demonstrated as well.

5. Results: We will uncover the results of the regressions and discuss their economical meaning.

6. Conclusion: Our findings will be summarized and we will spur for further research.

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Author Supervisor

Chapter 1

Introduction

"Productivity is not everything, but in the long run, it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker."

Paul Krugman, *The Age of Diminishing Expectations (1997)*

Productivity is most frequently defined as a ratio of the output and the total amount of inputs. It is one of the most important economic indicators as it expresses a country's efficiency in the use of various inputs, such as capital or labour, to produce the given level of output. According to Cette *et al.* (2017): *"Productivity is the main source of gains in GDP per capita and therefore of the increase of the average living standard of a population."*
Despite the massive success of the Czech economy in recent years, low productivity is still limiting convergence towards OECD standards of living (OECD 2018). While some might be interested in the causes of relatively low productivity, our thesis instead examines its relationship with other economic variables, such as output, wages, and full-time equivalents.

As a motivation, we can consider the research presented by William Baumol, who devoted a substantial part of his life to the study of differential productivity growth rate across industries and its impact on the overall economic condition. His hypothesis says that industries with below-average growth of productivity will tend to experience above-average rises in costs and wages. Not only will this cost explosion increase the prices in the given industry, but as a by-product, it will cause decreasing quality, and most importantly, a reduction in the country's aggregate rate of productivity. Baumol together with his co-authors decided to test their ideas on several sectors, namely on education (Baumol 1993), health care (Baumol 2012), or performing arts (Baumol *et al.* 1993). They chose these sectors since they are known to be price-elastic, which means that consumers are rarely deterred by price growth. The conclusions of Baumol's studies were, however, contested by other authors who questioned his proposed model supporting the presence of cost disease. For example, Cowen (1996), in his work called *"Why I do not believe in the cost-disease"* explains that rising costs in education, health care, or arts do not have to necessarily result from cost disease, but rather from an increase of quality or diversity. Nevertheless, the problem is that whether some authors were in favour, or against the Baumol's hypothesis, their works were leaned on descriptive statistics only. The breakthrough occurred when Nordhaus (2008) presented an econometric framework that revealed the presence of cost disease in the US economy. Ever since, several papers have been devoted to this paradox[1] of Baumol's diseases, and yet, no one has ever considered its investigation in the Czech Republic.

Our thesis uses the most recent available Czech data to investigate a relationship between lower productivity growth, inflation rate, growth of hours worked, growth of gross value added, and the level of wages. The primary purpose of the thesis is to elaborate on the Baumol's effect and to accurately define the correlation between productivity growth and growth of aggregate output, prices, or labour compensation, which will help us to deliver unprecedented findings of the Czech economy. At the end of our research, we will able to determine how, *ceteris paribus*, productivity influences other economic indicators. Last but not least, the thesis compares our findings on an international basis and points out different outcomes between the Czech, Swiss, South Korean, Japanese or, for example, EU and US economies.

Its structure looks as follows: Chapter 2 presents the concept of productivity on a country's level, and it also defines the key terms that are used for the rest of the thesis. Furthermore, it includes the literature written about this phenomenon, together with the results of the individual studies. Chapter 3 offers the data collection as well as it presents the descriptive statistics in the

[1] For instance, Hartwig (2011a) has decided to test if the medical care expenditure in 19 selected OECD countries is primarily driven by wage increases that are in excess of productivity growth. Not only did he find robust evidence supporting the Baumol's theory, but his findings also suggested that relative price in health care is a statistically significant explanatory variable for expenditure in the health care industry.

form of graphs and tables. In Chapter 4, we justify the models that investigate the hypotheses supporting Baumol's theory. Subsequently, Chapter 5 summarizes the results of the regressions and explains the meaning of the regressions' coefficients. Finally, Chapter 6 describes our findings and acts as a spur for further research.

Chapter 2

Productivity

2.1 Conceptual Framework

Productivity can be defined as a ratio between a measure of output and input. There are various types of productivity measures such as capital productivity or total factor productivity; nevertheless, labour productivity is probably the most important once a country is analyzed from a statistical or economic perspective (Freeman 2008)[1]. It measures how efficient are the production inputs, mainly full-time equivalent (FTE) or the total amount of employed workers, in producing the given level of output. With the help of this indicator, we can implicitly compare living standards, economic growths, or competitiveness between two economies and use it for country performance assessments. According to Krugman (1997), the growth of productivity is, from a long-term point of view, the only possible way to attain improvements in the quality of life or living standards. Not only does it affect economic indicators, but it can enhance investment in education, improve infrastructure, or reduce poverty (Jalilian & Kirkpatrick 2002). In other words, labour productivity shows what value an employee creates for a particular time unit. For example, better productivity can be improved by organizing work, innovations, introducing modern technologies, improving employee selection or motivation - generally by reducing costs and increasing the price of a product or service (Appelbaum *et al.* 2001). This all has led to the consensus that productivity growth is an essential

[1]Freeman (2008) reasons that: *"Labour productivity is a revealing indicator of several economic indicators as it offers a dynamic measure of economic growth, competitiveness, and living standards within an economy. It is the measure of labour productivity (and all that this measure takes into account) which helps explain the principal economic foundations that are necessary for both economic growth and social development."*

aspect of an economy and that its factors should be understood, in both policy and research.

For instance, one might use the productivity data to assess the influence of a new labour market regulation on economic performance. Also, the growth of productivity might serve as a pivotal element to model the production capacity of an economy, which can be subsequently used for assessment of aggregate demand and inflationary or deflationary pressures (Fan 1997). Last but not least, it allows us to analyze and determine capacity utilization, which facilitates the evaluation of an economy's position in the business cycle as well as the forecast of economic growth (Krugman 1997).

Even though the indicator of labour productivity offers a unique way to measure the efficiency with which services and goods are produced within an economy, it can be determined in several ways. The choice between them usually depends either on the available data or on the purpose of the productivity investigation. The volume of output is either measured by gross domestic product (GDP) or by gross value added (GVA). On the contrary, the input is expressed by total hours worked or by total employment.

2.2 Definition of Key Terms

The measure of output can be either expressed by gross value added or gross domestic product. Both output measures can be subsequently used for calculating total factor productivity (TFP) and labour productivity growth. While the former measure does exclude such intermediate inputs as materials, energy, and services used during the process of production, the latter includes these values. Consequently, GVA has significant benefits because it is a simpler measure that deals with difficulty caused by the intra-industry and inter-industry flow of services and goods (Cobbold 2003). In addition to that, the value-added concept appears to be more consistent if the condition of firm profit maximization is taken under concern (van der Wiel 1999).

Even though there is a strong correlation between them, gross value added is preferred since taxes on products and services are excluded, which avoids potential biases. The difference between these two concepts is less obvious at the aggregate level, though. Sourcing intermediate inputs from imports cause the only differentiation at the national level. However, at the sector level, intermediate usage happens to be a much higher proportion of the final gross output. Therefore, these two approaches of measuring total output can vary significantly (Cobbold 2003). In other words, gross value added is more meaningful if there is a significant presence of outsourcing as it is the total sum of all revenues, from final sales and subsidies. Also, from the information mentioned above, it can be easily deduced that GVA is more appropriate for international comparison. Even though the only country examined is the Czech Republic, both real and nominal GVA are chosen for the investigation since intermediate inputs included in GDP could bring a potential bias that would distort our results.

As far as data processing is concerned, the procedure is rather intuitive. Once the quantity indices of value-added are acquired, weighted averages adding to unity can be formed, where the weights are simply percentages of each industry in the whole economy. This adjustment enables us to compare value added-based growth patterns across industries as the productivity measures are now expressed in the form of weighted averages of their components (OECD 2001). However, despite all the advantages that the concept of value-added approach offers, it suffers from some shortcomings which have been constantly condemned as:

- Industry estimates based on the nominal value-added approach of productivity growth are generally higher than gross output estimates[2].
- Measures based on GVA might distort productivity growth rates over time (Gullickson & Harper 1999) and also distort comparisons of productivity growth across industries[3].

The measure of input, in an optimal world, should reflect all the effort, time, and skill that workers use for production. However, this information is hardly

[2]Harchaoui *et al.* (2004) explain in a more profound way why the MFP growth based on GVA exceeds the measure based on gross output by the factor that is equal to the ratio between these two different measures.

[3]Cobbold (2003) comments it in the following way: *"The relationship between the two measures for a given industry may not be stable over time because the share of value-added in gross output changes as shifts occur in the use of intermediate inputs relative to capital and labour. As a result, a constant rate of multifactor productivity (MFP) growth measured on a gross output basis could be consistent with an accelerating or decelerating rate of MFP growth measured on a value-added basis."*

available due to the difficulties related to the measurement of such qualities. Therefore, as it was already mentioned, the measure of input can be represented by the total amount of hours worked or by headcount. Even though it can be difficult for accurate calculation, the total amount of hours worked is generally preferred to the sum of employed persons since it does not distort the following data:

- Simpler headcount of total employment can hide the changes or adjustments in average hours worked.
- The number of total employment does not account for the evolution of part-time work.
- Some sectors diminish the fluctuation of employees by increasing or decreasing working hours - the variations are ignored.
- Absence from work is not considered as well.

Therefore, not only does this measurement capture the input better than per employee data, but it is also easily accessible. Both the Czech Statistical Office and EU KLEMS provide us with the Database of National Accounts where all the necessary data about employees is stated. Despite all the benefits that have been listed, there are still some statistical problems too. For instance, different methods of measurement across countries are used, which complicates international comparison. Furthermore, the fact that the data does not consider educational level, skills, or experience of the workforce is one of the shortcomings that need to be taken into account when evaluating the results.

Labour productivity is the value of the number of goods and services a worker produces at any given time. It can increase as a result of improved technologies, higher working skills, or increasing the quality of labour equipment (Krugman 1997). Commonly, it is a ratio between the output volume and the labour input. As opposed to TFP, it does not take into account the input of capital (Sargent *et al.* 2001).

We also differentiate labour productivity based on what we consider to be a unit of labour. If this unit of labour is human labour - labour done by man-measured labour cost, we are talking about the productivity of living labour (Robinson & Vaizeyd 2016). When we consider the unit of labour to be the work contained in all inputs to a particular transformation process, we are talking about the productivity of social work, which is measured by the price of all inputs into the production process - both live and materialized labour. The volume of produced values is also differentiated; for instance, at the national economy level, it may be the gross domestic product, gross value-added, gross national product, national income, *et cetera*. At this level, the productivity of living labour per capita is used as a unit of measurement.

However, labour productivity differs among individual regions as it has many determinants. Among the factors influencing the labour productivity the most, we can consider (Abdel-Maksoud 2004):

- Location and technological or physical factors.
- Religious, cultural, motivational, and other behavioral factors.
- Level of innovativeness, efficiency, and overall interest of foreign companies to invest money into the economy.
- Economic, political, or legal environments.
- Level of the barrier to entry, levels of flexibility and the presence of traditional craft.
- Effectiveness in recruiting, training or the level of rewards and wage system.

Total factor productivity is calculated as a ratio where the nominator consists of total production and the denominator is the weighted average of inputs, commonly labour and capital. More generally, it is the ratio between aggregate output and aggregate input (Sickles & Zelenyuk 2019). In other words, total factor productivity (TFP) is representing growth in real gross value added, which is excessive to the growth in labour or capital. As for the weights, the economic theory suggests the weighting of 0.3 for capital and the remaining 0.7 for labour (Gordon 2017). It is well known that total factor productivity is a measurement of economic efficacy and it is one of the main determinants of the differences in income per capita (Prescott 1997). The most universally used production function is the Cobb-Douglas function (Murthy 2002), which looks as follows:

$$Y = AK^{\alpha}L^{\beta} \tag{2.1}$$

where:

- Y = Total output (real value of all goods produced within a year)
- L = Labour input (total amounts of hours worked and the amount of full time equivalents)
- K = Capital input (a measurement of all buildings, equipment or machinery)
- A = Total factor productivity
- α & β stand for output elasticities of capital and labor, respectively. Both values are constants and are primarily determined by the level of available technology.

Therefore, K^α and L^β explain the weighted average of inputs. Once we arrange the formula for total output, we obtain:

$$TFP = A = \frac{Y}{K^\alpha L^\beta} \tag{2.2}$$

Thus, TFP is explained as the increase in total output, which is excessive to the increase that stems from rising inputs. It might result from factors such as the level of education, technological change, synergies, research and development(Apokin & Ipatova 2016), and so forth. Nevertheless, the value of total factor productivity is not intuitive as such, but it is more useful to observe this variable over time. The following growth equation perfectly explicates the relationship between the growth of total output, growth in total factor productivity, and growth in labour and capital:

$$\frac{\Delta A}{A} = \frac{\Delta Y}{Y} - \alpha \times \frac{\Delta K}{K} - \beta \times \frac{\Delta L}{L} \tag{2.3}$$

2.3 Baumol's Theoretical Model

William Baumol was the pioneer of the idea that the U.S. economy has been experiencing an unbalanced growth. In his model, which is pivotal for this research, he divided it into a progressive and stagnant[4] sector. The model assumes that labour productivity tends to increase only in the progressive sector, but wages grow by the same rate that is equivalent to the growth of labour productivity in the non-stagnant sector. It can be rewritten as (Hartwig 2008):

$$Y_{1t} = \alpha L_{1t} \tag{2.4}$$

$$Y_{2t} = \beta L_{2t} e^{rt} \tag{2.5}$$

$$W_t = W e^{rt} \tag{2.6}$$

Where L_{1t} and L_{2t} describe labour forces employed in both sectors at time t and Y_{1t} and Y_{2t} are outputs of non-progressive and progressive sectors, respectively. W is the rate of wage, r is the rate by which labour productivity in the progressive sector is growing, and finally, α and β are constants. One of the implications resulting from his model concerns the per-worker costs of output:

$$c_1 = \frac{W_t L_{1t}}{Y_{1t}} = \frac{W e^{rt} L_{1t}}{\alpha L_{1t}} = \frac{W e^{rt}}{\alpha} \tag{2.7}$$

$$c_2 = \frac{W_t L_{2t}}{Y_{2t}} = \frac{W e^{rt} L_{2t}}{\beta L_{2t} e^{rt}} = \frac{W}{\beta} \tag{2.8}$$

where c_1 and c_2 are costs per worker in stagnant and productive industries, respectively. Therefore, according to equation 2.7, the costs per worker grow towards infinity in the sector with no productivity growth. That is not the case in the non-stagnant sector as it grows by a constant $\frac{W}{\beta}$. Hence, if prices in the sectors would increase proportionally to the costs and the demand for goods and services would not be price-inelastic, the stagnant industry would finally disappear. However, Baumol points out that health care and education are necessities and do not satisfy the assumption of higher price-elasticity. To account for this phenomenon, he introduces the following equation:

$$\frac{\beta}{\alpha}\frac{Y_1}{Y_2} = \frac{\beta}{\alpha}\frac{\alpha L_1}{\beta L_2 e^{rt}} = \frac{L_1}{L_2 e^{rt}} = \lambda \tag{2.9}$$

which requires the proportion between real outputs of these two industries to remain constant (λ). Supposing that the total workforce $L = L_1 + L_2$, the

[4]Service industries that are primarily financed by taxes or social contributions. For example, we can think of health care or education that are supposed to be acquiring a larger and larger portion of the total expenditure.

equation 2.9 gives us:

$$L_1 = \lambda(L - L_1)e^{rt} \iff L_1(1 + \lambda e^{rt}) = L\lambda e^{rt} \iff L_1 = \frac{L\lambda e^{rt}}{1 + \lambda e^{rt}} \tag{2.10}$$

and at the same time

$$L_2 = L - L_1 = \frac{L + L\lambda e^{rt} - L\lambda e^{rt}}{1 + \lambda e^{rt}} = \frac{L}{1 + \lambda e^{rt}} \tag{2.11}$$

which implies that $L_1 \to L$ and $L_2 \to 0$ with $t \to \infty$. Therefore, the model assumes that costs and workforce will eventually shift into the stagnant sector. The last thing that remains is to show what will happen to the GDP growth rate if the real shares of these two sectors will be preserved constant:

$$GDP = w_1 Y_1 + w_2 Y_2 = w_1 \alpha L_1 + w_2 \beta L_2 e^{rt} \tag{2.12}$$

where w_1 and w_2 are weighted averages of the total value added for both sectors. Once we substitute labour with equations 2.10 and 2.11:

$$GDP = \frac{(w_1 \alpha A + w_2 \beta) L e^{rt}}{1 + A e^{rt}} = \frac{X e^{rt}}{1 + A e^{rt}} \tag{2.13}$$

where X is used as a substitute for:

$$X = (w_1 \alpha A + w_2 \beta) L$$

With the use of this shorter form, we can apply the first derivative:

$$\frac{\delta GDP}{\delta t} = \frac{X(re^{rt}(1 + Ae^{rt}) - Are^{2rt})}{(1 + Ae^{rt})^2} = \frac{rXe^{rt}}{(1 + Ae^{rt})^2} \tag{2.14}$$

The final equation of the real GDP growth rate is obtained in the following way:

$$\frac{\frac{\delta GDP}{\delta t}}{GDP} = \frac{r}{1 + Ae^{rt}} \tag{2.15}$$

Supposing that r and A remain real constant numbers, $t \to \infty$ would cause the GDP growth rate to drop toward zero eventually. The mathematical modeling itself, hence, offers many implications, so-called diseases. Nordhaus (2008) has widened the theory of William Baumol and offered a regression model that not only takes into account the growth of costs per worker, employment, or output, but it also includes growth of prices. Moreover, he also introduced panel estimators with fixed effects.

2.4 Types of Baumol Diseases

There exist various syndromes that might occur when the productivity growth rates across industries differ, and also, they might result in several imperfections. Since this thesis aims to examine six of Baumol's effects on the Czech data, we provide the potential reader with an overview that describes their reasoning:

Baumol's cost and price disease is a consequence of a proportionate increase in salaries in jobs that have experienced fragile productivity growth, resulting from the fact that salaries have risen in other more productive industries. Baumol (1993) explains that the productivity growth of labour is unbalanced and that cost disease is primarily caused by shifting expenditures from more to less technologically advanced activities, such as health care or education, which are financed by tax money[5]. This effect is contradictory to the laws of classical economics, which states that real wage change should be closely related to labour productivity growth (Sharpe *et al.* 2008). The reason to pay higher wages in industries with stagnant labour productivity arises from the need to acquire competitive employees who logically desire competitive salaries. For example, if managers in the manufacturing sector would be paid significantly less than equally skilled managers in the automobile industry, they might have tendencies to quit the job. Nevertheless, their remuneration would have to be increased to make them stay. Therefore, their salaries would be increased not by increased productivity growth in the manufacturing industry, but by higher productivity growth in the car industry.

Baumol *et al.* (1993) have decided to analyze this pattern. Examining the effect of different productivity growth rates of individual industries on the condition of the overall economy, they came up with a hypothesis that sectors with below-average productivity growths were experiencing above-average cost rises. Therefore, according to the authors, the stagnant sectors have been experiencing inflationary pressures on prices. Furthermore, Baumol predicted that man-

[5]Hartwig (2011b) also explains that demand for this type of services is highly price-inelastic, meaning that a larger increase in price is accompanied by a small change of demanded quantity.

ufacturing employment share will keep declining, whereas the service industry will attract a larger and larger share of the population, all combined resulting in a stagnant economy. As an explanation we can consider the fact that manufacturing has been becoming more and more efficient, and consequently, the price of manufactured goods has fallen significantly. Thus, a larger portion of people's savings could be spent on labour-intensive services[6]. As a result, more and more of our economy is dedicated to the production of these products, and more and more jobs are concentrated on their delivery. During the process of labour shift, the cost disease might spread out from the less productive sectors into the whole economy, causing the reduction of real output or slowing down the total productivity growth.

Hence, Baumol's cost disease can be described as a lack of productivity growth, mostly in public services. Such institutions as public schools or public hospitals that do not rely on routine human activities have been empirically proved to have lower growth in productivity over time (Baily & Montalbano 2016). It takes the same amount of time for nurses to take care of their patients as it did in 1900, even though their wages are incomparably higher than before. The reactions of employers to cost disease might vary. Some of the possible effects are decreased quality or decreased profit margin.
On the other hand, it can result in an increased price or employing more volunteers. In chapter 4, we present a model that assumes that costs in stagnant industries grow much faster. Therefore, to uncover the cost-price disease in the Czech economy, we would have to find a negative, statistically significant correlation between price and productivity growth.

Unbalanced growth occurs when low productive industries tend to have a rising share in the nominal output. Baumol's hypotheses presume that cost disease might increase the output price of a non-progressive industry. However, the effect the cost disease could be outweighed by increasing real output in progressive industries. Thus, the effect on nominal output growth might be ambiguous. The hypothesis of the unbalanced growth would be confirmed if there was a negative correlation between productivity and nominal output growths.

[6]Such as medical care, child care, eating out, education and so forth.

Constant shares of real output can be a direct effect of cost disease. Baumol presumed that technologically advanced and non-progressive sectors would maintain the same share of real output over time. However, the results of existing literature instead demonstrate the evidence of decreasing real output share for less productive industries[7]. Since this hypothesis has never been tested on the Czech data, we will be the first who investigate whether the correlation between productivity and real output growths in the Czech Republic is statistically different from zero or not.

The effect on hours worked mainly depends on the structure of the production process. If the demand in the industry for output is price elastic, the higher productivity growth will be positively correlated with the number of hours worked. Nonetheless, the equations 2.10 and 2.11 from the previous section expect the opposite to happen. Our research will aim to confirm the hypothesis of Baumol *et al.* (1985) who revisited the topic of unbalanced growth to come to a conclusion that:

"The U.S. labour force has been absorbed predominantly by the stagnant subsector of the services rather than the services as a whole."

In our case, we will look for a negative correlation between productivity and FTE growths.

The uniform growth of wages is another hypothesis that will be tested. We have already demonstrated that the same growth rate of wages between progressive and non-progressive sectors would cause the costs per worker in the stagnant part of the economy to grow immensely high. Thus, the main question here is whether the wages across different industries have been growing uniformly or not. Both Hartwig (2010) and Nordhaus (2008) have concluded that the coefficients obtained from the regression of wage growth rates on labour productivity growth are small and statistically insignificant, meaning that both Swiss and American wage growth rates have been complying with the Baumol's model.

[7] For example, Oh & Kim (2015) while examining the Korean economy have concluded that the constant shares of real output have not been preserved which moderated the impact of other Baumol's diseases.

Growth disease is an ultimate hypothesis in our thesis, which can also be a product of different productivity growth rates across industries. It concerns how the changing structure of output will affect productivity growth. Cost disease, the fact that stagnating industries have experienced a rise in prices, can imply growth disease if and only if it is accompanied by rising nominal output shares of less technological sectors. If, at the same time, the progressive sectors dismissed labour and the stagnant ones would be absorbing it, the overall economic growth would be converging to the growth of technologically less developed industries. Baumol (1967) comments it with the following words:

"An attempt to achieve balanced growth in a world of unbalanced productivity must lead to a declining rate of growth relative to the rate of growth of the labour force. In particular, if productivity in one sector and the total labour force remain constant the growth rate of the economy will asymptotically approach zero."

The proper investigation of the relationship between the level of growth in nominal output and labour or total factor productivity will be scrutinized in the empirical part of the thesis.

2.5 Literature Review

According to Baumol (1967), the economy should be divided into progressive and non-progressive sectors[8]. In his theoretical study, Baumol explains that the total productivity growth experiences a monotonical decrease as the share of employment or nominal value added in the non-progressive sectors expand. Since he was the first to come up with this idea, it is nowadays called Baumol's disease. His model predicted that services industries had been acquiring increasing shares of total expenditures, which was one of the factors for productivity growth decline.

For several years a great effort has been devoted to the study of the Baumol hypothesis about if expansion in non-progressive industries has an adverse effect on the macroeconomic performance (Bates & Santerre 2013). The focus of recent research has been mainly on the situation where structural change was represented by the expansion of the service sector, which is considered to

[8] The former consists of those that ensure a higher productivity growth rate while the latter is composed of industries with relatively lower productivity growth.

be of the least labour productivity growth (Tang & Wang 2004). However, not all researchers took into consideration that Baumol's cost disease and Baumol's growth disease could occur separately, one without the other. Fase & Winter (1999) examined the Baumol's law in the Dutch economy to come to robust results in favor of Baumol's hypothesis. They discovered that while wages in the manufacturing and service sectors moved in line with the rest of the economy, the evolution of labour productivity in these two industries systematically diverged. A similar observation has been provided by Tang & Wang (2004), who have proved that high labour productivity growth sectors did not manage to attract resources from stagnant industries in the United States or Canada. Baumol's theory was also confirmed by Nordhaus (2008), who has used industry data from the period 1948-2001 to demonstrate that sectors with technological incapability to grow, suffer from rising relative prices, and decreasing real outputs. In addition to that, his research uncovered that technologically progressive sectors are predisposed to have slower employment and hours growth. Last but not least, his data indicate the presence of Baumol's growth disease since the lower overall productivity growth has been partly caused by an increasing share of stagnant sectors in nominal output. Another author that claims the Baumol's diseases to be universal is Hartwig (2008), who emphasizes the fact that Baumol's cost disease still lingers in the US economy.

On the contrary, some authors question the lower productivity growth of services. For instance, Maroto-Sánchez & Cuadrado-Roura (2009), whose study focuses on the effect of tertiarisation on total productivity growth. Opposite to what similar researches suggest (Bonatti & Felice 2008), their examination based on 37 OECD countries for the period 1980-2005 concludes that service activities play a much more critical role in the overall productivity growth than was historically believed. Oh & Kim (2015) also found a qualitatively different Baumol effect in the Korean economy. Even though the cost disease was found to be significant, it had a small effect, and the aggregate labour productivity growth was not declining over time. Nevertheless, the weak cost disease still led to a weak growth disease.

Therefore, the existing literature cannot decidedly conclude whether Baumol's disease is universal or not, and the results may highly depend on the period, country and sectors examined. Consequently, it can be assumed that the growth dynamics are different for a particular economy and the implications of Baumol's discoveries can vary accordingly. Thus, what does the model offer for the Czech economy?

Even though the existing papers have investigated the growth dynamics in Western countries, many of them have failed to avoid shortcomings. For example, Baumol (2012) successfully uncovers the consequences of labour productivity growth dynamics, but omits the sources. Conversely, there are authors like Peneder (2003), who has been rather focusing on causes of labour productivity growth rates but ignored the consequences in his paper. Second of all, studies investigated by Tang & Wang (2004) or Nordhaus (2008), in the hope of uncovering Baumol's diseases, divided the economies into three sectors: primary, secondary and tertiary. Although this classification might appear classical, our thesis extends their approach and explores each sector in a more detailed way. Therefore, this measurement will take into account the structural change that has occurred. We look more deeply at the growth rates of each variable and demonstrate it by various tables and figures to account for the descriptive statistics. Such a 'within' approach will help us to decide whether the Czech Republic suffers from Baumol's diseases or not.

Chapter 3

Data

3.1 Data Collection

We have collected data from two primary sources. Firstly, we extracted the data from Czech Statistical Office (CZSO) for the period 1993-2018, where the information about hours worked, wages or nominal gross value added is available in the Database of National Accounts. The annual data is classified into 20 different subsegments, but we used the data from CZSO only to provide a view on the overall economy[1]. Nevertheless, the regression part of the thesis is based on the data from the EU KLEMS Growth and Productivity Accounts Database[2]. The EU KLEMS data about prices, real gross value-added, gross fixed capital formation or capital stocks is consistent with Eurostat at the corresponding sector levels and turns out to be an indispensable part of our analysis. However, one of the shortcomings of this database is that at the point of writing this thesis[3], the Czech data is available only for the period 1995-2015. On the other hand, the EU KLEMS database offers a much more sophisticated view on the Czech economy as it consists of a total number of 39[4] individual segments and subsegments.

[1]The data from CZSO is used for some statistical calculations as well as well for graphs and tables since the information is available up to 2018.

[2]The EU KLEMS was found to be very useful while examining Baumol's diseases. For the purpose of investigation the presence of Baumol's diseases in the Korean economy, Oh & Kim (2015) have extracted the data from sixty-two industries about prices, nominal and real value-added or hours worked. Nishi *et al.* (2016) used this database to test hypotheses on Japanese economy.

[3]August, 2019

[4]The table lists 3.1 them all and also provides growth rates for total industries and market economy.

Table 3.1: Annual Average Growth Rates for Individual Industries (1995-2015)

#	Industry	LP	Price	Real VA	Hours
1	TOTAL INDUSTRIES	5.59%	3.07%	2.24%	-0.21%
2	MARKET ECONOMY	5.49%	2.42%	2.70%	-0.28%
3	AGRICULTURE, FORESTRY AND FISHING	5.21%	3.09%	-0.26%	-2.57%
4	MINING AND QUARRYING	5.67%	4.93%	-3.80%	-4.78%
5	TOTAL MANUFACTURING	6.23%	0.39%	5.64%	-0.17%
6	Food products, beverages and tobacco	5.08%	2.61%	0.85%	-1.63%
7	Textiles, wearing apparel, leather and related prodcuts	5.62%	2.13%	-1.91%	-5.03%
8	Wood and paper products; printing and reproduction of recorded media	5.21%	-0.30%	4.05%	-1.29%
9	Coke and refined petroleum products	8.34%	-15.16%	16.23%	-9.33%
10	Chemicals and chemical products	3.88%	1.69%	2.35%	0.30%
11	Rubber and plastics products, and other non-metallic mineral products	6.87%	0.30%	7.29%	0.71%
12	Basic metals and fabricated metal products	4.31%	3.33%	0.83%	-0.04%
13	Electrical and optical equipment	8.01%	-2.45%	13.27%	2.01%
14	Machinery and equipment n.e.c.	6.10%	-0.65%	6.67%	-0.33%
15	Transport equipment	8.05%	-0.85%	12.76%	3.39%
16	Other manufacturing; repair and installation of machinery and equipment	5.55%	1.5%	3.90%	-0.05%
17	ELECTRICITY, GAS AND WATER SUPPLY	4.24%	5.85%	-1.23%	-0.18%
18	CONSTRUCTION	5.46%	5.22%	-1.52%	-1.50%
19	WHOLESALE AND RETAIL TRADE	5.75%	-0.77%	6.17%	-0.15%
20	Wholesale and retail trade and repair of motor vehicles	5.37%	2.79%	2.03%	-0.17%
21	Wholesale trade, except of motor vehicles	5.55%	-1.11%	7.00%	0.53%
22	Retail trade, except of motor vehicles and motorcycles	5.68%	-1.20%	6.21%	-0.58%
23	TRANSPORTATION AND STORAGE	4.52%	5.07%	-0.87%	-0.29%
24	Transport and storage	4.51%	5.51%	-1.18%	-0.14%
25	Postal and courier activities	4.03%	2.10%	0.64%	-1.37%
26	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	2.06%	6.15%	-3.46%	0.62%
27	INFORMATION AND COMMUNICATION	5.82%	2.94%	5.31%	2.34%
28	Publishing, audiovisual and broadcasting activities	7.27%	4.72%	2.70%	0.15%
29	Telecommunications	6.29%	0.01%	5.26%	-1.18%
30	IT and other information services	6.89%	5.64%	6.25%	4.9%
31	FINANCIAL AND INSURANCE ACTIVITIES	5.79%	2.15%	4.56%	0.73%
32	REAL ESTATE ACTIVITIES	4.54%	5.42%	1.48%	2.16%
33	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	4.87%	4.40%	1.07%	0.70%
34	COMMUNITY SOCIAL AND PERSONAL SERVICES	5.24%	5.51%	-0.08%	0.10%
35	Public administration and defence; compulsory social security	5.33%	3.98%	0.78%	-0.55%
36	Education	5.44%	4.45%	1.23%	0.15%
37	Health and social work	6.69%	9.26%	-2.24%	0.06%
38	ARTS, ENTERTAINMENT AND RECREATION	2.85%	5.93%	-1.59%	1.25%
39	Arts, entertainment and recreation	3.69%	6.29%	-0.93%	1.46%
40	Other service activities	2.21%	5.75%	-2.19%	1.10%
41	Activities of households as employers	5.21%	3.45%	8.97%	6.98%

Source: EU KLEMS (2019), author's computations.

Note: Mind that the subsegments are not written in upper-case style. LP stands for labour productivity and VA for value-added. Labour productivty growth is calculated from nominal GVA. The horizontal lines divide the table between agriculture, mining, manufacturing, utilities, construction and services. The table states the average growth rates (geometric mean).

The advantage of the EU KLEMS database is that manufacturing, wholesale and retail trade, and information and communication industries are divided into individual subsegments, which significantly improves the scope of our thesis. The table 3.1 presents all industries together with their growth rates. The third column implies that all industries have experienced a positive labour productive growth. The rates fluctuated between 2.06% and 8.34%, though. The industry with the lowest growth was accommodation and food service activities, while coke and refined petroleum products revealed itself to be the most labour-productive industry. As far as the growth of the price level is concerned, the range of values is much more extensive. Coke and refined petroleum products experienced an annual price drop of 15.16%, whereas the price level at health and social work increased by 9.26% annually. The annual average growth rate of real value-added was found to be the lowest for the mining and quarrying industry as it equaled to -3.80%. Negative growth was also experienced by the arts industry or, for instance, by accommodation and food service activities. The first figure in the last column implies that the total amount of hours worked in the Czech Republic decreased by 0.21% annually. However, most of the negative growth rates can be spotted in industry-oriented segments. Especially the heavy industry, such as mining and quarrying or coke and refined petroleum products, has decreased the number of hours worked dramatically during the period 1995-2015. The workforce was absorbed by telecommunication, financial services, or real estate activities.

Table 3.2 offers a look at the Czech economy from a different perspective. As far as employment is concerned, more than 60% of workers are employed in services. The second-largest sector, in terms of people, is manufacturing, which is occupied by almost 27% of working population. Similarly, its full-time equivalent equals 25.89%. Both hours worked and employment turn out to have very similar shares, but due to the reasons stated in chapter 2, hours worked are preferred in the ultimate analysis. If we move to the output variables, some differences can be immediately spotted. Mainly once manufacturing is taken into consideration since this sector is known for completing the final product through multiple numbers of subcontractors. While the manufacturing industry accounted only for 26.83% of the nominal gross value added, its share when the nominal output is considered, is almost 40%. In this example, we can see how excluding intermediate inputs can influence the structure of the whole economy. On the other hand, the share of service is significantly higher if the

Table 3.2: Variables as Shares of Each Sector in 2017

Sector	Variable					
	Hours worked	*Employment*	*Nominal GVA*	*Nominal output*	*Compensation*	*Wages*
Agriculture, forestry and fishing	3.35%	3.04%	2.29%	2.25%	1.96%	1.98%
Mining and quarrying	0.52%	0.55%	0.73%	0.58%	0.81%	0.78%
Manufacturing	25.89%	26.69%	26.83%	39.14%	28.43%	28.37%
Utilities	1.77%	1.83%	4.15%	4.43%	2.39%	2.40%
Construction	8.12%	7.53%	5.32%	6.75%	4.55%	4.61%
Services	60.35%	60.36%	60.68%	46.85%	61.85%	61.86%

Source: author's computation based on CZSO (2019) data.

output is measured value-added terms. The last two variables in the table measure the share of income for each sector. At first glance, an attentive reader can notice that both wage and compensation have a very similar distribution of shares among sectors. Again, the most significant percentage is taken by the services industry as it reaches almost 62%. Once we compare the columns of income and inputs[5], we can immediately determine how each sector is compensated based on the amount of work performed. For example, the agriculture, forestry, and fishing industry employ 3.04% of workers whose compensation is below 2% of the total share, meaning that they obtain below-average pay. Conversely, workers from the utilities industry, such as gas, electricity or water supply, receive a higher portion of income than they account for.

3.2 Description of Variables

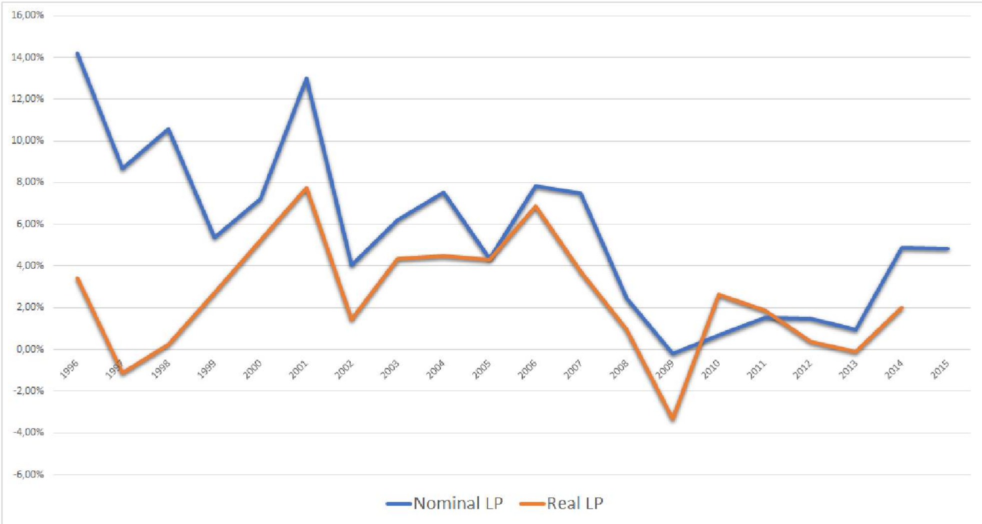
Labour productivity growth is one of the essential indicators that influences per capita standards of living. Therefore, the recent stagnation of the labour productivity in the Czech Republic [6] has been recognized as a puzzle that needs to be explained and solved, both from academic or business and policy-making point of view (Goldin *et al.* 2018). Since labour productivity is of the highest importance for our thesis, we decided to calculate in both real and nominal terms.

As can be seen from figure 3.1, the growth rate of labour productivity has been gradually slowing down in the long-term. The transition was not very smooth, though, as the most massive plunge occurred during the financial crisis

[5] Employment and hours worked stand for input, whereas compensation and wages account for income.

[6] We calculated that after adjusting for inflation, labour productivity in the Czech Republic during the period 1995–2014 had by increasing by 2.48% per annum. However, since the post-crisis period, which started in 2009, it grew only by 1.34% annually.

Figure 3.1: Development of Labour Productivity Growth in the Czech Republic



Source: EU KLEMS (2019), author's computations.
Note: Mind that the growth rates are based on the ratio between the total gross value added and the total amount of hours worked. Real LP stands for real labour productivity, which is calculated from real value-added while nominal LP is not price-adjusted..

in 2008 and both real and nominal labour productivities experienced negative growth. According to figure 3.1, labour productivity growth on the aggregate level spiked during the period 1999-2001 when the year-to-year growth reached almost 8% in real terms. To better understand the curve fluctuation, the table 3.3 scrutinized the development of nominal labour productivity on the industry level. At first glance, we can register a significant difference between the development of labour productivity after and before the Financial crisis in 2008-2009 when the Czech economy experienced the most significant decline. In total, all industrial sectors weakened as far as labour productivity is concerned. Most notably, sectors such as mining and quarrying or electricity, gas and water supply ended up in negative values. The reason is that the Czech economy during recession required fewer mined materials, resulting in a lower level of sales. Once less coal was mined, the volume of produced electricity decreased as well. At the same time, due to the smaller amount of mining, less energy was used for subsequent processing of raw materials.

It can also be spotted that the lowest labour productivity growth rate throughout the period 1995-2015 was experienced in the accommodation, food service, and arts industries. The last-mentioned sector was of the main interest

Table 3.3: Development of Labour Productivity Growth in the Czech Republic on the Industry Level during the Period 1995-2015

#	Industry	Δ 1995-2009	Δ 2009-2015	Δ 1995-2015
1	TOTAL INDUSTRIES	6.99%	2.38%	5.59%
2	MARKET ECONOMY	6.74%	2.65%	5.49%
3	AGRICULTURE, FORESTRY AND FISHING	3.73%	8.76%	5.21%
4	MINING AND QUARRYING	8.55%	-0.75%	5.67%
5	TOTAL MANUFACTURING	7.19%	4.01%	6.23%
6	ELECTRICITY, GAS AND WATER SUPPLY	7.98%	-3.98%	4.24%
7	CONSTRUCTION	6.99%	1.97%	5.46%
8	WHOLESALE AND RETAIL TRADE	6.65%	3.67%	5.75%
9	TRANSPORTATION AND STORAGE	5.93%	1.32%	4.52%
10	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	1.70%	2.91%	2.06%
11	INFORMATION AND COMMUNICATION	7.45%	2.13%	5.82%
12	FINANCIAL AND INSURANCE ACTIVITIES	7.50%	1.89%	5.79%
13	REAL ESTATE ACTIVITIES	5.20%	3.00%	4.54%
14	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	6.18%	1.87%	4.87%
15	COMMUNITY SOCIAL AND PERSONAL SERVICES	6.95%	1.37%	5.24%
16	EDUCATION	6.97%	1.96%	5.44%
17	HEALTH CARE AND SOCIAL WORK	8.36%	2.9%	6.69%
18	ARTS, ENTERTAINMENT AND RECREATION	4.01%	0.21%	2.85%

Source: EU KLEMS (2019), author's computations.
Note: Mind that the growth rates are based on the ratio between the total nominal gross value added and the total amount of hours worked. The total period growth rate was obtained using the formula for multiple years average.

of Baumol *et al.* (1993), where the authors tried to explain the financial problems stemming from increasing costs in the arts industry in the USA.

Although there have been some technological advances implemented in recent years, labour productivity in the Czech Republic was only 74.7% of the European Union average in 2017 (Eurostat 2018), which is not very promising value once we realize that it was already 72.3% in 2007. Moreover, multifactor productivity that indicates how efficiently labour and capital are being used in the process of production, has been increasing at a relatively slower pace as well (Eurostat 2019b). While some economists refer to it as a consequence of the Financial crisis, others claim that the Czech economy lags behind Western European countries due to the relatively lower value-added. More specifically, Kureková (2018) claims that:

"Many domestic firms provide low value added products and services in the global supply chains. This may suggest an investment need to support the uptake of technology and increase the innovation performance of domestic firms."

From the text above, we can deduce that the recent productivity slowdown might be caused by lower value-added of Czech enterprises. In fact, the domestic economy is industry-oriented and focused on export. Therefore, the major part of produced components is subsequently carried out abroad and transformed into finished, and more expensive, products with higher value-added.

While labour productivity remains stagnant in the Czech Republic, the hourly wage costs are rising at the second-fastest pace from the EU countries. Labour costs in the country grew by 11.2 percent in 2018 compared to the same period last year (Eurostat 2019c). The only economy that has experienced a higher increase in the prices of employees within EU was Latvia. Nevertheless, as was already said, this increase in labour costs was not supported by an increase in labour productivity since it only increased by 0.8 percent year-on-year (CZSO, 2019). However is such a differentiation between productivity and wage growth sustainable? Furthermore, what consequence can it bring?

Figure 3.2: Development of Labour Productivity Growth vs. Wages Growth

Source: EU KLEMS (2019), author's computations.
Note: Mind that labour productivity is depicted in real terms. Wages growth is adjusted for hours worked in the industry to eliminate the effect of the structural shift.

Total factor productivity is one of the most sustainable sources of long-term economic growth (Cette *et al.* 2009), and in our analysis, it will serve as one of three explanatory variables[7]. Nevertheless, the EU KLEMS dataset about total factor productivity is not complete, and that is why some industries such

[7] TFP data is less accessible in the EU KLEMS database than the rest of the dataset and as a result, the number of observations for TFP regressions is smaller, and we will cover only the period 1996-2014.

Table 3.4: Development of Real TFP and Labour Productivity Growth in the Czech Republic on the Industry Level during the Period 1996-2014

#	Industry	Δ TFP	Δ LP
1	TOTAL INDUSTRIES	-0.03%	2.48%
2	MARKET ECONOMY	0.31%	3.01%
3	AGRICULTURE, FORESTRY AND FISHING	2.96%	2.31%
4	MINING AND QUARRYING	-0.64%	1.12%
5	TOTAL MANUFACTURING	3.1%	5.96%
6	ELECTRICITY, GAS AND WATER SUPPLY	-2.8%	-1.08%
7	CONSTRUCTION	-2.61%	-0.02%
8	WHOLESALE AND RETAIL TRADE	4.04%	6.29%
9	TRANSPORTATION AND STORAGE	-2.78%	-0.52%
10	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	-5.43%	-4.03%
11	FINANCIAL AND INSURANCE ACTIVITIES	0.2%	3.19%
12	INFORMATION AND COMMUNICATION	-2.62%	2.71%
13	REAL ESTATE ACTIVITIES	-0.68%	-0.74%
14	PROFESSIONAL, SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE ACTIVITIES	-2.39%	0.33%
15	COMMUNITY SOCIAL AND PERSONAL SERVICES	-1.77%	-0.17%
16	EDUCATION	-0.61%	1.03%
17	HEALTH AND SOCIAL WORK	-3.41%	-2.24%
18	ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES	-3.29%	-2.87%

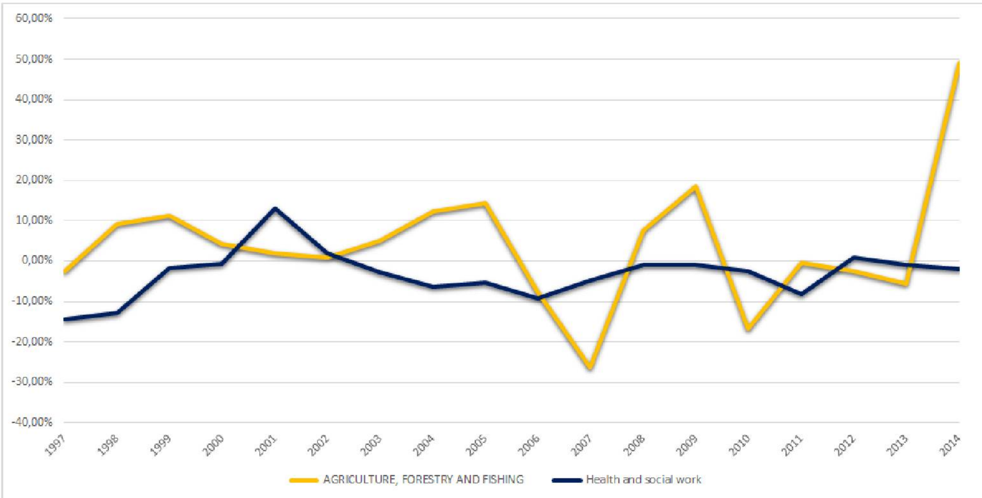
Source: EU KLEMS (2019), author's computations.
Note: The total period growth rate was obtained using the formula for multiple years average (geometric mean). The TFP is based on GVA. Both variables are depicted in real terms.

as Coke and refined petroleum or Activities of households have to be omitted from the investigation. Even though the first mentioned was the one that has experienced the most considerable productivity growth in labour, its absence in our dataset with TFP values is not the only reason why total factor productivity for the whole economy is so low. The values in the table 3.4 are price adjusted relative to the year 2010, and hence, they are in real terms.

The right column in the 3.4 Table suggests that labour productivity is significantly smaller once inflation is taken into consideration. The most surprising value is the labour productivity growth rate of accommodation and food services industry, which has been continuously decreasing by an annual rate of -4.03%. According to Eurostat (2019a), this decline can be explained by the fact that this industry employs many workers on a part-time basis and is also characterized by a significant number of working owners as well as unpaid family workers. However, the growth rate of real TFP is even lower. What more, it is in the majority of sectors negative, which implies that we have witnessed feeble technological progress in the last twenty years. Nonetheless, some industries have performed much better than the rest of the economy. One of those is agriculture, which has, on average, increased its productivity by 2.96%

year-on-year. According to (IFPRI), an increasing trend in the efficiency of agricultural production[8] has a positive effect on the amount of food produced and is critical for improving food security. To better understand what TFP means in the example of agriculture, we should regard it as an indicator of how efficiently agricultural capital, land, materials and labor have been combined to produce a country's crops and livestock. The technological improved of agriculture is well depicted in figure 3.3, where we used the health care and social work industry as a tool for comparison:

Figure 3.3: Development of Agriculture and Health Care TFP Growth in the Czech Republic



Source: EU KLEMS (2019), author's computations.

Once we both curves are captured in the same graph, we can immediately determine which sector is more cyclical. While the total factor productivity growth of health care and social work has recorded a significantly lower variance, the opposite can be said about the agriculture industry. Even though the last period of measurement (2013–2014) markedly influenced the average TFP growth in agriculture as the value increased from 91.68 to 136.72[9], it is not the most important finding in the graph. Figure 3.3 indicates that the TFP growth in health care and social work was in the majority of years negative. There is no doubt that productivity is not the most crucial indicator[10] once health care

[8]Efficiency in this sense is understood as producing more from the same amount of resources.

[9]Where both values reflect the level of total factor productivity relative to the year 2010.

[10]The most used health care outcome measures are mortality, the safety of care, life expectancy, patients experience, etc.

Table 3.5: Annual Average Growth Rates for Hours Worked and Industries' Proportions (1995-2015)

#	Industry	Δ Hours worked	% in 2015
1	AGRICULTURE, FORESTRY AND FISHING	-2.57%	3.42%
2	MINING AND QUARRYING	-4.78%	0.62%
3	TOTAL MANUFACTURING	-0.17%	25.85%
4	ELECTRICITY, GAS AND WATER SUPPLY	-0.18%	1.77%
5	CONSTRUCTION	-1.5%	8.55%
6	WHOLESALE AND RETAIL TRADE	-0.15%	14.59%
7	TRANSPORTATION AND STORAGE	-0.29%	6.17%
8	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	0.62%	4.05%
9	INFORMATION AND COMMUNICATION	2.34%	2.61%
10	FINANCIAL AND INSURANCE ACTIVITIES	0.73%	1.65%
11	REAL ESTATE ACTIVITIES	2.16%	1.96%
12	PROFESSIONAL, SCIENTIFIC AND OTHER ACTIVITIES	0.7%	8.18%
13	EDUCATION	0.15%	5.35%
14	HEALTH AND SOCIAL WORK	0.06%	6.11%
15	ARTS, ENTERTAINMENT AND RECREATION	1.25%	3.32%

Source: EU KLEMS (2019), author's computations.
Note: The table states the average growth rates (geometric mean).

is taken into account, but it might be the ultimate reason why costs in this sector have experienced an 'explosion'(Nordhaus 2008).

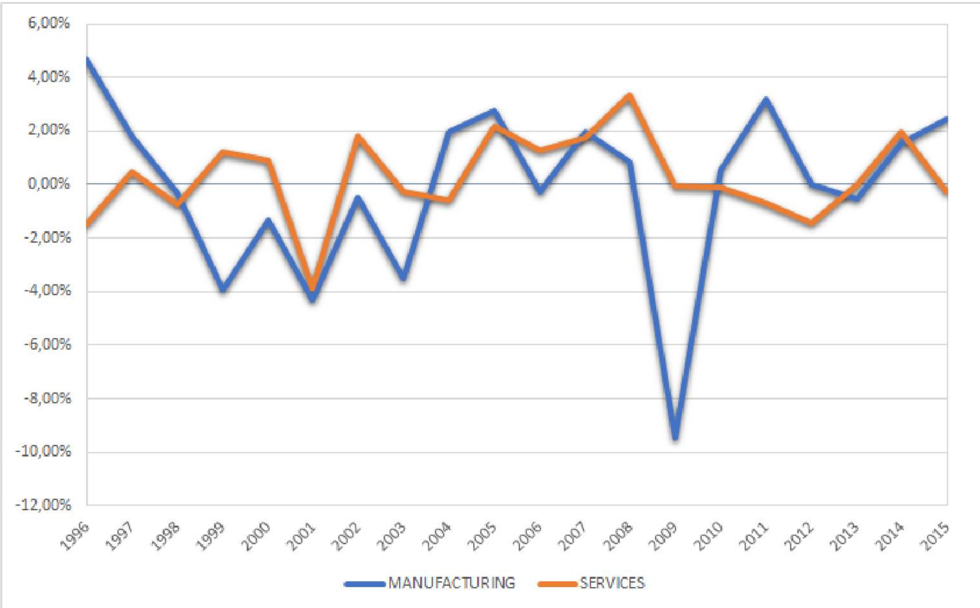
Hours worked is defined as the total number of hours worked per year. Its main advantage is that it includes both full-time and part-time workers, overtime payments or maternity leave, schooling and training absence, or even public holidays and additional jobs. In the measurement of productivity, it will eliminate the differences caused by different worktime among workers. We have already demonstrated that there are indeed some differentials between total employment and full-time equivalent as far as the proportions in the Czech economy are concerned. For example, table 3.2 displays that the manufacturing industry employs 26.69% of all workers, whereas the share of the total hours worked equals 25.89% only.

The table 3.5 demonstrates the transfer of labour force from the industry to the services sector[11]. Although manufacturing still accounts for 25.85% of FTE's of working Czechs, more than 81 million[12] hours were dropped out. At first glance,

[11] Only two industries from the service sector - the wholesale and transportation and storage industries, have had a negative growth rate of hours.
[12] 2,432 million hours in 1995 vs. 2,350 million hours in 2015.

the potential reader can spot that sectors in services have been continuously raising their FTE's. For instance, relatively higher increase in hours worked was registred by the real estate industry that features by below-average increase in labour productivity. One of the least productive industries of all, the arts and recreation industry, has been increasing its amount of hours by 1.25% annually.

Figure 3.4: Full-time Equivalent Growth Rate between the Services and Manufacturing Industry



Source: EU KLEMS (2019), author's computations.

Figure 3.4 depicts the development of hours worked growth rate between manufacturing and services. The most significant difference occurred between the years 2008 and 2009. While the services industry almost preserved the same number of FTE's, the manufacturing industry experienced a drop of almost 10%. Therefore, the manufacturing in the Czech Republic appears to be much vulnerable to a crisis as well as to other cyclical patterns. However, the long-run trend deduced from numbers says that workers from highly productive manufacturing[13] transfer to less productive services.

Nominal Gross Value Added is the differential between the official price of a product and the cost incurred by producing it. It can also serve as a repre-

[13] This sector has experienced above-average growth rates of real TFP and real labour productivity. The values for the period 1996–2014 were 3.10% and 5.96%, respectively.

Table 3.6: Shares of Employment and Proportional Nominal Gross Value Added

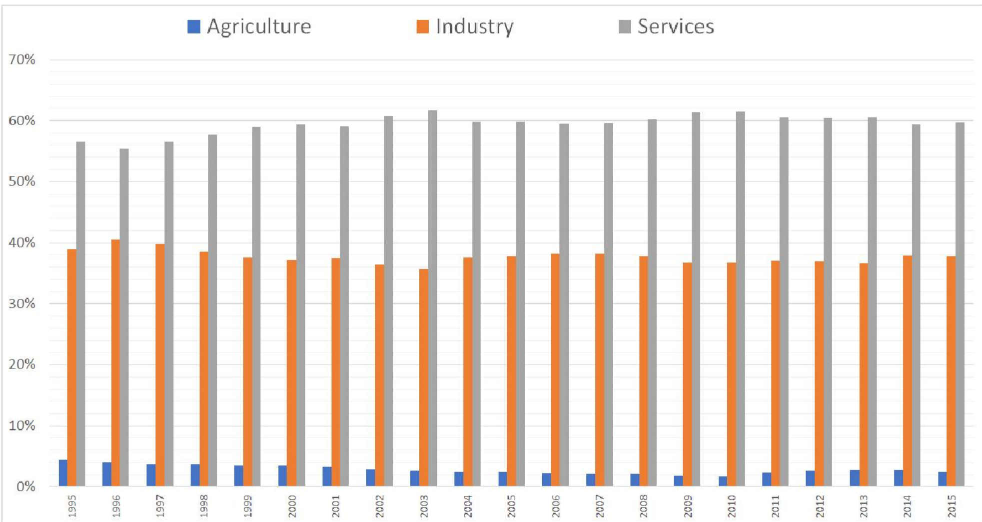
Industry	**1993**	**1998**	**2003**	**2008**	**2013**	**2017**
A Agriculture, forestry and fishing	5.64%	5.08%	3.83%	3.24%	3.29%	3.04%
	4.53%	3.73%	2.59%	2.13%	2.69%	2.29%
B Mining and quarrying	1.87%	1.36%	0.96%	0.86%	0.66%	0.55%
	2.73%	1.61%	1.07%	1.40%	0.87%	0.73%
C Manufacturing	26.95%	28.39%	26.70%	26.93%	25.75%	26.69%
	23.40%	25.34%	24.04%	24.51%	24.83%	26.83%
D Electricity and gas	1.03%	0.88%	0.81%	0.65%	0.65%	0.69%
	4.67%	3.14%	3.11%	4.12%	4.14%	3.10%
E Water supply	0.78%	1.09%	1.06%	1.10%	1.16%	1.13%
	0.84%	1.04%	1.03%	1.09%	1.11%	1.05%
F Construction	9.63%	9.20%	8.69%	8.54%	8.49%	7.53%
	6.87%	7.43%	6.45%	6.56%	5.75%	5.32%
G Wholesale and retail trade	13.41%	13.41%	14.15%	13.77%	14.31%	13.61%
	9.97%	10.41%	11.48%	10.81%	10.29%	11.10%
H Transportation and storage	6.42%	6.31%	6.19%	6.30%	6.06%	6.18%
	6.75%	6.88%	7.24%	6.23%	5.71%	5.70%
I Accommodation and food service activities	3.04%	2.85%	3.65%	3.78%	3.95%	3.90%
	2.65%	3.22%	2.59%	2.09%	1.97%	2.12%
J Information and communication	1.45%	1.86%	1.95%	2.43%	2.54%	2.76%
	2.54%	3.93%	4.64%	5.17%	5.03%	5.27%
K Financial and insurance activities	1.25%	1.74%	1.66%	1.73%	1.88%	1.73%
	5.04%	4.00%	3.36%	4.09%	4.65%	4.00%
L Real estate activities	1.05%	1.30%	1.49%	1.92%	1.88%	1.84%
	7.10%	6.79%	7.85%	8.35%	8.77%	8.53%
M Professional, scientific and technical activities	4.32%	4.16%	4.94%	5.22%	5.43%	5.77%
	4.95%	4.18%	4.86%	4.98%	4.96%	5.01%
N Administrative and support service activities	2.44%	2.44%	2.65%	2.92%	2.88%	2.85%
	1.94%	1.73%	1.56%	1.97%	1.76%	1.77%
O Public administration and defence	6.80%	7.01%	6.50%	6.06%	5.57%	5.74%
	6.59%	7.02%	7.30%	6.45%	6.43%	6.17%
P Education	5.59%	5.24%	5.87%	5.72%	5.81%	5.95%
	3.95%	3.65%	4.21%	4.01%	4.40%	4.29%
Q Human health and social work activities	5.85%	4.95%	5.65%	5.69%	6.15%	6.42%
	3.22%	3.35%	3.93%	3.80%	4.41%	4.50%
R Arts, entertainment and recreation	1.03%	1.05%	1.32%	1.27%	1.41%	1.50%
	1.03%	1.01%	1.18%	1.13%	1.00%	1.02%
S Other service activities	1.43%	1.63%	1.82%	1.75%	1.97%	1.93%
	1.21%	1.52%	1.45%	1.06%	1.16%	1.07%
T Activities of households	0.03%	0.06%	0.10%	0.13%	0.15%	0.19%
	0.02%	0.03%	0.05%	0.06%	0.09%	0.10%

Source: author's computation based on CZSO (2019) data.
Note: Mind that the shares of nominal GVA are stated in the second row of each industry.

sentation of the value of labor and capital utilized in producing gross output. Consequently, the sum of value added throughout all sectors of the economy is equivalent to the gross domestic product. The results obtained from the analysis could be rather interpreted as the sector's ability to translate technological change into aggregate income.

If we take a deep look on the data in the Table 3.6, we can immediately see which industries have the major impact on the total value-added and how the proportions evolved in time. Firstly, it is evident that the Czech Republic has been deagriculturalizing since the gross value added in that sector has shrunk by half from 4.53% to 2.29%. From the perspective of both total employment and value-added, the breakthrough in the Czech economy occurred in 1998. Not only did the GVA in the manufacturing and construction sector peaked, but the output share of services began to rise. Another industry that should be scrutinized is art. Baumol *et al.* (1993), in their study called *"Performing Arts - The Economic Dilemma"*, have already explained the financial problems of the performing arts and explored the implications of the increasing unit of costs in this industry. The problem can be seen from the Table 3.6 since while the share of employment in the Czech art increased from 1.03% to 1.50% (by 45.63%), the proportional value-added of this industry reamined unchanged.

Figure 3.5: Sector-based Development of Nominal Gross Value Added



Source: EU KLEMS (2019), author's computations.
Note: The division of the industries into the three main sectors is based on Nishi *et al.* (2016). The industry sector contains manufacturing, utilities, mining and quarrying, as well as construction. Such an arrangement secures lucidity of the graph.

Figure 3.5 shows how the nominal value-added has been distributed among the three main industries in the last 20 years. Since the beginning of the observed period, services have been contributing more and more to the nominal output. The trend changed, though, in 2004, when this sector fell below 60% of total nominal GVA. As far as agriculture is concerned, it has experienced a decline from 4.36% to 2.52% during the investigated period. The remaining 36.86% pertain to the industry sector, which, according to our data, appears to be more technologically advanced than the rest of the economy.

Real Gross Value Added is an inflation-adjusted measure that takes into consideration nominal GVA expressed in base-year prices, which is 2010 in our case. Unlike nominal GVA, real GVA is able to account for price fluctuation and offer a more accurate estimate of economic growth. Also, real gross value added makes the comparison between individual years more meaningful as it allows us to compare the actual volume of goods and services. While the growth rate of nominal GVA was 5.37% between 1995-2014, the real term registered an increase of only 2.24%[14]. To see which industries have experienced the largest advancement in terms of growth, we can take a look at table 3.7.

Once adjusted for inflation, the growth rates across industries fluctuate between -3.46% and 16.23% on a yearly basis. Despite a huge technological progress, health and social work have been gradually decreasing by 2.24%, even though the growth in hours worked was slightly above zero. On the other hand, coke and refined petroleum industry has had the most substantial increase in real GVA, although the total amount of time in this industry has shrunk by 10% during the same period. The trend that can be seen in the Czech Republic is that heavy and other manufacturing industries have much more benefited from the technological advancement made in the latest 20 years.

The relatively smaller real GVA growth of some industries would not have to be such an issue if these sectors did not acquire a larger and larger share of the total output. Hypothesis 3 asks if the shares of real output between progressive and stagnant sectors remained the same. The closer look at the Table 3.8 could give us an idea about the result of based on the latest Czech data.

[14] author's computation based on EU KLEMS (2019) data.

Table 3.7: The Growth Rates in Real Gross Value Added between 1995 – 2014

#	Industry	Δ of Real GVA
1	TOTAL INDUSTRIES	2.24%
2	MARKET ECONOMY	2.70%
3	AGRICULTURE, FORESTRY AND FISHING	-0.26%
4	MINING AND QUARRYING	-3.80%
5	TOTAL MANUFACTURING	5.64%
6	Food products, beverages and tobacco	0.85%
7	Textiles, wearing apparel, leather and related prodcuts	-1.91%
8	Wood and paper products; printing and reproduction of recorded media	4.05%
9	Coke and refined petroleum products	16.23%
10	Chemicals and chemical products	2.35%
11	Rubber and plastics products, and other non-metallic mineral products	7.29%
12	Basic metals and fabricated metal products, except machinery and equipment	0.83%
13	Electrical and optical equipment	13.27%
14	Machinery and equipment n.e.c.	6.67%
15	Transport equipment	12.76%
16	Other manufacturing; repair and installation of machinery and equipment	3.90%
17	ELECTRICITY, GAS AND WATER SUPPLY	-1.23%
18	CONSTRUCTION	-1.52%
19	WHOLESALE AND RETAIL TRADE;	6.17%
20	Wholesale and retail trade and repair of motor vehicles and motorcycles	2.03%
21	Wholesale trade, except of motor vehicles and motorcycles	7.00%
22	Retail trade, except of motor vehicles and motorcycles	6.21%
23	TRANSPORTATION AND STORAGE	-0.87%
24	Transport and storage	-1.18%
25	Postal and courier activities	0.64%
26	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	-3.46%
27	INFORMATION AND COMMUNICATION	5.31%
28	Publishing, audiovisual and broadcasting activities	2.70%
29	Telecommunications	5.26%
30	IT and other information services	6.25%
31	FINANCIAL AND INSURANCE ACTIVITIES	4.56%
32	REAL ESTATE ACTIVITIES	1.48%
33	PROFESSIONAL, SCIENTIFIC, TECHNICAL AND SERVICE ACTIVITIES	1.07%
34	COMMUNITY SOCIAL AND PERSONAL SERVICES	-0.08%
35	Public administration and defence; compulsory social security	0.78%
36	Education	1.23%
37	Health and social work	-2.24%
38	ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES	-1.59%
39	Arts, entertainment and recreation	-0,93%
40	Other service activities	-2.19%
41	Activities of households as employers	8.97%

Source: author's computation based on EU KLEMS (2019) data.
Note: The table states the average growth rates (geometric mean).

Table 3.8: The Industry Shares of Real Gross Value Added in 1995 and 2014

#	Industry	Share in 1995	Share in 2014
1	TOTAL INDUSTRIES	100%	100%
2	MARKET ECONOMY	69.81%	75.97%
3	AGRICULTURE, FORESTRY AND FISHING	2.9%	1.81%
4	MINING AND QUARRYING	3.78%	1.19%
5	TOTAL MANUFACTURING	13.34%	24.83%
6	ELECTRICITY, GAS AND WATER SUPPLY	7.75%	4.02%
7	CONSTRUCTION	12.59%	6.17%
8	WHOLESALE AND RETAIL TRADE	5.72%	11.69%
9	TRANSPORTATION AND STORAGE	9.19%	5.11%
10	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	5.45%	1.83%
11	INFORMATION AND COMMUNICATION	3.14%	5.51%
12	FINANCIAL AND INSURANCE ACTIVITIES	3.29%	5.04%
13	REAL ESTATE ACTIVITIES	10.89%	9.44%
14	PROFESSIONAL, SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE ACTIVITIES	8.52%	6.84%
15	COMMUNITY SOCIAL AND PERSONAL SERVICES	25.97%	16.80%
16	ARTS, ENTERTAINMENT, RECREATION AND OTHER ACTIVITIES	4.50%	2.18%

Source: author's computation based on EU KLEMS (2019) data.

The most massive increase was recorded by manufacturing as its share on total real GVA almost doubled, and in 2014, it contributed to the one-fourth of the overall output. We already know from table 3.7 that this industry was among the most progressive ones as far as the growth of real GVA is concerned and the percentage increase is simply an implication of it. On the other hand, the largest plunge could have been observed at community social and personal services, where we have witnessed a drop from 25.97% to 16.80%. According to the EU KLEMS database, this industry consists of public administration and defense, education and health and social work, and all three sub-industries have weakened their percentage share on the total real output.

The compensation of employees represents another form of what a worker is being paid for his work. The correct definition of compensation of employees is stated as follows[15]:

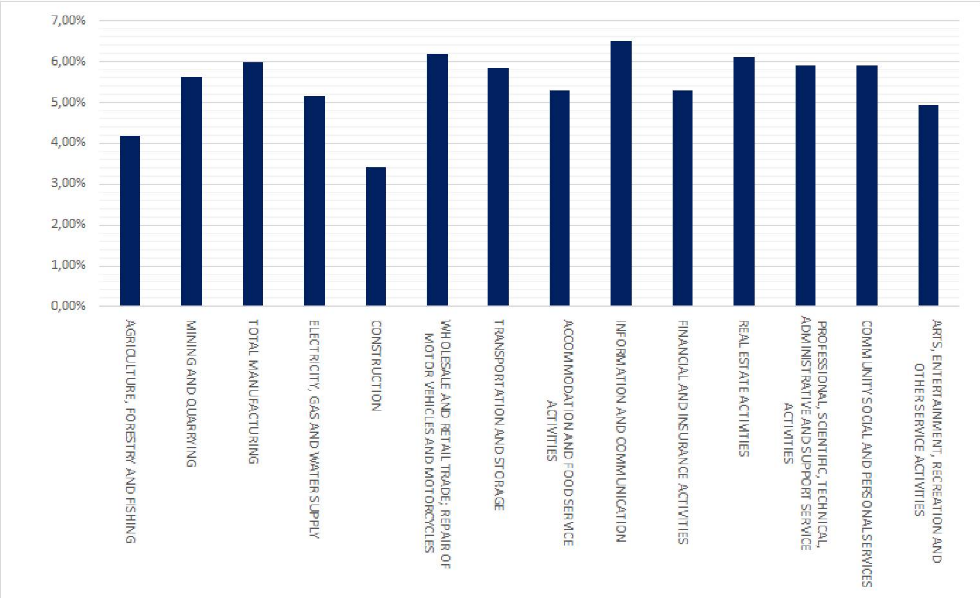
"Compensation of employees is defined as the total remuneration, in cash or in kind, payable by an employer to an employee in return for work done by the latter during the accounting period. Compensation of employees consists of wages and salaries, and of employers' social contributions."

Consequently, compensations are higher than wages in absolute values as they also account for non-cash benefits that the employee obtains. We are interested in this variable in order to clarify the hypothesis about the uniform growth of wages that presumes the growths of compensation in both productive and unproductive sectors to be rising by the same rate. If this was true, we could

[15] Based on Eurostat (2018).

confirm the presence of one of the Baumol's diseases in the Czech economy. As can be seen from the graph 3.6, though, the rates of growth across individual industries vary significantly. For example, the maximum growth rate of

Figure 3.6: Growth Rate of Compensation per Hour Worked during 1995–2015



Source: EU KLEMS (2019), author's computations.
Note: The compensation is per hour adjusted. Therefore, the growth rates do not take into account the movement in hours worked in each industry.

compensation in the given period is 6.51%, while the lowest growth observed was 3.41%. Once we compound the growth rates for the given period, the difference is immense. While, on average, the compensation of a worker in the information and communication industry increased by 253.29%, compensation of jobs delivered by construction workers rose only by 95.51%. Nonetheless, the paradox is that the TFP in these two industries recorded almost the same growth rate. Baumol *et al.* (1993) used to claim that the growth of salary, which is not supported by the growth of productivity, might result in cost disease. Nevertheless, the hypothesis cannot be determined only by descriptive statistics as it needs to be confirmed by a regression analysis, which will be presented in chapter 5.

Prices are the last variable to be included in our investigation. The data about price indices in each year is expressed as nominal gross value-added, and the base year is 2010. This method compares changes in prices between nominal and real GVA over several periods. This type of inflation offers less

Table 3.9: The Industry Growth of Prices between 1995 and 2014

#	**Industry**	**Δ of Prices**
1	TOTAL INDUSTRIES	3.07%
2	MARKET ECONOMY	2.42%
3	AGRICULTURE, FORESTRY AND FISHING	3.09%
4	MINING AND QUARRYING	4.93%
5	TOTAL MANUFACTURING	0.39%
6	ELECTRICITY, GAS AND WATER SUPPLY	5,85%
7	CONSTRUCTION	5.22%
8	WHOLESALE AND RETAIL TRADE	-0.77%
9	TRANSPORTATION AND STORAGE	5.07%
10	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	6.15%
11	INFORMATION AND COMMUNICATION	2.94%
12	FINANCIAL AND INSURANCE ACTIVITIES	2.15%
13	REAL ESTATE ACTIVITIES	5.42%
14	PROFESSIONAL, SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE ACTIVITIES	4.40%
15	COMMUNITY SOCIAL AND PERSONAL SERVICES	5.51%
16	EDUCATION	4.45%
17	HEALTH AND SOCIAL WORK	9.26%
18	ARTS, ENTERTAINMENT, RECREATION AND OTHER SERVICE ACTIVITIES	5.93%

Source: author's computation based on EU KLEMS (2019) data.

deceptive results while comparing outputs between two years as it accounts for price changes. Once we move to the Baumol's terminology, cost-price disease presumes that average costs and prices in less productive industries would grow proportionally to the average.

While the geometric mean of price growth was approximately 3.07%, the values range between -0.77% and 9.26%. Once we analyze the sub-industries[16] as well, the gap between the maximum and minimum value is even more significant. For example, thanks to the massive technological in the manufacturing industry, the price index in electrical and optical equipment, and the transport equipment sector decreased by the annual rate of 2.45% and 0.85%, respectively. Conversely, prices in services have been growing by the above-average rate. Nordhaus (2008) warned that costs in a non-productive industry could theoretically grow towards infinity, and he was emphasizing particularly health care and education since these two sectors got out of control in the US. In the Czech Republic, the price index in health has accumulated a growth of 437.98%, which is equivalent to the annual growth of 9.26% (author's computation). The second 'most expensive' industry in terms of price growth was the accommodation and food service sector. Although they differed from the total economy only by 3% on a yearly basis, the accumulated growth between

[16] For the purpose of clarity of the Table 3.9, these values were not included.

1995 and 2014 reached 211.06%, meaning that the accommodation and food services are now (as of 2014) three times more expensive than in 1995.

Chapter 4

Modeling

To answer the hypotheses about the Czech economy, we employ the methodology used by Oh & Kim (2015), Nordhaus (2008), and Hartwig (2011b). The assumption we make based on Nordhaus' paper is that the production function can be written in the Cobb-Douglas form. By doing so, each industry has its own Cobb-Douglas value-added production function that only produces final goods from capital and labour and also includes time-varying exogenous technology. Hypotheses (1) to (5) can be in econometric terms interpreted as reduced-form equations in which explained variables such as output, compensations, or price are explained by explanatory variable in the of technological change. The general equation can be written as:

$$\widehat{x_{it}} = \beta_{0i} + \beta_1 \widehat{a_{it}} + \epsilon_{it}^p \tag{4.1}$$

where β_{0i} stands for fixed industry effects, and $\widehat{a_{it}}$ is the growth rate of productivity at time t and industry i. The disturbances are included in ϵ_{it}^p. By introducing such a smart econometric panel data framework, Nordhaus (2008) managed to combine Baumol's theoretical approach with an empirical model that can be subsequently estimated by the fixed effects model. By doing so, he was able to confirm almost all the hypotheses tested on the US economy. The only conjecture that he did not find evidence of was about the real output of progressive and stagnant sectors remaining constant.

Even though the general model for the first five hypotheses looks the same, the dependent variable $\widehat{x_{it}}$ differs depending on the Baumol's disease tested. Table 4.1 provides us with a well-organized description of each model:

Table 4.1: Coefficients explanation

H1: Cost and price disease
$\widehat{x_{it}} = \Delta$ of prices in industry i. H_0: $\beta_1 < 0$
H2: Unbalanced growth
$\widehat{x_{it}} = \Delta$ of nominal output in industry i. H_0: $\beta_1 < 0$
H3: Constant share of real output
$\widehat{x_{it}} = \Delta$ of real output in industry i. H_0: $\beta_1 = 0$
H4: Effect on hours worked
$\widehat{x_{it}} = \Delta$ of hours worked within industry i. H_0: $\beta_1 < 0$
H5: Uniform growth of wages
$\widehat{x_{it}} = \Delta$ of wages in industry i. H_0: $\beta_1 = 0$

In total, three different productivity measures will be examined: (1) Labour productivity in real and (2) in nominal values. (3) Total factor productivity where capital stocks are included.

The only research hypothesis that will use a different mathematical approach is the one concerning Baumol's growth disease. For investigating the potential decline in the aggregate productivity growth rate caused by structural change, we will use the proposed non-parametric test and the model will be separately introduced in section 4.1.

4.1 Growth Disease Model

The last question that remains to be defined is whether the structural change has had a negative effect on the overall productivity growth in the Czech Republic or not - the phenomenon called 'Baumol's growth disease'. It states that the growth of total productivity is calculated as a weighted average of the productivity growth rates from each industry, where the weights are acquired from the shares of nominal value-added. Therefore, the overall productivity growth rate will decrease over time if the stagnating sectors will have ever-increasing weight.

To answer the problem of Baumol's growth disease, we decided to adopt the method of Nordhaus (2008), who weighted the sectors' productivity growth rates with their GVA proportional shares in nominal output, changing the weights alternatively depending on each year. What Baumol's model suggests is that updating the base years should result in a significantly lower productivity growth rate. However, to be better see this effect, we first need to decompose aggregate productivity growth $\widehat{a_t}$, which is the growth rate of total factor productivity for one period:

$$\widehat{a_t} = \widehat{x_t} - \widehat{y_t} = \sum_{i=1}^{n} \widehat{x_{it}} S_{it} - \sum_{i=1}^{n} \widehat{y_{it}} V_{it} \tag{4.2}$$

where $\widehat{x_t}$ and $\widehat{y_t}$ are the growth rates of aggregate outputs and inputs. Most importantly,

$$V_{it} = \frac{Y_{it}}{\sum_{j=1}^{n} Y_{jt}} \quad \text{and} \quad S_{it} = \frac{X_{it}}{\sum_{j=1}^{n} X_{jt}}$$

are the so-called Törnqvist shares, which are here used to express weights of inputs and outputs for each industry i in period t. By simple mathematical operation of adding and subtracting $\sum_{i=1}^{n} \widehat{y_{it}} S_{it}$ we obtain:

$$\widehat{a_t} = \sum_{i=1}^{n} (\widehat{x_{it}} - \widehat{y_{it}}) S_{it} - \sum_{i=1}^{n} \widehat{y_{it}} (V_{it} - S_{it}) = \sum_{i=1}^{n} \widehat{a_{it}} S_{it} + \sum_{i=1}^{n} \widehat{y_{it}} (S_{it} - V_{it}) \tag{4.3}$$

where we divided the right-hand side part of the equation into two parts. The first one measures the aggregate growth rate of productivity as a weighted sum of individual sector growth rates. On the other hand, the second part of the equation 4.3 is an interaction between the growth rates of aggregate inputs and the difference between output and input shares in a sector. Fortunately, this term is argued by Nordhaus to be zero as long as we use TFP with superlative output indexes, and output equals income. The final form of the Baumol's growth disease model for a fixed year T is, therefore:

$$\widehat{a_T} = \sum_{i=1}^{n} \widehat{a_{it}} S_{iT} \tag{4.4}$$

If the value of $\widehat{a_T}$ is gradually decreasing with later years T used as the base years[1], the Baumol growth effect would be found to be negative, indicating that the occurring structural change would diminish the potential for economic growth. Hence, Baumol's hypothesis could not be rejected.

[1] In other words, by updating the base years of weights, we will obtain a declining series of TFP growth rates.

Chapter 5

Results

5.1 Baumol's Cost and Price Disease

According to Baumol's theory regarding the cost disease, industries with relatively lower total factor and labour productivity should experience a relatively higher raise in the price. This hypothesis was tested while applying the analytical framework described in the chapter 4 on Czech data. We present the results of our regression in table 5.1, and it distinguishes between six different types of regressions. The coefficient for total factor productivity growth, for both 17 major industries as well as for 31 sub-industries, is significantly negative at the 0.1% level. The value itself presents that a 10% increase in TFP growth would be associated with a reduction in prices by 4.10% or 4.14%, respectively. The correlation between labour productivity in real terms and prices is estimated to be even lower as the coefficients are significantly negative and equal to -0.4743 and -0.4965. These results provide evidence in favour of the cost and price disease in the Czech Republic and are consistent with the findings of Hartwig (2008), Nordhaus (2008), and Oh & Kim (2015). In the larger sample, the size of the coefficient (–0.4101) significantly exceeds the effect of TFP on prices in Korea (–0.088) and Switzerland (–0.200). However, it is more than twice lower than in the United States (–0.965). This comparison implies that Czech consumers benefit much more from technological change than their Korean and Swiss counterparts[1]. We can conclude that cost disease exists in the Czech economy but is qualitatively different from the existing literature.

[1] According to our estimates, higher productivity growth is associated with a much higher decrease in prices comparing to what Oh & Kim (2015) and Hartwig (2008) found.

Table 5.1: H1: Baumol's Cost and Price Disease

Variable and time period	# of Industries	Estimate	Std. Error	t-value	N
Nominal LP growth (1996-2014)	18	0.3992***	0.0486	8.2169	342
TFP growth (1997-2014)	17	-0.4135***	0.0424	-9.7584	306
Real LP growth (1996-2014)	18	-0.4743***	0.0488	-9.7183	342
Nominal LP growth (1996-2014)	33	0.3053**	0.1229	2.4836	627
TFP growth (1997-2014)	31	-0.4101***	0.0284	-14.415	558
Real LP growth (1996-2014)	33	-0.4965***	0.0554	-8.9561	627

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The explained variable is the growth of inflation.

5.2 Unbalanced Growth of Nominal Output

According to another Baumol's hypothesis, cost and price disease might lead to an increase in the price of stagnant industry's output, and at the same time, it might cause its real output to raise. Consequently, it is not known how these two effects will offset each other and what will be the final effect on the growth of nominal output in the less productive sector. Table 5.2 demonstrates that the estimated coefficients of both labour and total factor productivity are positive, ranging from 0.3449 to 0.9194, depending on the regression. To interpret these results accurately, we can say that an increase of 10 percentage points in productivity growth would raise, *ceteris paribus*, the Czech nominal value added-growth by 3.4%–9.2%. Moreover, these estimates are statistically significant at 0.1% level in all six cases. We can spot that the impact of TFP growth is relatively lower compared to labour productivity growth, both for extended and reduced versions of the equation. Therefore, we can reject the hypothesis of unbalanced growth and conclude that despite the presence of cost disease, productivity and nominal GVA are positively correlated. Our findings are in line with Oh & Kim (2015), who found a coefficient of TFP growth to be positive, ranging between 0.39 to 0.52. The opposite effect was found by Nordhaus (2008), who uncovered a negative corrrelation between productivity and nominal output growth in the US (-0.28 to -0.21). Similarly, Hartwig (2011b) investigated the relationship between these two variables on the data for the whole European Union to obtain a coefficient of -0.032 for labour and -0.152 for multifactor productivity while working with the EU KLEMS data.

Table 5.2: H2: Unbalanced Growth of Nominal Output

Variable and time period	# of Industries	Estimate	Std. Error	t-value	N
Nominal LP growth (1996-2015)	18	0.8629***	0.0343	25.1571	360
TFP growth (1997-2014)	17	0.3449***	0.0462	7.470	306
Real LP growth (1996-2014)	18	0.4476***	0.0558	8.0191	342
Nominal LP growth (1996-2015)	33	0.9194***	0.0271	33.9399	660
TFP growth (1997-2014)	31	0.3915***	0.0323	12.139	558
Real LP growth (1996-2014)	33	0.4372***	0.0619	7.0534	627

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The explained variable is the growth of nominal gross value-added.

Table 5.3: H3: Constant Share of Real Output

Variable and time period	# of Industries	Estimate	Std. Error	t-value	N
Nominal LP growth (1996-2015)	18	0.4440***	0.0528	8.4152	342
TFP growth (1997-2014)	17	0.7044***	0.0303	23.2822	306
Real LP growth (1996-2014)	18	0.8602***	0.03101	27.732	306
Nominal LP growth (1996-2015)	33	0.7338***	0.1032	7.1132	627
TFP growth (1997-2014)	31	0.7842***	0.0233	33.6439	558
Real LP growth (1996-2014)	33	0.8556***	0.0354	24.138	561

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The explained variable is the growth of real gross value-added.

5.3 Constant Share of Real Output

One of the possible implications of Baumol's cost disease is the impact on real output. Nevertheless, table 5.3 clearly rejects the 'constant share of real output' assumption as all estimates are positive. On top of that, the coefficients are statistically significant in all six estimating processes. It can be seen that the values fluctuate between 0.4440 and 0.8602. This result is not so surprising because, despite a significant cost disease, we have still found a strong positive correlation between productivity and nominal GVA growths. Similar positive values were estimated by Nordhaus (2008)[2], Hartwig (2008) and also by Oh & Kim (2015). The outcome of our regressions indicates that Czech industries with high productivity advancement grow, on average, substantially faster than industries with lower productivity growth. Once more technological industries grow faster than the less progressive ones, then their share of real output will increase. With that being stated, we can reject the Baumol's hypothesis about a constant share of real output in the Czech Republic.

[2]In fact, this was the only hypothesis of Nordhaus to be rejected when examining the US data.

Table 5.4: H4: Effect on Hours Worked

Variable and time period	# of Industries	Estimate	Std. Error	t-value	N
Nominal LP growth (1996-2015)	18	-0.0977**	0.0029	-3.0649	360
TFP (1997-2014)	17	0.0528*	0.0263	2.0075	306
Real LP growth (1996-2014)	18	-0.0955**	0.0306	-3.118	342
Nominal LP (1996-2015)	33	-0.0344	0.0241	-1.4254	660
TFP (1997-2014)	31	0.0740***	0.0193	3.8304	558
Real LP growth (1996-2014)	33	-0.0963**	0.0344	-2.7995	627

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The explained variable is the growth of hours.

5.4 Effect on Hours Worked

Another possible effect of cost disease is the rise in employment in industries with lower productivity. Table 5.4 implies that there is indeed a significant negative correlation between labour productivity and FTE's growths. The effect is rather weak, though, since a 10 percentage point increase in LP growth tends to lower working time by 0.96 percent. Conversely, the coefficent on TFP growth is significant and positive. Therefore, the evidence on this hypothesis is mixed in the Czech data.

Once we compare our results to the existing literature, the effect varies depending on the method used. For example, Hartwig (2010) regressed LP growth[3] on the full-time equivalents growth between 1991-2007 in Switzerland to find a negative, significant coefficient ranging between -0.568 and -0.204 depending on the number of industries used. On the other hand, the same author replicated the same estimating process on EU data to find a coefficient ranging between -0.174 and 0.814 percent (Hartwig 2011b).

5.5 The Uniform Growth of Wages

The next suggestion of Baumol is that wage growth should not be correlated with the growth of productivity, which means that wages across all industries should grow uniformly. Again, the relationship between productivity and compensation growth is ambiguous, and therefore, we cannot decidedly reject the Baumol's assumption of uniform growth of wages. For instance, the coefficient

[3]The variable of labour productivity was expressed as gross value-added per worker.

Table 5.5: H5: The Uniform Growth of Wages

Variable and time period	# of Industries	Estimate	Std. Error	t-value	N
Nominal LP growth (1996-2015)	18	0.1649***	0.0454	3.6327	360
TFP growth (1997-2014)	17	0.0283	0.0351	0.8083	306
Real LP growth (1996-2014)	18	-0.0506	0.04719	-1.0725	342
Nominal LP growth (1996-2015)	33	0.0917**	0.0304	3.0186	660
TFP growth (1997-2014)	31	0.0837**	0.0262	3.1953	558
Real LP growth (1996-2014)	33	-0.0987'	0.0504	-1.9603	627

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The explained variable is the growth of workers' compensation adjusted for working hours.

from the sixth row of table 5.5, which is significant at the 10% level, expects a negative effect of labour productivity growth on the growth of wages.

On the other hand, three out of the six estimated values are positive and significant at least at the 1% level. For example, we might assume that a 10% rise in LP would, holding other variables fixed, increase the wages by 1.65%. However, if we look at the outcomes from the economic perspective, the coefficients are rather insignificant. In all other cases, the estimates are negligibly small, and in the case of TFP growth, the estimate is not even statistically different from zero. We would need an approximately 11.95%[4] increase in TFP to make the wages grow by 1%. Our results are very similar to Nordhaus (2008), who finds both small positive and negative coefficient values where the estimates differed depending on the given sub-sample. Hartwig (2011b), however, finds a very small and positive correlation[5] between these two variables, but he concluded that wage growth in Switzerland is *"in line with the predictions of Baumol's model."*

5.6 Growth Disease

Perhaps the most exceptional hypothesis was the one concerning the Baumol's growth disease. We have already noted that cost disease might imply growth disease on the condition when stagnant industries have increasing shares of nominal output. The main idea standing behind this phenomenon is well described by Nordhaus (2008), who explains its presence in the US economy by the following words:

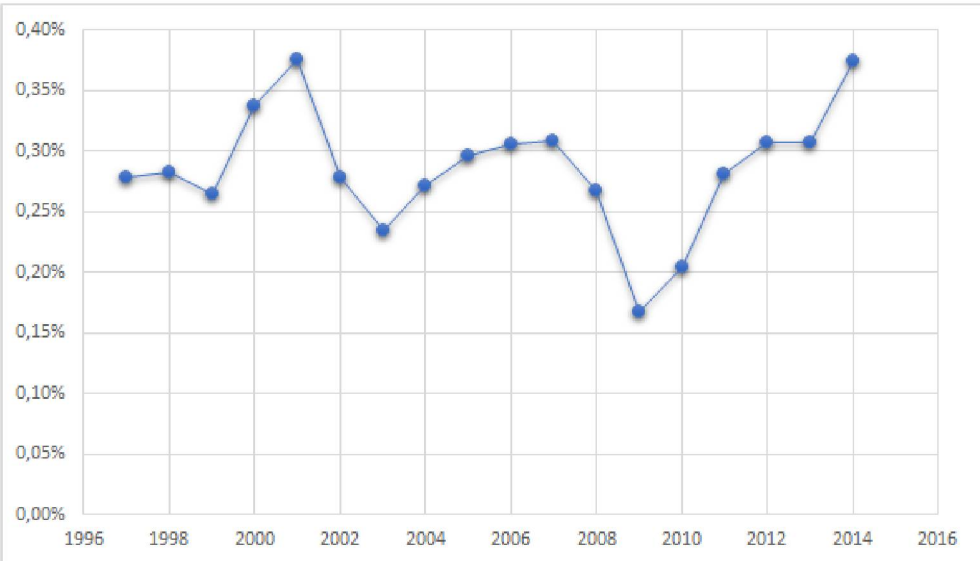
[4] 1% increase in TFP is associated with a 0.0837% increase in labour compensation.

[5] His highest estimate was equal to 0.042.

"Because the composition of output has shifted away from industries with rapid productivity growth like manufacturing toward those with stagnant technologies like government, education, and construction - aggregate productivity growth has slowed."

To be able to decide whether there was a growth disease in the Czech Republic during the period 1996–2015, we had to weight the growth rates of the industries' total factor and labour productivity with their nominal value added shares in alternative years[6]. Baumol's theory suggests that if the stagnant industries gain weight in nominal GVA, then productivity growth rate should be higher if earlier years are used as a base. Therefore, Baumol's model presumes that by updating the base year, we would witness a decline in the overall productivity growth rate. Opposite to what Nordhaus (2008) finds in the US economy, the Czech aggregate TFP growth rather shows a cyclical pattern.

Figure 5.1: Fixed-Shares Growth Rate of Total Factor Productivity for Different Base Years



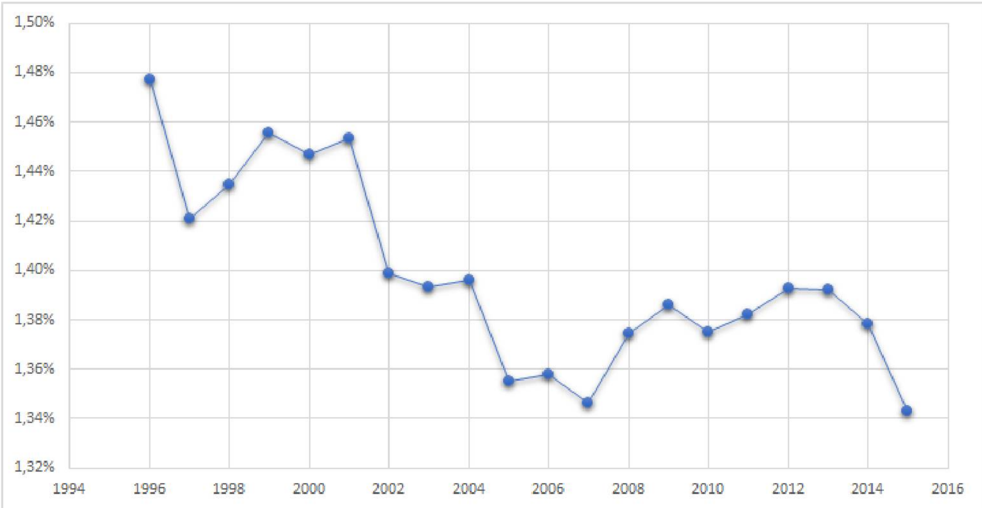
Source: EU KLEMS (2019), author's computations.

Figure 5.1 demonstrates that two periods could be possibly affected by the growth disease. However, both 2001-2003 and also 2007-2009 were a crisis or

[6]To better understand the concept, we provide clarification: For instance, the year 2000 considers the shares of nominal GVA for all industries and takes the year 2000 as a base year. These weights are subsequently multiplied by productivity growth rates. Once we sum up productivity growths for each year multiplied by the corresponding share of nominal GVA from 2000, we obtain a time series for entire industries. Lastly, we take a geometric mean of this time series to obtain a single number of productivity growth.

post-crisis periods, and the Czech economy experienced a sudden drop in the output. Nonetheless, in the majority of the cases, updating the base year increases the overall TFP growth rate meaning that recent productivity slowdown does not stem from sectoral shifts. The Figure 5.2 depicts the development of

Figure 5.2: Fixed-Shares Growth Rate of Labour Productivity for Different Base Years



Source: EU KLEMS (2019), author's computations.
Note: Labour productivity is computed from real gross value-added to account for price movement. The exactly same method was implied by Oh & Kim (2015), Nordhaus (2008), or Hartwig (2010)

labour productivity growth rate once the base years are updated. It shows the aggregate rate of growth of labour productivity during 1996–2014, where the individual industries are weighted based on nominal output proportions. For instance, if we used fixed shares of nominal GVA for 1996, the average growth of labour productivity for the period 1996–2014 would be 1.48% annually. Conversely, most recent shares from 2014 caused that average labour productivity growth would be only 1.34 per cent per year. This fact implies that the structure of output diminished the growth by approximately 14 basis points on the year basis over the examined period. Even though the decreasing trend was detected for labour productivity concept only, we can still conclude that the Baumol growth disease forced the structure of output to move towards sectors with lower growth of labour productivity.

Table 5.6 depicts real share and nominal share of output for the years 1995 and 2015[7], respectively. Moreover, it contains average growth rates of productivity

[7]The data for real GVA is available only until 2014.

Table 5.6: Key Figures for Selected Czech Industries

	Manufacturing	*Construction*	*Wholesale and retail*	*Financial services*
Real share	13.34% (1995) 24.83% (2014)	12.59% (1995) 6.17% (2014)	5.72% (1995) 11.69% (2014)	3.29% (1995) 5.04% (2014)
Nominal share	23.72% (1995) 26.97% (2015)	7.59% (1995) 5.71% (2015)	10.41% (1995) 10.87% (2015)	3.34% (1995) 4.19% (2015)
Prices	0.39% p.a. (1995–2014)	5.22% p.a. (1995–2014)	-0.77% p.a. (1995–2014)	2.15% p.a. (1995–2014)
Labour productivity	5.96% p.a. (1995–2015)	-0.02% p.a. (1995–2015)	6.29% p.a. (1995–2015)	3.19% p.a. (1995–2015)
TFP	3.10% p.a. (1996–2014)	-2.61% p.a. (1996–2014)	4.04% p.a. (1996–2014)	0.20% p.a. (1996–2014)
	Education	*Health and social work*	*Arts and recreation*	*IT*
Real share	5.27% (1995) 4.37% (2014)	9.08% (1995) 3.87% (2014)	4.50% (1995) 2.18% (2014)	1.20% (1995) 2.50% (2014)
Nominal share	4.04% (1995) 4.22% (2015)	3.42% (1995) 4.44% (2015)	2.59% (1995) 2.05% (2015)	0.77% (1995) 2.68% (2015)
Prices	4.45% p.a. (1995–2014)	9.26% p.a. (1995–2014)	6.29% p.a. (1995–2014))	5.64% p.a. (1995–2014)
Labour productivity	1.03% p.a. (1995–2015)	-2.24% p.a. (1995–2015)	-2.87% p.a. (1995–2015)	2.71% p.a. (1995–2015)
TFP	-0.61% p.a. (1996–2014)	-3.41% p.a. (1996–2014)	-3.29% p.a. (1996–2014)	-0.63% p.a. (1996–2014)

Source: EU KLEMS (2019), author's computations.
Note: Labour productivity is computed from real gross value-added to account for price movement.

as well as average growth rate of inflation from eight selected industries. We can see that industries that have experienced significant negative growth of total productivity have also shrunk as far as the real share of output is concerned. This fact was already anticipated from section 5.3. Nonetheless, manufacturing has higher productivity growth accompanied by the lowest growth of prices. Moreover, even though its real share of output nearly doubled, the nominal share, which served as a weight for the overall productivity growth while examining the growth disease, remained almost stagnant. It can serve as one of the explanations why the Czech Republic showed signs of the Baumol's growth disease. On the other hand, education or health care and social work experienced growth of share in nominal output, while decreasing in the share of real output. Presumably, the main driver was the expansion of the price level. Fortunately, the effect caused by these unproductive industries was partly slowed down by industries with above-average growth of productivity, such as financial services or wholesale and retail trade. These two industries with stronger productivity growth increased their share of real output and at least preserved the constant share of nominal output. Thanks to maintaining their relative shares, the overall nominal and real output could grow.

Table 5.7: H1: Baumol's Cost and Price Disease - Comparison between Fixed Effects and Bootstraping

Variable and time period	**Fixed Effects**			**Bootstrapping**		
	Estimate	Std. Error	t-value	Avg. Estimate	2.5%	97.5%
Nominal LP growth (1996-2014)	0.3992***	0.0486	8.2169	0.3968	0.3061	0.4879
TFP growth (1997-2014)	-0.4135***	0.0424	-9.7584	-0.4129	-0.4715	-0.3574
Real LP growth (1996-2014)	-0.4743***	0.0488	-9.7183	-0.5049	-0.5978	-0.4192
Nominal LP growth (1996-2014)	0.3053**	0.1229	2.4836	0.3052	0.0838	0.5536
TFP growth (1997-2014)	-0.4101***	0.0284	-14.415	-0.4092	-0.4817	-0.3478
Real LP growth (1996-2014)	-0.4965***	0.0554	-8.9561	-0.5030	-0.6006	-0.4006

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The percentages stand for 25^{th} and 975^{th} ranked estimated values.

5.7 Robustness Check

One of the possible shortcomings of our thesis is the number of observations available for each regression. Generally, if the size of the sample is not large enough, the asymptotic distribution of the statistics could very poorly approximate the true one (Hounkannounon 2008). Therefore, we decided to perform a robustness check in the form of bootstrapping, which is a method that enabled us to attain a more accurate approximation of the test statistic distribution. The main idea behind this concept is that an estimate of the population unknown from the sample is made by resampling the sample data and estimating the sample known from resampled data. Since the population is the sample itself, we can measure the quality of the inference. Moreover, we do not have to assume that neither our sample data nor the underlying population, have the normal distribution. The normality of the resampling distribution will be secured by the central limit theorem. Also, the 95% confidence intervals are easily attainable from the distribution of the sample.

We performed 1000 bootstrap resamples in order to get the 95% confidence intervals. We achieved that by taking 25^{th} and 975^{th} ranked estimated values.

For instance, table 5.7 that compares the estimates for the price-cost disease shows that the average estimated values by the bootstrapping method are very close to the estimates from the regression. Since we confirmed Baumol's cost disease for both productivities introduced in real values, we will now focus on the confidence intervals obtained from bootstrapping. We can conclude that there is a 95% likelihood that the coefficient of TFP will range between -0.4817

Table 5.8: H2: Unbalanced Growth of Nominal Output - Comparison between Fixed Effects and Bootstraping

Variable and time period	**Fixed Effects**			**Bootstrapping**		
	Estimate	Std. Error	t-value	Avg. Estimate	2.5%	97.5%
Nominal LP growth (1996-2015)	0.8629***	0.0343	25.1571	0.8622	0.7957	0.9291
TFP growth (1997-2014)	0.3449***	0.0462	7.470	0.3442	0.2525	0.4424
Real LP growth (1996-2014)	0.4476***	0.0558	8.0191	0.4247	0.3294	0.5215
Nominal LP growth (1996-2015)	0.9194***	0.0271	33.9399	0.9193	0.8716	0.9700
TFP growth (1997-2014)	0.3915***	0.0323	12.139	0.3921	0.3329	0.4560
Real LP growth (1996-2014)	0.4372***	0.0619	7.0534	0.4332	0.3133	0.5396

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The percentages stand for 25^{th} and 975^{th} ranked estimated values.

Table 5.9: H3: Constant Share of Real Output - Comparison between Fixed Effects and Bootstraping

Variable and time period	**Fixed Effects**			**Bootstrapping**		
	Estimate	Std. Error	t-value	Avg. Estimate	2.5%	97.5%
Nominal LP growth (1996-2015)	0.4440***	0.0528	8.4152	0.4435	0.3683	0.5213
TFP growth (1997-2014)	0.7044***	0.0303	23.2822	0.7049	0.6281	0.7739
Real LP growth (1996-2014)	0.8602***	0.03101	27.732	0.8588	0.8044	0.9135
Nominal LP growth (1996-2015)	0.7338***	0.1032	7.1132	0.7331	0.6454	0.8267
TFP growth (1997-2014)	0.7842***	0.0233	33.6439	0.7840	0.7445	0.8216
Real LP growth (1996-2014)	0.8556***	0.0354	24.138	0.8627	0.8004	0.9297

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The percentages stand for 25^{th} and 975^{th} ranked estimated values.

and -0.3478 once the larger sample is taken into account. It means that even though we used limited data, we still can justify the presence of Baumol's costs disease in the Czech Economy. Very similar inference can be done about the coefficient on real labour productivity, whose bootstrap confidence intervals are significantly below zero.

The same can be said about the hypothesis of the unbalanced growth of nominal output. Again, the resampling only confirmed the robustness of our results. However, the 95% confidence interval is wider for the estimate of the effect of TFP growth on nominal output growth as it ranges between 0.2525 and 0.4424. Fortunately, the range is in positive values, and hence, we do not have to be uncertain about the outcomes of the regression. Therefore, the rejection of the unbalanced growth hypothesis turned out to be the correct decision.

Since all six estimates of the impact of productivity growth on the growth of real output are positive and statistically different from zero at the 0.1% significance

Table 5.10: H4: Effect on Hours Worked - Comparison between Fixed Effects and Bootstraping

Variable and time period	**Fixed Effects**			**Bootstrapping**		
	Estimate	Std. Error	t-value	Avg. Estimate	2.5%	97.5%
Nominal LP growth (1996-2015)	-0.0977**	0.0029	-3.0649	-0.0981	-0.1626	-0.0359
TFP (1997-2014)	0.0528*	0.0263	2.0075	0.0525	0.0007	0.0983
Real LP growth (1996-2014)	-0.0955**	0.0306	-3.118	-0.0898	-0.1435	-0.0398
Nominal LP (1996-2015)	-0.0344	0.0241	-1.4254	-0.0343	-0.0766	0.0141
TFP (1997-2014)	0.0740***	0.0193	3.8304	0.0725	0.0355	0.1087
Real LP growth (1996-2014)	-0.0963**	0.0344	-2.7995	-0.0968	-0.1563	-0.0328

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The percentages stand for 25^{th} and 975^{th} ranked estimated values.

level, the bootstrap method only confirmed the correctness of our outcomes. Once more, the average estimates converged to the estimates obtained by fixed effects model, and the confidence intervals were relatively narrow and positive. Thus, rejecting the hypothesis of the constant growth of nominal output is well justified.

From table 5.10, we can deduce that the results about the effect on hours worked are ambiguous. Both estimates using TFP as the productivity growth measure are positive and statistically significant at least at the 10% level, but once we consider 25^{th} lowest-ranked values of the resampling distribution, the coefficients lose their economic significance. However, three out of four intervals with labour productivity coefficients are negative, implying that there is indeed a negative correlation between the growths of working hours and labour productivity. The values are rather small, though. Last but not least, we used the bootstrapping estimating process in order to obtain confidence intervals for the coefficients that explain the relationship between productivity and wage growth. All three estimates from the fixed effects model that were found to be statistically significant at the 1% significance level, have positive confidence intervals once the bootstrapping method is applied.

To sum it up, the bootstrapping served as a perfect tool that justified the inferences made during the process of our analysis. We can conclude that even though the data provided by the EU KLEMS for the Czech Republic were fairly limited, it was entirely sufficient for any economic inference.

Table 5.11: H5: The Uniform Growth of Wages - Comparison between Fixed Effects and Bootstraping

Variable and time period	**Fixed Effects**			**Bootstrapping**		
	Estimate	Std. Error	t-value	Avg. Estimate	2.5%	97.5%
Nominal LP growth (1996-2015)	0.1649***	0.0454	3.6327	0.1654	0.0702	0.2587
TFP growth (1997-2014)	0.0283	0.0351	0.8083	0.0274	-0.0381	0.0949
Real LP growth (1996-2014)	-0.0506	0.04719	-1.0725	-0.0445	-0.1354	0.0439
Nominal LP growth (1996-2015)	0.0917**	0.0304	3.0186	0.0908	0.0355	0.1488
TFP growth (1997-2014)	0.0837**	0.0262	3.1953	0.0825	0.0329	0.1334
Real LP growth (1996-2014)	-0.0987'	0.0504	-1.9603	-0.1023	-0.1905	-0.012

Note: 'significant at 10 percent;*significant at 5 percent; **significant at 1 percent; ***significant at 0.1 percent. LP expresses gross value added per hours worked. The percentages stand for 25^{th} and 975^{th} ranked estimated values.

Chapter 6

Conclusion

This thesis has investigated a series of hypothesis regarding the impacts of productivity change on prices, compensations, economic growth and the total amount of hours worked in the economy. We pursued an empirical analysis based on Baumol's (1967) assumptions of cost and growth diseases.

As we could see, the evidence of Baumol's diseases in the Czech Republic is ambiguous, though. Firstly, our findings are in line with the predictions and assumptions of Baumol's model as relative prices decrease in non-stagnant sectors; and wage growth in an industry is rather independent with regards to the productivity growth. Baumol's hypothesis of a cost-price disease could not be rejected while using inflation-adjusted productivity data. By introducing the fixed effects model, we showed that stagnant industries with relatively low productivity growth experience above-average growth of prices. Our model predicts that a 1% growth in productivity is associated with a reduction in prices by approximately 0.41%, holding other factors fixed.

Moreover, our thesis concludes that the sectoral growth of labour productivity in the Czech Republic is accompanied by a diminishing share of employment. Even though the coefficient on correlation between labour productivity and working hours growth is rather small as it varies between -0.098 and -0.096 depending on the sample and measures used, it is significantly different from zero at the 1% level.

However, contrary to what Baumol (1967) suggests, we could reject the hypothesis of the 'constant real share' as productivity growth tend to raise real output. And because the magnitude of this effect (0.856) is relatively stronger than the decrease in the prices (-0.500), technological advancement has resulted in nominal output growth in the Czech Republic. Last but not least, we demonstrated that Baumol's growth disease has acted as one of the factors that slowed the labour productivity dynamics. Once fixing nominal shares of output for 1996, the average annualy growth rate of labour productivity during 1996–2014 was equal to 1.48% whereas it was only 1.34% when using shares for 2014. Therefore, the labour productivity growth was lowered by 14 basis points annually due to the changing composition of output.

Thanks to the use of the EU KLEMS database, our inferences could be compared to Oh & Kim (2015) and Hartwig (2010), who tested Baumol's diseases on the data from the very same source to come to similar conclusions about the Korean and Swiss economies. After organizing data in the same way as these authors, we can conclude that the Czech economy shares some similarities with the countries examined in the current literature. For instance, Oh & Kim (2015) came to conclusion that the cost disease led to the growth disease in South Korea. Also, the declining effect of prices in the progressive industries was outweighed by increasing their 'share' in real output. This is opposite to what Nordhaus found in the US economy as he concluded that non-progressive sectors tend to have increasing relative prices and declining proportional real outputs.

The improvement of our analysis could be made if a new updated database would be available, especially if it contained data before 1995 or after 2015. However, despite working with relatively small dataset, our results were found to be robust by finding the bootstrapping confidence intervals. Another shortcomings that we faced while using the model presented by the current literature was the use of Cobb-Douglas production function since the value of the capital-labor substitution elasticity is denied by the data (Gechert *et al.* 2019).

Nonetheless, in spite of many limitations, our thesis brings unique and unprecedented findings about the Czech economy as it shows that countries worldwide are similarly impacted by 'Baumol's diseases'. The evidence of Baumol's cost-price and growth diseases might prompt other researchers to investigate productivity growth in the Czech Republic or other European countries more elaborately. As it was out of the scope of our study, future research of Baumol's diseases in other European countries would substantially enrich the current literature and current knowledge about this economic phenomenon.

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Appendix A

Baumol's Growth Diseases

Table A.1: H6: Growth Disease

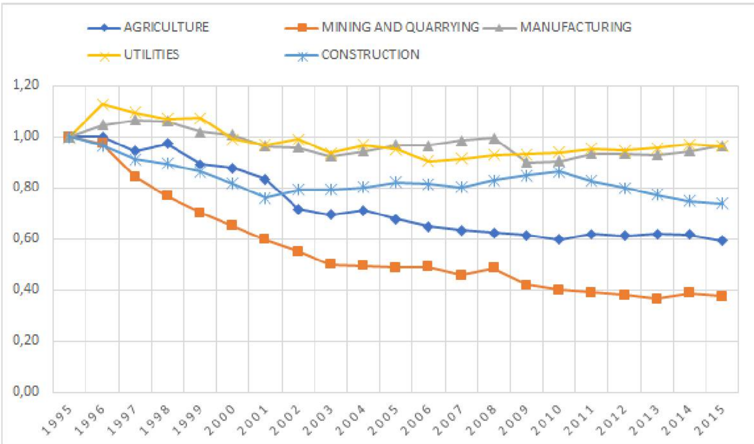
Base year	Geometric Average of TFP Growth	Geometric Average of LP Growth
1996	-	1.48%
1997	0.28%	1.42%
1998	0.28%	1.43%
1999	0.26%	1.46%
2000	0.34%	1.45%
2001	0.38%	1.45%
2002	0.28%	1.40%
2003	0.23%	1.39%
2004	0.27%	1.40%
2005	0.30%	1.36%
2006	0.31%	1.36%
2007	0.31%	1.35%
2008	0.27%	1.37%
2009	0.17%	1.39%
2010	0.20%	1.37%
2011	0.28%	1.38%
2012	0.31%	1.39%
2013	0.31%	1.39%
2014	0.37%	1.38%
2015	-	1.34%

Note: To better understand the concept, we provide clarification: For instance, the year 2000 considers the shares of nominal GVA for all industries and takes the year 2000 as a base year. These weights are subsequently multiplied by productivity growth rates. Once we sum up productivity growths for each year multiplied by the corresponding share of nominal GVA from 2000, we obtain a time series for entire industries. Lastly, we take a geometric mean of this time series to obtain a single number of productivity growth.

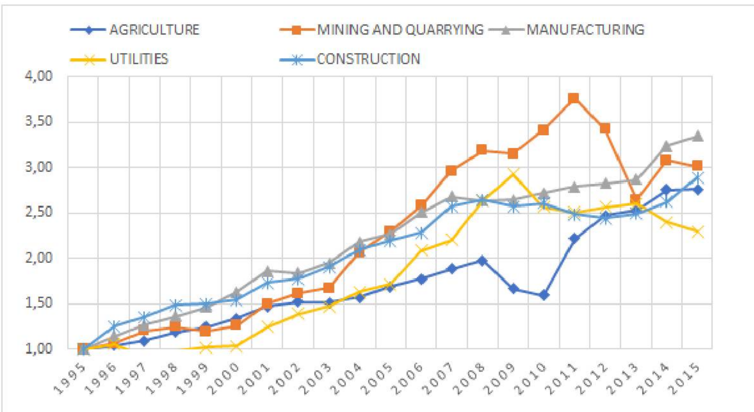
Appendix B

Developments of the Key Variables

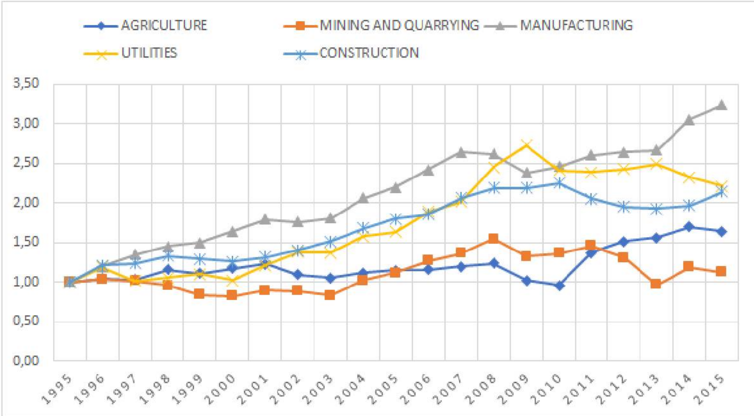
Development of Hours Worked in the Industry Sector



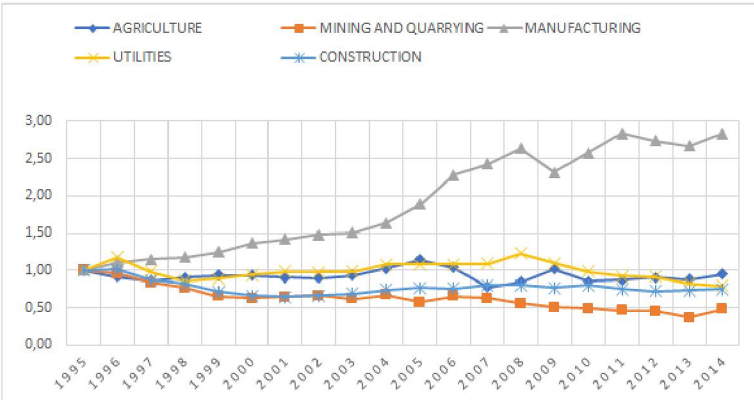
Development of Labour Productivity in the Industry Sector



Development of Nominal Gross Value-Added in the Industry Sector

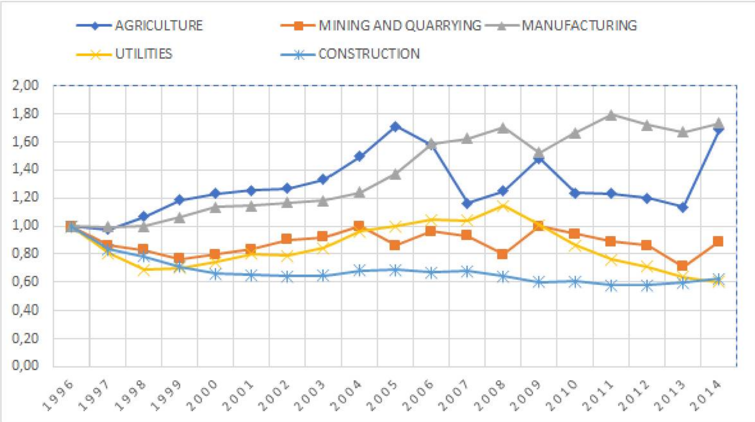


Development of Real Gross Value-Added in the Industry Sector

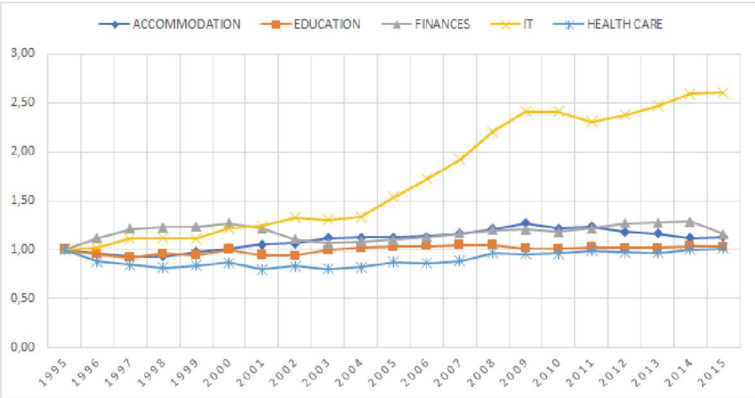


Development of Prices in the Industry Sector

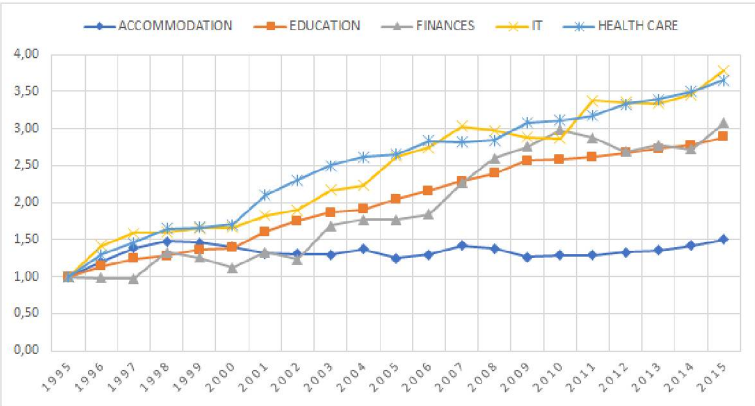
Development of Total Factor Productivity in the Industry Sector



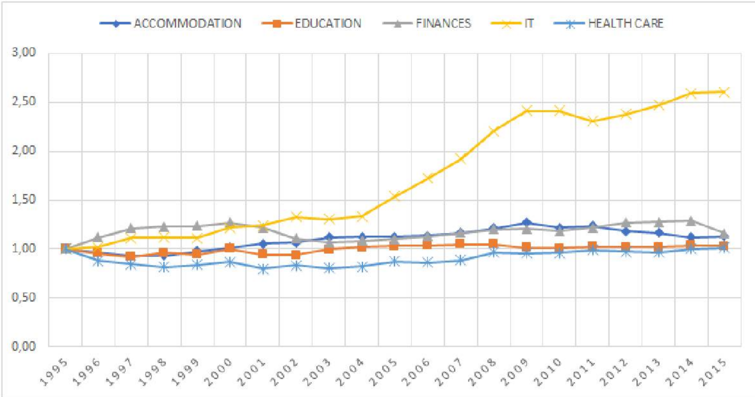
Development of Hours Worked in the Services Sector



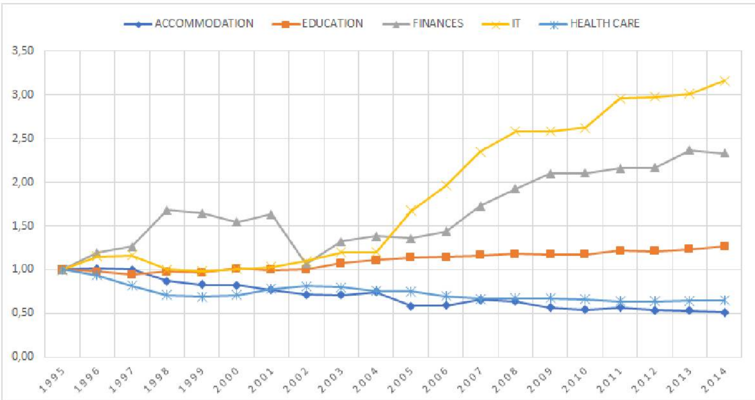
Development of Labour Productivity in the Services Sector



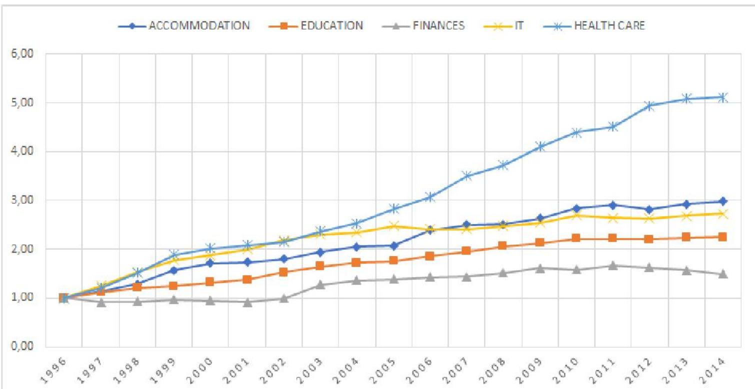
Development of Nominal Gross Value-Added in the Services Sector



Development of Real Gross Value-Added in the Services Sector



Development of Prices in the Services Sector



Development of Total Factor Productivity in the Services Sector