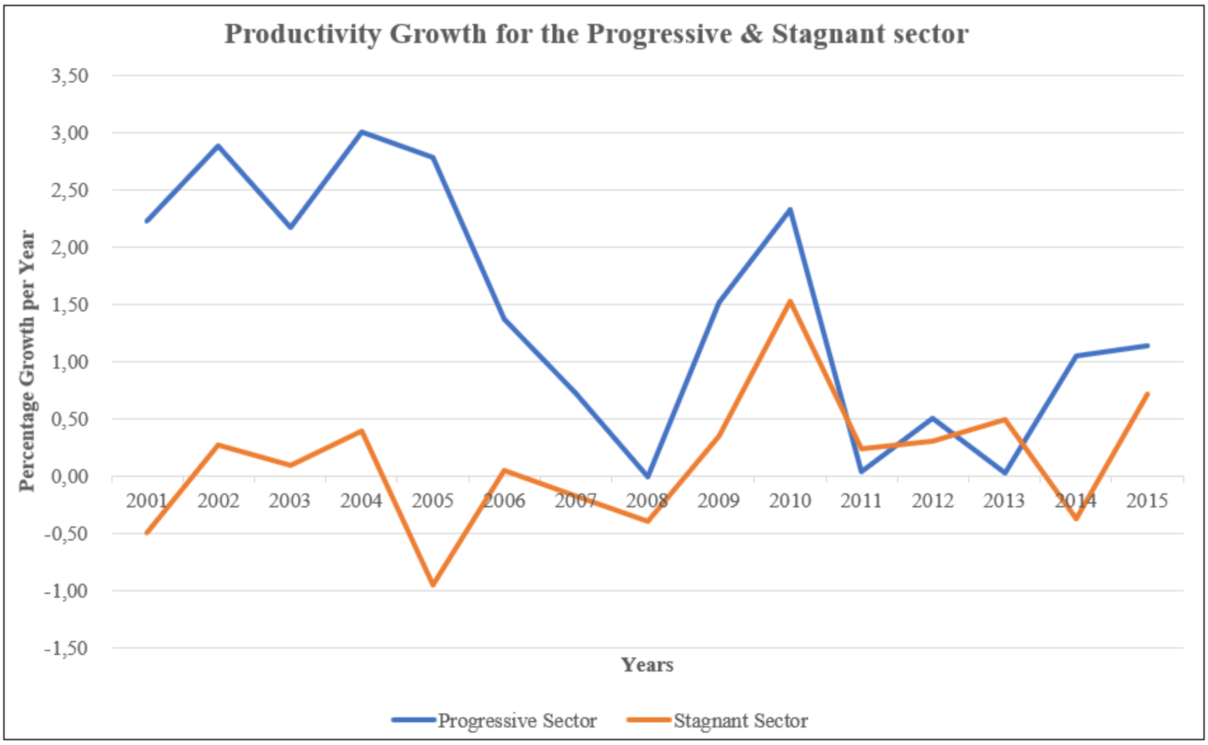
# The Factors behind Unbalanced Economic Growth

Research about factors that drive unbalanced economic growth

Master Thesis

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28th of August 2018

TU Delft

# The Factors behind Unbalanced Economic Growth

Research about factors that drive unbalanced economic growth

Master thesis submitted to Delft University of Technology

in partial fulfilment of the requirements for the degree of

**MASTER OF SCIENCE**

in **Engineering and Policy Analysis**

Faculty of Technology, Policy and Management

by

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Student number: 4467906

To be defended in public on August 28th 2018

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# Acknowledgements

Dear reader,

This research report is the final product of a master thesis graduation research that took 25 weeks to complete.
The first five weeks were mainly dedicated to literature research with respect to unbalanced growth modelling. This helped to narrow down the research and to come up with a conceptual model that served as input for the unbalanced growth model.
The next ten weeks focused on the core of this research: model building, model parametrization and model testing. This was an iterative process of improving the unbalanced growth model, performing data and econometric analyses to parametrize the model, and testing the model to check if the results were plausible to assume.
The next five weeks were focused around simulation and analysis of the results. The method of exploratory modelling was used to explore which factors drive unbalanced growth.
The final five weeks were focused around improving the research and report. The research report was written in parallel to the research and has gone through an iterative writing process.

I would like to thank my graduation committee for giving feedback and advice on my research report, research methodology and research activities.

Sincerely,

Menno Koens

# Executive Summary

These days, technological progress and automation are widespread, but productivity growth and thus overall economic growth lags behind. There is a strong conviction that the declining growth rates are caused by a shortfall in aggregate demand. This shortfall in aggregate demand might be due to the development of a 'dual economy'. A dual economy is an economy in which a limited number of economic activities experience high productivity growth rates due to automation and technological progress (progressive sector), meanwhile the remaining economic activities experience almost no productivity growth because automation is barely present (stagnant sector). A dual economy develops due to unbalanced economic growth between the progressive and stagnant sector. To assure stable economic growth, it is important to slow down unbalanced growth. However, until today it is not known how to effectively target unbalanced growth, because the driving factors are not well known.

This research tries to improve the understanding of unbalanced growth by finding the driving factors behind unbalanced growth. This means that a more transparent view is created about how a nation's economy behaves with respect to unbalanced growth. Conclusions that provide information about which factors drive unbalanced growth, and how these factors should be influenced by policy makers to slow down unbalanced growth and stimulate stable growth are provided. To achieve the described objective and deliverable a modelling approach is used. An already existing static macroeconomic model of unbalanced growth is the starting point for this research. This model is improved on several points. First, important macroeconomic theory of unbalanced growth is added to the model. Second, ordinary differential equations are used to model unbalanced growth instead of static equations. Third, the model is parametrized with empirical data of the U.S. economy. Finally, the model is simulated according to the exploratory modelling methodology, and the results are analysed with the help of sensitivity analysis and scenario discovery. These improvement points help to generate richer simulation results with respect to unbalanced growth and the driving factors.

The research results show a clear sign of unbalanced growth. Progressive sector real output grows over the years. However, employment in the progressive sector declines, because productivity grows faster than real output does. Stagnant sector real output declines over the years and thus employment declines too. With respect to unbalanced growth there is a growing gap between progressive and stagnant sector real output, price level and productivity. Due to unbalanced growth, average productivity grows relatively slow. To slow down unbalanced growth, it is important to moderately invest in the progressive sector and to make large investments in the stagnant sector. On the one hand, this helps to stimulate economic growth and employment in the progressive and stagnant sector and assures that average productivity grows over the years. On the other hand, due to make moderate investments in the progressive sector and large investments in the stagnant sector, unbalanced growth with respect to sector output, price level and productivity is slowed down.

Fiscal and monetary policy can help to accommodate the process of stable growth, but policy makers should look further than their standard set of macroeconomic policy tools to slow down unbalanced growth. The focus should be on stimulating private investments, especially in the stagnant sector, and on retraining workers that become obsolete due to dualistic growth. Further research should focus on the stagnant sector of the economy and how private investments in this sector can lead to more significant productivity growth.

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# List of Abbreviations

| | |
|---|---|
| AD | Aggregate Demand |
| AI | Artificial Intelligence |
| ARDL | Autoregressive Distributed Lag |
| ARIMA | Autoregressive Integrated Moving Average |
| BEA | Bureau of Economic Analysis |
| EHS | Educational, Health and Private Social Services |
| EMA | Exploratory Modelling and Analysis |
| FIRE | Finance, Insurance and Real Estate |
| GDP | Gross Domestic Product |
| ICT | Information and Communication Technology |
| ISIC | International Standard Industrial Classification |
| KPI | Key Performance Indicator |
| N/A | Not Applicable |
| ODE | Ordinary Differential Equation |
| OECD | Organisation for Economic Cooperation and Development |
| OLS | Ordinary Least Squares |
| PPP | Purchasing Power Parity |
| PRIM | Patient Rule Induction Method |
| R&D | Research and Development |
| SD | System Dynamics |
| UN | United Nations |
| U.S. | United States |

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# 1 Introduction

## 1.1 The Puzzle of High Technological Progress and Low Productivity Growth

Around 800 million global workers lose their jobs or need to be retrained by 2030 due to robotization, artificial intelligence (AI), and machine learning, in short automation (Manyika, et al., 2017). Many people are afraid that they will lose their job in the coming decade and this feeling is reinforced by the media (Vincent, 2017; BBC, 2017; Davidson, 2017). For example, Vincent (2017) states that there is widespread fear among people about the fact that they might lose their job due to robots and AI. And BBC (2017) highlighted in their news report that according to the McKinsey Global Institute up to one-fifth of the global work force will be affected by automation. The societal debate is about how we can prevent massive unemployment due to automation, because we have to accept that automation is a fact (Vincent, 2017). Lukily there is also a more optimistic view about automation. Davidson (2017) states that automation could destroy around 73 million U.S. jobs by 2030, but economic growth, rising productivity and other forces could more than offset the losses. According to Manyika, et al. (2017) the productivity of the global economy could grow between 0.8 and 1.4 percent of global Gross Domestic Product (GDP) annualy.

Despite the fact that there is significant technological progress and automation, productivity growth and thus overall economic growth lags behind (OECD, 2017). The 2016 average labour productivity growth rate figure for the Organization for Economic Cooperation and Development (OECD) countries is 0.4 (OECD, 2016). So, there is significant technological progress due to automation, but overall productivity growth lags behind and declines over the years since the 1980s (Storm, 2017). This is also known as 'secular stagnation', in essence a slow down of macroeconomic growth rates over the years (productivity, employment, wage, output) (Eichengreen, 2015).

The fact that technological progress is widespread and productivity growth lags behind might be due to the development of a 'dual economy' (Temin, 2016). A dual economy is an economy in which a limited number of economic activities experience high productivity growth rates due to automation and technological progress, meanwhile the remaining economic activities experience almost no productivity growth because automation is barely present (Temin, 2016). Since productivity in highly automated sectors increases, less labour is required in these sectors. Therefore, there is a labour shift from highly automated sectors to sectors with less automation. As a result, the aggregate economic productivity growth rate is declining (Storm, 2017).

## 1.2 Unbalanced Economic Growth

The development of a dual economy is an unwanted economic phenomenon that indirectly causes economic growth rates to decline over the years. Storm (2017) argues that the declining growth rates are directly caused by the shortfall in aggregate demand for goods and services. This demand shortfall can be attributed to the dual economy, in essence unbalanced economic growth (Storm, 2017). The theory of unbalanced growth is developed by W.J. Baumol in 1967. Baumol made a model of unbalanced growth where he divided the economy in two sectors: a stagnant sector and a progressive sector. The productivity growth in the stagnant sector is lower than in the progressive sector and the ratio between progressive to stagnant output is constant. As a result, the price of stagnant sector products relative to progressive sector products rises (cost disease). However, the demand for stagnant sector products increases, because the output ratio is constant. Productivity growth in the stagnant sector is lower than in the progressive sector, therefore more employment is needed in the stagnant sector to meet the increasing demand for stagnant sector products. Due to the difference in productivity growth between the sectors and the constant output ratio, there is a strong tendency towards a full stagnant sector economy in terms of employment (Baumol, 1967). Examples of progressive sectors are manufacturing and information (ICT) and examples of stagnant sectors are utilities and services. According to Storm (2017), the progressive sector is shedding jobs, and the stagnant sector or 'survivalist' sector acts as an 'employer of last resort'. Two important assumptions are that the Baumol model operates under full employment and that overall wages grow with the same pace as average productivity does (Baumol, 1967). There are many studies that apply the model of unbalanced growth to real world cases and conclude that the theory of unbalanced growth holds true (Fuchs, 1968; Picot, 1968; Worton, 1969; Spann, 1977; Inman, 1985; Summers, 1985; Rowthorn & Wells, 1987; Grubel & Walker, 1989; Felli & Rosatti, 1995; Hartwig, 2008).

Even before Baumol presented his model of unbalanced growth in 1967, there was already discussion about whether unbalanced growth is desirable or not. There are scholars who emphasise the importance of unbalanced growth to generate economic growth, by forward and backward linkages (Hirschman, 1958). Hirschman states that investments should be made in leading economic sectors and that the spill over effect of these leading sectors will boost the remaining sectors. However, the dominant view is that a strategy of balanced growth, where all sectors of the economy grow simultaneously, generates economic growth (Rosenstein-Rodan, 1943; Nurkse, 1953; Scitovsky, 1954; Fleming, 1955). This was later confirmed by Baumol (1967). Therefore, this research report is written with the philosophy that unbalanced growth is an unwanted phenomenon.

Due to unbalanced growth more and more workers are pushed out of the progressive sector and try to find work in the stagnant sector. This reduces aggregate productivity growth rates and this negatively affects living standards. According to Ross (2018) the level of productivity is the most important determinant of living standards. A higher level of productivity allows people to get there products faster or to get more of the same products in the same amount of time. If productivity increases supply rises, real prices drop and real wages increase. So, higher productivity increases the living standards of people and thus the welfare level. However, as described above, unbalanced growth may cause a shortfall in demand. And a shortfall in demand causes secular stagnation and thus declining growth rates, including lower productivity growth rates. This in turn negatively affects the living standards in the Western world (OECD, 2017). Moreover, if the (productivity) growth rates do not increase with the same pace as automation does, unemployment levels are likely to rise (Manyika, et al., 2017).

Automation reinforces unbalanced growth and thus a dual economy is likely to be created. The dual economy lowers the overall demand for goods and services, this in turn leads to declining growth rates and causes secular stagnation. Secular stagnation is marked by lower overall living standards and higher levels of unemployment (Figure 1-1).

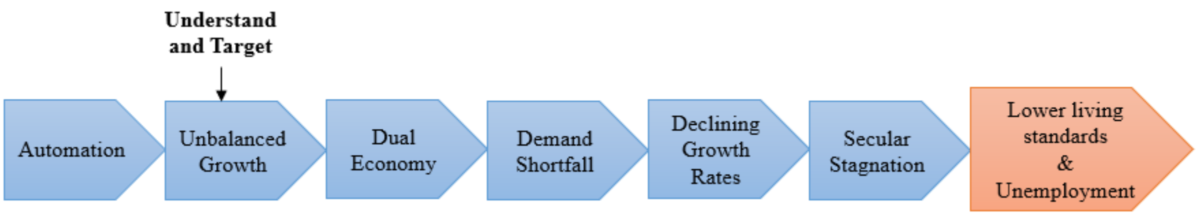



*Figure 1-1: Consequences of unbalanced growth*

## 1.3 Current Research around Unbalanced Growth and the Knowledge Gap

Since Baumol presented his model of unbalanced growth, many studies have successfully applied the model to real world cases. Hartwig (2008) states that health care expenditure, which is part of the stagnant sector, rises rapidly in almost all OECD countries. From Baumol's model we know that productivity growth in the stagnant sector is lower than in the progressive sector. However, overall real wages grow at the same rate as average productivity does. Therefore, health care expenditure is driven by wage increases that grow faster than productivity. Spann (1977) uses the model of unbalanced growth to predict the growing stagnant public sector, Spann measures the growth rates of per capita government expenditures, government's share of GDP and the pattern of government expenditure growth. The model predictions are compared with real data of aggregate government expenditures. Spann concludes that the model predictions support the Baumol model. There are many more studies that apply the model of unbalanced growth and conclude that the model is a good description of reality (Gemmell, 1987; Kyer, 1989; Curtis & Murthy, 1998; Notarangelo, 1999; Krishna & Perez, 2005; Kapur, 2012).

Despite the fact that there are many studies that apply the model of unbalanced growth to real world cases, there is almost no literature that studies the factors that drive unbalanced growth. By factors is meant: which macroeconomic components are important with respect to the development of unbalanced growth. For example, what happens with unbalanced sectorial growth if productivity grows a percentage point faster in the progressive sector compared to the previous year? Or, is unbalanced growth reinforced or weakened if investments are made disproportionally between the stagnant and progressive sector? These types of questions are barely answered and, therefore, it is not known which factors drive unbalanced growth. Of course, the current set of literature describes factors that are related to unbalanced growth, but it is not known which of these factors drive unbalanced growth. Moreover, the current set of literature around unbalanced growth is rather abstract and, therefore, it is hard to point towards specific factors that drive unbalanced growth. However, it is important to know the driving factors behind unbalanced growth, otherwise well-designed policies that slow down unbalanced growth cannot be made.

***Problem Statement***

*There is a clear gap between knowing that unbalanced growth exists and knowing which factors drive unbalanced growth.*

## 1.4 The Research Objective and Deliverable

The objective of this research is to enhance the understanding of unbalanced growth by finding the driving factors behind unbalanced growth. This means that a more transparent view is created about how a nation's economy behaves with respect to unbalanced growth. The deliverables are conclusions and recommendations that provide information about which factors drive unbalanced growth and how policy makers should influence these factors to slow down unbalanced growth and stimulate stable growth.

## 1.5 Research Questions

Based on the problem statement and the research objective the main research question is formulated. Four sub questions are proposed that help to answer the main question.

***Main question***

*What are the factors that drive unbalanced growth, and how can fiscal and monetary policy makers influence these to slow down unbalanced growth and stimulate stable growth?*

Sub questions

1. What is the macroeconomic theoretical explanation for unbalanced growth?
2. How do the different macroeconomic system components of unbalanced growth relate to each other?
3. What empirical evidence can be found for unbalanced growth?
4. What are the sensitive factors with respect to the development of unbalanced growth and how should they be influenced to slow down unbalanced growth and stimulate stable growth?

## 1.6 Modelling Approach & Methodology

A modelling approach is used to get to know the driving factors behind unbalanced growth and how these factors should be influenced. A macroeconomic model of unbalanced growth is built, which represents the macroeconomic system of unbalanced growth. With the help of this model it is possible to understand the relations between the system components, which helps to find the driving factors behind unbalanced growth. The unbalanced growth model of Groot & Schettkat (1999) is used as a starting point for this research. Groot & Schettkat are among the few who have tried to understand the development of unbalanced growth. However, just as the Baumol model, the Groot & Schettkat model is rather abstract and is not specific enough to help to find the factors that drive unbalanced growth. So, there is room for improvement.

Groot & Schettkat (1999) study the macroeconomics of unbalanced growth and made two ‘Baumol inspired’ models. A model in which product demand is characterized as price-driven and a model in which product demand is characterized as income-driven. Both the price-driven and income-driven model divide the economy into a progressive and stagnant sector. Each model has three variants (Table 1-1).

*Table 1-1: Simulation model variants of Groot & Schettkat (1999)*

| **Three model variants for the price-driven and income-driven models** | |
|---|---|
| 1: | Wages in both sectors are identical and change with average productivity<br>Full-employment assumed |
| 2: | Wages in the sectors develop according to industry-specific productivity trends<br>Full-employment assumed |
| 3: | Nominal wages develop according to average productivity growth<br>Full-employment condition relaxed |

The model structure is defined by a set of equations and is considered static or mathematical (Radzicki, 2010). The price-driven model has ten equations and ten endogenous variables. The income-driven model has thirteen equations and thirteen endogenous variables. Groot & Schettkat run the model for different input values of labour productivity in the progressive sector. They look at four Key Performance Indicators (KPI’s): ratio of real output in the progressive sector over real output in the stagnant sector, ratio of nominal output in the progressive sector over nominal output in the stagnant sector, total real income, and employment ratios. Groot & Schettkat look at how the KPI’s vary when increasing labour productivity in the progressive sector.

This research uses the model of Groot & Schettkat (1999) as starting point and improves it on several points to be able to get to know the driving factors behind unbalanced growth, and how these factors should be influenced. The improvement points and the methodologies to accomplish these improvements are described in the following four sections, and correspond to the sub research questions.

### 1.6.1 Macroeconomic Theoretical Explanation for Unbalanced Growth

It is important to understand the macroeconomic theoretical explanation for unbalanced growth to get to know the scope and scale of this research. With the help of desk research in the area of unbalanced growth (modelling) and macroeconomic theory it becomes clear what the macroeconomic explanation for unbalanced growth is. This also reveals where the current model of Groot & Schettkat (1999) can be expanded. The Groot & Schettkat model is incomplete, because it lacks important macroeconomic theory with respect to investments.

### 1.6.2 Relations between Macroeconomic Unbalanced Growth Components

To understand how unbalanced growth works it is important to know how the macroeconomic system components of unbalanced growth relate to each other. The Groot & Schettkat model is described by a static set of equations and this model can only describe the state of the system for a specific parametrization. So, with this static model it is hard to understand the relations between the system components. With the use of Ordinary Differential Equations (ODE), it is much easier to discover how the macroeconomic components of unbalanced growth relate to each other, because the simulation results are generated over time. Modelling with differential equations is something that has been done for quite a while (Leeper & Sims, 1994). With the help of this modelling formalism one can describe phenomena that involve change over time by using differential equations (Judson, 2017). For this research the phenomenon of interest is unbalanced growth and one is interested in which factors drive the changes over time. Radzicki (2010) explains the use of ODE modelling in an economic context.

With the help of desk research and modelling an ODE model suitable for its purpose can be build (*from now on unbalanced growth model*). First, desk research is required to find existing macroeconomic theory and models that provide interesting ideas or components for the model building process. Second, the macroeconomic theory of unbalanced growth is modelled as a set of ODEs. Modelling is performed in the software package Vensim (Ventana, 2015). Vensim is often used to build System Dynamic (SD) models (Forrester, 1961; Forrester, 1969; Forrester, 1971). The unbalanced growth model is by no means an SD model, but Vensim is a useful software package to numerically solve ODEs and is, therefore, used.

### 1.6.3 Empirical Evidence of Unbalanced Growth

The use of empirical data helps to understand the magnitude of the relations between the macroeconomic components of unbalanced growth. The Groot & Schettkat model is parametrized with fictive data and thus the magnitude of the relations between the model components are not realistic. To make sure that the magnitude of the relations between the components in the model are correct, the unbalanced growth model is parametrized with empirical data. With the help of desk research, data analysis and econometrics the U.S. economy is divided into a progressive and stagnant sector, and the exogenous parameters and coefficients of the unbalanced growth model are empirically estimated.

The U.S. economy is used as case. The U.S. is chosen for two reasons. First, for practical reasons, because a large amount of open data is available (BEA, 2018; OECD, 2018). Second, there is clear evidence of unbalanced growth in the U.S. economy (Storm, 2017). By means of desk research the U.S.

economy is divided into specific economic activities. Next, by means of data analysis each of the economic activities can be placed in the progressive or stagnant sector. As a result, a progressive and stagnant sector are created, based on real U.S. economic data.

The unbalanced growth model parametrization is divided in two parts. First, exogenous parameters that can be parametrized rather straightforward by finding the data on the website of the OECD. Second, coefficients that need to be estimated first, before they can be parametrized. The former parametrization uses the method of data analysis by combining specific macroeconomic values so that they can be inserted into the unbalanced growth model. The latter parametrization uses the method of data analysis and econometrics. By means of data analysis a data set is created. Next, the data set is used to estimate the value of a specific coefficient. The estimation technique relies on regression, which is part of the econometrics paradigm. The statistical software that is used is STATA, which is a package often used to perform econometric analyses (STATA, 2018).

### 1.6.4 Sensitive Factors with Respect to Unbalanced Growth

The sensitive factors behind the development of unbalanced growth and how these factors should be influenced can be found with the help of advanced simulation and analysis techniques. The Groot & Schettkat model was simulated via a simple spreadsheet programme, which is limited in its simulation and analysis options. With the help of sensitivity analysis, the sensitive factors with respect to the development of unbalanced growth are found. With sensitivity analysis one tries to find the input parameters that are most influential on output (Zhang, Trame, Lesko, & Schmidt, 2015). For example, if one slightly changes a specific input parameter and this small change has a large effect on the output, then the input parameter is sensitive. If this small change has barely or no effect on the output, then the input parameter is not sensitive. Sensitive input parameters are important to monitor, because these parameters significantly influence the system. With the help of scenario discovery, policy makers know how to influence these sensitive parameters to slow down unbalanced growth and stimulate stable growth. Scenario discovery uses algorithms to find ranges of input parametrizations that produce specific output. For this research scenario discovery is used to find value ranges, for a specified set of input parameters, that produce desirable output (Bryant & Lempert, 2010).

Simulation, sensitivity analysis and scenario discovery are performed with the help of the Exploratory Modelling and Analysis (EMA) workbench. The EMA workbench is aimed at providing support for doing simulation and analysis on models developed in various modelling packages, including the software Vensim (Ventana, 2015). To be able to perform simulation and analysis with the EMA workbench, J.H. Kwakkel of the Delft University of Technology developed the EMA workbench in the programming language Python (Python, 2018). The EMA workbench offers support for setting up simulation runs, performing simulation runs, and analysing the results (Kwakkel, 2012). By using the EMA workbench exploratory modelling is used to simulate the unbalanced growth model many times for different exogenous parameter settings. The result is an ensemble of simulation runs. The simulation runs are analysed with the help of visual analysis, sensitivity analysis and scenario discovery.

## 1.7 Purpose of the Unbalanced Growth Model

These four improvement points make the Groot & Schettkat model more realistic and the simulation results more valuable with respect to understanding the driving factors behind unbalanced growth. The purpose of the unbalanced growth model for this research is to explore “what if” questions. The unbalanced growth model is used as exploration tool that helps to find the driving factors behind unbalanced growth, and how these factors should be influenced to slow down the development of unbalanced growth and stimulate stable growth. With the help of sensitivity analysis, the sensitive factors with respect to the development of unbalanced growth can be found, and these sensitive factors are closely linked to the driving factors of unbalanced growth. With the help of scenario discovery, it is possible to find how the sensitive factors should be influenced to slow down unbalanced growth and stimulate stable growth.

## 1.8 Report Outline

This chapter has introduced the research, the remaining part of the report is structured as follows. In chapter 2 the macroeconomic theory with respect to unbalanced growth is explained. Based on the Groot & Schettkat model and the unbalanced growth theory a conceptual model of unbalanced growth is built. This conceptual model of unbalanced growth serves as input for the unbalanced growth model. Chapter 3 explains how the different macroeconomic components of unbalanced growth relate to each other, with the help of the unbalanced growth model. The model is based on macroeconomic equations and divides the economy into a progressive and stagnant sector. The simulation techniques rely on visual analysis, sensitivity analysis and scenario discovery, and are explained. Chapter 4 shows empirical evidence of unbalanced growth in the U.S. economy. Based on this evidence the unbalanced growth model is parametrized and tested. Aggregate data of the U.S. economy are used to parametrize the unbalanced growth model to use the correct magnitude between the model components. Some of the exogenous parameters in the model are estimated based on econometric regression models. Testing consist out of verification and validation. Verification is meant to check if the model is correct. Validation is meant to check if the model can be used for its purpose. This chapter ends with the experimental setup. Chapter 5 shows the results, based on visual analysis, sensitivity analysis and scenario discovery. The unbalanced growth model is simulated many times for different exogenous parameter settings and for different macroeconomic policy settings. In chapter 6 conclusions and recommendations are made based on the results presented in chapter 5, and a discussion is written that reflects back on this research.

# 2 The Macroeconomic Explanation of Unbalanced Growth

Unbalanced growth is explained by dividing a nation's economy into a progressive and stagnant sector that both develop differently in terms of real output (GDP), employment, price level, wage level, and productivity. This chapter explains the macroeconomics of unbalanced growth and this results in a conceptual model of unbalanced growth. The conceptual model is based on macroeconomic theory (2.1) and the unbalanced growth model of Groot & Schettkat (1999) (2.2). Based on the macroeconomic theory and the Groot & Schettkat model, input parameters and outcomes of interest are determined (2.3). Next, the main mechanism in the conceptual model is explained (2.4). This all together leads to the conceptual model of unbalanced growth (2.5). This conceptual model serves as input for the unbalanced growth model.

## 2.1 Macroeconomic Theory

Macroeconomics studies how the economy of a nation behaves. Important phenomena for macroeconomics are for example price levels, rate of growth, GDP, inflation and the level of unemployment (Investopedia, 2018c). An important concept in macroeconomics is aggregate demand (AD). This is the total demand for products and services in a nation's economy. Equation 2-1 shows the formula for aggregate demand (Investopedia, 2018a).

$$\mathrm{AD} = \mathrm{C} + \mathrm{G} + I_p + I_g + \mathrm{E} - \mathrm{M}$$

*Equation 2-1: Aggregate demand (Naastepad, 2002)*

- C: Consumer demand (households) for products and services
- G: Government demand, the current expenditures (e.g., payment of civil servants)
- $I_p$: Private investment demand (e.g., firms buying machines)
- $I_g$: Public investment demand (e.g., invest in infrastructure)
- E: Export demand
- M: Import demand

The macroeconomic policy frame, shown in Figure 2-1, provides a conceptual overview about how the macroeconomy can be influenced with policy instruments (Naastepad, 2002). It starts with a macroeconomic theory, for example the Neo-classical or Keynesian theory (described in Appendix I). These theories describe the behaviour of the macroeconomy. Each of these theories can be modelled. The macroeconomic model consists out of causal relations and identities defined by theory. In a nation's economy one wants stable economic growth, low unemployment, low inflation, technological progress, equal income distribution and sustainable growth. The output can be influenced by policies. The two macroeconomic policy instruments are fiscal and monetary policy.

National governments have the control over fiscal policy. The instruments are taxation (T) and public spending ($I_g$ and G). Fiscal policy is used to stimulate or slow down economic growth (GDP). If the economy is in a recession the government can decide to lower taxes (T) and/or increase public investments ($I_g$). This is called fiscal stimulus and is likely to boost the level of GDP. If the economy is growing fast and inflation becomes a problem, the government can decide to increase taxes (T) and/or lower public investments ($I_g$). This will likely reduce the rate of inflation (Naastepad, 2002; Heakal, 2018). Central banks have the control over monetary policy. They try to keep inflation low and employment high. The central banks do this by influencing the money supply ($M^S$). The money supply is influenced by setting the interest rate (i) for borrowing and lending. During recessions the interest rate is low to stimulate investment and discourage savings. When an economy is growing fast and the level of inflation increases, the central bank increases the interest rate to discourage investments and stimulate savings (Naastepad, 2002; Investopedia, 2018d).

The policy frame can be used in two ways. First, as exploratory method: change policies and discover what happens with the output. Second, as optimization method: set targets and look what kind of policies accomplish these targets. Since this research is concerned with finding the factors that drive unbalanced growth, exploration is the appropriate method.

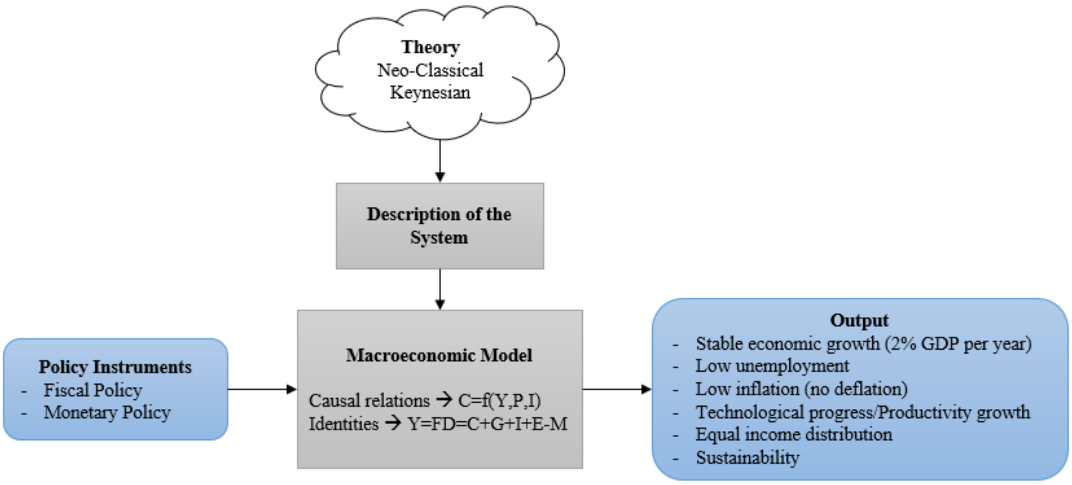



*Figure 2-1: The macroeconomic policy frame (Naastepad, 2002)*

## 2.2 Unbalanced Growth Model of Groot & Schettkat

The conceptual model is based on the Groot & Schettkat income-driven model, variant C. First, the income-driven model is more realistic than the price-driven model, because output is not only driven by price, but also by consumption. Consumption is an important component in the formula of aggregate demand. Second, variant C is chosen, because full employment does not exist and it is more likely that nominal wages develop according to average productivity growth than according to industry specific trends, emphasized by Baumol (1967). As a result, the conceptual model is built from a Keynesian perspective (Investopedia, 2018b). This is a demand driven theory, the causality goes from demand to supply and, therefore, the assumption of full employment cannot be made. Since there is no full employment, there is room for fiscal and monetary policy to improve macroeconomic output (Naastepad, 2002).

The technical aspects of the Groot & Schettkat model are briefly explained with the help of Table 2-1. The orange coloured boxes in the table are part of the income-driven model, variant C. The income-driven model consists out of five equations for the progressive sector and five equations for the stagnant sector. And an equation for the total real output evaluated at the initial price level. The price-driven model consists out of four equations for the progressive sector and four equations for the stagnant sector. Both the price- and income-driven model consist out of three variants. In variant A real wages (W) develop according to average productivity and full employment is assumed, so that $L_0 = L_p + L_s$. In variant B real wages (W) develop according to industry-specific productivity trends and full employment is assumed. In variant C nominal wages (W) develop according to average productivity and the condition of full employment is relaxed. Both the price- and income-driven model have seven exogenous variables and the variable for labour productivity in the progressive sector is the input variable that ranges between 1.0 and 2.0. Groot & Schettkat look at how the outcomes of interest change when changing the labour productivity value in the progressive sector. The outcomes of interest are: ratio of real output in the progressive sector over real output in the stagnant sector, ratio of nominal output in the progressive sector over nominal output in the stagnant sector, total real income, and employment ratios. Appendix II shows graphically the output for the model of Groot & Schettkat (1999).

*Table 2-1: Technical aspects of the Groot & Schettkat (1999) model; The orange coloured boxes show the income-driven model variant II-C*

| **Basic structure Price-driven model** | | **Basic structure Income-driven model** | |
|---|---|---|---|
| (1) $P_p = k\frac{W_p}{\pi_p}$ | (5) $P_s = k\frac{W_s}{\pi_s}$ | (1) $P_p = k\frac{W_p}{\pi_p}$ | (6) $P_s = k\frac{W_s}{\pi_s}$ |
| (2) $Q_p = \frac{1}{b_p}(a_p - P_p)$ | (6) $Q_s = \frac{1}{b_s}(a_s - P_s)$ | (2) $C_p = Caut_p + \beta Y_r - \delta Y_r^2$ | (7) $C_s = Caut_s + \beta Y_r - \delta Y_r^2$ |
| (3) $L_p = \frac{Q_p}{\pi_p}$ | (7) $L_s = \frac{Q_s}{\pi_s}$ | (3) $C_p = P_p Q_p$ | (8) $C_s = P_s Q_s$ |
| (4) $Y_p = Q_p P_p$ | (8) $Y_s = Q_s P_s$ | (4) $L_p = \frac{Q_p}{\pi_p}$ | (9) $L_s = \frac{Q_s}{\pi_s}$ |
| | | (5) $Y_p = Q_p P_p$ | (10) $Y_s = Q_s P_s$ |
| | | (11) $Y_r = P_p^0 Q_p + P_s^0 Q_s$ | |
| **Variants** | | **Variants** | |
| I-A (9) $W_p = W_s$ | (10) $L_0 = L_p + L_s$ | II-A (12) $W_p = W_s$ | (13) $L_0 = L_p + L_s$ |
| I-B (9) $\dot{W}_{p,r} = \dot{\pi}_p$ | (10) $L_0 = L_p + L_s$ | II-B (12) $\dot{W}_{p,r} = \dot{\pi}_p$ | (13) $L_0 = L_p + L_s$ |
| I-C (9) $W'_{p,n} = \pi' W_{p,n}^0$ | (10) $W'_{s,n} = \pi' W_{s,n}^0$ | II-C (12) $W'_{p,n} = \pi' W_{p,n}^0$ | (13) $W'_{s,n} = \pi' W_{s,n}^0$ |
| **Endogenous Variables** | | | |
| $P_{p/s}$: Price progressive/stagnant sector | | $P_{p/s}$: Price progressive/stagnant sector | |
| $W_{p/s}$: Nominal money wage progressive/stagnant sector | | $W_{p/s}$: Nominal money wage progressive/stagnant sector | |
| $Q_{p/s}$: Real output progressive/stagnant sector | | $Q_{p/s}$: Real output progressive/stagnant sector | |
| $L_{p/s}$: Employment level progressive/stagnant sector | | $L_{p/s}$: Employment level progressive/stagnant sector | |
| $Y_{p/s}$: Nominal output progressive/stagnant sector | | $Y_{p/s}$: Nominal output progressive/stagnant sector | |
| | | $C_{p/s}$: Consumption progressive/stagnant sector | |
| | | $Y_r$: Total real output evaluated at $P_0$ | |
| **Exogenous Variables** | | | |
| $\pi_s$: Labour productivity stagnant sector: 1.0 | | $\pi_s$: Labour productivity stagnant sector: 1.0 | |
| $a_p$: Constant in progressive sector: 1.5 | | $Caut_p$: Autonomous consumption progressive sector: 40 | |
| $a_s$: Constant in stagnant sector: 2.0 | | $Caut_s$: Autonomous consumption stagnant sector: 0 | |
| $b_p$: Part of price elasticity progressive sector: 0.01 | | $\beta$: Coefficient for consumption function: 0.4 | |
| $b_s$: Part of price elasticity stagnant sector: 0.02 | | $\delta$: Coefficient for consumption function: 0.001 | |
| $k$: Profit mark-up rate: 1.0 | | $k$: Profit mark-up rate: 1.0 | |
| $L_0$: Full employment level: 100 | | $L_0$: Full employment level: 100 | |
| **Exogenous Variable under Simulation** | | | |
| $\pi_p$: Labour productivity progressive sector: 1.0-2.0 | | $\pi_p$: Labour productivity progressive sector: 1.0-2.0 | |

## 2.3 Input Parameters and Outcomes of Interest

### 2.3.1 Fiscal and Monetary Policy as Input Parameters

Fiscal and monetary policy are the two most important macroeconomic instruments and are therefore used as input parameters. Input parameters are parameters that are set at a specific value at the start of a simulation run. The fiscal policy instruments are public investment ($I_g$) and taxation (T). The monetary policy instrument is the interest rate (i). Public investment is part of the aggregate demand formula and can boost the level of GDP if it increases. It is possible to decide to invest more in the progressive sector than in the stagnant sector or vice versa. Public income out of taxation can be used to boost public investment if necessary. The interest rate is used to increase or decrease private investments and consumption. A low interest rate setting increases investments and consumption and, therefore, it is likely that the level of GDP increases. So, all three instruments ($I_g$, T, i) have the potential to increase aggregate demand and thus the GDP level.

### 2.3.2 Outcomes of Interest

Parameters that measure economic growth, employment, price stability, income distribution and productivity are included in the conceptual model as outcomes of interest. Three sources were used to determine these outcomes of interest (Table 2-2). First, the already existing outputs determined by Groot & Schettkat (1999). Second, the macroeconomic policy objectives determined by Economics Discussion (2018). Third, the macroeconomic policy frame outputs determined by Naastepad (2002). The output indicators of 'balance of payments equilibrium and exchange rate stability' and 'sustainability' are considered out of scope for this research. Outcomes of interest are providing the interesting results of a simulation run. The specified outcomes of interest have the potential to show the development of unbalanced growth and the overall performance of a nation's economy.

*Table 2-2: Outcomes of interest related to unbalanced growth and macroeconomic output*

| **Groot & Schettkat (1999)** | **Economics Discussion (2018)** | **Naastepad (2002)** |
|---|---|---|
| Total real income | Economic growth | Stable economic growth |
| Employment ratios | Full employment | Low unemployment |
| Ratio of real output in the progressive sector over the stagnant sector | Price stability | Low inflation (no deflation) |
| Ratio of nominal output in the progressive sector over the stagnant sector | Balance of payments equilibrium and exchange rate stability | Equal income distribution |
| | Social objectives | Sustainability |
| | | Technological progress/ Productivity growth |

## 2.4 Main Conceptual Model Mechanism

The main mechanism of the conceptual model is based on the income-driven model variant C of Groot & Schettkat (1999). This model includes the following components: price, wage, real output, nominal output, employment, income and consumption. The conceptual model is expanded on the following points: investment, endogenous productivity and policy instruments.

In the Groot & Schettkat (1999) income-driven model variant C the only component that drives output or aggregate demand is consumption. Next to consumption, investment is an important driver of aggregate demand (Naastepad, 2002). The mechanism of the conceptual model is expanded by including private and public investment. Private investment can be made endogenous rather easily by making it dependent on business profits (Office For National Statistics, 2007). Business profits can be modelled as the difference between revenue (real output times the price level) and costs (employment times the wage level). Public investment is included as an exogenous policy variable. Now aggregate demand

(AD) depends on consumption (C), private investment ($I_p$) and public investment ($I_g$). Public expenditure (G), imports (I) and exports (E) are considered out of scope for this research. A significant driver of productivity is investment. Direct investment in education, the work environment, physical capital and research & development (R&D) drive productivity (Kalpana, 2018). So productivity in the conceptual model is made dependent on private business investments. Next to public investment, taxation and the interest rate are included in the conceptual model as policy variables. The income out of taxation can be used to increase public investment. The interest rate can be used to boost or lower consumption and investment.

## 2.5 Conceptual Model

The final result of this chapter is a conceptual model of unbalanced growth and this model serves directly as input and demarcation for the unbalanced growth model. The conceptual model is shown in Figure 2-2 and provides the relations between the economic variables of unbalanced growth. The white boxes show the main endogenous variables in the model. The blue boxes are the policy variables. The red boxes are the outcomes of interest.

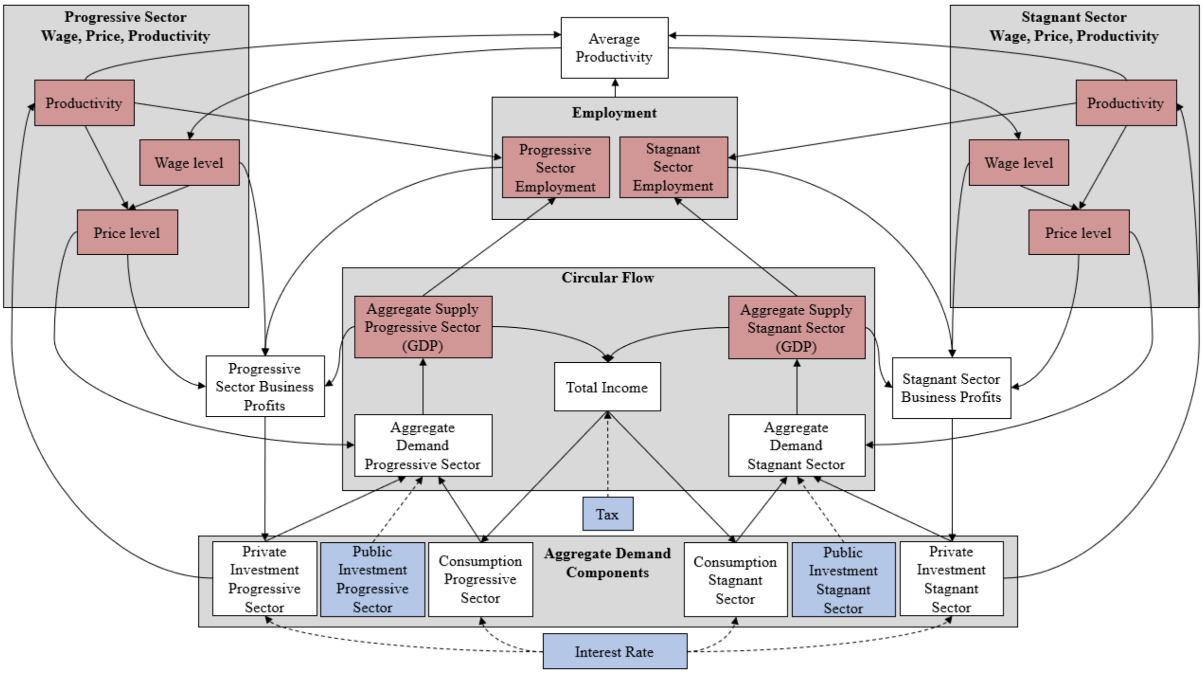



*Figure 2-2: Conceptual model*

The conceptual model clearly shows that the economy is divided in a progressive sector (left) and stagnant sector (right). The two sectors are connected via average productivity and total income. Wages in both sectors grow with the same pace as average productivity does, as hypothesized by Baumol (1967). The price level per sector is determined by sector wage level and sector productivity level. In the progressive sector it is expected that productivity grows faster than productivity in the stagnant sector. Therefore, the price level of progressive sector products and services is expected to be lower than the price level of stagnant sector products and services. The sector price level has a significant impact on aggregate demand for sector products and services. In essence demand increases if prices decrease.

Aggregate demand per sector is the only driver of aggregate supply per sector, simply said the level of GDP per sector. The sum of progressive and stagnant sector GDP determines the total income level of a nation's economy. The higher the income the higher the consumption for progressive and stagnant sector products, which increases sector aggregate demand. This feedback loop from demand to supply to income to consumption back to demand, describes the circular flow of the economy (Naastepad, 2002).

Next to consumption, private investment per sector is a driver of aggregate demand per sector and is driven by business profits per sector. Business profits are revenues minus costs. Revenues are determined by sector GDP times sector price level. Costs are determined by sector employment times sector wage level. This feedback loop from demand to supply to profits to investment back to demand, describes the Keynesian philosophy of the macroeconomy: demand drives supply.

Employment per sector is simply determined by sector level GDP divided by sector productivity. The more goods and services are demanded per sector, the more employers are demanded. However, due to the increase in productivity the same amount of work can be done with less employers. To avoid increasing levels of unemployment in the total economy, overall GDP should grow at least with the same rate as average productivity does.

Besides being a driver of aggregate demand, private investment per sector also drives productivity per sector. However, it is hypothesized that the correlation between investments and productivity growth in the progressive sector is stronger than in the stagnant sector. So, productivity grows faster in the progressive sector compared to the stagnant sector.

This macroeconomic conceptual model of unbalanced growth is the input for the unbalanced growth model. With the model it is interesting to observe how unbalanced sectorial growth develops with respect to real output, employment, price level, wage level and productivity. And it is even more interesting to find the factors that drive unbalanced growth.

# 3 The Macroeconomic System Components of Unbalanced Growth

The progressive and stagnant sector are connected to each other via the overall price level, average national productivity, and national income. This chapter describes and explains the relations between the macroeconomic components of unbalanced growth with the help of the unbalanced growth model. The model is based on economic equations (3.1). These economic equations are connected to each other in the software package Vensim and this results in the unbalanced growth model (3.2). Finally, the simulation and analysis techniques are described (3.3).

## 3.1 Economic Theory Explained and Substantiated

Each economic equation that is built into the unbalanced growth model is described and explained and based on macroeconomic theory. Each equation is explained separately. Black coloured variables are endogenous, yellow coloured variables are exogenous, red coloured coefficients are estimated with the help of econometrics, and blue coloured variables are macroeconomic policies. So, the values of the yellow coloured exogenous variables and the red coloured coefficients in the equations are based on empirical data.

### 3.1.1 Nominal Wage level function

Nominal wages (W) in both sectors are driven by average productivity (π') and start at a specific wage level ($W^0_n$) (Equation 3-1). This is the standard equation determined in Groot & Schettkat (1999) and corresponds to the model of unbalanced growth as described in Baumol (1967). This means that wages grow at the same rate in the overall economy. The variables in this equation are dimensionless, because the intention of this relation is to show the change in wage level.

| Progressive sector | Stagnant sector | Units |
|---|---|---|
| $W'_{p,n} = \pi' W^0_{p,n}$ | $W'_{s,n} = \pi' W^0_{s,n}$ | $W = Dimensionless$<br>$\pi' = Dimensionless$ |

*Equation 3-1: Nominal wage level function*

### 3.1.2 Price level function

Prices (P) in both sectors are driven by the price mark-up (k), sector wage level (W) and sector productivity (π) (Equation 3-2). The price mark-up is 1 plus the profit mark-up. This is the standard equation determined in Groot & Schettkat (1999). Prices increase if the profit mark-up and wage level increase but decrease if productivity increases. The variables in this equation are dimensionless, because the intention of this equation is to show the change in price level.

| Progressive sector | Stagnant sector | Units |
|---|---|---|
| $P_p = k \frac{W_p}{\pi_p}$ | $P_s = k \frac{W_s}{\pi_s}$ | $P = Dimensionless$<br>$k = Dimensionless$<br>$W = Dimensionless$<br>$\pi = Dimensionless$ |

*Equation 3-2: Price level function*

### 3.1.3 Consumption function

Consumption (C) in both sectors is driven by autonomous sector consumption (Caut), real disposable income ($Y_d$) and the real interest rate (R.i) (Equation 3-3). The relation between real disposable income and consumption is econometrically estimated ($\beta_1$) and this equation is based on Groot & Schettkat

(1999). The interest rate component is added to the equation of Groot & Schettkat (1999). If the interest rate increases, savings become more attractive and consumption goes down. The relation between real interest and consumption is econometrically estimated ($\beta_2$). Autonomous consumption reflects the willingness to consume, for example the willingness to consume is lower during recessions. All variables in the equation are in billions of dollars, except for the econometric coefficient $\beta_1$ which is dimensionless. And the real interest rate, which is in percentage points and thus dimensionless.

| **Progressive sector** | **Stagnant sector** | **Units** |
|---|---|---|
| $C_p = Caut_p + \beta 1_p(Y_d) - \beta 2_p(R.i)$ | $C_s = Caut_s + \beta 1_s(Y_d) - \beta 2_s(R.i)$ | $C = Billions\ of\ Dollars$<br>$Y = Billions\ of\ Dollars$<br>$R.i = Dimensionless$<br>$\beta 1 = Dimensionless$<br>$\beta 2 = Billions\ of\ Dollars$ |

*Equation 3-3: Consumption function*

### 3.1.4 Real profit function

Real profits in both sectors are the difference between sector nominal output ($P_pQ_p$ & $P_sQ_s$) and total sector labour costs ($W_pL_p$ & $W_sL_s$), divided by the overall price level ($P_t$) (Equation 3-4). This equation is based on macroeconomic theory described in Naastepad (2002). In equilibrium the real profits are zero. This is the case when the price mark-up (k) is equal to 1. Real output (Q) and Employment (L) are in billions of dollars. The price (P) and wage (W) level are dimensionless. As a result, real profits are in billions of dollars.

| **Progressive sector** | **Stagnant sector** | **Units** |
|---|---|---|
| $Real\ profits_p = \frac{Profits_p}{P_t} = \frac{P_pQ_p}{P_t} - \frac{W_pL_p}{P_t}$ | $Real\ profits_s = \frac{Profits_s}{P_t} = \frac{P_sQ_s}{P_t} - \frac{W_sL_s}{P_t}$ | $R.pro. = Billions\ of\ Dollars$<br>$P = Dimensionless$<br>$W = Dimensionless$<br>$Q = Billions\ of\ Dollars$<br>$L = Billions\ of\ Dollars$ |

*Equation 3-4: Real profit function*

### 3.1.5 Private investment function

Private investment ($I_p$) in both sectors is driven by autonomous sector investment (Iaut), sector real profits and the real interest rate (R.i) (Equation 3-5). This equation is based on macroeconomic theory described in Naastepad (2002). The relation between real profits and investments is econometrically estimated ($\alpha_1$) and this relation is based on literature (Office For National Statistics, 2007). If the interest rate increases, investments become more expensive and therefore private investment goes down. The relation between real interest and investment is econometrically estimated ($\alpha_2$). Autonomous investment reflects the willingness to invest, for example the willingness to invest is lower during recessions. All variables in the equation are in billions of dollars, except for the econometric coefficient $\alpha_1$ which is dimensionless. And the real interest rate, which is in percentage points and thus considered dimensionless.

| **Progressive sector** | **Stagnant sector** | **Units** |
|---|---|---|
| $I_{pp} = Iaut_p +$ $\alpha 1_p(Real\ profits_p) - \alpha 2_p(R.i)$ | $I_{sp} = Iaut_s +$ $\alpha 1_s(Real\ profits_s) - \alpha 2_s(R.i)$ | $I = Billions\ of\ Dollars$ <br> $R.pro. = Billions\ of\ Dollars$ <br> $R.i = Dimensionless$ <br> $\alpha 1 = Dimensionless$ <br> $\alpha 2 = Billions\ of\ Dollars$ |

*Equation 3-5: Private investment function*

### 3.1.6 Public investment function

Public investment ($I_g$) in both sectors is driven by income out of taxation ($Y_r$-$Y_d$). This equation is based on macroeconomic theory described in Naastepad (2002). The government can decide where to invest the income out of taxation by varying the progressive/stagnant sector investment switch (σ) and the government can decide how much money out of taxation will be used for public investment by varying the propensity to invest (δ) (Equation 3-6). All variables in the equation are in billions of dollars, except for the progressive/stagnant sector investment switch (σ) and the propensity to invest (δ), both are dimensionless.

| **Progressive sector** | **Stagnant sector** | **Units** |
|---|---|---|
| $I_{pg} = (Y_r - Y_d) * \delta * \sigma$ | $I_{sg} = (Y_r - Y_d) * \delta * (1 - \sigma)$ | $I = Billions\ of\ Dollars$ <br> $Y = Billions\ of\ Dollars$ <br> $\sigma = Dimensionless$ <br> $\delta = Dimensionless$ |

*Equation 3-6: Public investment function*

### 3.1.7 Real output function

The real output function (Q) reflects the level of GDP per sector and is driven by the main components of aggregate demand: consumption (C), private investment ($I_p$) and public investment ($I_g$) (Investopedia, 2018a). To reflect the real level of output, the equation is divided by the fraction of sector price level (P) divided by the total price level ($P_t$) (Equation 3-7). All variables in the equation are in billions of dollars, except for the dimensionless price level variable.

| **Progressive sector** | **Stagnant sector** | **Units** |
|---|---|---|
| $Q_p = \frac{C_p + I_{pp} + I_{pg}}{P_p/P_t}$ | $Q_s = \frac{C_s + I_{sp} + I_{sg}}{P_s/P_t}$ | $Q = Billions\ of\ Dollars$ <br> $C = Billions\ of\ Dollars$ <br> $I = Billions\ of\ Dollars$ <br> $P = Dimensionless$ |

*Equation 3-7: Real output or GDP function*

### 3.1.8 Nominal output function

Nominal output in both sectors (Y) is driven by sector real output (Q) times sector price level (P) (Equation 3-8). All variables in the equation are in billions of dollars, except for the dimensionless price level variable. This equation is directly taken from Groot & Schettkat (1999).

| **Progressive sector** | **Stagnant sector** | **Units** |
|---|---|---|
| $Y_p = Q_p P_p$ | $Y_s = Q_s P_s$ | $Y = Billions\ of\ Dollars$ <br> $Q = Billions\ of\ Dollars$ <br> $P = Dimensionless$ |

*Equation 3-8: Nominal output*

### 3.1.9 Employment function

Employment in both sectors (L) is driven by sector real output (Q) divided by sector productivity ($\pi$) (Equation 3-9). Higher real output leads to more employment, higher productivity leads to lower employment. All variables in the equation are in billions of dollars, except for the dimensionless productivity variable. This equation is directly taken from Groot & Schettkat (1999).

| Progressive sector | Stagnant sector | Units |
|---|---|---|
| $L_p = (\frac{Q_p}{\pi_p})$ | $L_s = (\frac{Q_s}{\pi_s})$ | $L = Billions\ of\ Dollars$<br>$Q = Billions\ of\ Dollars$<br>$\pi = Dimensionless$ |

*Equation 3-9: Employment function*

### 3.1.10 The Labour Productivity function

Labour productivity per sector ($\pi$) is driven by both an exogenous component ($\pi_0$) and endogenous component ($K * I_p$) (Equation 3-10). Exogenous labour productivity is due to technology-push innovation based on public spending on basic research, private R&D and entrepreneurship (Lazonick, 2009, 2014; Mazzucato, 2013). Endogenous labour productivity depends on the amount of private sector investments ($I_p$). The relation between investments and labour productivity is econometrically estimated (K). According to the Office For National Statistics (2007) investments are positively correlated to labour productivity. This economic equation is based on Verdoorn's law, which follows the functional form of: $Y = a + bX$. Where 'Y' is productivity, 'a' is exogenous labour productivity, 'b' is the Verdoorn coefficient and 'X' is investment (Verdoorn, 1980). The investment variable is in billions of dollars and the econometric coefficient has unit 1/ billions of dollars. As a result, labour productivity is dimensionless.

| Progressive sector | Stagnant sector | Units |
|---|---|---|
| $\pi_p = \pi_{p0} + K(I_{pp})$ | $\pi_s = \pi_{s0} + K(I_{sp})$ | $K = \frac{1}{Billions\ of\ Dollars}$<br>$I = Billions\ of\ Dollars$<br>$\pi = Dimensionless$ |

*Equation 3-10: Labour productivity function*

### 3.1.11 Average Labour productivity Function

Average labour productivity ($\pi$') is the weighted average of total real output ($Q_p + Q_s$) divided by total employment ($L_p + L_s$) (Equation 3-11). Since both real output and employment are in billions of dollars, average labour productivity is dimensionless. This equation is directly taken from Groot & Schettkat (1999).

| Progressive & Stagnant sector | Units |
|---|---|
| $\pi' = \frac{(L_p * \pi_p) + (L_s * \pi_s)}{L_p + L_S} = \frac{Q_p + Q_s}{L_p + L_s}$ | $\pi = Dimensionless$<br>$L = Billions\ of\ Dollars$<br>$Q = Billions\ of\ Dollars$ |

*Equation 3-11: Average labour productivity function*

### 3.1.12 Total real income function

Total real income ($Y_r$) is total nominal output ($Y_p$ + $Y_s$) divided by the overall price level ($P_t$) (Equation 3-12). Real income and nominal output are in billions of dollars and the price level is dimensionless. This equation is directly taken from Groot & Schettkat (1999).

| **Progressive & Stagnant sector** | **Units** |
|---|---|
| $Y_r = \frac{Y_p + Y_s}{P_t}$ | $P = Dimensionless$<br>$Y = Billions\ of\ Dollars$ |

*Equation 3-12: Total real income*

### 3.1.13 Total real disposable income

Total real disposable income ($Y_d$) is total real income ($Y_r$) minus the taxation (Tax) (Equation 3-13). Income is in billions of dollars and tax is a dimensionless variable that ranges between 1 (full tax) and 0 (no tax). This equation is based on macroeconomic theory described in Naastepad (2002).

| **Progressive & Stagnant sector** | **Units** |
|---|---|
| $Y_d = Y_r(1 - Tax)$ | $Tax = Dimensionless$<br>$Y = Bilions\ of\ Dollars$ |

*Equation 3-13: Total real disposable income*

### 3.1.14 Overall price level function

Overall price ($P_t$) is driven by total nominal output ($Y_p$ + $Y_s$) divided by total real output ($Q_p$ + $Q_s$) (Equation 3-14). Since both nominal and real output are in billions of dollars, the overall price level is dimensionless. This equation is directly taken from Groot & Schettkat (1999).

| **Progressive & Stagnant sector** | **Units** |
|---|---|
| $P_t = \frac{Y_p + Y_s}{Q_p + Q_s}$ | $P = Dimensionless$<br>$Y = Billions\ of\ Dollars$<br>$Q = Billions\ of\ Dollars$ |

*Equation 3-14: Overall price level function*

### 3.1.15 Real interest rate function

The real interest rate (R.i) is driven by the nominal interest rate (i) divided by the overall price level ($P_t$) (Equation 3-15). The overall price level is dimensionless and the nominal interest rate is in percentage points and thus dimensionless. As a result, the real interest rate is also dimensionless. This equation is based on macroeconomic theory described in Naastepad (2002).

| **Progressive & Stagnant sector** | **Units** |
|---|---|
| $R.i = \frac{i}{P_t}$ | $R.i = Dimensionless$<br>$i = Dimensionless$<br>$P = Dimensionless$ |

*Equation 3-15: Real interest rate function*

## 3.2 Using Vensim to Build the Unbalanced Growth Model

This section explains how the macroeconomic equations described in section 3.1 relate to each other, with the help of the unbalanced growth model built in Vensim. The model is divided in three modules: the command module, the core module and the investment module. Each module is graphically shown and explained. All variables in the unbalanced growth model have a colour. Black variables are endogenous variables, yellow variables are exogenous variables, red variables are econometrically estimated exogenous variables, blue variables are policy variables and green variables are time delay variables. A graphical overview of the full unbalanced growth model is shown in Appendix III.

### 3.2.1 Command Module

The module is called the command module, because this module controls for the largest part the behaviour in the unbalanced growth model (Figure 3-1). Parts of this module are: productivity, employment, overall price and nominal wage. The module is symmetric, the left part describes the progressive sector and the right part the stagnant sector. These sectors are connected via average productivity and overall price.

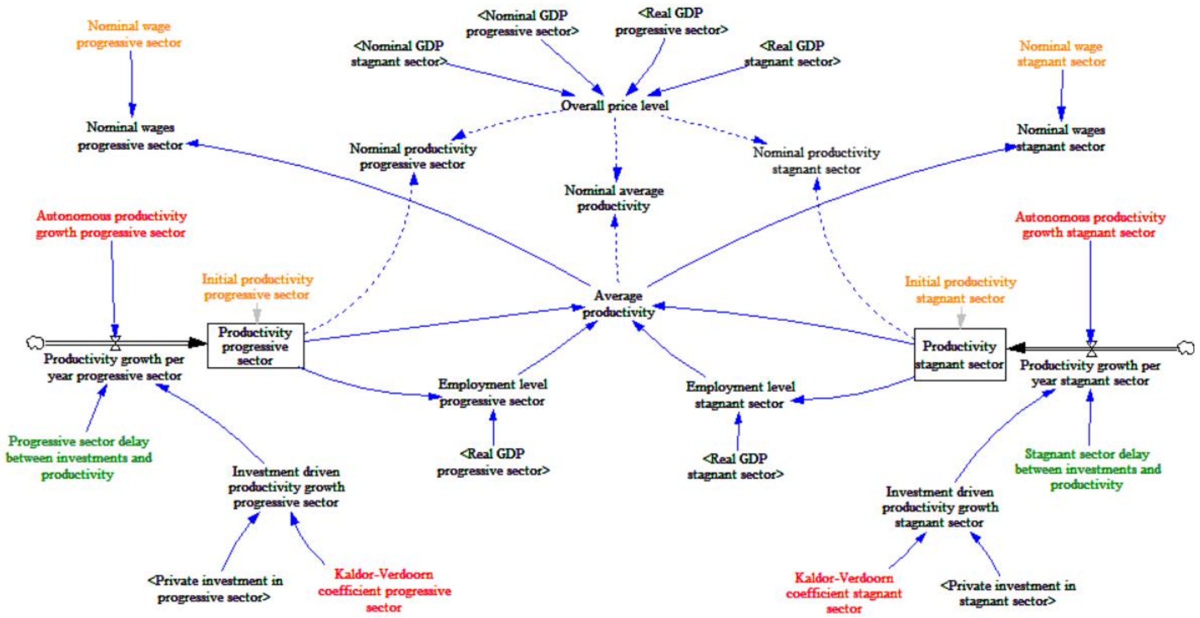



*Figure 3-1: Command module of the unbalanced growth model*

Table 3-1 shows the stocks and flows of the command module. The stocks are integral equations and have an initial value. The stocks grow or decline per year with the value of the flow variable. The flow variable is determined by the sum of autonomous productivity growth plus investment driven productivity growth. The stock units are dimensionless (percentages/100) and the flow units are dimensionless per year (percentages growth/100). In the unbalanced growth model nominal wages are driven by average productivity growth, just as in the variant C model of Groot & Schettkat (1999). However, to also have the option to model variant A and B, nominal productivity growth per sector and nominal average productivity are modelled, but not connected to the nominal wages.

*Table 3-1: Stocks and flows of the command module*

| **Stocks** | **Flows** |
|---|---|
| **Productivity progressive sector**<br>Equation:<br>*INTEG(Productivity growth per year progressive sector)*<br>Initial value:<br>*Initial productivity progressive sector* | **Productivity growth per year progressive sector**<br>Equation:<br>*Autonomous productivity growth progressive sector + Investment driven productivity growth progressive sector* |

| **Productivity stagnant sector** | **Productivity growth per year stagnant sector** |
|---|---|
| Equation:<br>*INTEG(Productivity growth per year stagnant sector)*<br>Initial value:<br>*Initial productivity stagnant sector* | Equation:<br>*Autonomous productivity growth stagnant sector + Investment driven productivity growth stagnant sector* |

### 3.2.2 Core Module

The module is called the core module, because this module includes the core concepts of macroeconomics: aggregate demand and supply (Investopedia, 2018a) (Figure 3-2). Parts of this module are: aggregate demand, aggregate supply or GDP, consumption, income and price. The module is symmetric, the left part describes the progressive sector and the right part the stagnant sector. These sectors are connected via total income and overall price.

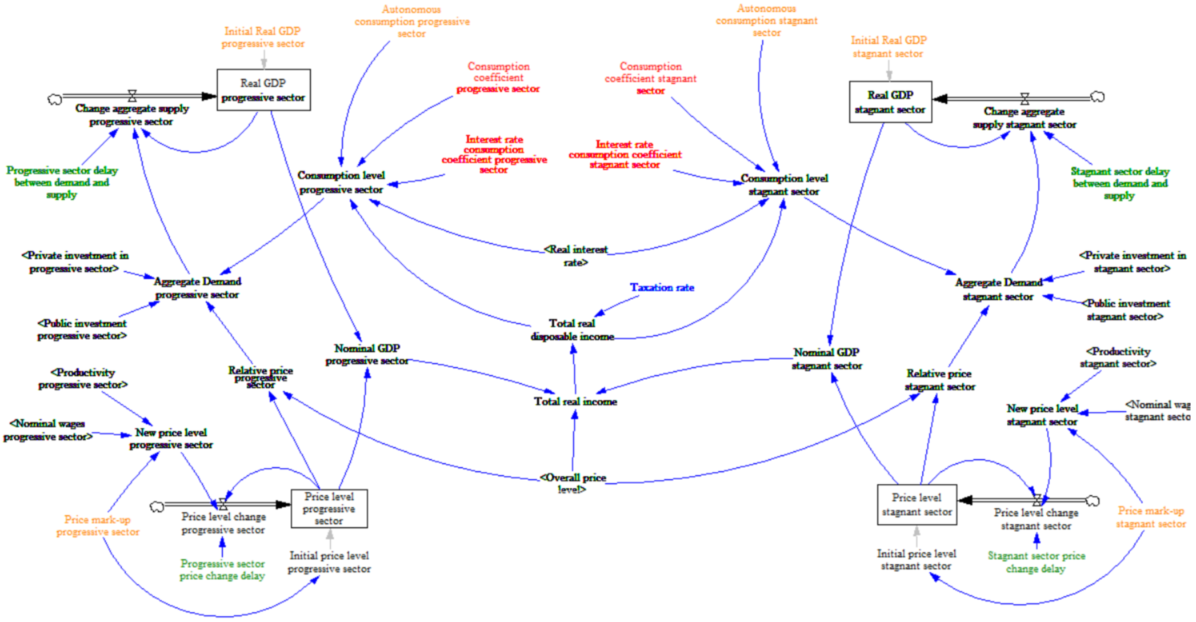



*Figure 3-2: Core module of the unbalanced growth model*

Table 3-2 shows the stocks and flows of the core module. The stocks are integral equations and have an initial value. The stocks grow or decline per year with the value of the flow variable. The core module consists out of four stock/flow structures. Two stock/flow structures for progressive and stagnant sector GDP and two for progressive and stagnant sector price level. The GDP flow variable is the difference between aggregate demand and aggregate supply. If demand is larger than supply, the inflow into the stock is positive. If demand is smaller than supply, the inflow into the stock is negative. The stock units are billions of U.S. dollars and the flow units are billions of U.S. dollars per year. The price level flow variable is the difference between the new price level and current price level. If the new price level is larger than the current price level, the inflow into the stock is positive. If the new price level is smaller than the current price level, the inflow into the stock is negative. The stock units are dimensionless and the flow units are dimensionless per year.

*Table 3-2: Stocks and flows of the core module*

| Stocks | Flows |
|---|---|
| **Real GDP progressive sector**<br>Equation:<br>*INTEG(Change aggregate supply progressive sector)*<br>Initial value:<br>*Initial Real GDP progressive sector* | **Change aggregate supply progressive sector**<br>Equation:<br>*Aggregate Demand progressive sector-Real GDP progressive sector* |
| **Real GDP stagnant sector**<br>Equation:<br>*INTEG(Change aggregate supply stagnant sector)*<br>Initial value:<br>*Initial Real GDP stagnant sector* | **Change aggregate supply stagnant sector**<br>Equation:<br>*Aggregate Demand stagnant sector-Real GDP stagnant sector* |
| **Price level progressive sector**<br>Equation:<br>*INTEG(Price level change progressive sector)*<br>Initial value:<br>*Initial price level progressive sector* | **Price level change progressive sector**<br>Equation:<br>*New price level progressive sector-Price level progressive sector* |
| **Price level stagnant sector**<br>Equation:<br>*INTEG(Price level change stagnant sector)*<br>Initial value:<br>*Initial price level stagnant sector* | **Price level change stagnant sector**<br>Equation:<br>*New price level stagnant sector-Price level stagnant sector* |

### 3.2.3 Investment Module

The module is called the investment module, because this module models private and public investment (Figure 3-3). Parts of this module are: private investment, public investment, profits and the interest rate. The module is symmetric, the left part describes the progressive sector and the right part the stagnant sector. Progressive and stagnant sector private investment are not connected. Progressive and stagnant sector public investment are connected via the investment switch, which determines how much will be invested in the progressive sector and how much in the stagnant sector.

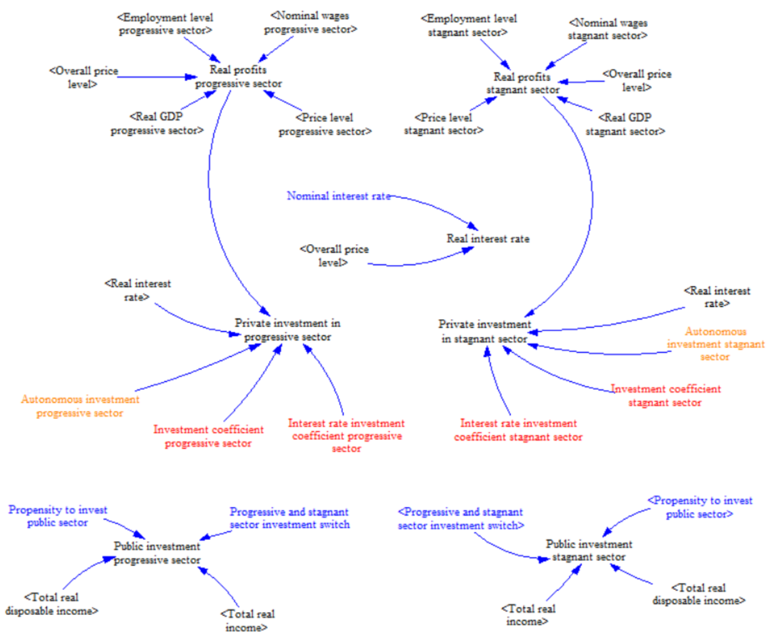



*Figure 3-3: Investment module of the unbalanced growth model*

## 3.3 Simulation and Analysis Techniques

### 3.3.1 Simulation Technique

The unbalanced growth model is simulated according to the method of exploratory modelling with the help of the EMA workbench (Kwakkel, 2012). Exploratory modelling or open exploration is used to observe how the outcomes of interest change with respect to changes in the input space. The unbalanced growth model is simulated 34,000 times for different exogenous parameter settings. So, a specific part of the input parameters is parametrized with a value range instead of a single point estimate, these are the uncertain input parameters. After simulation an ensemble of simulation runs is created. Since unbalanced growth is a phenomenon that gradually changes over time it is important to simulate the model over a significant amount of time. There is chosen to simulate the model over a time span of 25 years, starting in 2015 until 2040. As a result, the units of time in the unbalanced growth model are years. The base year 2015 is chosen, because the model is parametrized with data based on the year 2015.

### 3.3.2 Visual Analysis

Each outcome of interest has its own ensemble of simulation results that are visualised by means of line plots and/or two pair scatter plots. For line plots time is plotted on the x-axis and the outcome of interest on the y-axis. By means of this visualising technique it is rather easy to observe how a specific outcome of interest behaves over time. With two pair scatter plots two outcomes of interest are plotted against each other. This helps to get more information about the relation between the outcomes of interest. With simple statistic metrics the ensemble of simulation results for each outcome of interest is divided into desirable and non-desirable outcomes. These types of visual analysis are performed with the EMA workbench (Kwakkel, 2012).

### 3.3.3 Sensitivity Analysis

Sensitivity analysis is used to find which factors are sensitive with respect to the outcomes of interest. The technique of global sensitivity analysis is used. With global sensitivity analysis the uncertain input parameters are sampled at the same time instead of checking each input separately. The SOBOL technique or variance-based sensitivity analysis is used to perform global sensitivity analysis (Zhang, Trame, Lesko, & Schmidt, 2015). SOBOL is based on variance decomposition. This means that the analysis tells us the fraction of total variance of the outcome of interest added by each uncertain input parameter. Two specific metrics are used: first-order effect (S1) and total effect (ST) metrics. With the results of the first-order effect one knows how much a specific uncertain input parameter adds to the variance of a specific outcome on its own. With the results of the total effect one knows how much a specific uncertain input parameter adds to the variance of a specific outcome, including all the interactions with the other uncertain input parameters. The general rule is to prioritize input parameters with a high S1 index and discard inputs with a low ST index. The results are shown in a graph and an example is shown in Figure 3-4. For each specific outcome of interest, a graph is produced. On the x-axis the uncertain input parameters are placed and each uncertain input parameter has a S1 and ST score ranging between 0 and 1. The higher the score, the more sensitive is the specific input parameter. Global sensitivity analysis in combination with SOBOL is performed with the EMA workbench (Kwakkel, 2012).

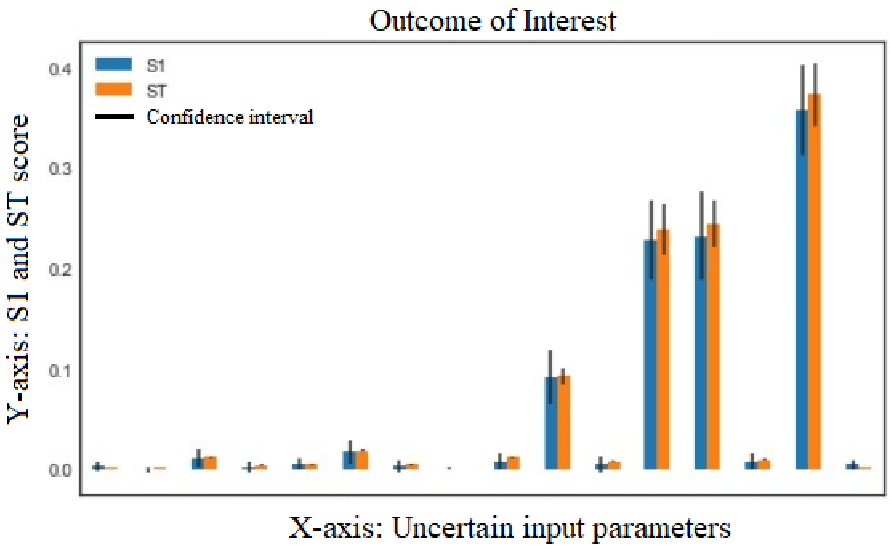



*Figure 3-4: SOBOL sensitivity analysis output*

### 3.3.4 Scenario Discovery

Scenario discovery finds subspaces in the uncertainty space that result in characteristic outputs (Bryant & Lempert, 2010). For this research scenario discovery is used to find out how the sensitive input parameters should be influenced to generate desirable outcomes of interest, which slow down unbalanced growth and stimulate stable growth. Scenario discovery is performed with the Patient Rule Induction Method (PRIM) algorithm (Friedman & Fisher, 1999). Each outcome of interest has a desirable ensemble of outcomes and a non-desirable ensemble of outcomes. For this research the desirable ensemble of outcomes is considered the best 25 percent of the simulation results.

PRIM searches for a subspace in the uncertain input space that produces characteristic or desirable output. PRIM describes these subspaces in the form of hyper rectangular boxes of the uncertain input variables (Figure 3-5). So, with PRIM it is possible to determine which input parameter ranges result in desirable output. As a result, it is possible to determine if the sensitive input parameters should have a high or low value to generate the desirable ensemble of outcomes. Scenario discovery in combination with PRIM is performed with the EMA workbench (Kwakkel, 2012).

PRIM produces multiple hyper rectangular boxes. Each box represents a subspace of the uncertain input space. And each box has a specific coverage and density, with a score attached to it ranging from zero till one. Coverage means: how much of the uncertain input space is covered by the box. A score of zero means no coverage and a score of one means full coverage of the input space. Density means: how much of the scenarios within the specific box generate desirable outcomes of interest. A score of zero means that within this specific box there are no scenarios that generate desirable outcomes of interest. A score of one means that within this specific box all scenarios generate desirable outcomes of interest. One wants to have a box with high scores for coverage and density. However, it is a trade-off, because if coverage is high, it is likely that within the box a significant number of scenarios do not generate desirable outcomes of interest and therefore the density is low, and vice versa. For this research there is chosen to use a coverage and density that have a similar score. This means that the coverage and density are ranging between 0.64 and 0.73.

The use of scenario discovery for this research is limited. The only purpose is to find out if the sensitive parameters should have a low or high value to slow down unbalanced growth and stimulate stable growth.

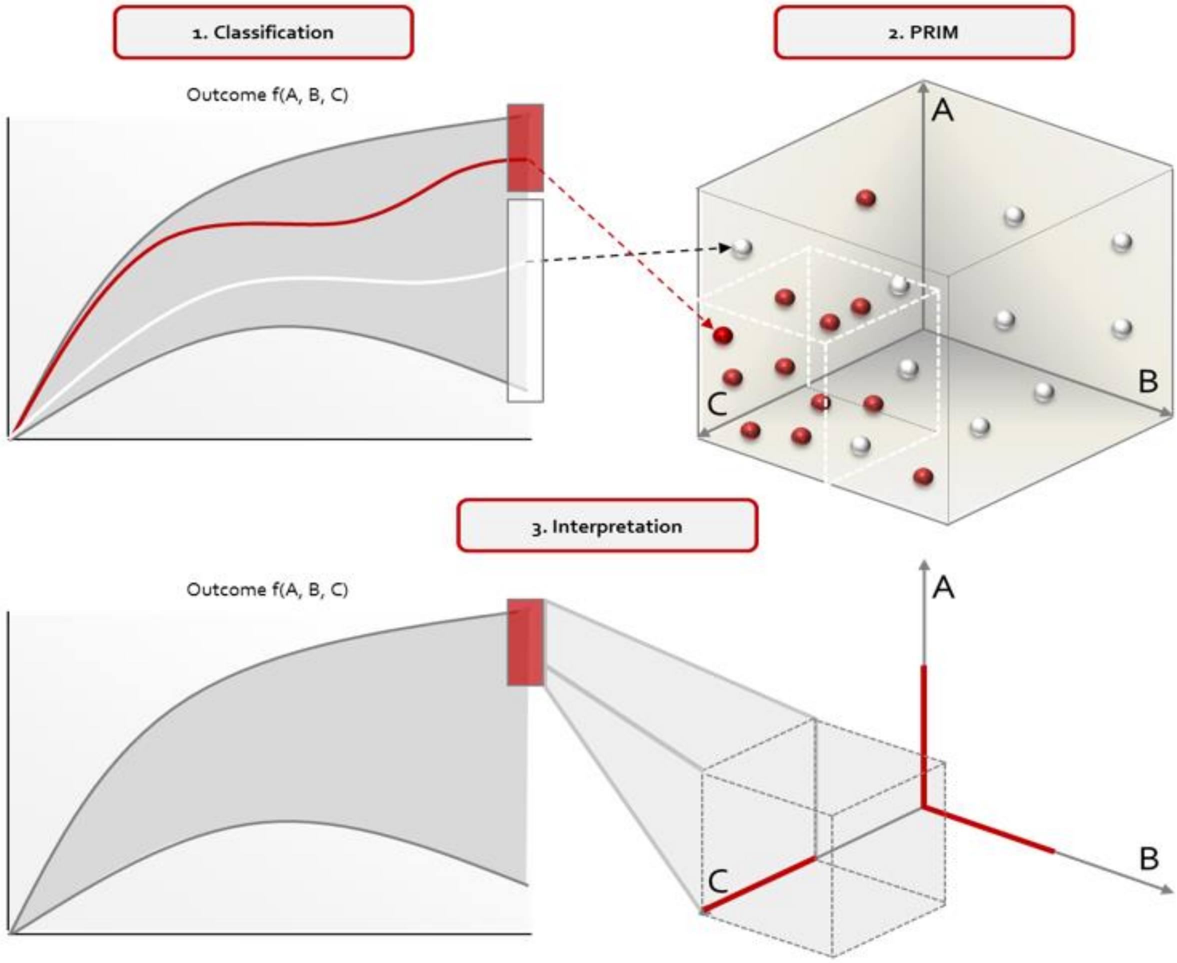



*Figure 3-5: PRIM explanation (Greeven, 2015)*

# 4 Empirical Evidence of Unbalanced Growth

Empirical evidence of unbalanced growth is found in the U.S. economy, the progressive sector grows significantly faster than the stagnant sector in terms of productivity growth. Based on this empirical evidence the unbalanced growth model is parametrized, verified and validated. The U.S. economy is divided into two sectors, a progressive sector with high productivity growth and a stagnant sector with low productivity growth (4.1). After the creation of a progressive and stagnant sector, data analysis is performed to parametrize the unbalanced growth model. Data analysis is divided into two parts. First, analysis of data without the help of econometric models (4.2). Second, the estimation of coefficients with the help of econometric models (4.3). Only data of the OECD statistics website are used (OECD.stat, 2018). Next, an overview of all the exogenous model input parameters and coefficients is provided (4.4). Based on this overview the model is parametrized, verified and validated (4.5). This chapter ends with the experimental set-up (4.6).

## 4.1 Evidence of Unbalanced Growth in the U.S. Economy

When analysing the aggregate economic data for the U.S. economy, clear evidence of unbalanced growth is found, because for some economic activities productivity grows significantly faster compared to other economic activities. Therefore, it is possible to divide the economy in a progressive and stagnant sector. However, a common classification of economic activities should be established first. Revision 4 of the International Standard Industrial Classification of All Economic Activities (ISIC Rev.4) is used (UN, 2018). ISIC divides the economy into 21 economic activities, each activity is indicated with a letter, ranging from A to U. The OECD statistics are based on the ISIC classification and for this research only data based on ISIC Rev.4 are used.

*Table 4-1: Progressive and stagnant sector activities based on empirical data (OECD.stat, 2018)*

| Economic activities | Average productivity growth per year in percentages over the period 2001-2015 | Progressive or Stagnant sector |
|---|---|---|
| B: Mining and quarrying<br>D: Electricity, gas, steam and air conditioning supply<br>E: Water supply; sewerage, waste management and remediation activities | 0.09 | Stagnant |
| C: Manufacturing | 0.57 | Progressive |
| F: Construction | -0.12 | Stagnant |
| G: Wholesale and retail trade; repair of motor vehicles and motorcycles<br>H: Transportation and storage<br>I: Accommodation and food service activities | 0.16 | Stagnant |
| J: Information and communication | 0.50 | Progressive |
| K: Financial and insurance activities | 0.20 | Progressive |
| M: Professional, scientific and technical activities<br>N: Administrative and support service activities | 0.17 | Progressive |
| All activities (BDEFGHIJKMN), without manufacturing (C) | 0.17 | |
| Progressive sector activities (CJKMN) | 1.45 | |
| Stagnant sector activities (BDEFGHI) | 0.14 | |

The progressive sector of the economy is marked by high technological progress and the stagnant sector of the economy is marked by low technological progress. The best indicator for technological progress is productivity growth (OECD, 2017). Therefore, productivity growth is used to divide the economy into a progressive and stagnant sector. The OECD has productivity growth statistics per year for the U.S. economy from 2001 till 2015 for a large number of economic activities. The most important information is shown in Table 4-1. The first column provides the economic activities for which data are available, the second column shows the average productivity growth per year in percentages measured over the period 2001 till 2015 and the third column places economic activities into the progressive or stagnant sector. The full productivity data set can be found in Appendix IV. Unfortunately, longer timeseries are not available for this level of aggregation.

If an economic activity belongs to the progressive or stagnant sector depends on the fact if the productivity growth of the specific economic activity is higher or lower than the average productivity growth of all activities, excluding manufacturing. If it is higher than or equal to the average growth of 0.17 percent per year, the economic activity belongs to the progressive sector. If it is lower than the average growth of 0.17 percent per year, the economic activity belongs to the stagnant sector. The reason to exclude manufacturing from the calculation is because it pushes the average productivity growth value upwards. Manufacturing has an average productivity growth of 0.57 percent per year measured over the period 2001 till 2015. This is by far the largest growth number compared to the other economic activities. The reason for this is that in the end technological progress materializes in manufacturing due to the intensive use of new and innovative capital (Kalpana, 2018). So, based on this classification method the progressive and stagnant sector are created. The average productivity growth per year in percentages for the progressive sector is 1.45 and 0.14 for the stagnant sector. To place the remaining economic activities in the progressive or stagnant sector a more qualitative judgement is required, because data are not available. Table 4-2 places the remaining economic activities in the progressive or stagnant sector based on a qualitative judgement.

*Table 4-2: Progressive and stagnant sector activities based on qualitative judgement*

| **Economic activities** | **Qualitative judgement** | **Progressive or Stagnant sector** |
|---|---|---|
| A: Agriculture, forestry and fishing | Labour intensive work, expected to have low productivity growth | Stagnant |
| L: Real estate activities | Classified by Storm (2017) as a progressive sector as part of “Finance, Insurance and Real Estate” (FIRE) | Progressive |
| O: Public administration and defence; compulsory social security | Public sector work is considered labour intensive and therefore low productivity growth is expected | Stagnant |
| P: Education | Classified by Storm (2017) as a stagnant sector as part of “Educational, health and private social services” (EHS) | Stagnant |
| Q: Human health and social work activities | Classified by Storm (2017) as a stagnant sector as part of “Educational, health and private social services” (EHS) | Stagnant |
| R: Arts, entertainment and recreation | Classified by Storm (2017) as a stagnant sector as part of “Rest” | Stagnant |

| | | |
|---|---|---|
| S: Other service activities | Classified by Storm (2017) as a stagnant sector as part of "Rest" | Stagnant |
| T: Activities of households as employers; undifferentiated goods- and services-producing of households for own use | Since production takes place on an individual scale, productivity growth is expected to be low | Stagnant |
| U: Activities of extraterritorial organizations and bodies | Labour intensive work, expected to have low productivity growth | Stagnant |

Figure 4-1 shows the productivity growth in percentages per year for the progressive and stagnant sector, based on the data shown in Table 4-1. Between the years 2001 and 2008, the growth in the progressive sector was significantly higher compared to the stagnant sector. Between 2008 and 2013 the growth rate in both sectors is similar. After 2013 the progressive sector grows again faster than the stagnant sector.

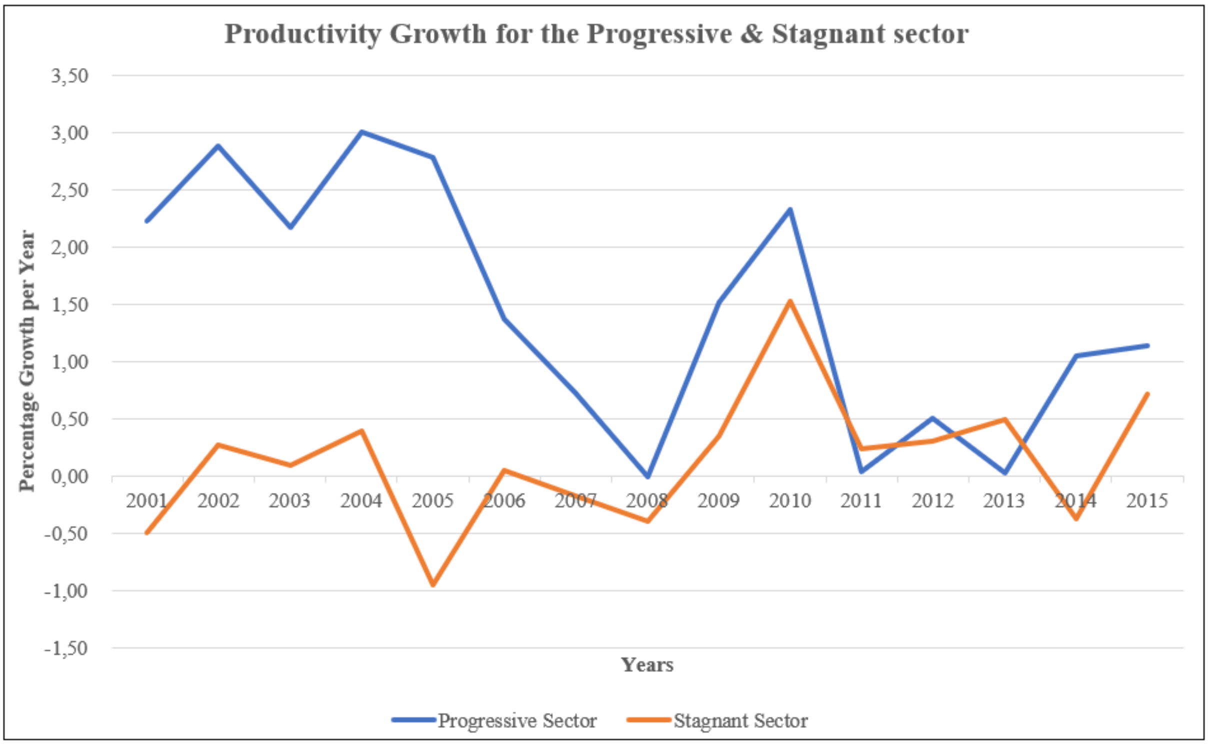



*Figure 4-1: Productivity growth per year in percentages for the progressive and stagnant sector*

## 4.2 Model Parametrization Based on Data Analysis

Part of the model parametrization relies on data analysis. This section substantiates the model parametrization based on empirical data of the U.S. economy.

### 4.2.1 GDP and Aggregate Demand Components per Sector

The progressive and stagnant sector are of the same size in terms of output (Table 4-3). The output of the progressive sector was 7,885 billion U.S. dollars in 2015. The output of the stagnant sector was 7,859 billion U.S. dollars in 2015 (OECD.stat, 2018). These figures are based on constant prices with 2009 as national base year. How these figures are determined can be found in Appendix V. In the unbalanced growth model, the progressive and stagnant sector GDP levels of 2015 are used as initial values for the progressive and stagnant sector GDP stocks.

*Table 4-3: Total and sector level GDP (OECD.stat, 2018)*

| **Sector** | **Output level 2015**<br>***Billions of U.S. Dollars*** |
|---|---|
| Progressive sector | 7,885 (50% of total GDP) |
| Stagnant sector | 7,859 (50% of total GDP) |
| Total level of GDP | 15,744 |

The progressive and stagnant sector GDP levels shown in Table 4-3 are driven by the components of aggregate demand shown in Table 4-4 (OECD.stat, 2018). Household consumption (C) is by far the largest component of aggregate demand. Almost 70 percent of GDP is dedicated to household consumption. Around 20 percent of GDP is due to private investment ($I_p$) and around 15 percent is due to public investment and expenditure ($I_g$ and G). Although the component of public expenditure is out of scope for this research, for simplicity it is taken together with public investment. Exports and imports are out of scope for this research. The percentage sum of household consumption, private investment and public investment and expenditure is 102.28 percent. The unbalanced growth model is parametrized so that 68 percent of GDP is due to household consumption, 20 percent due to private investment and 12 percent due to public investment. This is a slight deviation from the empirical values shown in Table 4-4, but the sum is exactly 100 percent. How these figures are determined can be found in Appendix VI.

*Table 4-4: Importance of aggregate demand components (OECD.stat, 2018)*

| **Aggregate Demand Components** | **Percentage of GDP 2015** |
|---|---|
| Household consumption (C) | 68.06 |
| Private investment ($I_p$) | 19.81 |
| Public investment and consumption ($I_g$ & G) | 14.41 |
| Export (E) | 12.50 |
| Import (M) | 15.39 |
| $AD = C + I_p + I_g + G + E\text{-}M$ | 99.39 |
| $AD = C + I_p + I_g + G$ | 102.28 |

To make sure that the unbalanced growth model reflects these aggregate demand proportions, autonomous consumption in the progressive sector is set at 2,135 billion U.S. dollars and autonomous consumption in the stagnant sector is set at 3,500 billion U.S. dollars. Autonomous investment in the progressive and stagnant sector is both set at zero, because the business profits are sufficient to make the required investments. The propensity to invest from the public sector is set at 0.4. This means that 40 percent out of taxation is used for public investments.

### 4.2.2 Remaining Empirical Values

**Taxation rate**

Total real income will be taxed with 30 percent. It is of course hard to find a single value for income tax, because the lowest wage jobs are taxed around 10 percent and the highest wage jobs are taxed around 40 percent (OECD.stat, 2018). However, a tax rate of 30 percent of total income is plausible to assume and will, therefore, be used in the unbalanced growth model as base value.

**Profit & Price mark-up**

The profit mark-up that is used in the unbalanced growth model is 30 percent. The profit mark-up is determined as total revenue minus total costs, which gives the total profits. The total profits are divided by the total costs and this gives the profit mark-up (Investopedia, 2018f). If the profit mark-up is below zero than revenues are lower than costs. If the profit mark-up is zero than revenues are equal to costs. If the profit mark-up is above zero than revenues are larger than costs. Again, it depends on industry and company what the profit mark-up is. Some industries or companies have a marginal profit mark-up below 10 percent, for example the aviation industry (OECD.stat, 2018). But there are also industries and companies where the profit mark-up is way larger. A profit mark-up of 30 percent is not low nor high and, therefore, serves as a good profit mark-up to use in the unbalanced growth model (Gleeson, 2018). This means that the base value for the price mark-up in the model is equal to 1 plus 0.3 which is 1.3.

**Nominal interest rate**

Since the financial crisis in 2008 the nominal interest rate for borrowing and lending is on a downturn. The reason for a low interest rate is to stimulate consumption and investment. The OECD provides timeseries data for the short and long-term nominal interest rate. Just before the financial crisis in 2007 both the short and long-term nominal interest rate were around 5 percent. In 2016 the short-term nominal interest rate was 0.64 percent and the long-term nominal interest rate was 1.80 percent (OECD.stat, 2018). To reflect the current situation regarding interest rates in the unbalanced growth model, a low and plausible nominal interest rate of 1 percent is used as base value.

**Balance between public investment in progressive and stagnant sector**

The U.S. government invests around 50 percent of their total investments in the progressive sector and the remaining 50 percent in the stagnant sector. This conclusion is made after the analysis of the input-output table of the U.S. for the year 2011 (OECD.stat, 2018). The column "*TTL_C75: Public administration and defence; compulsory social security*" is taken and for each row is determined if the money is spent in the progressive or stagnant sector. Appendix VII shows the specific column and rows of the U.S. 2011 input-output table. So, in the unbalanced growth model the progressive and stagnant sector investment switch is set at 0.5.

**Nominal wage, Productivity and Price**

The nominal wage level and productivity level in both the progressive and stagnant sector start in the unbalanced growth model with an initial value of 1. The starting value is not interesting, the behaviour over time is interesting, especially between the sectors. Therefore, it is important to have a common baseline for both sectors. The price level in both sectors starts with an initial value of 1.3, this is due to the relation that is built into the model (Equation 4-1). As determined before the profit mark-up is 30 percent and, therefore, the value of 1.3 is inserted for the price mark-up. Since wage and productivity start with the value 1, the price level for both sectors starts at 1.3. Again, it is important to have a common baseline for both sectors to discover price level differences between the sectors over time.

$$Price\ level = price\ mark\ up * \frac{Wage\ level}{Productivity\ level} = 1.3 * \frac{1}{1} = 1.3$$

*Equation 4-1: Price level equation in unbalanced growth model*

## 4.3 Model Parametrization Based on Econometrics

Part of the unbalanced growth model parametrization relies on econometrics. To be able to use a realistic magnitude for the relations between the macroeconomic components of unbalanced growth, coefficients are empirically estimated with the help of econometrics. It concerns the relations between: income and consumption, interest rate and consumption, profits and investments, interest rate and investments, and investments and productivity. Aggregate economic data of the U.S. economy is used to perform the analyses.

In econometrics one tries to empirically estimate the relation between variables with the help of statistical methods or econometric models. One of the best known and used methods is regression (Hill, Griffiths, & Lim, 2011). For this research econometrics is used to roughly estimate the relation between variables. The relation between variables is estimated with the help of Ordinary Least Squares (OLS) regression (Hill, Griffiths, & Lim, 2011). Data from OECD.stat (2018) are used, these are timeseries data. Timeseries data cannot be used directly for econometric analyses, because of non-stationarity, autocorrelation, and spurious regression (Hill, Griffiths, & Lim, 2011). To roughly overcome these issues the data that are used for the analyses are growth rates per year. This helps to make the data stationary, which eliminates spurious regression and autocorrelation. Next, a data set is created and the analysis is performed. The econometric models are built and simulated in the statistical software package STATA (STATA, 2018). For each econometric model the following results are shown: coefficient name, the coefficient value, P-statistics, number of observations (N), R-squared and F-statistics. The script written in STATA and the data set to perform the econometric analyses are shown in Appendix VIII.

### 4.3.1 Regression of Income on Consumption

Equation 4-2 shows the functional form of the regression models, with consumption as dependent variable and income as independent variable. The interesting coefficients are β1p and β1s. These coefficients give the relation between income on progressive sector consumption (β1p) and stagnant sector consumption (β1s). To be able to perform an econometric analysis data for both income and consumption per sector are required. Timeseries data from 1970 until 2015 on a yearly basis are used. OECD.stat (2018) provides data for net national disposable income in millions of U.S. dollars and final consumption expenditure of households on the territory and abroad in millions of U.S. dollars. These data are based on constant prices and constant PPPs for OECD base year 2010. The data are divided by a factor 1,000 to make it billions of U.S. dollars and the first difference is taken to express the data in growth rates. After analysis of the U.S. input-output table for the year 2011 it is possible to conclude that 53 percent of total consumption is dedicated to progressive sector consumption and 47 percent is dedicated to stagnant sector consumption. To determine this the row table "*HFCE: Households final consumption expenditure*" out of the 2011 U.S. input-output table is taken and for each column is determined if the money is spent in the progressive or stagnant sector.

$$Consumption\ P = \beta 0p + \boldsymbol{\beta 1p} * Income$$
$$Consumption\ S = \beta 0s + \boldsymbol{\beta 1s} * Income$$

*Equation 4-2: Regression model of income on consumption*

After the econometric analysis the results are shown in Table 4-5. The relation between income and progressive sector consumption is 0.259 and the relation between income and stagnant sector consumption is 0.230. Both values are significantly different from zero on a 95 percent significance level. So, if income increases with 1 billion U.S. dollar, consumption in the progressive sector increases with 0.259 billion U.S. dollars and in the stagnant sector with 0.230 billion U.S. dollars.

*Table 4-5: The OLS regression results for income on consumption*

| **Coefficient** | **Value** | **Significance (P < 0.05)** | **N** | **$R^2$** | **F** |
|---|---|---|---|---|---|
| β1p | **0.259** (dimensionless) | 0.000 | 46 | 0.6770 | 95.33 |
| β1s | **0.230** (dimensionless) | 0.000 | 46 | 0.6770 | 95.33 |

The values shown in Table 4-5 are directly inserted in the unbalanced growth model, because no conversion factor is required. For the econometric analysis growth rates in billions of U.S. dollars are used for consumption and income. In the unbalanced growth model, the real values for consumption and income per year are used in billions of U.S. dollars. This means that the relation between the variables does not change. Appendix IX shows the prepared data and the regression output tables.

### 4.3.2 Regression of Interest Rate on Consumption

Equation 4-3 shows the functional form of the regression models, with consumption as dependent variable and the interest rate as independent variable. The interesting coefficients are β1p and β1s. These coefficients give the relation between interest rate on progressive sector consumption (β1p) and stagnant sector consumption (β1s). To be able to perform an econometric analysis data for both the interest rate and consumption per sector are required. Timeseries data from 1970 until 2015 on a yearly basis are used. OECD.stat (2018) provides data for the short-term nominal interest rate. Econometric analysis with the real short-term interest rate (nominal interest rate minus inflation) does not yield plausible and significant results, therefore the nominal short-term interest rate is used. The short-term nominal interest rate is divided by a factor 100. For the nominal short-term interest rate, it is not necessary to use growth rates, because the data are already stationary. The consumption data for both the progressive and stagnant sector as described in section 4.3.1 and Appendix IX are used.

$$Consumption\ P = \beta 0p - \boldsymbol{\beta 1p} * Short\ Term\ Interest\ Rate$$
$$Consumption\ S = \beta 0s - \boldsymbol{\beta 1s} * Short\ Term\ Interest\ Rate$$

*Equation 4-3: Regression model of interest rate on consumption*

After the econometric analysis the results are shown in Table 4-6. The relation between nominal short-term interest rate and progressive sector consumption is -708 and the relation between nominal short-term interest rate and stagnant sector consumption is -628. Both values are significantly different from zero on a 95 percent significance level.

*Table 4-6: The OLS regression results for interest rate on consumption*

| **Coefficient** | **Value** | **Significance (P < 0.05)** | **N** | $\mathbf{R^2}$ | **F** |
|---|---|---|---|---|---|
| β1p | -708 (Billions of U.S. Dollars/ (percentages/100)) | 0.004 | 46 | 0.17 | 9.01 |
| β1s | -628 (Billions of U.S. Dollars/ (percentages/100)) | 0.004 | 46 | 0.17 | 9.01 |

The values shown in Table 4-6 cannot be directly inserted into the unbalanced growth model, because in the econometric model growth rates are used for consumption and in the unbalanced growth model real values for consumption per year are used. Meanwhile, in both the econometric model and unbalanced growth model the interest rate in percentages per year divided by a factor 100 is used (Table 4-7). After analysis of the growth rate consumption data and real value consumption data has been concluded that the interest rate coefficients should be multiplied with a factor 34 to reflect the difference between the econometric and unbalanced growth model relation. So, if the interest rate increases with 1 percent (0.01), consumption in the progressive sector decreases with 240.72 billion U.S. dollars and in the stagnant sector with 213.52 billion U.S. dollars. Appendix X shows the prepared data and the regression output tables.

*Table 4-7: Conversion factor for interest rate on consumption*

| Econometric relation | Unbalanced growth model relation | Vensim value | |
|---|---|---|---|
| Consumption (B.$ growth)<br>Interest rate (%/100) | Consumption (B.$)<br>Interest rate (%/100) | β1p | -708*34 = **-24,072** |
| | | β1s | -628*34 = **-21,352** |

### 4.3.3 Regression of Business Profits on Investments

Equation 4-4 shows the functional form of the regression models, with investment as dependent variable and business profits as independent variable. The interesting coefficients are β1p and β1s. These coefficients give the relation between progressive and stagnant sector business profits on progressive sector investments (β1p) and stagnant sector investments (β1s). To be able to perform an econometric analysis data for both the business profits and investments per sector are required. Timeseries data from 1998 until 2014 on a yearly basis are used. Longer timeseries are not available for this level of aggregation. OECD.stat (2018) provides data for the gross operating surplus in millions of U.S. dollars (business profits) and gross fixed capital formation in millions of U.S. dollars (Investments). These data are based on current prices, because data based on constant prices are not available for business profits. However, this is not a problem, because for both the investments and business profits current prices are used, so the relation between the variables does not change. The data are divided by a factor 1,000 to make it billions of U.S. dollars and the first difference is taken to express the data in growth rates. For both the business profits and investments, the data are available per economic activity, so it is rather straightforward to create a data set for the progressive and stagnant sector.

$$Investments\ P = \beta 0p + \boldsymbol{\beta 1p} * Business\ Profits\ P$$
$$Investments\ S = \beta 0s + \boldsymbol{\beta 1s} * Business\ Profits\ S$$

*Equation 4-4: Regression model of business profits on investments*

After the econometric analysis the results are shown in Table 4-8. The relation between progressive sector business profits and progressive sector investments is 1.183 and the relation between stagnant sector business profits and stagnant sector investments is 0.585. Both values are significantly different from zero on a 95 percent significance level. Investors are much more willing to invest in the progressive sector compared to the stagnant sector. So, if business profits increase with 1 billion U.S. dollar, investments in the progressive sector increase with 1.183 billion U.S. dollars and in the stagnant sector with 0.585 billion U.S. dollars.

*Table 4-8: The OLS regression results for business profits on investments*

| Coefficient | Value | Significance ($P < 0.05$) | N | $R^2$ | F |
|---|---|---|---|---|---|
| β1p | **1.183** (dimensionless) | 0.011 | 17 | 0.3597 | 8.43 |
| β1s | **0.585** (dimensionless) | 0.009 | 17 | 0.3765 | 9.06 |

The values shown in Table 4-8 are directly inserted in the unbalanced growth model, because no conversion factor is required. For the econometric analysis growth rates in billions of U.S. dollars are used for business profits and investments. In the unbalanced model the real values for business profits and investments per year are used in billions of U.S. dollars. This means that the relation between the variables does not change. Appendix XI shows the prepared data and the regression output tables.

### 4.3.4 Regression of Interest Rate on Investments

Equation 4-5 shows the functional form of the regression models, with investment as dependent variable and the interest rate as independent variable. The interesting coefficients are β1p and β1s. These coefficients give the relation between interest rate on progressive sector investment (β1p) and stagnant sector investment (β1s). To be able to perform an econometric analysis data for both the interest rate and investment per sector are required. Timeseries data from 1998 until 2014 on a yearly basis are used. Longer timeseries are not available for this level of aggregation. OECD.stat (2018) provides data for the long-term nominal interest rate and inflation in percentages. To determine the real long-term interest rate the inflation has been deducted from the long-term nominal interest rate. The real long-term interest rate is divided by a factor 100 and the first difference is taken to express the data in growth rates. Gross fixed capital formation in millions of U.S. dollars is used for investments. These data are based on constant prices with 2009 as national base year. The investment data are divided by a factor 1,000 to make it billions of U.S. dollars and the first difference is taken to express the data in growth rates. For investments, the data are available per economic activity, so it is rather straightforward to create a data set for the progressive and stagnant sector.

$$Investments\ P = \beta 0p - \boldsymbol{\beta 1p} * Long\ Term\ Interest\ Rate$$
$$Investments\ S = \beta 0s - \boldsymbol{\beta 1s} * Long\ Term\ Interest\ Rate$$

*Equation 4-5: Regression model of interest rate on investments*

After the econometric analysis the results are shown in Table 4-9. The relation between real long-term interest rate and progressive sector investment is -2,142 and the relation between real long-term interest rate and stagnant sector investment is -2,670. β1s is significantly different from zero on a 95 percent significance level, but β1p is not. Despite the fact that β1p is not significantly different from zero, the value is of the same growth order as β1s and, therefore, plausible to assume. As a result, β1p is parametrized as -2,142. So, if the interest rate increases with 1 percent (0.01), investment in the progressive sector decreases with 21.42 billion U.S. dollars and in the stagnant sector with 26.70 billion U.S. dollars.

*Table 4-9: The OLS regression results for interest rate on investments*

| Coefficient | Value | Significance (P < 0.05) | N | $R^2$ | F |
|---|---|---|---|---|---|
| β1p | **-2,142** (Billions of U.S. Dollars/ (percentages/100)) | 0.297 | 17 | 0.0723 | 1.17 |
| β1s | **-2,670** (Billions of U.S. Dollars/ (percentages/100)) | 0.001 | 17 | 0.5109 | 15.67 |

The values shown in Table 4-9 are directly inserted in the unbalanced growth model, because no conversion factor is required. For the econometric analysis growth rates in billions of U.S. dollars are used for investments and growth rates in percentages divided by 100 are used for the long-term interest rate. In the unbalanced growth model, the real values for investments and interest rates are used. This means that the relation between the variables does not change. Appendix XII shows the prepared data and the regression output tables.

### 4.3.5 Regression of Investments on Productivity

Equation 4-6 shows the functional form of the regression models, with productivity as dependent variable and investment and GDP as independent variables. The interesting coefficients are β0p, β1p, β0s and β1s. β0p (progressive sector) and β0s (stagnant sector) are the intercept coefficients and reflect autonomous productivity growth. The coefficients β1p (progressive sector) and β1s (stagnant sector) give the relation between sector investments and sector productivity growth. Coefficients β0p and β0s are estimated with productivity and investment data. Coefficients β1p and β1s are estimated with productivity and GDP data. GDP is used as a proxy for investments, because with investment data alone a significant relation between productivity and investment could not be found. The assumption that GDP growth reflects investment growth is made. To be able to perform an econometric analysis data for investments, GDP and productivity per sector are required. Timeseries data from 2001 until 2015 on a yearly basis are used. Longer timeseries are not available for this level of aggregation. OECD.stat (2018) provides data for gross fixed capital formation in millions of U.S. dollars (Investments), GDP in millions of U.S. dollars and industry contribution to business sector labour productivity growth in percentages. The investment and GDP data are based on constant prices with 2009 as national base year. The investment and GDP data are divided by a factor 1,000 to make it billions of U.S. dollars and the first difference is taken to express the data in growth rates. The productivity data are divided by a factor 100. For investments, GDP and productivity the data are available per economic activity, so it is rather straightforward to create a data set for the progressive and stagnant sector.

$$Productivity\ P = \boldsymbol{\beta 0p} + \beta 1p * Investments\ P$$
$$Productivity\ S = \boldsymbol{\beta 0s} + \beta 1s * Investments\ S$$

$$Productivity\ P = \beta 0p + \boldsymbol{\beta 1p} * GDP\ P$$
$$Productivity\ S = \beta 0s + \boldsymbol{\beta 1s} * GDP\ S$$

*Equation 4-6: Regression model of investments on productivity*

After the econometric analysis the results are shown in Table 4-10. Autonomous productivity growth in the progressive sector is 1.36 percent per year and the coefficient for investment driven productivity growth in the progressive sector is 0.0000462. These two values are significantly different from zero on a 90 percent significance level. The coefficients β0s and β1s for the stagnant sector are not significantly different from zero. This does not mean that there is no productivity growth in the stagnant sector, but that with this analysis no relation could be established. For practical reasons, in the unbalanced growth model stagnant sector investment driven productivity growth is set at zero and autonomous productivity growth in the stagnant sector is set at 0.14 percent, as determined in Table 4-1.

*Table 4-10: The OLS regression results for investments on productivity*

| **Coefficient** | **Value** | **Significance (P < 0.1)** | **N** | **$R^2$** | **F** |
|---|---|---|---|---|---|
| β0p | **0.0136** (percentages/100) | 0.001 | 15 | N/A | N/A |
| β1p | 0.0000462 ((percentages/100)/ Billions of U.S. Dollars) | 0.058 | 14 | 0.2673 | 4.38 |
| β0s | 0.0011 (percentages/100) | 0.452 | 15 | N/A | N/A |
| β1s | 6.22e-06 ((percentages/100)/ Billions of U.S. Dollars) | 0.704 | 14 | 0.0124 | 0.15 |

The value for β1p shown in Table 4-10 cannot be directly inserted into the unbalanced growth model, because in the econometric model growth rates are used for GDP and in the unbalanced growth model real values for investments per year are used. Meanwhile, in both the econometric model and unbalanced growth model productivity growth in percentages per year divided by a factor 100 are used (Table 4-11). After analysis of the growth rate GDP data and real value investment data has been concluded that the investment coefficient β1p should be divided by a factor 11 to reflect the difference between the econometric and unbalanced growth model relation. So, if investments are 1,000 billion U.S. dollars in a specific year, productivity growth due to investments is equal to 0.42 percent per year. Appendix XIII shows the prepared data and the regression output tables.

*Table 4-11: Conversion factor for investments on productivity*

| **Econometric relation** | **Unbalanced growth model relation** | **Vensim value** | |
|---|---|---|---|
| Productivity (%/100 growth)<br>GDP (B.$ growth) | Productivity (%/100 growth)<br>Investments (B.$) | β1p | 0.0000462/11 =<br>**0.0000042** |

## 4.4 Overview of Exogenous Parameters and Coefficients

All the exogenous unbalanced growth model parameters and coefficients are obtained by means of data analysis or econometrics, and the data clearly shows unbalanced growth between the progressive and stagnant sector. In Table 4-12 an overview is presented of all the exogenous model parameters, their corresponding empirical values and their units.

*Table 4-12: Exogenous unbalanced growth model parameters and coefficients*

| **Unbalanced growth model parameter** | **Value** | **Units** |
|---|---|---|
| **Input parameters** | | |
| Autonomous consumption progressive sector | 2,135 | Billions of U.S. Dollars |
| Autonomous consumption stagnant sector | 3,500 | Billions of U.S. Dollars |
| Autonomous investment progressive sector | 0 | Billions of U.S. Dollars |
| Autonomous investment stagnant sector | 0 | Billions of U.S. Dollars |
| Propensity to invest public sector | 0.4 | Dimensionless |
| Nominal wage progressive sector | 1 | Dimensionless |
| Nominal wage stagnant sector | 1 | Dimensionless |
| Taxation rate | 0.3 | Dimensionless |
| Price mark-up progressive sector | 1.3 | Dimensionless |
| Price mark-up stagnant sector | 1.3 | Dimensionless |
| Progressive and stagnant sector investment switch | 0.5 | Dimensionless |
| Nominal interest rate | 0.01 | Dimensionless |
| **Stock initial values** | | |
| Productivity progressive sector | 1 | Dimensionless |
| Productivity stagnant sector | 1 | Dimensionless |
| Price level progressive sector | 1.3 | Dimensionless |
| Price level stagnant sector | 1.3 | Dimensionless |
| Real GDP progressive sector | 7,885 | Billions of U.S. Dollars |
| Real GDP stagnant sector | 7,859 | Billions of U.S. Dollars |
| **Input coefficients (econometrically estimated)** | | |
| Autonomous productivity growth progressive sector | 0.0136 | Dimensionless |
| Kaldor-Verdoorn coefficient progressive sector | 4.2e-06 | 1/ Billions of U.S. Dollars |
| Autonomous productivity growth stagnant sector | 0.0014 | Dimensionless |
| Kaldor-Verdoorn coefficient stagnant sector | 0 | 1/ Billions of U.S. Dollars |
| Consumption coefficient progressive sector | 0.259 | Dimensionless |
| Interest rate consumption coefficient progressive sector | -24,072 | Billions of U.S. Dollars |
| Consumption coefficient stagnant sector | 0.230 | Dimensionless |
| Interest rate consumption coefficient stagnant sector | -21,352 | Billions of U.S. Dollars |
| Investment coefficient progressive sector (profits used for investments) | 1.183 | Dimensionless |
| Interest rate investment coefficient progressive sector | -2,142 | Billions of U.S. Dollars |
| Investment coefficient stagnant sector (profits used for investments) | 0.585 | Dimensionless |
| Interest rate investment coefficient stagnant sector | -2,670 | Billions of U.S. Dollars |

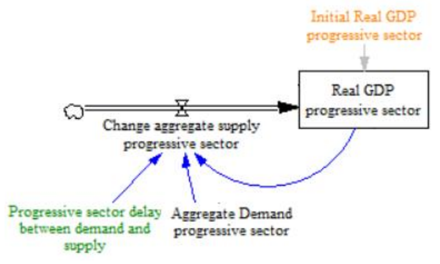
## 4.5 Verification and Validation

Verification and validation are used to build confidence in the unbalanced model by checking if the model is built correctly (verification) and by testing if the model is suitable for its purpose (validation) (Oreskes, Shrader-Frechette, & Belitz, 1994). The model is checked on correctness by assessing if all model parameters are dimensionally consistent with each other and by checking if the integration method is correct. With respect to validation, the unbalanced growth model is assessed on structure and behaviour (Forrester & Senge, 1980; Sterman, 2000). The structure of the model is assessed by using the following tests: structure assessment, parameter assessment and boundary adequacy. The behaviour of the model is assessed by using the following tests: behaviour reproduction, and behavioural/numerical validation with theory and empirical data. These tests show that the model has heuristic value with respect to the purpose of this research (Oreskes, Shrader-Frechette, & Belitz, 1994). As a result, the model can be used as tool to help to find the driving factors behind unbalanced growth and how these factors should be influenced. The unbalanced growth model is validated on the base case, the model is parametrized with the empirical data found in this chapter, see Table 4-12.

### 4.5.1 Verification

**Dimensional Consistency**
In the unbalanced growth model all equations/variables have units which are dimensionally consistent with each other. Only for the GDP and price stock/flow structure a 'year factor' is used to model the flow variables as 'unit per year'. Why this is done can be explained with the help of Table 4-13. This table shows the stock/flow structure for progressive sector GDP. Without the 'year factor' both the flow and stock variable are in billions of U.S. dollars. The flow variable is in billions of U.S. dollars, because the difference is taken between progressive sector GDP and progressive sector aggregate demand, which are both in billions of U.S. dollars. However, the flow variable is the change in GDP per year. So, therefore the 'year factor' is used. A similar structure is used for the following stock/flow structures: stagnant sector GDP, progressive sector price level and stagnant sector price level.

*Table 4-13: Progressive sector GDP stock/flow structure*

| Model structure | Equations | Units |
|---|---|---|
|  | <u>Flow</u>: (Aggregate Demand progressive sector-Real GDP progressive sector)/Year factor | Billions of U.S. Dollars/ Year |
| | <u>Stock</u>: Change aggregate supply progressive sector | Billions of U.S. Dollars |

**Integration Error**
The simulation results are not sensitive for time step and numerical integration method changes. The unbalanced growth model is tested with different timesteps and numerical integration methods. The following timesteps are used: 0.03125/year, 0.0625/year and 0.125/year. The following numerical integration methods are used: Runge-Kutta 4 Auto, Runge-Kutta 4 Fixed and Euler. For all combinations the results are exactly the same. Only Euler shows a slightly different behaviour compared to Runge-

Kutta when it comes to oscillation. However, the small difference cancels out over time. As a result, the simulation results are not sensitive for time step nor numerical integration method changes.

### 4.5.2 Validation

**Structure Assessment**

The unbalanced growth model is built to explore the phenomenon of unbalanced growth in a macroeconomic context. Therefore, the model is limited to economic relations and built on a macroeconomic aggregation level. The assessment of the structure of the model is shown in Table 4-14.

*Table 4-14: Structure assessment of the unbalanced growth model*

| Questions | Substantiation |
|---|---|
| Is the model structure consistent with relevant descriptive knowledge of the system? | The descriptive knowledge of the system is captured in macroeconomic theory and the model is modelled as such. For each component sound macroeconomic equations are formulated. |
| Is the level of aggregation appropriate? | The intention is to model on a macroeconomic aggregation level. The model is able to produce simulation results with respect to important macroeconomic KPI's. These are: real output, wage, price, employment and technological progress (productivity). And the model is able to show unbalanced growth behaviour, because the macroeconomy is modelled as a progressive and stagnant sector. As a result, one can conclude that the model produces results that are interesting in the context of this research and, therefore, the level of aggregation is appropriate. |
| Does the model conform to basic physical laws? | The model is built according to macroeconomic theory and the corresponding equations, see section 3.1. |
| Do the decision rules capture the behaviour of the actors in the system? | Human behaviour is not explicitly modelled in the model. However, implicitly the macroeconomic equations take human behaviour into account. For example, if price decreases, demand increases. |

**Parameter Assessment**

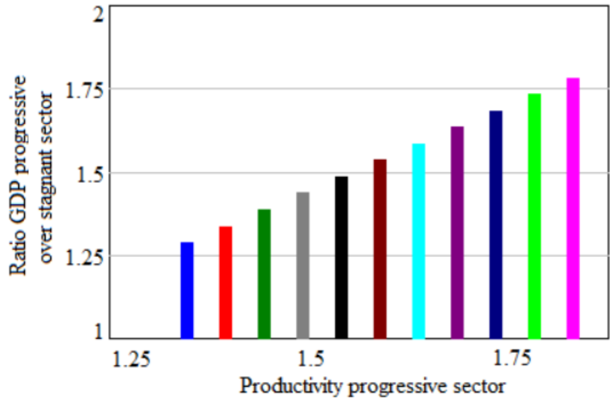
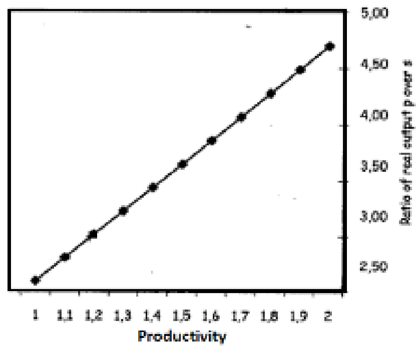
All unbalanced growth model parameter values provide relevant descriptive and numerical knowledge of the system. However, not all parameters have real world counterparts, because this is an economic model and not a simulation model. As a result, some parameters represent ratios between two variables, for example 'relative price progressive sector'. This parameter represents the ratio between progressive sector price level and overall price level. There is obviously no real-world counterpart of this parameter, but it is still important to use this parameter in the unbalanced growth model, because it helps to model the economic relation between demand and price. After assessment can be concluded that all parameters are relevant even if they do not represent a real-world counterpart. As a result, the model can be used in an economic modelling context, to explore economic phenomena, but cannot be used to explore operational phenomena, because it is not a full simulation model.

**Boundary Adequacy**

From an economic perspective all main components that are important to assess unbalanced growth are endogenous. Aggregate supply is driven by aggregate demand and aggregate demand is driven by the endogenous components of consumption, private investment and public investment. Productivity, price and wage are the three most important components when addressing unbalanced growth and these are all endogenous. However, from a modelling and simulation perspective more components can be made endogenous. For example, productivity is next to investments also driven by education, and real output is next to productivity also driven by demographics. The same conclusion as for parameter assessment holds true: the unbalanced growth model can be used in an economic modelling context, to explore economic phenomena, but cannot be used to explore operational phenomena, because it is not a full simulation model.

**Behaviour Reproduction**

The unbalanced growth model reproduces the simulation results of the income-driven model variant C of Groot & Schettkat (1999) and this strengthens the economic validaty of the unbalanced growth model. Figure 4-2 shows the unbalanced growth model simulation results on the left side and Groot & Schettkat income-driven model variant C results on the right side. The results are shown for two outcomes of interest used by Groot & Schettkat (1999): ratios between real output and employment. The plots cannot be compared on numerical values, because the paramatrization for both models is different, but it can be compared on behaviour. The 'ratio GDP progressive over stagnant sector' is similar for both models when only focused on behaviour. This means that the progressive sector in terms of output grows relatively compared to the stagnant sector if productivity increases in the progressive sector. The 'ratio employment level progressive over stagnant sector' is similar too for both models when only focused on behaviour. This means that the employment ratio between the progressive and stagnant sector stays constant despite the fact that productivity increases in the progressive sector.

<table>
<tr><th>Unbalanced growth model behaviour</th><th>Groot & Schettkat income-driven model variant C behaviour</th></tr>
<tr><td colspan="2"><u>Ratio GDP progressive over stagnant sector</u></td></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Ratio employment level progressive over stagnant sector

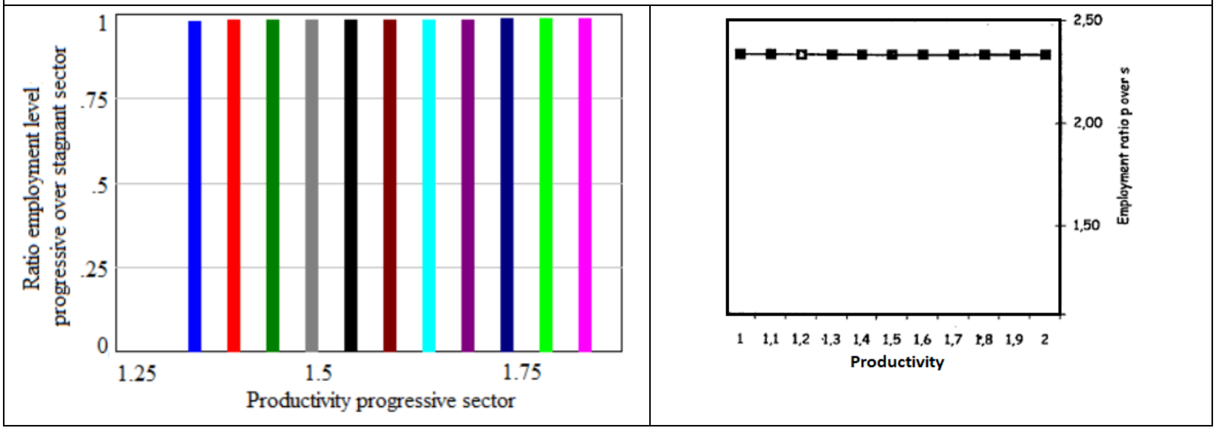



*Figure 4-2: Behaviour reproduction of Groot & Schettkat income-driven model variant C*

**Simulation Results compared to Reality**

The unbalanced growth model simulation results are in line with reality from a behavioural point of view and are reasonably in line with reality from a numerical point of view. Simulation results are generated for the five most important outcomes of interest: economic growth, employment, price level, wage level and productivity. The simulation results are based on the base case parametrization as shown in Table 4-12. For each outcome of interest, the behaviour is explained, next the simulation results are compared to reality from a behavioural and numerical point of view.

Economic Growth

In terms of real output (GDP) growth there is clear unbalanced sectorial growth (Figure 4-3). The progressive sector grows and the stagnant sector declines over the years. One can observe a steady growth rate for progressive sector products and services. This is due to the fact that progressive sector productivity grows rapidly, as a result progressive sector prices decline and thus demand for these goods and services increases. Meanwhile the growth rate for stagnant sector products and services is negative. Wages grow quicker than productivity does and thus prices increase. This results in lower demand for stagnant sector products and services. The effect is that total real GDP shows barely no growth.

Employment Level

The demand for employment in both sectors is quite concerning (Figure 4-3). Despite the fact of GDP growth in the progressive sector, productivity grows faster than progressive sector real output. Therefore, employment in the progressive sector declines over the years. Employment in the stagnant sector declines as well over the years, because demand for stagnant sector products and services decreases due to higher prices. As a result of the downward trend in both the progressive and stagnant sector, total employment declines rapidly over the years. The ratio between progressive and stagnant sector employment stays constant. So, with respect to employment there is no unbalanced growth between the progressive and stagnant sector. However, the rapid decline in employment over the years is concerning and is a negative consequence of unbalanced growth.

The remarkable behaviour between 2015 and 2020 shown in the figure “Ratio employment level progressive over stagnant sector” is due to the fact that in the first three years employment in the progressive sector declines more rapidly than employment in the stagnant sector, in year four and five this is the other way around. After 2020 the decline in employment in both sectors per year is comparable.

Price Level

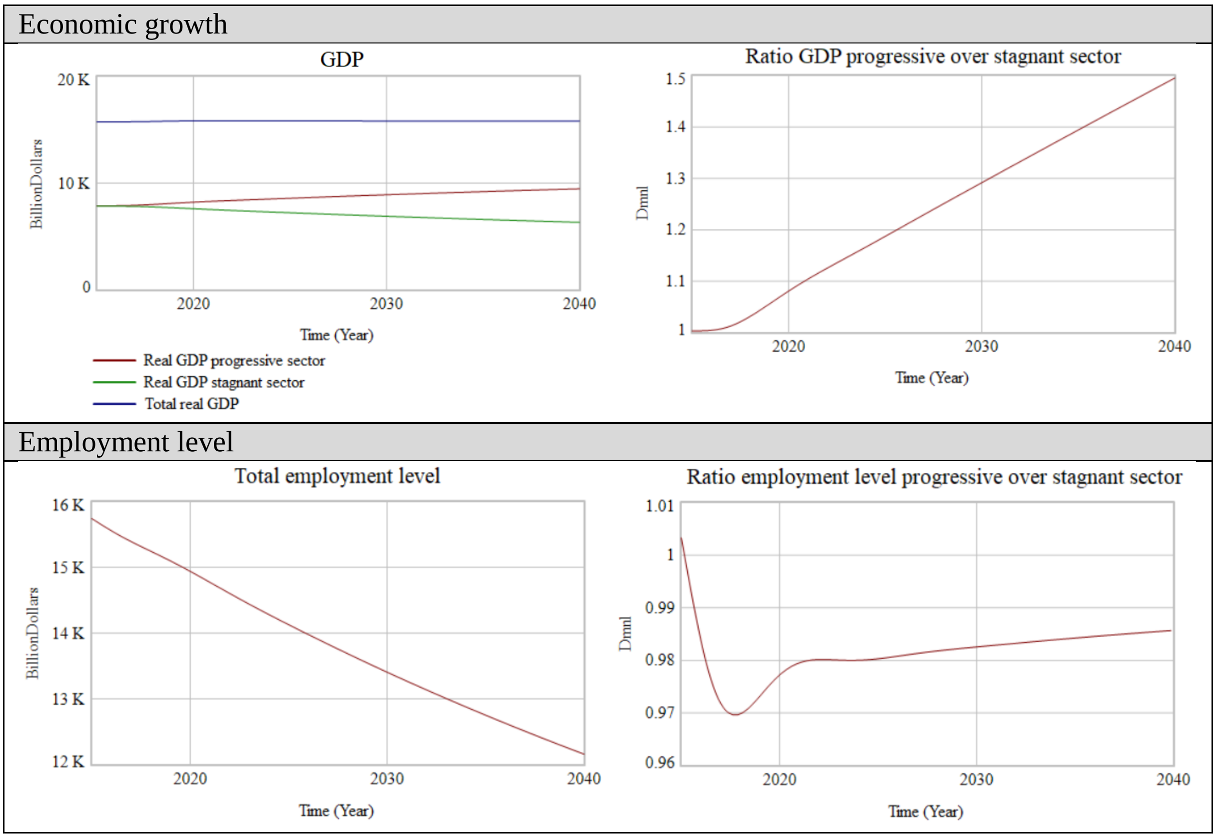
In terms of price level there is clear evidence of unbalanced growth (Figure 4-3). Nominal wages in the progressive sector increase slower than progressive sector productivity does, therefore the price level of progressive sector goods and services decreases over years. Nominal wages in the stagnant sector increase faster than stagnant sector productivity does, therefore the price level of stagnant sector goods and services increases. There is a growing gap between the price of progressive and stagnant sector goods and services. This is what Baumol (1967) calls the 'cost disease'.

Wage Level

Nominal wages in both the progressive and stagnant sector develop according to average productivity growth and are therefore the same. So, the ratio between progressive and stagnant sector wages is equal to one (Figure 4-3).

Productivity

In terms of productivity there is clear evidence of unbalanced growth (Figure 4-3). Productivity in the progressive sector grows significantly faster than productivity in the stagnant sector. Productivity growth per year in the progressive sector is roughly 2.2 percent. 1.4 percent is due to autonomous productivity growth and 0.9 percent is due to private investments in the progressive sector. Productivity growth per year in the stagnant sector is roughly 0.14 percent. This results in an average productivity growth of 1.2 percent per year.



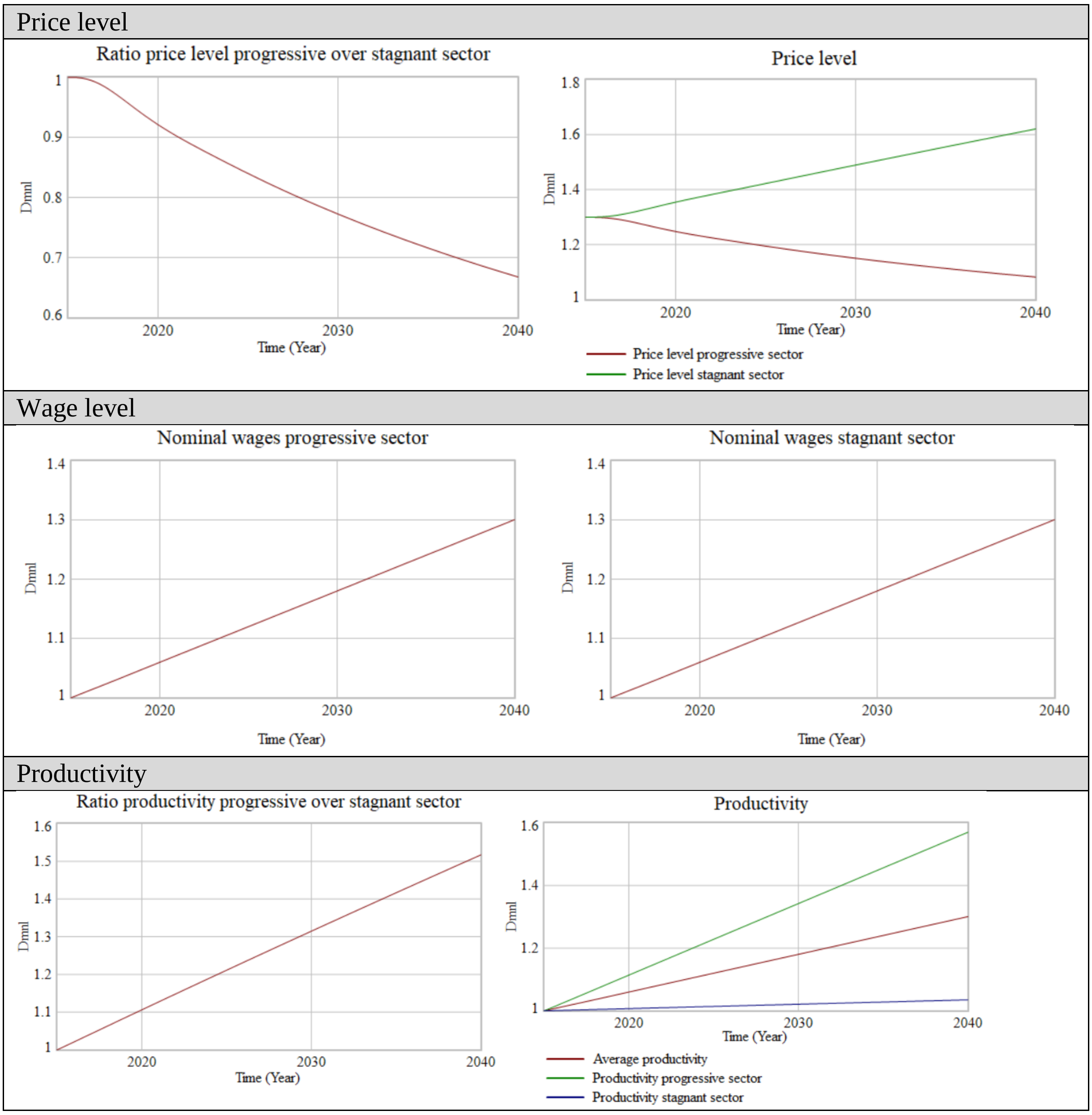



*Figure 4-3: Simulation results for the outcomes of interest*

<u>Comparison to Reality</u>

From a behavioural point of view the results are in line with reality. The simulation results show real output growth in the progressive sector and decline in the stagnant sector, this leads to declining growth rates for the overall economy, which is known as secular stagnation (Eichengreen, 2015). The simulation results also show that without policy interventions or structural changes, employment demand declines over the years, just as hypothesized by Manyika, et al. (2017) who states that 800 million workers will lose their jobs by 2030 if they are not retrained. The simulation results also clearly show the cost disease as described by Baumol (1967), stagnant sector prices increase when compared to progressive sector prices. Think about health care costs, health care is part of the stagnant sector and the costs are rising over the years. Finally, the simulation results show large productivity growth over years in the progressive sector, barely no productivity growth in the stagnant sector and therefore slow overall productivity growth. This is in line with the articles about productivity, published by the OECD (2016, 2017).

From a numerical point of view, the results are reasonably in line with reality. With respect to employment Illanes, Lund, Mourshed, Rutherfor, & Tyreman (2018) state that around 2030 14 percent of the global workforce must switch work due to automation to avoid unemployment. The simulation results show that without policy interventions and structural changes employment declines with roughly 1 percent per year starting in 2015. So, in 2030 this is roughly a decline of 15 percent of the total workforce. With respect to productivity growth the simulation results show that productivity in the progressive sector grows with 2.2 percent per year. However, the empirically estimated results in section 4.1 show that the average productivity growth in the progressive sector over the past years was 1.45 percent per year. So, the simulation results seem to be overestimated. However, the 1.45 percent figure includes the financial crisis years from 2008 untill 2011 and in these years productivity growth was almost zero. So, productivity growth in the progressive sector of approximately 2 percent per year is plausible to assume. With respect to total real output or GDP growth, the simulation results show barely no economic growth over the coming 25 years. On the one hand, this provides evidence for secular stagnation as pointed out by Eichengreen (2015). On the other hand, barely no growth in the coming decades is not very plausible to assume if one takes into account the forecasts of U.S. GDP growth made by several institutions (Knoema, 2018). They show roughly a growth of 2 percent per year over the next 5 years. The difference between the simulation results and the forecasts might be explained due to the fact that demographics are not included in the unbalanced growth model.

### 4.5.3 Conclusion Verification and Validation

The unbalanced growth model is fit for its purpose to help to find the driving factors behind unbalanced growth, and how these factors should be influenced. Based on the structure assessment it is possible to conclude that the model is built on an appropriate macroeconomic aggregation level, so that the model can be used in an economic modelling context, to explore the unbalanced growth phenomenon and the driving factors. The behaviour assessment of the model strengthens the confidence in the results, because the unbalanced growth model results are comparable to the Groot & Schettkat model results, and the unbalanced growth model results are in line with reality from a behavioural point of view.

However, the explanation is only valid as long as it is a macroeconomic explanation for the driving factors. The reason for this is that the unbalanced growth model is based on macroeconomic theory and built on a macroeconomic aggregation level. As long as the model is used within the macroeconomics paradigm, the behavioural tests show that the model is able to produce plausible results with respect to the development of unbalanced growth. And with the help of sensitivity analysis and scenario discovery the model can be used as exploration tool to explore “what if” questions, thereby finding which factors are sensitive with respect to unbalanced growth development and how these factors should be influenced. Thus, the primary value of this model is heuristic. The unbalanced growth model is useful for guiding further study, but is not susceptible to proof (Oreskes, Shrader-Frechette, & Belitz, 1994).

## 4.6 Experimental Set-Up

The experimental set-up is determined in a way that exploratory modelling or open exploration can be performed. Simulation and analysis are performed with the EMA workbench (Kwakkel, 2012). The EMA workbench works with the programming language Python (Python, 2018). With the Python script the simulation runs are set up, specified, executed, visualised and analysed. The unbalanced growth model is simulated over a time span of 25 years from 2015 until 2040. The correct timestep is a trade-off between efficiency and accuracy. After testing is concluded that a timestep of 0.125/year should be used. The simulation results are exactly the same for timestep 0.03125/year, 0.0625/year and 0.125/year.

Furthermore, with timestep 0.125/year it is still possible to run a large amount of experiments and also perform analysis on the results. To numerically solve ODEs in Vensim, the Euler and Runge-Kutta method can be used (Davis & Rabinowitz, 1984). These numerical methods are compared on efficiency and accuracy. To simulate the unbalanced growth model, efficiency is not a problem. Simulation is performed quite fast and does not depend on the numerical integration method. However, Runge-Kutta is more accurate than Euler. Therefore, Runge-Kutta 4 Auto is used.

The unbalanced growth model, built in Vensim (Ventana, 2015), is connected to the Python script with the help of the EMA Vensim connector. Furthermore, necessary libraries, functions and workbench specific features are imported into Python.

The uncertainties, outcomes of interest and constants are determined (Table 4-15). The outcomes of interest are focused on economic growth, employment, price level and productivity. Wage level is excluded from the analysis, because the ratio between progressive and stagnant sector wage level is always equal to one, because nominal wages in both sectors grow with average productivity. And since nominal wages grow with the same pace as average productivity does, the wage level results are identical to average productivity.

*Table 4-15: Simulation specification of uncertainties, constants and outcomes of interest*

| Uncertainties | Value range | Substantiation |
|---|---|---|
| Autonomous consumption progressive sector | 2,000 - 2,350 | In section 4.2 is concluded, based on empirical evidence that around 68 percent of aggregate demand is due to household consumption. A plausible uncertainty bandwidth is 5 percent above and below the specified value (63-73%). The specified value ranges are chosen in a way that it reflects the bandwidth. |
| Autonomous consumption stagnant sector | 3,400 - 3,600 | |
| Consumption coefficient progressive sector | 0.23 - 0.28 | |
| Consumption coefficient stagnant sector | 0.21 - 0.25 | |
| Investment coefficient progressive sector (profits used for investments) | 0.9 - 1.4 | In section 4.2 is concluded, based on empirical evidence that around 20 percent of aggregate demand is due to private investment. A plausible uncertainty bandwidth is 5 percent above and below the specified value (15-25%). The specified value ranges are chosen in a way that it reflects the bandwidth. |
| Investment coefficient stagnant sector (profits used for investments) | 0.4 - 0.8 | |
| Propensity to invest public sector | 0.245 - 0.55 | In section 4.2 is concluded, based on empirical evidence that around 12 percent of aggregate demand is due to public investment. A plausible uncertainty bandwidth is 5 percent above and below the specified value (7-17%). The specified value range is chosen in a way that it reflects the bandwidth. |
| Price mark-up progressive sector | 1.27 - 1.33 | A bandwidth of 10 percent above and below the specified value is used. This is a large bandwidth, if one takes into account that the lowest taxing level is 27% and the highest taxing level is 33%. However, the values are not unrealistic. |
| Price mark-up stagnant sector | 1.27 - 1.33 | |
| Autonomous productivity growth progressive sector | 0.01224 - 0.01496 | |
| Autonomous productivity growth stagnant sector | 0.00126 - 0.00154 | |
| Kaldor-Verdoorn coefficient progressive sector | 0.00000378 - 0.00000462 | |
| Taxation rate | 0.27 - 0.33 | |
| Progressive and stagnant sector investment switch | 0.45 - 0.55 | |

| | | |
|---|---|---|
| Nominal interest rate | 0 - 0.03 | Nominal interest rates are low and close to zero. It is expected that nominal interest rates will not fall below zero and that the nominal interest rate in the near future will not be higher than 3 percent (OECD.stat, 2018). |
| Kaldor-Verdoorn coefficient stagnant sector | 0 – 0.00000084 | This is the same bandwidth as used for the progressive sector: 0.00000462 - 0.00000378 = 0.00000084 |
| **Constants** | **Value** | **Substantiation** |
| Autonomous investment stagnant sector | 0 | These parameters are explicitly not used as uncertainties, because all investments are endogenously generated due to business profits, via the coefficients: 'Investment coefficient progressive sector' and 'Investment coefficient stagnant sector'. |
| Autonomous investment progressive sector | 0 | |
| Interest rate consumption coefficient progressive sector | -24,072 | Using the interest rate coefficient as uncertainty is not of added value for this research. Since these coefficients are not related to unbalanced growth. |
| Interest rate consumption coefficient stagnant sector | -21,352 | |
| Interest rate investment coefficient progressive sector | -2,142 | |
| Interest rate investment coefficient stagnant sector | -2,670 | |
| Nominal wage progressive sector | 1 | In section 4.2 is argued why these values should start at 1. |
| Nominal wage stagnant sector | 1 | |
| Initial productivity progressive sector | 1 | |
| Initial productivity stagnant sector | 1 | |
| Initial Real GDP progressive sector | 7,885 | There is no uncertainty around these numbers. These are the GDP values in billions of U.S. dollars for the progressive and stagnant sector of the U.S. economy of the year 2015. |
| Initial Real GDP stagnant sector | 7,859 | |
| **Outcomes of Interest** | | **Category** |
| Ratio GDP progressive over stagnant sector | | Indicator of unbalanced growth with respect to economic growth |
| Real GDP progressive sector | | Indicator of economic growth |
| Real GDP stagnant sector | | Indicator of economic growth |
| Employment level progressive sector | | Indicator of employment level |
| Employment level stagnant sector | | Indicator of employment level |
| Ratio price level progressive over stagnant sector | | Indicator of unbalanced growth with respect to price level |
| Ratio productivity progressive over stagnant sector | | Indicator of unbalanced growth with respect to productivity |
| Average productivity | | Indicator of productivity/welfare growth |

In total 34,000 simulation runs or experiments are performed with the help of SOBOL sampling, an 'N' of 1,000 is used (Zhang, Trame, Lesko, & Schmidt, 2015). The confidence intervals show that more simulation runs are not required. More simulation runs will not significantly change the simulation results. This means that 34,000 different scenarios times 1 policy times 1 model are generated (Equation 4-7).

$$34{,}000 \text{ scenarios } * \text{ 1 policies } * \text{ 1 model(s) } = 34{,}000 \text{ experiments}$$

*Equation 4-7: Simulation execution equation*

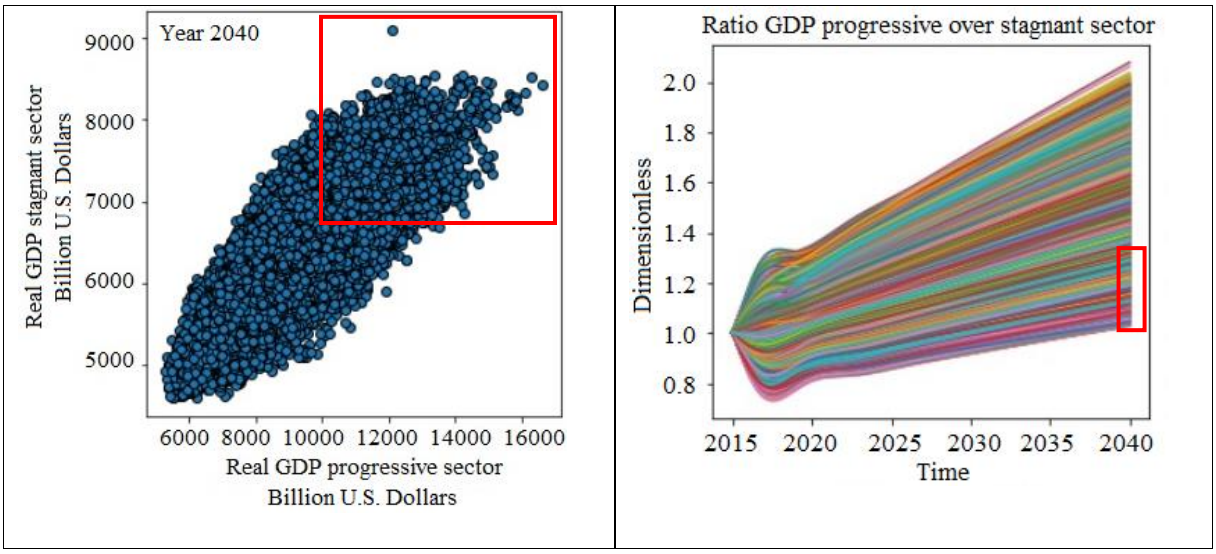
# 5 Simulation Results

The simulation results show clear evidence of unbalanced growth and private investments and macroeconomic policies are the most sensitive factors with respect to the development of unbalanced growth. Policy makers can influence macroeconomic policies directly, but can only influence private investments indirectly. Evidence for unbalanced growth and the sensitive factors is substantiated by visualising the simulation results (5.1) and showing the SOBOL sensitivity analysis results (5.2). How the sensitive factors should be influenced to slow down unbalanced growth and stimulate stable growth is analysed with the help of scenario discovery and the PRIM algorithm (5.3).

## 5.1 Open Exploration – Visual Analysis

Unbalanced growth develops over the years and this influences economic growth, the level of employment, price stability and productivity growth negatively. This can be observed when the simulation results are visualised with the help of scatter and line plots.

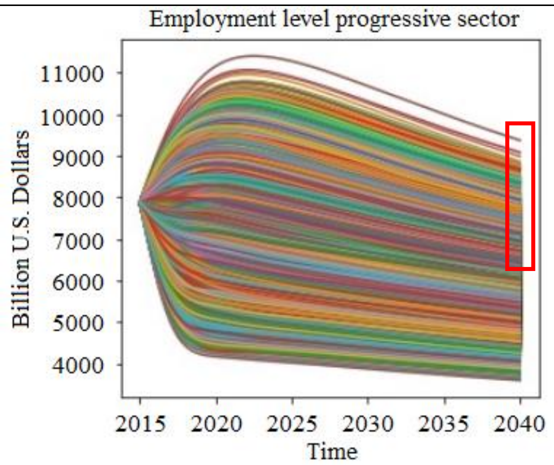
Figure 5-1 shows the simulation results for the economic growth outcomes of interest. The scatter plot shows the end state results (year 2040) for real GDP in the progressive sector and real GDP in the stagnant sector, in billions of U.S. dollars. Remarkable is that GDP for a significant number of scenarios in the progressive sector is higher than in the stagnant sector. However, when taking the GDP ratio between the progressive and stagnant sector into account, shown in the line plot, it can be concluded that at the initial time (year 2015) the ratio between progressive and stagnant sector GDP is close to one. This means that over the years the progressive and stagnant sector are growing with an unbalanced rate. As a result, the GDP ratio grows over the years, as shown in the line plot. This is a clear sign of unbalanced growth. In a desirable and balanced growth situation both sectors should show stable growth and thus the ratio between the two sectors stays constant over the years and close to one. Despite the fact that there is unbalanced growth between the sectors, there are scenarios that are closer to the desirable situation compared to other scenarios. This means stable growth in the progressive sector, slow decline in the stagnant sector and a ratio that is as close as possible to one. These scenarios are shown within the red rectangle and are considered the ‘best’ 25 percent in the year 2040, see the data under the figures. For progressive sector GDP this means larger than 9,956 billion U.S. dollars. For stagnant sector GDP this means larger than 6,697 billion U.S. dollars. For the ratio between the sectors this means smaller than 1.32.

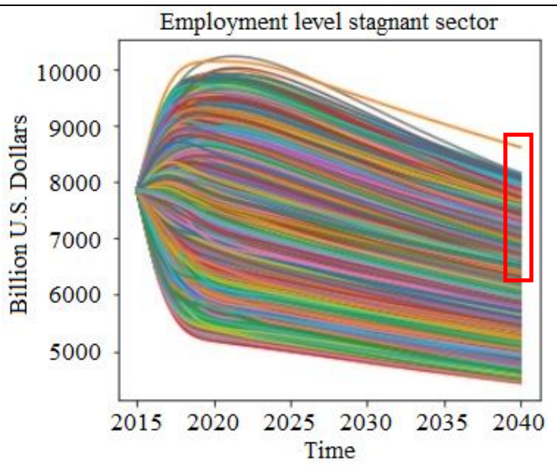


| **Real GDP progressive sector (2040)** | **Real GDP stagnant sector (2040)** | **Ratio GDP (2040)** |
|---|---|---|
| mean: 9015 | mean: 6262 | mean: 1.44 |
| min: 5280 | min: 4601 | min: 1.03 |
| **75%: 9956** | **75%: 6697** | **25%: 1.32** |
| max: 16636 | max: 9105 | max: 2.08 |

*Figure 5-1: Economic growth visualized*

Figure 5-2 shows the simulation results for the employment level outcomes of interest. The progressive and stagnant sector tend to decline in terms of employment. This is a negative consequence of unbalanced growth. In a desirable situation labour demand is equal to labour supply. So, for example, it is not a problem that employment declines in the progressive sector due to productivity growth, but than one should observe employment growth in the stagnant sector or vice versa. Despite the fact that both sectors are declining, there are scenarios that are closer to the desirable situation compared to other scenarios. This means slow decline of employment in both sectors. These scenarios are shown within the red rectangle and are considered the ‘best’ 25 percent in the year 2040, see the data under the figures. For progressive sector employment this means larger than 6,286 billion U.S. dollars. For stagnant sector employment this means larger than 6,392 billion U.S. dollars.

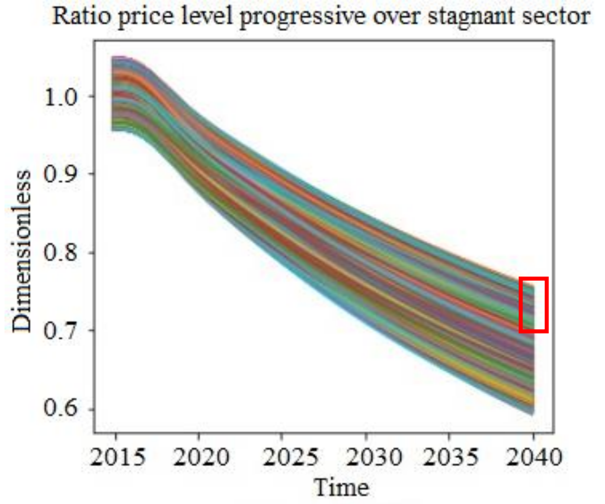



| **Employment level progressive sector (2040)** | **Employment level stagnant sector (2040)** |
|---|---|
| mean: 5773 | mean: 5987 |
| min: 3601 | min: 4431 |
| **75%: 6286** | **75%: 6392** |
| max: 9374 | max: 8625 |

*Figure 5-2: Employment level visualized*

Figure 5-3 shows the simulation results for the price level outcome of interest. There is growing price gap between the progressive and stagnant sector. In a desirable situation prices grow or decline with the same rate in both sectors and thus the ratio should be constant around one. Despite the fact that the simulation results show differently one can try to slow down the price gap between the sectors. This means that the ratio stays as close as possible to one. These scenarios are shown within the red rectangle and are considered the ‘best’ 25 percent in the year 2040, see the data next to the figure. For the price level ratio this means larger than 0.70.




**Ratio price level progressive over stagnant sector (2040)**

mean: 0.68

min: 0.59

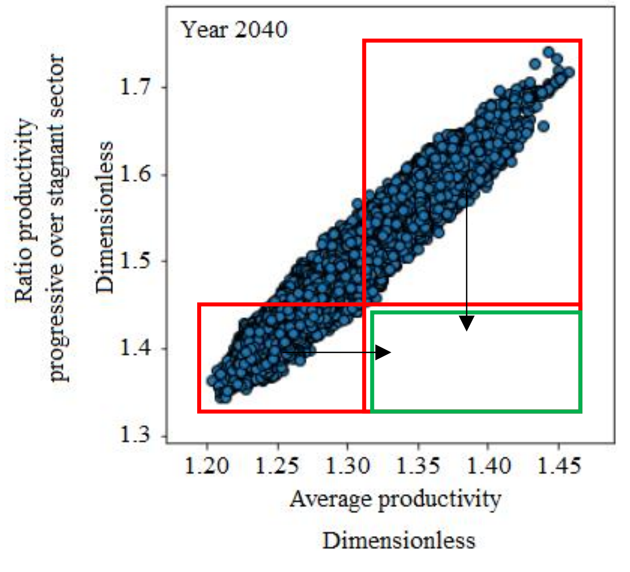
**75%: 0.70**

max: 0.76

*Figure 5-3: Price level visualized*

Figure 5-4 shows the simulation results for the productivity outcomes of interest. Average productivity is a proxy for welfare and the productivity ratio between the sectors is a proxy for unbalanced growth. The scatter plot shows the end state results (year 2040) for average productivity and the productivity ratio between the sectors. At the initial time in 2015, productivity in both sectors started at one. This means that in 2015 the productivity level in the progressive sector, the stagnant sector and the ratio were equal to one. In 2040 one can observe that both average productivity and the productivity ratio are larger than one. Moreover, there is a positive correlation between average productivity growth and a growing productivity ratio. This means that average productivity growth is mainly driven by progressive sector productivity growth, which is a clear sign of unbalanced growth. The larger average productivity growth, the larger the productivity ratio. In a desirable situation average productivity grows with a steady rate and the ratio between the sectors stays constant and close to one. Despite the fact that the ratio is larger than one, there are scenarios that are closer to the desirable situation compared to other scenarios. This means steady average productivity growth and a low productivity ratio between the sectors. These scenarios are shown within the red rectangles and are considered the 'best' 25 percent in the year 2040, see the data next to the figure. For average productivity this means larger than 1.32. For the productivity ratio between the progressive and stagnant sector this means smaller than 1.45.

However, the red rectangular boxes have no overlap. This means that only one desirable situation can be achieved: moderate productivity growth and clear unbalanced growth or low productivity growth and a slow development of unbalanced growth. Both situations are not desirable. It is important to move towards the green rectangle. In this area there is significant productivity growth, but the productivity ratio between the sectors is low. To achieve this, it is important that stagnant sector productivity grows as well. This will boost average productivity growth and will slow down unbalanced growth between the two sectors.




**Average productivity (2040)**
mean: 1.30
min: 1.20
**75%: 1.32**
max: 1.46

**Ratio productivity progressive over stagnant sector (2040)**
mean: 1.49
min: 1.34
**25%: 1.45**
max: 1.74

*Figure 5-4: Productivity visualized*

## 5.2 Open Exploration – Global Sensitivity Analysis

The main sensitive factors with respect to unbalanced growth development are private investments and fiscal and monetary policy. For each of the eight outcomes of interest the sensitive factors are determined with the help of SOBOL sensitivity analysis. The graphs are shown in Appendix XIV. In total 16 uncertain input parameters are used in the analysis and each uncertain input parameter has a first-order effect (S1) and total effect (ST) score per outcome of interest. The S1 and ST score are not significantly different from each other and, therefore, no distinction will be made between them. The higher the score, or the bar, the more sensitive the uncertain input parameter is with respect to the specific outcome of interest.

The results show that private investments in both the progressive and stagnant sector have a high influence on economic growth, which is in line with the Keynesian philosophy of macroeconomics. Private investments are significantly more important than consumption, but that does not mean that the level of consumption is not important. Moreover, the level of consumption in both sectors should be sufficient to make sure that investments result in economic growth. The main sensitive factor that affects the GDP ratio between the sectors is private investment in the progressive sector, so this factor has a large influence on unbalanced growth with respect to real output. When taking the fiscal and monetary policy instruments into account it can be concluded that the taxation rate and the decision on which sector to focus on when publicly investment, have no impact on the economic growth results. However, the nominal interest rate and the level of fiscal stimulus have impact on economic growth in the progressive and stagnant sector.

For the level of employment, the results are similar as for economic growth, which is not strange because economic growth and employment demand are closely linked to each other. Again, to assure employment in both sectors, private investments and consumption should be sufficient and the nominal interest rate and the level of fiscal stimulus have impact on the level of employment in the progressive and stagnant sector.

Figure 5-5 shows the SOBOL results for progressive sector GDP. This figure indeed substantiates the fact that private investments, fiscal stimulus, the interest rate and until a certain extent consumption are sensitive factors.

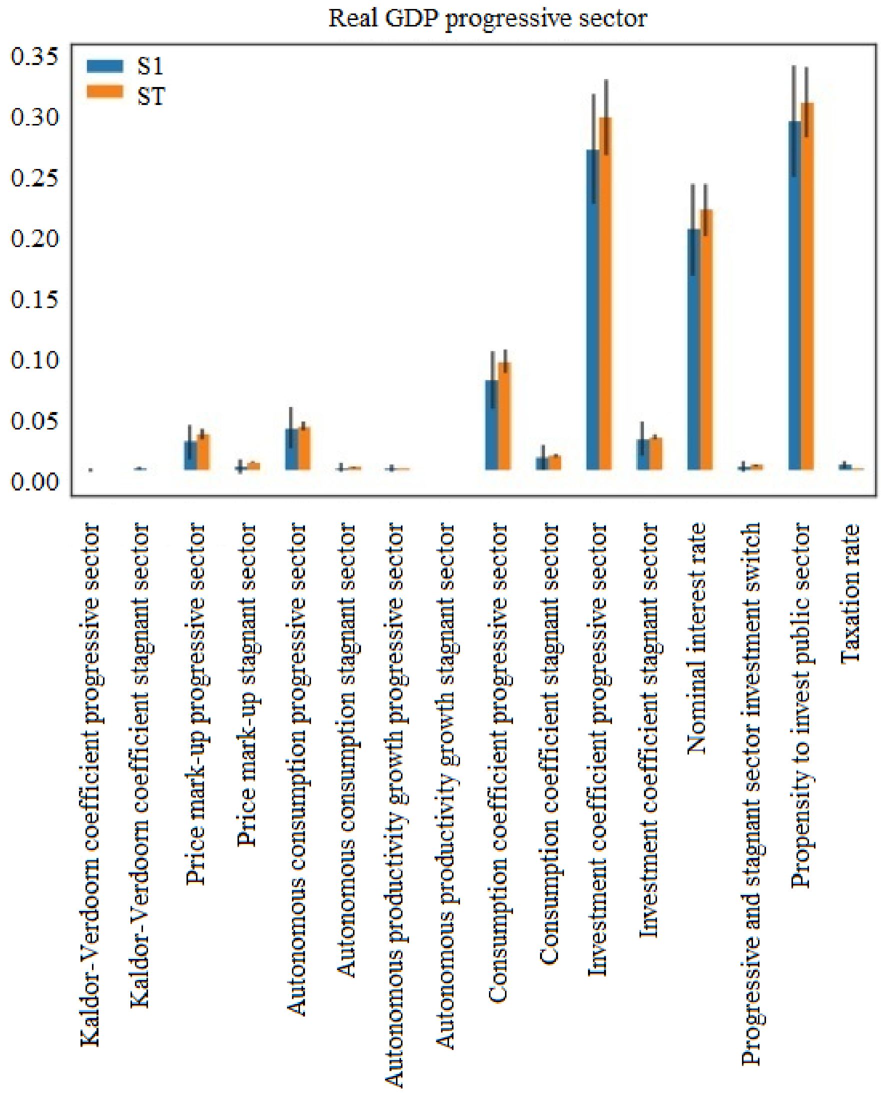



*Figure 5-5: Sensitive factors for progressive sector GDP*

Just as for economic growth and employment, unbalanced price level growth between the sectors is mainly influenced by private investments in the progressive sector. The stagnant sector price mark-up and autonomous productivity growth in the progressive sector have some influence on the price ratio. All other variables have barely no influence, including the fiscal and monetary policy instruments. However, the nominal interest rate and the level of fiscal stimulus have some influence that can help to close the price gap between the sectors.

Just as for the other outcomes of interest, average productivity growth is mainly influenced by private investments in the progressive sector, as shown in Figure 5-6. However, private investment in the progressive sector is also the main factor that influences the productivity ratio between the sectors. In essence, unbalanced growth with respect to productivity. Other variables that have some influence are autonomous productivity growth and the price mark-up in the progressive sector. All other variables have barely no influence, including the fiscal and monetary policy instruments. However, the nominal interest rate and the level of fiscal stimulus have some influence that can help to close the productivity gap between the sectors.

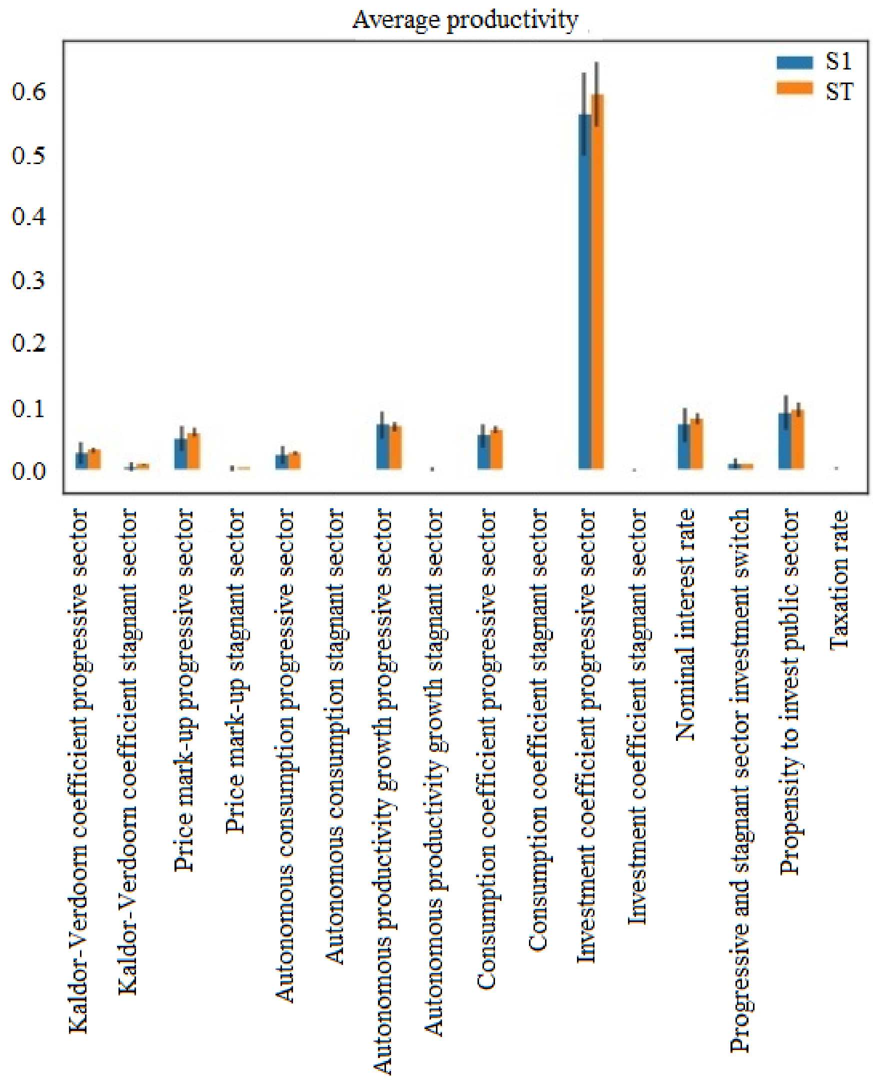



*Figure 5-6: Sensitive factors for average productivity*

After the sensitivity analysis it can be concluded that macroeconomic policies have influence on economic growth and thus employment in both the progressive and stagnant sector. However, these macroeconomic policies have barely no influence on unbalanced growth with respect to GDP, the price level and productivity. The GDP, price level and productivity ratios between the sectors keep growing over the years and are mainly influenced by private investments. Policy makers should look further than their standard set of macroeconomic policy tools to slow down unbalanced growth.

## 5.3 Open Exploration – Scenario Discovery

The factors that are sensitive with respect to unbalanced growth are determined and the next question is how these factors should be influenced to slow down unbalanced growth and stimulate stable growth. This section uses the scenario discovery technique to identify how the sensitive factors should be influenced. Scenario discovery is performed with the help of the PRIM algorithm. The PRIM results are provided in Appendix XV.

### 5.3.1 Influencing the Sensitive Factors

To slow down unbalanced growth and stimulate stable growth it is important to moderately invest in the progressive sector and to make large investments in the stagnant sector. The scenario discovery results are shown in Table 5-1. The rows of the table show the outcomes of interest, their threshold value and if the desirable outcomes should be lower or higher than the threshold value. These threshold values were determined in section 5.1. For each outcome of interest also the coverage and density are given. The columns of the table show the most sensitive input parameters and their uncertainty range. There are six sensitive input parameters defined, four of them are normal exogenous parameters and two of them are policy parameters. The value ranges in the table show the desirable range for the input parameters so that the outcome of interest threshold is met. If the box is green, the higher the value the better. If the box is orange, the lower the value the better. Next to the value ranges in the table, also the quasi-p values are given. These values are all zero or close to zero, which means that the value ranges are significant.

In the ideal situation one wants to slow down unbalanced growth and stimulate stable growth. To approach the ideal situation the ratio between progressive and stagnant sector real GDP, price level and productivity should not be growing too fast over the years. Real GDP in the progressive sector should grow over time and real GDP in the stagnant sector should have a slow decline over time. So that total real GDP grows over the years. To make sure that unemployment levels are not rising, the sum of employment (progressive plus stagnant) should not decline too fast over the years. And to experience welfare it is important that the average productivity in the overall economy is growing with a significant rate.

According to the scenario discovery results it is possible to achieve the situation described above. It is important to moderately invest in the progressive sector and to make large investments in the stagnant sector. On the one hand, this helps to stimulate economic growth and employment in the progressive and stagnant sector, and assures that average productivity grows over the years. On the other hand, due to make moderate investments in the progressive sector and large investments in the stagnant sector, balanced growth with respect to sector real output, price level and productivity is stimulated. To accommodate balanced growth, it is important that the GDP ratio between the sectors does not become too large and, therefore, consumption in the progressive and stagnant sector should stay in balance. If autonomous productivity growth in the progressive sector grows moderately over the years, one can assure stable productivity growth, but also balanced growth with respect to productivity. There are two policy variables that have significant influence. These are: 'propensity to invest public sector' and 'nominal interest rate'. The former policy instrument can also be seen as fiscal stimulus and is part of fiscal policy. The latter policy instrument is part of monetary policy. If fiscal stimulus is high and the nominal interest rate low, then these instruments have the ability to boost economic growth, employment and average productivity. However, they cannot slow down unbalanced growth on their own. Next to fiscal stimulus and a low nominal interest rate, it is important to stimulate private investments.

*Table 5-1: Desirable scenarios that slow down unbalanced growth and stimulate stable growth; Green coloured boxes mean the higher the value the better; Orange coloured boxes mean the lower the value the better*

| | **SENSITIVE INPUT PARAMETERS** | | | | | |
|---|---|---|---|---|---|---|
| | **Exogenous variables** | | | | **Policy variables** | |
| | **Investment coefficient progressive sector (profits used for investments)** | **Investment coefficient stagnant sector (profits used for investments)** | **Consumption coefficient progressive sector** | **Autonomous productivity growth progressive sector** | **Propensity to invest public sector (fiscal stimulus)** | **Nominal interest rate (monetary policy)** |
| **Uncertainty range** | **0.9-1.4** | **0.4-0.8** | **0.23-0.28** | **0.012-0.015** | **0.245-0.55** | **0-0.03** |
| **Real GDP progressive sector**<br>*> 9.956 Billion U.S. Dollars*<br>*Coverage: 0.65*<br>*Density: 0.66* | **1.1-1.4**<br>*qp=0.0* | | | | **0.39-0.55**<br>*qp=0.0* | **0-0.027**<br>*qp=2.2e-21* |
| **Real GDP stagnant sector**<br>*> 6.697 Billion U.S. Dollars*<br>*Coverage: 0.65*<br>*Density: 0.66* | | **0.55-0.8**<br>*qp=1.7e-217* | | | **0.4-0.55**<br>*qp=0.0* | **0-0.024**<br>*qp=2.9e-53* |
| **Ratio GDP progressive over stagnant sector**<br>*< 1.32*<br>*Coverage: 0.67*<br>*Density: 0.68* | **0.9-1.1**<br>*qp=0.0* | **0.42-0.8**<br>*qp=8.4e-06* | **0.23-0.26**<br>*qp=7.4e-99* | | | **0.0013-0.03**<br>*qp=0.00022* |
| **Employment level progressive sector**<br>*> 6.286 Billion U.S. Dollars*<br>*Coverage: 0.64*<br>*Density: 0.65* | **1.1-1.4**<br>*qp=5.4e-156* | | | | **0.39-0.55**<br>*qp=0.0* | **0-0.023**<br>*qp=1,7e-80* |
| **Employment level stagnant sector**<br>*> 6.392 Billion U.S. Dollars*<br>*Coverage: 0.65*<br>*Density: 0.66* | | **0.55-0.8**<br>*qp=3.1e-211* | | | **0.39-0.55**<br>*qp=0.0* | **0-0.023**<br>*qp=8.9e-75* |
| **Ratio price level progressive over stagnant sector**<br>*> 0.70*<br>*Coverage: 0.65*<br>*Density: 0.66* | **0.9-1.1**<br>*qp=0.0* | | | | | |
| **Average productivity**<br>*> 1.32*<br>*Coverage: 0.66*<br>*Density: 0.69* | **1.2-1.4**<br>*qp=0.0* | | | | **0.28-0.55**<br>*qp=9.1e-13* | **0-0.026**<br>*qp=3.2e-17* |
| **Ratio productivity progressive over stagnant sector**<br>*< 1.45*<br>*Coverage: 0.66*<br>*Density: 0.73* | **0.9-1.1**<br>*qp=0.0* | | | **0.012-0.014**<br>*qp=1e-121* | | |

### 5.3.2 Interpretation of the Results

Policy makers should look further than their standard set of macroeconomic policy tools to slow down unbalanced growth. This is the real-world interpretation of the results. The distinction should be made between the sensitive policy parameters and sensitive exogenous parameters, because fiscal and monetary policy makers can directly influence the nominal interest rate and level of fiscal stimulus. However, they cannot directly influence the other sensitive exogenous parameters, such as private investments.

Central bankers should keep the interest rate low to stimulate private investments and consumption, unless inflation becomes a problem. National governments should use fiscal stimulus to boost the economy, unless this leads to crowding out of the private sector. Important to note is that the public investments can be made with income out of taxation and not with debt, according to the simulation results.

The remaining sensitive exogenous parameters can only be indirectly influenced, because there are no macroeconomic policies that directly change these parameters. In chapter 4 the exogenous parameters are empirically estimated. The empirical results show that the private investment coefficients (profits turned into investments) for the progressive and stagnant sector are respectively 1.183 and 0.585. If one compares these values with the results shown in Table 5-1 it is possible to conclude that private investments in the progressive sector are on track (*1.183 is a good compromise for the two desirable ranges: 0.9-1.1 and 1.1-1.4*), but that private investments in the stagnant sector are weak (*0.585 is at the lower part of the desirable bandwidth: 0.55-0.8*). So, policy makers should focus on ways to make private investments in the stagnant sector more attractive. The empirically estimated values with respect to consumption and autonomous productivity growth in the progressive sector are respectively 0.259 and 0.0136 and are thus within the desirable ranges as shown in Table 5-1, and do not require policy intervention. One can only argue that the progressive sector consumption coefficient of 0.259 is high, however designing policies that indirectly slow down the level of consumption in the progressive sector would be unusual and are, therefore, not considered.

# 6 Conclusions, Discussion and Recommendations

## 6.1 Conclusions

From a macroeconomic perspective the most important factor that drives unbalanced growth are private investments. Unbalanced growth between the progressive and stagnant sector with respect to real output (GDP), price level and productivity is driven by private investments. Due to private investments, productivity in the progressive sector grows significantly faster than productivity in the stagnant sector and this is because of two reasons. First, private investments in the progressive sector are twice as large as in the stagnant sector. Second, private investments easily translate into productivity growth in the progressive sector, which is unfortunately not the case for the stagnant sector. As a result, there is a growing productivity gap between the progressive and stagnant sector. The consequence is that the progressive sector is more efficient in comparison to the stagnant sector. In the progressive sector efficiency, thus productivity, grows faster than nominal wages and, therefore, production costs of progressive sector goods and services are pushed downwards. This is exactly the other way around for the stagnant sector, in this sector nominal wages grow faster than productivity and, therefore, production costs of stagnant sector goods and services are pushed upwards. To be profitable, prices in the progressive sector can go down and prices in the stagnant sector should go up. This is the cost disease as described by Baumol (1967). Due to lower prices in the progressive sector, the demand for goods and services in this sector increases and this results in real output growth. Due to higher prices in the stagnant sector the demand for goods and services in this sector decreases and this results in a decline of real output.

Next to being a driver of unbalanced growth, private investments in both the progressive and stagnant sector are also directly stimulating aggregate demand and employment demand. However, the unbalanced growth phenomenon reduces for a large part the positive effect that private investments have on aggregate demand and employment demand, because the research results show barely no overall real output growth and a decline of employment over the years. Employment declines, because less workers are required in the progressive sector due to the fact that productivity grows faster than real output. These workers try to find work in the stagnant sector, but this is hard due to the fact that this sector is declining in terms of real output.

Policy makers can use fiscal and monetary policies to influence macroeconomic output. By using fiscal stimulus and maintaining a low interest rate, these policy instruments have a positive effect on real output growth and employment demand in both sectors. Unfortunately, the positive effect on real output and employment is not structural, because these policy measures are not the solution for the unbalanced growth phenomenon. The macroeconomic policies have barely no influence on unbalanced growth with respect to real output, the price level and productivity. The real output, price level and productivity ratios between the sectors keep growing over the years even if the macroeconomic policies are accommodating growth. To slow down unbalanced growth and stimulate stable growth policy makers should look further than their standard set of macroeconomic policy tools.

Since private investments are the main driver of unbalanced growth, policy makers should focus on these investments. From a theoretical point of view moderate investments in the progressive sector and large investments in the stagnant sector, supported by fiscal stimulus and a low interest rate should slow down unbalanced growth and stimulate stable growth. Policy makers can directly influence the policy instruments, but should indirectly stimulate private investments. The research results show that private investments are on track in the progressive sector and, therefore, require no policy intervention. However, policy intervention is required to stimulate stagnant sector investments. On the short-run stagnant sector investments do create jobs and on the long-run it can boost innovation in the stagnant sector. Innovation leads to more efficiency, which helps to lower the prices of goods and services in comparison to the progressive sector. And if prices decline, demand is stimulated. From a theoretical and macroeconomic perspective this is the solution to slow down unbalanced growth and stimulate stable growth.

## 6.2 Discussion

### 6.2.1 Results and Methodology

This research is conducted in the field of macroeconomic modelling. This research used the unbalanced growth model of Groot & Schettkat as starting point and improved this model on several points. Improvements were done with respect to completeness of the model, the modelling method, the parametrization, and simulation method. These improvements were done to be able to use the model as exploration tool to find the driving factors behind unbalanced growth and how these factors should be influenced. Due to the fact that the unbalanced growth model is built within a macroeconomic research frame, the research results are also limited to a macroeconomic explanation for the driving factors of unbalanced growth. One can argue that by including only macroeconomic theory into the model important components that drive unbalanced growth cannot be found, which is true. It is indeed not possible to give an explanation outside the macroeconomics paradigm for factors that drive unbalanced growth. For example, employment is modelled as real output divided by productivity. A simulation model would use population cohorts to model employment. However, this does not mean that the macroeconomic explanation for unbalanced growth is not useful. On the contrary, due to this research, policy makers know that private investments are important drivers of unbalanced growth. This gives policy makers a high-level focus point and a macroeconomic area that can be monitored more closely. So, the results of this research should be interpreted as an aggregate economic explanation for the driving factors behind unbalanced growth. These driving factors can be studied and monitored more closely in follow up research.

Another point of critique that can be made is related to the simulation results. For each outcome of interest 34,000 experiments were conducted. After stabilizing, all the experiments follow a dominant growth or decline path, and linear development over the years. Each experiment has its own input parametrization. This input parametrization does not necessarily correspond to the initial model parametrization. So, in the first years the results need to stabilize (the shock phase), after that all the experiments follow a dominant growth or decline development over the years (the stable phase). This fits within the economics paradigm, stable phases alternate with shock phases. However, there are also researchers that will argue that economies will never enter into stable phases and, therefore, would argue that the simulation results lack dynamic behaviour. A simulation model can be made to model unbalanced growth based on the assumption that stable phases in the economy do not exist. This probably results in more dynamic behaviour, observed in the simulation results. I would argue that both a macroeconomic model and simulation model are complementary and that it is not a matter of which model is best. In essence, both models are used to explore what might happen in the future and not to predict the future. The macroeconomic model is suitable to find the driving factors behind unbalanced growth by means of sensitivity analysis, meanwhile a simulation model can help to better understand the dynamics of unbalanced growth over time. Both models help to better understand the phenomenon of unbalanced growth.

With respect to the methodology this research finds itself on the intersection of economics/econometrics and modelling/simulation. The fields of economics and econometrics are well known for its strong theoretical and empirical base. However, modellers find the static results not representative for the dynamic and non-linear real world (Forrester, Low, & Mass, 1974). Quite often economists and econometricians use static models to explain specific economic phenomena. Meanwhile, modellers prefer a dynamic simulation model. According to modellers the advantage of dynamic simulation models is that these models are a better representation of reality. However, in the eyes of economists and econometricians, modellers often use an unscientific approach with respect to model building (Nordhaus, 1973). There is a big difference with respect to model building and use between economists/econometricians and modellers. With this research I have taken the first step in bringing both fields of study closer to each other by using the strong theoretical and empirical base of macroeconomic theory and econometrics, and added the more dynamic components of modelling and simulation. This resulted in the unbalanced growth model built for this research. To bring both fields of study even closer to each other, one can build a simulation model of unbalanced growth, for example an SD model. So, include next to macroeconomic components, other factors such as population and education into the model.

### 6.2.2 Model

The unbalanced growth model is built according to the Keynesian philosophy. This means that demand drives supply and that full employment does not exist. Investments are an important factor in the Keynesian theory and this is also confirmed by the simulation results. Another large assumption is that nominal wages in the overall economy grow with the same pace as average productivity does, just as proposed by Baumol (1967). This seems to be more realistic than the fact that nominal wages grow with sector specific productivity trends.

The unbalanced growth model built for this research has many similarities with the Baumol (1967) model. However, there are also differences. The largest difference is that the Baumol model operates under full employment, which is not the case for the unbalanced growth model. The consequence of assuming full employment is that the stagnant sector keeps growing in the Baumol model, because workers are pushed out of the progressive sector due to productivity growth and are absorbed by the stagnant sector. However, in the unbalanced growth model full employment is not guaranteed, so the workers that are pushed out of the progressive sector due to productivity growth are not necessarily absorbed by the stagnant sector. They can only find work in the stagnant sector if there is sufficient demand. It seems to be more realistic to relax the full employment condition, because if there is no demand for products and services, there is also no demand for labour. So, full employment cannot be guaranteed, this depends on aggregate demand.

### 6.2.3 Data Analysis

**Econometrics**

Part of the unbalanced growth model parametrization relies on econometrics. Relations between coefficients were estimated with the help of OLS regression. OLS regression was a suitable method for this research, as long as the data set was transformed in a way that the data became stationary. However, econometricians prefer autoregressive integrated moving average (ARIMA) and autoregressive distributed lag (ARDL) models for time series data, because these models can deal directly with the phenomena of non-stationarity, autocorrelation and spurious regression without transforming the data (Katchova, 2015; Hill, Griffiths, & Lim, 2011). However, the use of ARIMA or ARDL models requires extensive knowledge of econometrics, and OLS regression can be performed rather straightforward. To be able to use OLS regression and still take care of non-stationarity, autocorrelation and spurious regression, growth rates were used in the data set. By using growth rates, the negative effects of these phenomena were cancelled out for the largest part, because the timeseries data set became almost stationary and this resolved the problems of autocorrelation and spurious regression.

The OLS regression results shown in section 4.3 are suitable for their purpose. In essence, provide roughly the estimation between variables, so that the unbalanced growth model can be parametrized. However, if one wants to do a more thorough econometric analysis, I strongly recommend to use timeseries models, such as ARIMA or ARDL models.

**Productivity**
Productivity growth depends on investments with respect to physical capital, education, innovation (R&D) and the work environment (Kalpana, 2018). In the unbalanced growth model productivity depends only on investments with respect to physical capital and the relation is econometrically estimated. Investments with respect to education, innovation and the work environment are exogenously modelled as exogenous productivity growth. Further research should focus on making all productivity drivers endogenous, since this will provide a richer picture about productivity growth over the years. The endogenous growth theory of Romer (1990) helps to understand how productivity can be made fully endogenous.

### 6.2.4 Simulation

When taking the simulation results into account, one should understand that these results are based on two major assumptions: nominal wages in the economy grow with average productivity and the full employment condition is relaxed. In section 2.2 and 6.2.2 is argued that it is realistic to assume that nominal wages grow with average productivity and that full employment does not exist. However, this does not mean that other assumptions should not be tested.

Table 6-1 shows four different macroeconomic assumptions. Assumption 1 is built and simulated in this research. If one wants to discover the differences in results when changing the macroeconomic assumptions, I strongly recommend to also model and simulate assumptions 2, 3 and 4. In assumption 1 and 2 the full employment condition is relaxed, because demand drives supply. This is a Keynesian perspective. If the assumption of full employment is relaxed it is expected that due to unbalanced growth, employment declines in both the progressive and stagnant sector. In assumption 3 and 4 full employment is guaranteed, because supply drives demand. This is a neo-classical perspective. With the full employment condition, it is expected that in terms of employment the progressive sector declines due to productivity growth and that all these workers are absorbed by the stagnant sector. So, the stagnant sector grows over time.

It is more realistic to assume that nominal wages grow with average productivity instead of industry specific productivity trends. However, it is interesting to observe what happens when nominal wages are allowed to grow with industry specific productivity trends. Nominal wages and sector productivity grow with the same pace. As a result, prices will not grow nor decline. This is good with respect to unbalanced growth. However, the nominal wages in the stagnant sector barely grow compared to the progressive sector. This results in growing income inequality and lower demand from workers employed in the stagnant sector.

To fully understand the differences of the simulation results when changing the macroeconomic assumptions, I recommend to model and simulate assumptions 1, 2, 3 and 4.

*Table 6-1: Different macroeconomic assumptions that can be modelled*

| Macroeconomic assumptions | Employment assumption | Wage growth assumption |
|---|---|---|
| Assumption 1 | Full employment condition relaxed | Nominal wages grow with average productivity |
| Assumption 2 | Full employment condition relaxed | Nominal wages grow with industry specific productivity trends |
| Assumption 3 | Full employment | Nominal wages grow with average productivity |
| Assumption 4 | Full employment | Nominal wages grow with industry specific productivity trends |

### 6.2.5 Recommendations to Improve and Extend this Research

This research can be improved and extended on the following points. First, next to the macroeconomic unbalanced growth model built for this research, it is interesting to make a simulation model that can help to enrich the dynamic understanding of unbalanced growth. The macroeconomic model and simulation model can complement each other. Second, perform a more thorough econometric analysis by using timeseries specific models, such as ARIMA or ARDL models. Third, make productivity in the simulation model fully endogenous. Make productivity dependent on: physical capital, education, innovation (R&D) and the work environment (Kalpana, 2018). Finally, simulate multiple models to see how the simulation results change when macroeconomic assumptions change.

## 6.3 High-level Policy Recommendations

All around the world, economies show dualistic growth patterns, in essence unbalanced economic growth. One part of the economy, the progressive sector, experiences significant technological progress and productivity growth, for example the economic activity information and communication. Meanwhile the other part of the economy, the stagnant sector, barely benefits from automation, for example the economic activity wholesale and retail trade. Productivity in the progressive sector grows faster than real output does, so less workers are required over the years in this sector. These workers try to find work in the stagnant sector. However, this is difficult, because the stagnant sector declines over the years. As a result, unemployment levels are likely to rise. This reduces the aggregate growth rate of aggregate demand, which results in secular stagnation (Eichengreen, 2015). The societal debate is about the fear of massive unemployment and how this can be prevented (Vincent, 2017).

It is important to focus on policies that slow down unbalanced growth to prevent secular stagnation and to keep unemployment levels low. To create an ideal environment for economic growth, central bankers can keep the interest rate low to stimulate private investments and consumption. However, this can only be done if inflation is not a problem. And national governments can use fiscal stimulus to boost the economy. However, fiscal stimulus is only effective if it does not crowd out the private sector. Unfortunately, these direct macroeconomic policies are not enough to change the dualistic growth patterns of economies, they can only accommodate the process of stable growth.

Policy makers have two plausible options for structural change. First, a proactive measure that tries to slow down unbalanced growth by stimulating private investments in the stagnant sector. Second, a preventive measure that focusses on retraining workers that become obsolete due to dualistic growth.

The proactive measure indirectly stimulates private investments, this is important because private investments have significant influence on unbalanced growth. Private investments are on track in the progressive sector, but lag behind in the stagnant sector. There is a strong conviction that stagnant sector private investments lag behind, because these investments do not translate into significant productivity growth and thus it is not interesting to invest in this sector of the economy. Policy makers should focus on making it more interesting for private entities to invest in the stagnant sector. National governments can make stagnant sector investments more attractive by using fiscal stimulus to subsidies private entities that are willing to invest in the stagnant sector. However, this is not a structural, but more temporarily solution for the unbalanced growth phenomenon. A structural solution to slow down unbalanced growth is when private investments in the stagnant sector do result in significant productivity growth, which also increases the productivity growth of the overall economy. How this can be achieved is subject for further research. Productivity growth in the stagnant sector will probably never reach the same growth rate as in the progressive sector, because stagnant sector work is often labour intensive. Nevertheless, based on the research results it is recommended to perform research about automation in the stagnant sector and how private investments translate into significant productivity growth, so that private entities are willing to invest in the stagnant sector. If that happens, a plausible solution to slow down unbalanced growth is found.

The preventive measure tries to facilitate the retraining of workers by means of public investments. Governments should stimulate and help private entities to retrain workers by giving them incentives. These incentives most probably come from subsidies. It is important to think about the retraining of workers, because due to automation the type of work that is demanded will change over the coming decades.

We all know that automation is a fact and this is not a problem as long as economic growth and rising productivity can offset the losses. However, action is required to achieve this and the proposed proactive and preventive measures are a starting point to make sure that unbalanced growth is replaced by stable economic growth.

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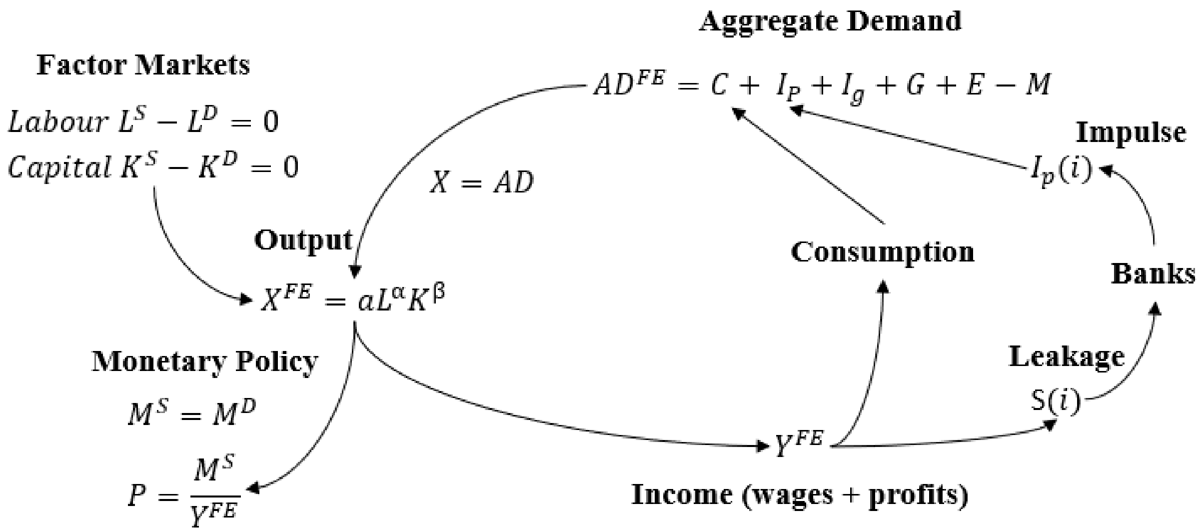
# Appendix I

## Neo-classical macroeconomics

Neo-classical economics was developed by W.S. Jevons, C. Menger and L. Walras in the 19th century and became popular in the early 20th century (Investopedia, 2018e). The figure below shows the circular flow of the economy, according to the Neo-classical theory (Naastepad, 2002). This theory assumes full employment (FE), this means that all factors of production are used. Labour supply ($L^S$) is equal to labour demand ($L^D$) and capital supply ($K^S$) is equal to capital demand ($K^D$). This determines the full employment level of output ($X^{FE}$), described by the Cobb-Douglas production function. For present purposes I assume that labour supply is exogenous in Neo-classical economics. As a result, in the Neo-classical theory the causality runs from supply to demand. The level of output determines the overall full employment income level ($Y^{FE}$). Part of the income is used for consumption (C) and contributes directly to the level of aggregate demand. The other part of the income is saved (S) and this money leaks out of the circular flow. The banks directly lend out this money for private investments ($I_p$). The banks function as an intermediary and need savings to be able to lend out money. The causality in this theory runs from savings to investments. In the end all the saved money comes back into the circular flow in the form of investments. This is regulated via the loanable funds market. This is a simplified model of the banking sector. Assume that the amount of savings is higher than the demand for investment money. The banks will lower the interest rate (i) so that saving money is discouraged and private investments are encouraged. Lowering the interest rate continues until savings are equal to investments. As a result, according to Neo-classical economists the economy is always in equilibrium and operates under full employment. The philosophy is also that governments and central banks should not intervene too much. Therefore, the role of fiscal and monetary policy is limited. By performing fiscal policy, the level of public investment ($I_g$) increases, but since the economy is already operating under full employment the level of private investment ($I_p$) must go down. Thus, fiscal policy is crowding out the private sector and does not contribute to the growth of the real economy. The task of monetary policy is to keep inflation low, by regulating the money supply ($M^S$). To keep prices (P) stable the money supply changes with the overall income level ($Y^{FE}$). In the Neo-classical theory money supply is equal to money demand ($M^D$).



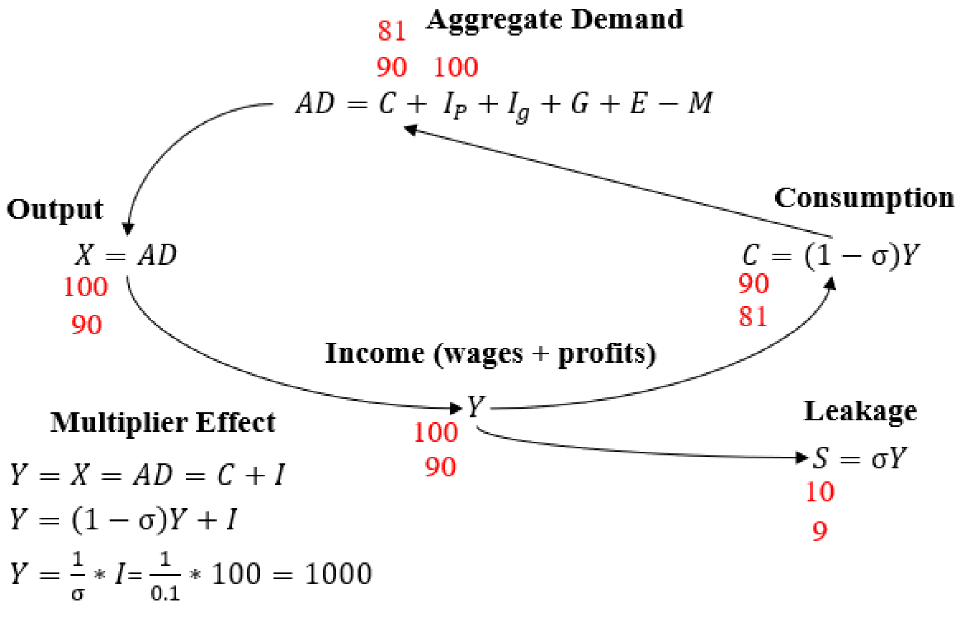

*Circular flow of Neo-classical macroeconomics (Naastepad, 2002)*

## Keynesian macroeconomics

Keynesian economics was developed by J.M. Keynes during the 1930s and became popular in the second half of the 20th century (Investopedia, 2018b). This is a demand driven theory, the causality goes from demand to supply and therefore the assumption of full employment cannot be made. Demand is driven by 'animal spirits', in essence the belief of investors that there is future demand for their products and services. The central force in this theory is autonomous investment, the amount of investments is based on future expectations and not so much on the interest rate (Naastepad, 2002).

The figure below shows the circular flow of the economy, according to the Keynesian theory (Naastepad, 2002). Aggregate demand (AD) drives output (X) and output results in a specific level of overall income (Y). Part of the income is used for consumption (C) and the other part is saved (S) and leaks out of the circular flow. In the Keynesian theory there is no market for loanable funds that assures that all savings are funnelled back into the circular flow. Banks also don't need savings to be able to lend out money to investors. Banks can create credit if there is demand for investments. An important mechanism according to Keynesian theory is the multiplier effect. And the effectiveness of the multiplier effect depends on the propensity to save (σ). The multiplier effect is best illustrated with an example. Assume that 10 percent of overall income (Y) is saved. So, the propensity to save (σ) is 0.1. The remaining 90 percent is used for consumption. Now assume that an investor invests 100 units in the economy. This results in an overall income increase of 100 units. The propensity to save is 0.1, so 10 units will be saved and 90 units will be used for consumption. In the next round the overall income increases with 90 units. 9 units will be saved and 81 units will be used for consumption. This multiplier process continues until additional consumption is 0. So, an initial investment of 100 units results in an overall income increase of 1000 units (see equation in figure; for the sake of simplicity only the level of consumption (C) and investment (I) are used). The effectiveness of the investment depends on the propensity to save. After the 2008 financial crisis people were uncertain and the propensity to save was higher, for example 0.5. If this was the case, the initial investment of 100 units would have generated only 500 units instead of 1000 units. The causality runs from investments to savings and not the other way around, which is the case in the Neo-classical theory.

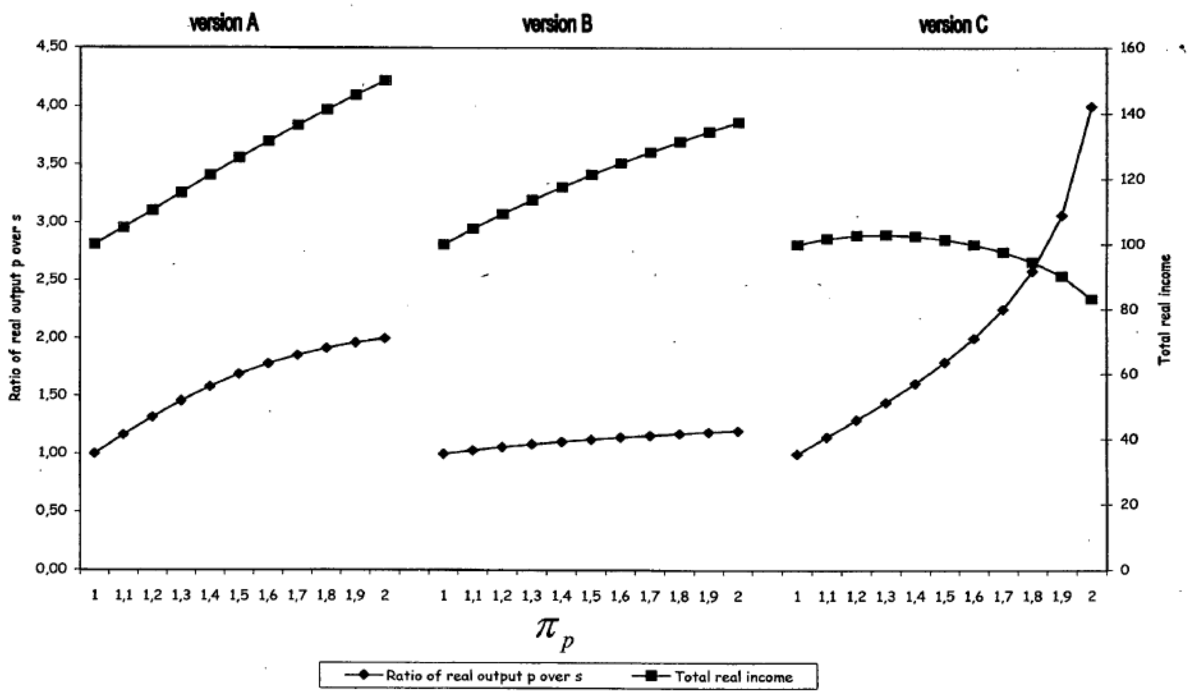
According to Keynes the economy is marked by up-swings and down-swings. During up-swings investors belief that there is future demand for their products and services and they heavily invest in the economy. Through the multiplier effect this generates economic growth. During down-swings investors have less optimistic expectations and are investing less, which slows down economic growth. Fiscal policy is used to counter the cyclical movement of the economy, by increasing public investment ($I_g$) during down-swings and reducing public investment during up-swings. The instrument for monetary policy is the interest rate (i), however it is assumed that future expectations are significantly more important for investment demand than the rate of interest. Therefore, the effect of monetary policy is limited.

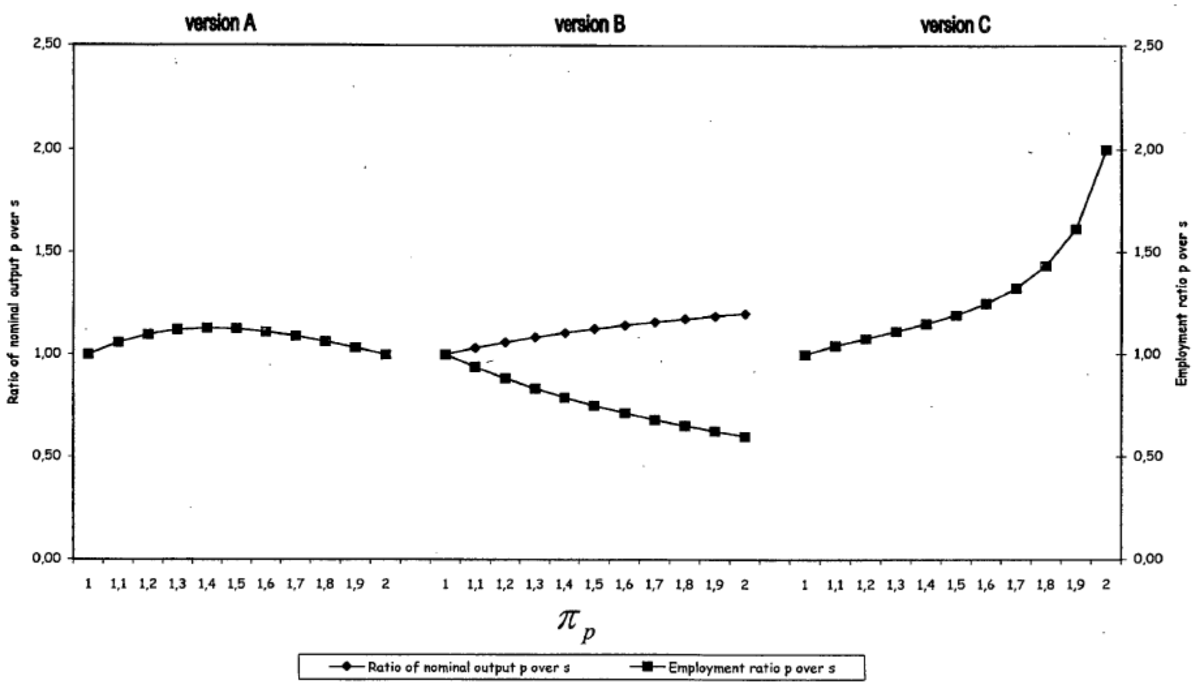



*Circular flow of Keynesian macroeconomics (Naastepad, 2002)*

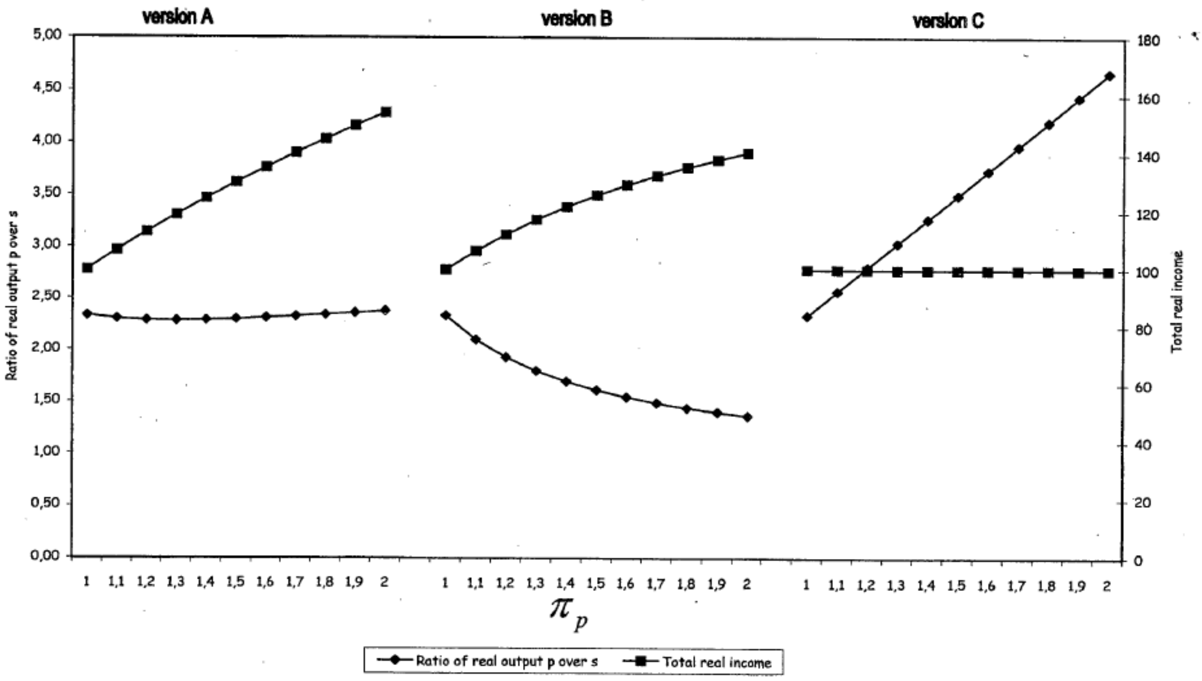
# Appendix II

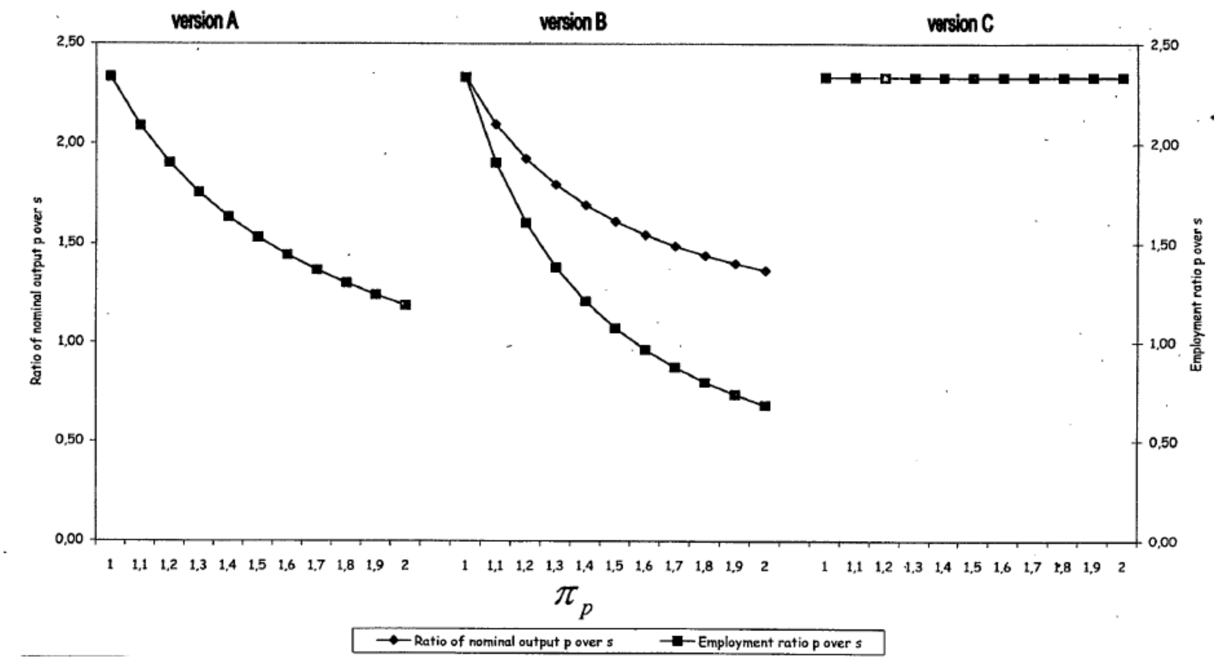
**Output for the price-driven model**



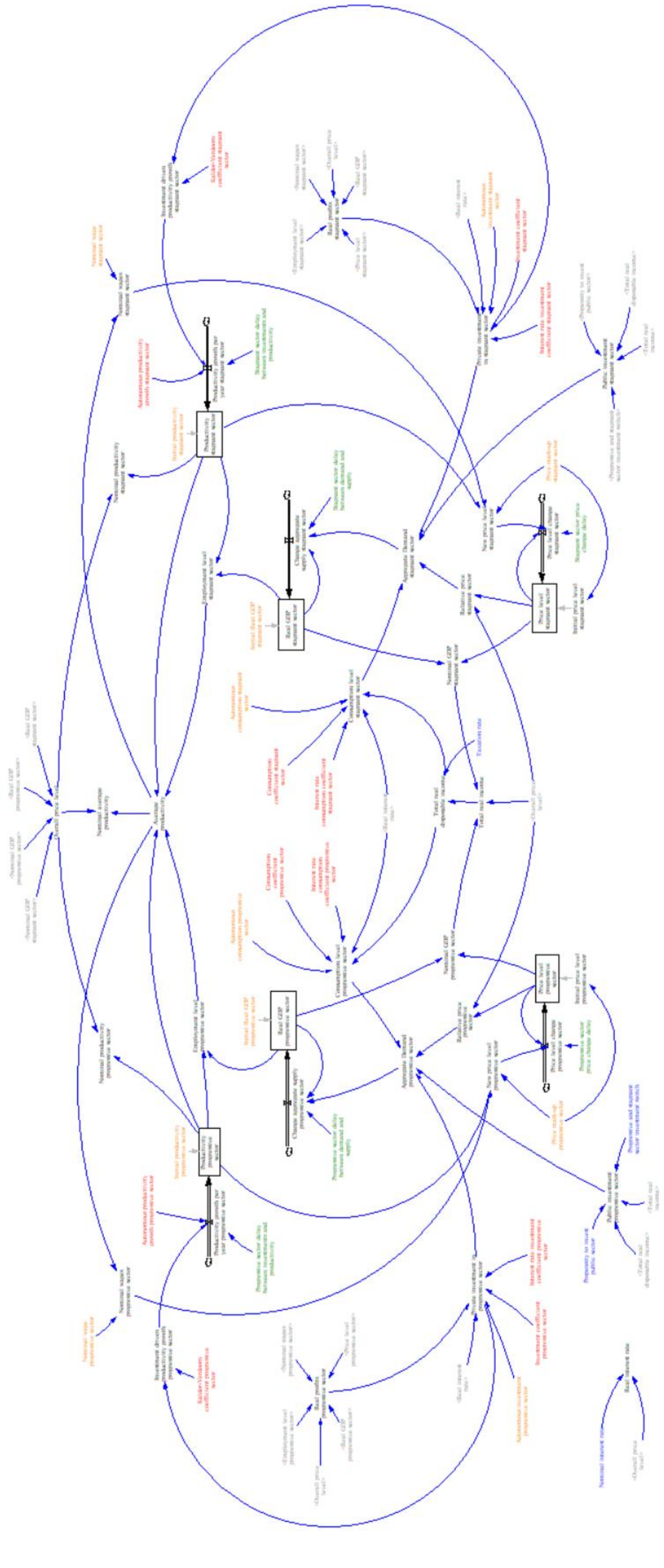
**Output for the income-driven model**



# Appendix III

**Vensim SD model unbalanced growth**



# Appendix IV

**Productivity growth rates**

[Dataset: Productivity and ULC by main economic activity (ISIC Rev.4)]

| | | | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | Average productivity growth per year in percentages |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Subject** | Industry contribution to business sector labour productivity; employment based | | | | | | | | | | | | | | | | | |
| **Measure** | Annual industry contribution, percentage points | | | | | | | | | | | | | | | | | |
| **Unit** | Percentage | | | | | | | | | | | | | | | | | |
| **Country** | **Activity** | | | | | | | | | | | | | | | | | |
| United States | BNEXCL: Non-agriculture business sector excluding real estate | | 1,7 | 3,2 | 2,3 | 3,4 | 1,9 | 1,4 | 0,5 | -0,5 | 1,8 | 3,9 | 0,3 | 0,8 | 0,5 | 0,7 | 1,8 | |
| | BNEXCL: Non-agriculture business sector excluding real estate | BDE: Mining and utilities | -0,2 | 0,1 | -0,2 | 0,1 | -0,3 | 0,3 | 0,2 | -0,1 | 0,5 | -0,0 | 0,2 | 0,2 | 0,1 | 0,3 | 0,2 | 0,09 |
| | | C: Manufacturing | 0,3 | 1,6 | 1,5 | 1,9 | 0,7 | 0,9 | 0,8 | -0,2 | 0,2 | 1,2 | -0,2 | -0,3 | 0,2 | -0,0 | 0,0 | 0,57 |
| | | F: Construction | -0,4 | -0,0 | -0,0 | -0,5 | -0,5 | -0,8 | -0,4 | 0,2 | 0,4 | 0,4 | 0,0 | 0,3 | -0,2 | -0,5 | 0,2 | -0,12 |
| | | G_I: Wholesale retail trade accommodation food services, transportation and storage | 0,1 | 0,3 | 0,4 | 0,8 | -0,2 | 0,5 | 0,0 | -0,6 | -0,5 | 1,1 | 0,1 | -0,2 | 0,6 | -0,2 | 0,3 | 0,16 |
| | | J: Information and communication | 0,4 | 1,1 | 0,5 | 1,3 | 0,7 | 0,1 | 0,8 | 0,5 | 0,1 | 0,5 | 0,2 | 0,4 | 0,3 | -0,1 | 0,8 | 0,50 |
| | | K: Financial and insurance activities | 1,2 | -0,1 | -0,0 | -0,2 | 1,0 | 0,3 | -0,4 | -1,4 | 2,2 | 0,3 | 0,1 | 0,4 | -0,8 | 0,6 | -0,2 | 0,20 |
| | | MN: Professional, scientific and technical activities, Administrative and support service activities | 0,3 | 0,3 | 0,2 | 0,0 | 0,4 | 0,0 | -0,5 | 1,1 | -1,0 | 0,3 | 0,0 | 0,1 | 0,3 | 0,6 | 0,5 | 0,17 |

Data extracted on 08 May 2018 13:47 UTC (GMT) from OECD.Stat

| | |
|---|---|
| **All activities without manufacturing** | **0,17** |
| **Prgressive sector activities** | **1,45** |
| **Stagnant sector activities** | **0,14** |

**Table can be found at stats.oecd.org:**

**Productivity --> Productivity and ULC by industry, Annual --> Productivity and ULC by main economic activity (ISIC Rev.4) --> Industry contribution to business sector productivity growth**

# Appendix V

**GDP data (constant prices with 2009 as national base year)**

Dataset: 1. Gross domestic product (GDP)

| | | |
|---|---|---|
| Country | United States | |
| Measure | V: Constant prices, national base year | |
| Unit | US Dollar, Millions, 2009 | |
| Year | 2014 | 2015 |

| Transaction | 2014 | 2015 | |
|---|---|---|---|
| B1_GA: Gross domestic product (output approach) | 15.982.255,0 | 16.397.178,0 | |
| B1_GA: Gross domestic product (output approach) — B1G_P119: Gross value added at basic prices, excluding FISIM | 15.341.092,0 | 15.727.861,0 | |
| B1G_P119: Gross value added at basic prices, excluding FISIM — B1G: Gross value added at basic prices, total activity | 15.341.092,0 | 15.727.861,0 | |
| B1G: Gross value added at basic prices, total activity — B1GVA: Agriculture, forestry and fishing (ISIC rev4) | 154.391,0 | 158.949,0 | Stagnant |
| B1GVB_E: Industry, including energy (ISIC rev4) | 2.527.672,0 | 2.565.274,0 | |
| B1GVB_E: Industry, including energy (ISIC rev4) — B1GVC: of which excluding: Manufacturing (ISIC rev4) | 663.912,0 | 674.071,0 | Stagnant |
| B1GVB_E: Industry, including energy (ISIC rev4) — B1GVC: of which: Manufacturing (ISIC rev4) | 1.863.760,0 | 1.891.203,0 | Progressive |
| B1GVF: Construction (ISIC rev4) | 594.747,0 | 623.855,0 | Stagnant |
| B1GVG_I: Distributive trade, repairs; transport; accommod., food serv. (ISIC rev4) | 2.463.151,0 | 2.532.019,0 | Stagnant |
| B1GVJ: Information and communication (ISIC rev4) | 1.005.736,0 | 1.090.852,0 | Progressive |
| B1GVK: Financial and insurance activities (ISIC rev4) | 1.009.733,0 | 1.004.832,0 | Progressive |
| B1GVL: Real estate activities (ISIC rev4) | 1.952.074,0 | 1.987.779,0 | Progressive |
| B1GVM_N: Prof., scientific, techn.; admin., support serv. activities (ISIC rev4) | 1.835.792,0 | 1.910.534,0 | Progressive |
| B1GVO_Q: Public admin.; compulsory s.s.; education; human health (ISIC rev4) | 3.327.679,0 | 3.383.546,0 | Stagnant |
| B1GVR_U: Other service activities (ISIC rev4) | 475.889,0 | 486.259,0 | Stagnant |

| | |
|---|---|
| Progressive (B.$) | 7.885 |
| Stagnant (B.$) | 7.859 |
| Total | 15.743,9 |

Data extracted on 28 May 2018 09:44 UTC (GMT) from OECD.Stat

**Table can be found at stats.oecd.org:**

**National Accounts --> Annual National Accounts --> Main Aggregates --> 1. Gross domestic product (GDP) --> 1. Gross domestic product (GDP)**

# Appendix VI

## Aggregate demand data

| | | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|
| Dataset: National Accounts at a Glance | | | | | | |
| Indicator | Household final consumption expenditure, percentage of GDP | | | | | |
| Unit | | | | | | |
| Time | | 2011 | 2012 | 2013 | 2014 | 2015 |
| Country | | | | | | |
| United States | | 68,88 | 68,40 | 68,07 | 68,07 | 68,06 |
| Data extracted on 04 May 2018 12:39 UTC (GMT) from OECD.Stat | | | | | | |
| Dataset: National Accounts at a Glance | | | | | | |
| Indicator | Gross fixed capital formation, percentage of GDP | | | | | |
| Unit | | | | | | |
| Time | | 2011 | 2012 | 2013 | 2014 | 2015 |
| Country | | | | | | |
| United States | | 18,28 | 18,97 | 19,21 | 19,70 | 19,81 |
| Data extracted on 04 May 2018 12:39 UTC (GMT) from OECD.Stat | | | | | | |
| Dataset: National Accounts at a Glance | | | | | | |
| Indicator | Exports of goods and services, percentage of GDP | | | | | |
| Unit | | | | | | |
| Time | | 2011 | 2012 | 2013 | 2014 | 2015 |
| Country | | | | | | |
| United States | | 13,57 | 13,61 | 13,64 | 13,62 | 12,50 |
| Data extracted on 04 May 2018 12:39 UTC (GMT) from OECD.Stat | | | | | | |
| Dataset: National Accounts at a Glance | | | | | | |
| Indicator | Imports of goods and services, percentage of GDP | | | | | |
| Unit | | | | | | |
| Time | | 2011 | 2012 | 2013 | 2014 | 2015 |
| Country | | | | | | |
| United States | | 17,31 | 17,11 | 16,59 | 16,54 | 15,39 |
| Data extracted on 04 May 2018 12:39 UTC (GMT) from OECD.Stat | | | | | | |
| Dataset: National Accounts at a Glance | | | | | | |
| Indicator | General government consumption expenditure, percentage of GDP | | | | | |
| Unit | | | | | | |
| Time | | 2011 | 2012 | 2013 | 2014 | 2015 |
| Country | | | | | | |
| United States | | 16,31 | 15,75 | 15,12 | 14,70 | 14,41 |
| Data extracted on 04 May 2018 12:40 UTC (GMT) from OECD.Stat | | | | | | |
| | | **99,73** | **99,62** | **99,45** | **99,55** | **99,38** |

**Table can be found at stats.oecd.org:**

**National Accounts --> National Accounts at a Glance --> National Accounts at a Glance --> 3. Expenditure**

# Appendix VII

**Public investment data**

**Dataset: Input-Output Tables**

| | |
|---|---|
| Variable | TTL: Total |
| Country | USA: United States |
| Time | 2011 |
| Unit | US Dollar, Millions |

| Column sector (to:) | C01T05: Agriculture, hunting, forestry and fishing | C10T14: Mining and quarrying | C15T16: Food products, beverages and tobacco | C17T19: Textiles, textile products, leather and footwear | C20: Wood and products of wood and cork | C21T22: Pulp, paper, paper products, printing and publishing | C23: Coke, refined petroleum products and nuclear fuel | C24: Chemicals and chemical products | C25: Rubber and plastics products | C26: Other non-metallic mineral products | C27: Basic metals | C28: Fabricated metal products | C29: Machinery and equipment, nec | C30T33X: Computer, Electronic and optical equipment | C31: Electrical machinery and apparatus, nec | C34: Motor vehicles, trailers and semi-trailers | C35: Other transport equipment | C36T37: Manufacturing nec; recycling |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TTL_C75: Public administration and defence; compulsory social security | 1597,2 | 1661,1 | 4553,9 | 363,9 | 364,2 | 4128,5 | 1372,2 | 4167,6 | 766,8 | 704,4 | 1730,4 | 1130,7 | 1001,6 | 766 | 359 | 1055,5 | 710,3 | 852,7 |
| | S | S | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D |

| C40T41: Electricity, gas and water supply | C45: Construction | C50T52: Wholesale and retail trade; repairs | C55: Hotels and restaurants | C60T63: Transport and storage | C64: Post and telecommunications | C65T67: Financial intermediation | C70: Real estate activities | C71: Renting of machinery and equipment | C72: Computer and related activities | C73T74: R&D and other business activities | C75: Public administration and defence; compulsory social security | C80: Education | C85: Health and social work | C90T93: Other community, social and personal services | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 666,6 | 1990,2 | 17971,3 | 6205,2 | 7732,4 | 3727,7 | 17142,6 | 18906,7 | 984,2 | 2812,9 | 13154,7 | 17786,3 | 7671,5 | 12673,4 | 6122,5 | 162834,2 |
| S | S | S | S | S | D | D | D | D | D | D | S | S | S | S | |

| | | |
|---|---|---|
| Progressive | 80756,5 | 0,50 |
| Stagnant | 82077,7 | 0,50 |

**<u>Table can be found at stats.oecd.org:</u>**

**Industry and Services --> Structural Analysis (STAN) Databases --> Input Output Database --> Input-Output Tables**

# Appendix VIII

## STATA data set

### Consumption

| Year1 | dConsumpP | dConsumpS | dIncome | NInterestS |
|---|---|---|---|---|
| 1970 | 59,5891659 | 52,84322259 | 116,6199815 | 0,0756 |
| 1971 | 100,5381161 | 89,15644254 | 246,7097019 | 0,05 |
| 1972 | 87,24054458 | 77,36425652 | 283,0817256 | 0,0467 |
| 1973 | -14,80401491 | -13,12808869 | -121,0501526 | 0,0842 |
| 1974 | 41,55767407 | 36,85303173 | -71,1920851 | 0,1024 |
| 1975 | 102,9848735 | 91,32620859 | 265,3311751 | 0,0644 |
| 1976 | 83,06682278 | 73,66303152 | 226,7814468 | 0,0527 |
| 1977 | 89,40747232 | 79,28587168 | 280,4268316 | 0,0564 |
| 1978 | 50,11215932 | 44,43908468 | 99,738185 | 0,0822 |
| 1979 | -8,851568372 | -7,849504028 | -125,6146451 | 0,1122 |
| 1980 | 29,65008516 | 26,29347174 | 146,5054903 | 0,1307 |
| 1981 | 25,33617888 | 22,46793222 | -80,3897356 | 0,1591 |
| 1982 | 122,6225554 | 108,7407567 | 227,7729519 | 0,1227 |
| 1983 | 119,0710368 | 105,5912967 | 513,7629803 | 0,0907 |
| 1984 | 128,2946331 | 113,7707123 | 240,1989633 | 0,1037 |
| 1985 | 104,6093954 | 92,76682232 | 149,4676108 | 0,0805 |
| 1986 | 88,96912639 | 78,89714981 | 271,8091931 | 0,0652 |
| 1987 | 111,123658 | 98,54362122 | 373,3736938 | 0,0686 |
| 1988 | 78,17708205 | 69,32684635 | 178,0760412 | 0,0773 |
| 1989 | 50,84057918 | 45,08504192 | 101,5154531 | 0,0909 |
| 1990 | -1,131719706 | -1,003600494 | 45,4818531 | 0,0815 |
| 1991 | 102,2591495 | 90,68264201 | 210,0821226 | 0,0583 |
| 1992 | 105,5793638 | 93,626983 | 179,7355397 | 0,0368 |
| 1993 | 122,129214 | 108,3032653 | 364,7197202 | 0,0317 |
| 1994 | 99,05863113 | 87,84444647 | 283,4107638 | 0,0463 |
| 1995 | 119,0095713 | 105,5367896 | 401,058533 | 0,0592 |
| 1996 | 143,4620491 | 127,2210625 | 495,4514004 | 0,0539 |
| 1997 | 195,3567074 | 173,2408537 | 545,2503065 | 0,0562 |
| 1998 | 205,0407556 | 181,8285945 | 445,120773 | 0,0547 |
| 1999 | 205,8651479 | 182,5596594 | 448,6282718 | 0,0533 |
| 2000 | 106,1897052 | 94,16822917 | 122,4137952 | 0,0646 |
| 2001 | 105,3901148 | 93,45915845 | 150,3567258 | 0,0369 |
| 2002 | 137,8713862 | 122,2633048 | 256,0411405 | 0,0173 |
| 2003 | 181,7814629 | 161,2024294 | 424,5206741 | 0,0115 |
| 2004 | 175,121085 | 155,2960565 | 352,7334959 | 0,0156 |
| 2005 | 141,123665 | 125,1474011 | 449,8311895 | 0,0351 |
| 2006 | 115,1307759 | 102,0971032 | -36,0480034 | 0,0515 |
| 2007 | -35,81280829 | -31,75852811 | -277,2718001 | 0,0527 |
| 2008 | -87,73981683 | -77,80700737 | -270,6043169 | 0,0296 |
| 2009 | 100,8486785 | 89,43184694 | 431,0274389 | 0,0056 |
| 2010 | 123,9596991 | 109,9265257 | 293,6356686 | 0,0031 |
| 2011 | 70,85675899 | 62,83523911 | 465,2729099 | 0,003 |
| 2012 | 78,64777823 | 69,74425617 | 179,1782538 | 0,0028 |
| 2013 | 164,8013543 | 146,1445972 | 453,1449692 | 0,0017 |
| 2014 | 211,8925392 | 187,9047045 | 471,3887146 | 0,0012 |
| 2015 | 157,2087499 | 139,411533 | 138,001881 | 0,0023 |

### Productivity

| Year2 | dProducP | dProducS | dInvestP1 | dInvestS1 | dGDPP | dGDPS |
|---|---|---|---|---|---|---|
| 2001 | 0,022281 | -0,0049138 | -71,175 | -72,819 | 116,1 | 96,86 |
| 2002 | 0,0287764 | 0,00277348 | 10,985 | 22,107 | 157 | 162,9 |
| 2003 | 0,0217096 | 0,00089381 | 38,977 | 23,981 | 240,4 | 205 |
| 2004 | 0,0299964 | 0,00392233 | 67,27 | 44,938 | 299,5 | 124,9 |
| 2005 | 0,0278467 | -0,0094397 | 62,38 | 45,275 | 219,3 | 143,4 |
| 2006 | 0,013673 | 0,00049796 | 67,121 | 9,343 | 219,6 | -7,155 |
| 2007 | 0,0072712 | -0,0016706 | -35,203 | 14,095 | -36,89 | -23,71 |
| 2008 | -2,57E-05 | -0,0039659 | -128,022 | -135,682 | -177,8 | -197,8 |
| 2009 | 0,0151553 | 0,00351569 | 45,324 | 10,439 | 223,4 | 80,87 |
| 2010 | 0,0232636 | 0,0152691 | 50,085 | 76,912 | 137,4 | 61,52 |
| 2011 | 0,000404 | 0,0024283 | 71,259 | 60,972 | 169 | 121,8 |
| 2012 | 0,005095 | 0,00307698 | 49,553 | -0,048 | 101,4 | 137,8 |
| 2013 | 0,0003095 | 0,00495625 | 52,34 | 71,054 | 185,8 | 137,4 |
| 2014 | 0,0105118 | -0,0037239 | 75,722 | -25,515 | 218,1 | 178,9 |
| 2015 | 0,0113698 | 0,00713065 | 44,677 | -48,771 | | |

### Investments

| Year3 | dInvestP2 | dInvestS2 | dInvestP3 | dInvestS3 | dProfitP | dProfitS | dInterestL |
|---|---|---|---|---|---|---|---|
| 1998 | 138,2 | 37,86 | 133,528 | 34,67 | 152,07 | 54,098 | -0,003 |
| 1999 | 97,294 | 74,336 | 68,664 | 73,704 | 58,55 | 79,519 | -0,008 |
| 2000 | -21,141 | 30,061 | -31,538 | 25,945 | 127,44 | 32,288 | -0,004 |
| 2001 | -33,797 | 4,205 | -24,456 | -22,254 | 201,626 | -1,249 | 0,008 |
| 2002 | 69,505 | 49,733 | 58,47 | 49,827 | 146,271 | 134,987 | -0,013 |
| 2003 | 166,259 | 66,005 | 129,375 | 39,988 | 168,136 | 158,493 | -0,001 |
| 2004 | 178,402 | 103,096 | 116,814 | 49,321 | 254,661 | 150,274 | -0,007 |
| 2005 | 61,984 | 125,086 | 2,426 | 71,878 | 143,631 | 132,561 | 0,007 |
| 2006 | -54,562 | 94,548 | -71,108 | 45,411 | 152 | 43,079 | 0,001 |
| 2007 | -197,449 | 89,948 | -193,258 | 42,707 | -22,057 | 81,274 | -0,018 |
| 2008 | -279,965 | -149,375 | -253,616 | -144,392 | 79,646 | -66,28 | 0,038 |
| 2009 | 24,854 | 3,065 | 26,471 | 0,309 | 186,647 | 145,665 | -0,021 |
| 2010 | 63,724 | 82,635 | 46,008 | 51,111 | 95,217 | 111,516 | -0,02 |
| 2011 | 143,48 | 78,155 | 129,083 | 44,28 | 187,416 | 72,278 | 0,001 |
| 2012 | 138,689 | -5,846 | 106,068 | -19,018 | 116,51432 | 144,1616 | 0,012 |
| 2013 | 113,575 | 110,858 | 74,121 | 73,813 | 157,23083 | 92,503006 | 0 |
| 2014 | 167,723 | -16,426 | 139,314 | -20,538 | 224,80158 | -56,29077 | 0,011 |

**STATA script**

```
*****GRADUATION MENNO KOENS ECONOMETRIC ANALYSES*****

/*
Titel: Econometric Analyses
Date: 28/5/2018
Name: Menno Koens
*/

cd "H:\Downloads\Econometrics"
capture log close
log using Logfolder\EconometricsAnalysis.txt, text replace

*******************************************************************************
*STATA data file
*use Datafolder\EcoTrie.dta, clear

*Explore the data
br
desc
sum

*******************************************************************************
***CONSUMPTION***
/*Time series data from 1970 till 2015. Progressive and Stagnant sector
consumption and disposable are used as growth rates, to make sure that the
data is stationary without a trend. The short term interest rate is used*/

*Explore the relations with a scatter plot and fitted line
twoway (scatter dConsumpP dIncome) (lfit dConsumpP dIncome)
twoway (scatter dConsumpS dIncome) (lfit dConsumpS dIncome)
twoway (scatter dConsumpP NInterestS) (lfit dConsumpP NInterestS)
twoway (scatter dConsumpS NInterestS) (lfit dConsumpS NInterestS)

/*OLS regression of disposable income (X) on progressive and stagnant sector
consumption (Y)*/
reg dConsumpP dIncome
reg dConsumpS dIncome

/*OLS regression of short term interest rate (X) on progressive and
stagnant sector consumption (Y)*/
reg dConsumpP NInterestS
reg dConsumpS NInterestS
*******************************************************************************
***PRODUCTIVITY***
/*Time series data from 2001 till 2015. Progressive and Stagnant sector
productivity and investment are used as growth rates, to make sure that the data
is stationary without a trend.*/

*Explore the relations with a scatter plot and fitted line
twoway (scatter dProducP dGDPP) (lfit dProducP dGDPP)
twoway (scatter dProducS dGDPS) (lfit dProducS dGDPS)

/*OLS regression of progressive and stagnant sector investment (X) on
progressive and stagnant sector productivity (Y)*/
reg dProducP dGDPP
reg dProducP dInvestP1
reg dProducS dGDPS
reg dProducS dInvestS1

*******************************************************************************
***INVESTMENT***
/*Time series data from 1998 till 2014. Progressive and Stagnant sector
investments and profits and long term interest rate are used as growth rates,
to make sure that the data is stationary without a trend.*/

*Explore the relations with a scatter plot and fitted line
twoway (scatter dInvestP2 dProfitP) (lfit dInvestP2 dProfitP)
twoway (scatter dInvestS2 dProfitS) (lfit dInvestS2 dProfitS)
twoway (scatter dInvestP3 dInterestL) (lfit dInvestP3 dInterestL)
twoway (scatter dInvestS3 dInterestL) (lfit dInvestS3 dInterestL)

/*OLS regression of progessive and stagnant sector profits (X) on progressive
and stagnant sector investment (Y)*/
reg dInvestP2 dProfitP
reg dInvestS2 dProfitS

/*OLS regression of long term interest rate (X) on progressive and
stagnant sector investment (Y)*/
reg dInvestP3 dInterestL
reg dInvestS3 dInterestL

*******************************************************************************
* Close the log file
log close
```

# Appendix IX

**Consumption and Income data (constant prices, constant PPPs, OECD base year 2010)**

| Time Series Data | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
| **Raw data** | | | | | | | | | | | | |
| Net national disposable income, millions of US $ | 4255436,57 | 4372056,55 | 4618766,25 | 4901847,98 | 4780797,83 | 4709605,74 | 4974936,92 | 5201718,36 | 5482145,19 | 5581883,38 | 5456268,73 | 5602774,22 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ | 2971998,41 | 3084430,80 | 3274125,35 | 3438730,16 | 3410798,05 | 3489208,76 | 3683519,84 | 3840249,69 | 4008943,04 | 4103494,28 | 4086793,21 | 4142736,77 |
| **Prepared data** | | | | | | | | | | | | |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) | 1575159,16 | 1634748,32 | 1735286,44 | 1822526,98 | 1807722,97 | 1849280,64 | 1952265,52 | 2035332,34 | 2124739,81 | 2174851,97 | 2166000,40 | 2195650,49 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) | 1396839,252 | 1449682,474 | 1538838,917 | 1616203,173 | 1603075,084 | 1639928,116 | 1731254,325 | 1804917,356 | 1884203,228 | 1928642,313 | 1920792,809 | 1947086,28 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 59589,17 | 100538,12 | 87240,54 | -14804,01 | 41557,67 | 102984,87 | 83066,82 | 89407,47 | 50112,16 | -8851,57 | 29650,09 | 25336,18 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 59,5891659 | 100,5381161 | 87,24054458 | -14,8040149 | 41,55767407 | 102,9848735 | 83,06682278 | 89,40747232 | 50,11215932 | -8,85156837 | 29,65008516 | 25,33617888 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 52843,22259 | 89156,44254 | 77364,25652 | -13128,0887 | 36853,03173 | 91326,20859 | 73663,03152 | 79285,87168 | 44439,08468 | -7849,50403 | 26293,47174 | 22467,93222 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 52,84322259 | 89,15644254 | 77,36425652 | -13,1280887 | 36,85303173 | 91,32620859 | 73,66303152 | 79,28587168 | 44,43908468 | -7,84950403 | 26,29347174 | 22,46793222 |
| Net national disposable income, millions of US $ **GROWTH** | 116619,98 | 246709,70 | 283081,73 | -121050,15 | -71192,09 | 265331,18 | 226781,45 | 280426,83 | 99738,19 | -125614,65 | 146505,49 | -80389,74 |
| Net national disposable income, billions of US $ **GROWTH** | 116,6199815 | 246,7097019 | 283,0817256 | -121,050153 | -71,1920851 | 265,3311751 | 226,7814468 | 280,4268316 | 99,738185 | -125,614645 | 146,5054903 | -80,3897356 |

| Years | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net national disposable income, millions of US $ | 5522384,49 | 5750157,44 | 6263920,42 | 6504119,38 | 6653587,00 | 6925396,19 | 7298769,88 | 7476845,92 | 7578361,38 | 7623843,23 | 7833925,35 | 8013660,89 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ | 4190540,88 | 4421904,19 | 4646566,52 | 4888631,87 | 5086008,09 | 5253874,36 | 5463541,64 | 5611045,57 | 5706971,19 | 5704835,87 | 5897777,66 | 6096984,01 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) | 2220986,67 | 2343609,22 | 2462680,26 | 2590974,89 | 2695584,29 | 2784553,41 | 2895677,07 | 2973854,15 | 3024694,73 | 3023563,01 | 3125822,16 | 3231401,53 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) | 1969554,213 | 2078294,969 | 2183886,266 | 2297656,978 | 2390423,801 | 2469320,951 | 2567864,572 | 2637191,418 | 2682276,46 | 2681272,86 | 2771955,502 | 2865582,485 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 122622,56 | 119071,04 | 128294,63 | 104609,40 | 88969,13 | 111123,66 | 78177,08 | 50840,58 | -1131,72 | 102259,15 | 105579,36 | 122129,21 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 122,6225554 | 119,0710368 | 128,2946331 | 104,6093954 | 88,96912639 | 111,123658 | 78,17708205 | 50,84057918 | -1,13171971 | 102,2591495 | 105,5793638 | 122,129214 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 108740,7567 | 105591,2967 | 113770,7123 | 92766,82232 | 78897,14981 | 98543,62122 | 69326,84635 | 45085,04192 | -1003,60049 | 90682,64201 | 93626,983 | 108303,2653 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 108,7407567 | 105,5912967 | 113,7707123 | 92,76682232 | 78,89714981 | 98,54362122 | 69,32684635 | 45,08504192 | -1,00360049 | 90,68264201 | 93,626983 | 108,3032653 |
| Net national disposable income, millions of US $ **GROWTH** | 227772,95 | 513762,98 | 240198,96 | 149467,61 | 271809,19 | 373373,69 | 178076,04 | 101515,45 | 45481,85 | 210082,12 | 179735,54 | 364719,72 |
| Net national disposable income, billions of US $ **GROWTH** | 227,7729519 | 513,7629803 | 240,1989633 | 149,4676108 | 271,8091931 | 373,3736938 | 178,0760412 | 101,5154531 | 45,4818531 | 210,0821226 | 179,7355397 | 364,7197202 |

| Years | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Net national disposable income, millions of US $ | 8378380,61 | 8661791,38 | 9062849,91 | 9558301,31 | 10103551,62 | 10548672,39 | 10997300,66 | 11119714,46 | 11270071,18 | 11526112,32 | 11950633,00 | 12303366,49 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ | 6327416,49 | 6514319,57 | 6738865,93 | 7009549,04 | 7378146,60 | 7765015,95 | 8153440,76 | 8353798,69 | 8552647,97 | 8812782,66 | 9155766,55 | 9486183,69 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) | 3353530,74 | 3452589,37 | 3571598,94 | 3715060,99 | 3910417,70 | 4115458,45 | 4321323,60 | 4427513,31 | 4532903,42 | 4670774,81 | 4852556,27 | 5027677,36 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) | 2973885,75 | 3061730,196 | 3167266,986 | 3294488,048 | 3467728,902 | 3649557,497 | 3832117,156 | 3926285,385 | 4019744,544 | 4142007,848 | 4303210,278 | 4458506,334 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 99058,63 | 119009,57 | 143462,05 | 195356,71 | 205040,76 | 205865,15 | 106189,71 | 105390,11 | 137871,39 | 181781,46 | 175121,08 | 141123,67 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 99,05863113 | 119,0095713 | 143,4620491 | 195,3567074 | 205,0407556 | 205,8651479 | 106,1897052 | 105,3901148 | 137,8713862 | 181,7814629 | 175,121085 | 141,123665 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 87844,44647 | 105536,7896 | 127221,0625 | 173240,8537 | 181828,5945 | 182559,6594 | 94168,22917 | 93459,15845 | 122263,3048 | 161202,4294 | 155296,0565 | 125147,4011 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 87,84444647 | 105,5367896 | 127,2210625 | 173,2408537 | 181,8285945 | 182,5596594 | 94,16822917 | 93,45915845 | 122,2633048 | 161,2024294 | 155,2960565 | 125,1474011 |
| Net national disposable income, millions of US $ **GROWTH** | 283410,76 | 401058,53 | 495451,40 | 545250,31 | 445120,77 | 448628,27 | 122413,80 | 150356,73 | 256041,14 | 424520,67 | 352733,50 | 449831,19 |
| Net national disposable income, billions of US $ **GROWTH** | 283,4107638 | 401,058533 | 495,4514004 | 545,2503065 | 445,120773 | 448,6282718 | 122,4137952 | 150,3567258 | 256,0411405 | 424,5206741 | 352,7334959 | 449,8311895 |

| Years | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Net national disposable income, millions of US $ | 12753197,68 | 12717149,68 | 12439877,88 | 12169273,56 | 12600301,00 | 12893936,67 | 13359209,58 | 13538387,83 | 13991532,80 | 14462921,52 | 14600923,40 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ | 9752454,76 | 9969682,64 | 9902111,30 | 9736564,47 | 9926845,00 | 10160731,22 | 10294423,22 | 10442815,26 | 10753761,21 | 11153558,45 | 11450178,74 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) | 5168801,02 | 5283931,80 | 5248118,99 | 5160379,17 | 5261227,85 | 5385187,55 | 5456044,31 | 5534692,09 | 5699493,44 | 5911385,98 | 6068594,73 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) | 4583653,735 | 4685750,839 | 4653992,31 | 4576185,303 | 4665617,15 | 4775543,676 | 4838378,915 | 4908123,171 | 5054267,768 | 5242172,473 | 5381584,006 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 115130,78 | -35812,81 | -87739,82 | 100848,68 | 123959,70 | 70856,76 | 78647,78 | 164801,35 | 211892,54 | 157208,75 | -2579298,35 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for progressive sector products and services * 0,53**) GROWTH | 115,1307759 | -35,81280829 | -87,73981683 | 100,8486785 | 123,9596991 | 70,85675899 | 78,64777823 | 164,8013543 | 211,8925392 | 157,2087499 | -2579,298348 |
| Final consumption expend. of res. households on the territory and abroad, millions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 102097,1032 | -31758,52811 | -77807,00737 | 89431,84694 | 109926,5257 | 62835,23911 | 69744,25617 | 146144,5972 | 187904,7045 | 139411,533 | -2287302,309 |
| Final consumption expend. of res. households on the territory and abroad, billions of US $ (**for stagnant sector products and services * 0,47**) GROWTH | 102,0971032 | -31,75852811 | -77,80700737 | 89,43184694 | 109,9265257 | 62,83523911 | 69,74425617 | 146,1445972 | 187,9047045 | 139,411533 | -2287,302309 |
| Net national disposable income, millions of US $ **GROWTH** | -36048,00 | -277271,80 | -270604,32 | 431027,44 | 293635,67 | 465272,91 | 179178,25 | 453144,97 | 471388,71 | 138001,88 | -14600923,40 |
| Net national disposable income, billions of US $ **GROWTH** | -36,0480034 | -277,2718001 | -270,6043169 | 431,0274389 | 293,6356686 | 465,2729099 | 179,1782538 | 453,1449692 | 471,3887146 | 138,001881 | -14600,9234 |

**<u>Table can be found at stats.oecd.org:</u>**

**National Accounts --> Annual National Accounts --> Main Aggregates --> 2. Disposable income and net lending - net borrowing --> Disposable income. US $, volume, constant PPPs**

**National Accounts --> Annual National Accounts --> Detailed Tables and Simplified Accounts --> 5. Final consumption expenditure of households**

## Progressive and Stagnant sector consumption data

| Industry | Millions US $ Household FC | Economic Activity | Sector | Stagnant Sector | Progressive Sector | Total |
|---|---|---|---|---|---|---|
| TTL_C01T05: Agriculture, hunting, forestry and fishing | 81329,9 | N/A | Stagnant | 4599259,9 | 5127898,1 | 9727158 |
| TTL_C10T14: Mining and quarrying | 11946,2 | BDE: Mining and Utilities | Stagnant | 0,47 | 0,53 | |
| TTL_C15T16: Food products, beverages and tobacco | 540663,6 | C: Manufacturing | Dynamic | | | |
| TTL_C17T19: Textiles, textile products, leather and footwear | 119677,7 | C: Manufacturing | Dynamic | | | |
| TTL_C20: Wood and products of wood and cork | 4571,1 | C: Manufacturing | Dynamic | | | |
| TTL_C21T22: Pulp, paper, paper products, printing and publishing | 131613,8 | C: Manufacturing | Dynamic | | | |
| TTL_C23: Coke, refined petroleum products and nuclear fuel | 303869,7 | C: Manufacturing | Dynamic | | | |
| TTL_C24: Chemicals and chemical products | 236683,1 | C: Manufacturing | Dynamic | | | |
| TTL_C25: Rubber and plastics products | 36418,7 | C: Manufacturing | Dynamic | | | |
| TTL_C26: Other non-metallic mineral products | 11682,5 | C: Manufacturing | Dynamic | | | |
| TTL_C27: Basic metals | 3329,2 | C: Manufacturing | Dynamic | | | |
| TTL_C28: Fabricated metal products | 19723,3 | C: Manufacturing | Dynamic | | | |
| TTL_C29: Machinery and equipment, nec | 20618,8 | C: Manufacturing | Dynamic | | | |
| TTL_C30T33X: Computer, Electronic and optical equipment | 103029 | C: Manufacturing | Dynamic | | | |
| TTL_C31: Electrical machinery and apparatus, nec | 38726 | C: Manufacturing | Dynamic | | | |
| TTL_C34: Motor vehicles, trailers and semi-trailers | 220664,3 | C: Manufacturing | Dynamic | | | |
| TTL_C35: Other transport equipment | 15715,2 | C: Manufacturing | Dynamic | | | |
| TTL_C36T37: Manufacturing nec; recycling | 122256,3 | C: Manufacturing | Dynamic | | | |
| TTL_C40T41: Electricity, gas and water supply | 177840,7 | BDE: Mining and Utilities | Stagnant | | | |
| TTL_C45: Construction | 229,9 | F: Construction | Stagnant | | | |
| TTL_C50T52: Wholesale and retail trade; repairs | 1070981,9 | G_I: Wholesale retail trade accommodation food services, transportation and storage | Stagnant | | | |
| TTL_C55: Hotels and restaurants | 546885,5 | G_I: Wholesale retail trade accommodation food services, transportation and storage | Stagnant | | | |
| TTL_C60T63: Transport and storage | 188708,3 | G_I: Wholesale retail trade accommodation food services, transportation and storage | Stagnant | | | |
| TTL_C64: Post and telecommunications | 365630,2 | J: Information and Communicatior | Dynamic | | | |
| TTL_C65T67: Financial intermediation | 1033379,5 | K: Financial and Insurance activiti | Dynamic | | | |
| TTL_C70: Real estate activities | 1551067,6 | N/A | Dynamic | | | |
| TTL_C71: Renting of machinery and equipment | 32720,7 | MN: Professional, scientific and technical activities, Administrative and support service activities | Dynamic | | | |
| TTL_C72: Computer and related activities | 26428,6 | J: Information and Communicatior | Dynamic | | | |
| TTL_C73T74: R&D and other business activities | 189429,2 | MN: Professional, scientific and technical activities, Administrative and support service activities | Dynamic | | | |
| TTL_C75: Public administration and defence; compulsory social security | 261420,1 | N/A | Stagnant | | | |
| TTL_C80: Education | 151986 | N/A | Stagnant | | | |
| TTL_C85: Health and social work | 1542063,4 | N/A | Stagnant | | | |
| TTL_C90T93: Other community, social and personal services | 550220 | N/A | Stagnant | | | |
| TTL_C95: Private households with employed persons | 15648 | N/A | Stagnant | | | |

<u>**Table can be found at stats.oecd.org:**</u>

**Industry and Services --> Structural Analysis (STAN) Databases --> Input Output Database --> Input-Output Tables**

**Regression output of Income on Consumption**

```
. reg dConsumpP dIncome

      Source |       SS           df       MS      Number of obs   =        46
-------------+----------------------------------   F(1, 44)        =     95.33
       Model |  125828.468         1  125828.468   Prob > F        =    0.0000
    Residual |  58076.1094        44  1319.91158   R-squared       =    0.6842
-------------+----------------------------------   Adj R-squared   =    0.6770
       Total |  183904.578        45  4086.76839   Root MSE        =    36.331

------------------------------------------------------------------------------
   dConsumpP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     dIncome |   .2589501   .0265216     9.76   0.000     .2054994    .3124008
       _cons |   39.44501    8.01698     4.92   0.000     23.28785    55.60217
------------------------------------------------------------------------------

. reg dConsumpS dIncome

      Source |       SS           df       MS      Number of obs   =        46
-------------+----------------------------------   F(1, 44)        =     95.33
       Model |  98951.6148         1  98951.6148   Prob > F        =    0.0000
    Residual |  45671.1021        44  1037.97959   R-squared       =    0.6842
-------------+----------------------------------   Adj R-squared   =    0.6770
       Total |  144622.717        45  3213.83815   Root MSE        =    32.218

------------------------------------------------------------------------------
   dConsumpS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     dIncome |    .229635   .0235191     9.76   0.000     .1822353    .2770347
       _cons |   34.97954   7.109397     4.92   0.000     20.65149    49.30759
------------------------------------------------------------------------------
```

# Appendix X

### Short term nominal interest rate data

**Interest Rate**

| Years | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Short term interest rate, percentages % | 7,56 | 5,00 | 4,67 | 8,42 | 10,24 | 6,44 | 5,27 | 5,64 | 8,22 | 11,22 | 13,07 | 15,91 | 12,27 | 9,07 | 10,37 | 8,05 | 6,52 | 6,86 | 7,73 | 9,09 | 8,15 | 5,83 | 3,68 | 3,17 |
| Short term interest rate, percentages %/100 | 0,0756 | 0,0500 | 0,0467 | 0,0842 | 0,1024 | 0,0644 | 0,0527 | 0,0564 | 0,0822 | 0,1122 | 0,1307 | 0,1591 | 0,1227 | 0,0907 | 0,1037 | 0,0805 | 0,0652 | 0,0686 | 0,0773 | 0,0909 | 0,0815 | 0,0583 | 0,0368 | 0,0317 |

| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4,63 | 5,92 | 5,39 | 5,62 | 5,47 | 5,33 | 6,46 | 3,69 | 1,73 | 1,15 | 1,56 | 3,51 | 5,15 | 5,27 | 2,96 | 0,56 | 0,31 | 0,30 | 0,28 | 0,17 | 0,12 | 0,23 | 0,64 |
| | 0,0463 | 0,0592 | 0,0539 | 0,0562 | 0,0547 | 0,0533 | 0,0646 | 0,0369 | 0,0173 | 0,0115 | 0,0156 | 0,0351 | 0,0515 | 0,0527 | 0,0296 | 0,0056 | 0,0031 | 0,0030 | 0,0028 | 0,0017 | 0,0012 | 0,0023 | 0,0064 |

**<u>Data can be found at</u>:**

https://data.oecd.org/interest/short-term-interest-rates.htm#indicator-chart

### Regression output of Interest Rate on Consumption

```
. reg dConsumpP NInterestS

      Source |       SS           df       MS      Number of obs   =        46
-------------+----------------------------------   F(1, 44)        =      9.01
       Model |  31259.788         1  31259.788     Prob > F        =    0.0044
    Residual |  152644.79        44  3469.19976    R-squared       =    0.1700
-------------+----------------------------------   Adj R-squared   =    0.1511
       Total |  183904.578        45  4086.76839   Root MSE        =      58.9

------------------------------------------------------------------------------
   dConsumpP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  NInterestS |  -708.3918   235.9909    -3.00   0.004        -1184   -232.7835
       _cons |    137.455    15.8418     8.68   0.000     105.5279     169.382
------------------------------------------------------------------------------

. reg dConsumpS NInterestS

      Source |       SS           df       MS      Number of obs   =        46
-------------+----------------------------------   F(1, 44)        =      9.01
       Model |  24582.724         1   24582.724    Prob > F        =    0.0044
    Residual |  120039.993        44  2728.18166   R-squared       =    0.1700
-------------+----------------------------------   Adj R-squared   =    0.1511
       Total |  144622.717        45  3213.83815   Root MSE        =    52.232

------------------------------------------------------------------------------
   dConsumpS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  NInterestS |  -628.1965   209.2749    -3.00   0.004    -1049.962   -206.4307
       _cons |    121.894   14.04839     8.68   0.000     93.58136    150.2067
------------------------------------------------------------------------------
```

# Appendix XI

### Business profits data (current prices)

**Profits**
added and its components by activity, ISIC rev4

Country: United States
Transaction: Gross operating surplus and gross mixed income
Measure: Current prices
Unit: US Dollar, Millions

| Activity | | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VTOT: Total activity | i | | | | | | | | | | | | | | | | | |
| VTOT: Total activity | | 3403674 | 3614769 | 3758917 | 3899107 | 4106593 | 4379018 | 4708597 | 5122191 | 5401714 | 5588888 | 5639266 | 5655286 | 5993643 | 6198252 | 6462692 | 6724013 | 6975908,997 |
| VA0: Agriculture, forestry and fishing | Stagnant | 77552 | 76225 | 82690 | 83181 | 69166 | 92469 | 112552 | 108392 | 96754 | 103026 | 114454 | 97875 | 121090 | 156168 | 137697 | 173060,3 | 149935,692 |
| VB: Mining and quarrying | Stagnant | 33927 | 38113 | 60761 | 71282 | 62614 | 85721 | 106287 | 154119 | 187255 | 217739 | 285910 | 195924 | 229063 | 278645 | 280663 | 315130,278 | 341200,147 |
| VC: Manufacturing | Progressive | 558938 | 580533 | 591297 | 549514 | 576374 | 632698 | 692534 | 752563 | 821777 | 849738 | 815458 | 812869 | 904192 | 942466 | 983273 | 1020477,89 | 1044304,134 |
| VD: Electricity, gas, steam and air conditioning supply | Stagnant | 89224 | 100159 | 95817 | 100816 | 87480 | 93504 | 104054 | 99249 | 118506 | 117370 | 118507 | 129765 | 143593 | 143598 | 134943 | 138907,704 | 150655,868 |
| VE: Water supply, sewerage, waste management and remediation activities | Stagnant | 7861 | 9370 | 9879 | 11590 | 12786 | 13850 | 12415 | 12642 | 9349 | 12249 | 11829 | 13001 | 14755 | 13199 | 12256 | 12331,29 | 13784,89 |
| VF: Construction | Stagnant | 123164 | 135446 | 149633 | 157280 | 162079 | 185320 | 222909 | 259302 | 269009 | 267331 | 212087 | 200885 | 189734 | 190471 | 209820 | 225278,791 | 243867,884 |
| VG: Wholesale and retail trade, repair of motor vehicles and motorcycles | Stagnant | 301818 | 304855 | 315274 | 313429 | 320223 | 348493 | 377748 | 416652 | 441131 | 443543 | 445863 | 458661 | 497287 | 495239 | 542911 | 571780,043 | 597102,802 |
| VH: Transportation and storage | Stagnant | 94020 | 92091 | 94159 | 95455 | 92745 | 106670 | 119134 | 127487 | 151815 | 137255 | 149885 | 141395 | 160173 | 160402 | 164645 | 170606,182 | 184489,905 |
| VI: Accommodation and food service activities | Stagnant | 56689 | 64475 | 75173 | 72773 | 82889 | 81713 | 87175 | 88666 | 94835 | 91597 | 86513 | 85551 | 89877 | 94449 | 97871 | 104447,353 | 107202,859 |
| VJ: Information and communication | Progressive | 222675 | 238359 | 185168 | 217629 | 289351 | 308631 | 357133 | 374181 | 374983 | 421800 | 453148 | 439842 | 467767 | 454136 | 453790 | 490867,579 | 468322,203 |
| VK: Financial and insurance activities | Progressive | 263745 | 276966 | 310847 | 342897 | 360428 | 372478 | 354680 | 416724 | 427280 | 377777 | 247957 | 372157 | 383439 | 381246 | 464145 | 445799,058 | 509323,117 |
| VL: Real estate activities | Progressive | 810293 | 878375 | 929010 | 1002892 | 1060987 | 1109182 | 1166201 | 1265334 | 1293384 | 1402361 | 1442626 | 1457806 | 1500868 | 1563036 | 1610553 | 1668024,2 | 1737799,305 |
| VM: Professional, scientific and technical activities | Progressive | 174188 | 191484 | 199849 | 211602 | 241885 | 244868 | 262434 | 265153 | 275080 | 289829 | 340818 | 309150 | 318136 | 324112 | 328502 | 323667,991 | 338752,445 |
| VN: Administrative and support service activities | Progressive | 125411 | 141603 | 149699 | 168776 | 165911 | 173350 | 176361 | 190049 | 215131 | 218130 | 237571 | 225400 | 229469 | 234092 | 246241 | 254181,599 | 261747,941 |
| VO: Public administration and defence, compulsory social security | Stagnant | 230546 | 238046 | 244397 | 247769 | 251540 | 257674 | 268620 | 288835 | 306237 | 322619 | 342396 | 355342 | 370917 | 391962 | 412820 | 421834,833 | 427919,5 |
| VP: Education | Stagnant | 36141 | 38636 | 41468 | 43622 | 42920 | 46681 | 51374 | 54612 | 58653 | 63484 | 69040 | 75458 | 77230 | 78509 | 79924 | 80441,046 | 83125,156 |
| VQ: Human health and social work activities | Stagnant | 82497 | 87295 | 92425 | 102071 | 110413 | 113712 | 119154 | 119671 | 126305 | 125536 | 147709 | 163039 | 164909 | 166960 | 164698 | 165056,398 | 168831,804 |
| VR: Arts, entertainment and recreation | Stagnant | 29641 | 32467 | 35021 | 29717 | 32881 | 36916 | 39794 | 41863 | 44202 | 45381 | 44211 | 45228 | 49161 | 49703 | 53335 | 56870,381 | 60131,098 |
| Data extracted on 03 May 2018 11:49 UTC (GMT) from OECD.Stat | | | | | | | | | | | | | | | | | | |
| Millions | Progressive | 2155250 | 2307320 | 2365870 | 2493310 | 2694936 | 2841207 | 3009343 | 3264004 | 3407635 | 3559635 | 3537578 | 3617224 | 3803871 | 3899088 | 4086504 | 4203018 | 4360249 |
| Millions | Stagnant | 1163080 | 1217178 | 1296697 | 1328985 | 1327736 | 1462723 | 1621216 | 1771490 | 1904051 | 1947130 | 2028404 | 1962124 | 2107789 | 2219305 | 2291583 | 2435745 | 2528248 |
| Millions | Total | 3318330 | 3524498 | 3662567 | 3822295 | 4022672 | 4303930 | 4630559 | 5035494 | 5311686 | 5506765 | 5565982 | 5579348 | 5911660 | 6118393 | 6378087 | 6638763 | 6888497 |
| | Progressive% | 0,65 | 0,65 | 0,65 | 0,65 | 0,67 | 0,66 | 0,65 | 0,65 | 0,64 | 0,65 | 0,64 | 0,65 | 0,64 | 0,64 | 0,64 | 0,63 | 0,63 |
| | Stagnant% | 0,35 | 0,35 | 0,35 | 0,35 | 0,33 | 0,34 | 0,35 | 0,35 | 0,36 | 0,35 | 0,36 | 0,35 | 0,36 | 0,36 | 0,36 | 0,37 | 0,37 |
| Millions | Progressive.G | 152070 | 58550 | 127440 | 201626 | 146271 | 168136 | 254661 | 143631 | 152000 | -22057 | 79646 | 186647 | 95217 | 187416 | 116514,3 | 157230,8 | 224801,6 |
| Millions | Stagnant.G | 54098 | 79519 | 32288 | -1249 | 134987 | 158493 | 150274 | 132561 | 43079 | 81274 | -66280 | 145665 | 111516 | 72278 | 144161,6 | 92503,01 | -56290,8 |
| Billions | Progressive.G | 152,07 | 58,55 | 127,44 | 201,626 | 146,271 | 168,136 | 254,661 | 143,631 | 152 | -22,057 | 79,646 | 186,647 | 95,217 | 187,416 | 116,5143 | 157,2308 | 224,8016 |
| Billions | Stagnant.G | 54,098 | 79,519 | 32,288 | -1,249 | 134,987 | 158,493 | 150,274 | 132,561 | 43,079 | 81,274 | -66,28 | 145,665 | 111,516 | 72,278 | 144,1616 | 92,50301 | -56,2908 |

**Table can be found at stats.oecd.org:**

**National Accounts --> Annual National Accounts --> Detailed Tables and Simplified Accounts --> 6A Value added and its components by activity, ISIC rev4**

## Investment data (current prices)

**Investments**

Capital formation by activity ISIC rev4

| | | | Country | United States | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Transaction | Gross fixed capital formation | | | | | | | | | | | | | | | | |
| | | | Measure | Current prices | | | | | | | | | | | | | | | | |
| | | | Unit | US Dollar, Millions | | | | | | | | | | | | | | | | |
| | | | Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Activity | | | i | | | | | | | | | | | | | | | | | |
| VTOT: Total activity | | | i | 2004938 | 2180997 | 2352627 | 2361550 | 2331957 | 2451194 | 2683458 | 2964956 | 3152026 | 3192012 | 3084509 | 2655170 | 2683090 | 2829449 | 3051085 | 3183929 | 3408360 |
| VTOT: Total activity | VA0: Agriculture, forestry and fishing | | Stagnant | 27088 | 23017 | 25036 | 26250 | 28936 | 30697 | 34679 | 37332 | 35777 | 36346 | 43473 | 42617 | 44847 | 50360 | 65103 | 72488 | 81904 |
| | VB: Mining and quarrying | | Stagnant | 41677 | 37625 | 40659 | 50756 | 41067 | 52756 | 63302 | 88588 | 124547 | 136557 | 156077 | 106778 | 121617 | 158508 | 187005 | 190505 | 212350 |
| | VC: Manufacturing | | Progressive | 304478 | 306433 | 326992 | 324617 | 289699 | 278990 | 289040 | 321304 | 345308 | 396548 | 411587 | 351689 | 361156 | 398118 | 427816 | 450509 | 462152 |
| | VD: Electricity, gas, steam and air conditioning supply | | Stagnant | 47099 | 49918 | 69564 | 78538 | 66596 | 64071 | 57685 | 63140 | 74474 | 96800 | 104031 | 106734 | 96465 | 104751 | 128351 | 115169 | 131706 |
| | VE: Water supply, sewerage, waste management and remediation activities | | Stagnant | 3285 | 3523 | 4005 | 3691 | 3255 | 3756 | 4449 | 4853 | 6265 | 5459 | 4559 | 4201 | 4852 | 6613 | 5405 | 5904 | 6292 |
| | VF: Construction | | Stagnant | 32071 | 35961 | 33100 | 29131 | 31682 | 28573 | 37369 | 40166 | 42989 | 46598 | 44190 | 19242 | 23102 | 27731 | 32495 | 39412 | 40817 |
| | VG: Wholesale and retail trade, repair of motor vehicles and motorcycles | | Stagnant | 109916 | 115115 | 128552 | 120444 | 117949 | 133458 | 147483 | 165791 | 169166 | 153924 | 150757 | 114835 | 124164 | 146717 | 157831 | 147533 | 175043 |
| | VH: Transportation and storage | | Stagnant | 76357 | 73770 | 76686 | 71944 | 53773 | 49859 | 56688 | 66474 | 77270 | 75289 | 82659 | 61248 | 67720 | 80553 | 89827 | 101584 | 127160 |
| | VI: Accommodation and food service activities | | Stagnant | 27820 | 29340 | 28786 | 28636 | 26408 | 27764 | 26474 | 32268 | 38415 | 45521 | 54820 | 37881 | 23243 | 26072 | 29647 | 34270 | 34997 |
| | VJ: Information and communication | | Progressive | 172217 | 208869 | 253176 | 235503 | 193968 | 192305 | 199370 | 209680 | 235269 | 250331 | 239860 | 221625 | 241424 | 243014 | 240553 | 263238 | 280549 |
| | VK: Financial and insurance activities | | Progressive | 118148 | 130973 | 134618 | 129841 | 125167 | 126152 | 143789 | 148091 | 157815 | 169709 | 145094 | 111569 | 118298 | 128106 | 149552 | 158320 | 179188 |
| | VL: Real estate activities | | Progressive | 458762 | 503245 | 524234 | 545193 | 596130 | 663586 | 791487 | 895899 | 885657 | 754073 | 582550 | 438335 | 417121 | 416420 | 479045 | 562132 | 619212 |
| | VM: Professional, scientific and technical activities | | Progressive | 66760 | 79675 | 85171 | 82099 | 92103 | 96116 | 94181 | 108456 | 103254 | 116609 | 130778 | 121444 | 119516 | 122037 | 135341 | 135891 | 130783 |
| | VN: Administrative and support service activities | | Progressive | 60390 | 89760 | 92058 | 77855 | 64244 | 73667 | 79208 | 92047 | 110158 | 95629 | 75581 | 60823 | 72824 | 86368 | 105236 | 106142 | 117923 |
| | VO: Public administration and defence, compulsory social security | | Stagnant | 338524 | 365345 | 388154 | 412420 | 441917 | 462701 | 486356 | 510456 | 549607 | 592428 | 632972 | 645210 | 650012 | 635879 | 612986 | 590578 | 592548 |
| | VP: Education | | Stagnant | 17745 | 17982 | 21361 | 23025 | 25683 | 25388 | 27230 | 25638 | 28995 | 31878 | 35720 | 35325 | 32266 | 32490 | 33589 | 32498 | 33821 |
| | VQ: Human health and social work activities | | Stagnant | 61179 | 62056 | 64373 | 66673 | 80184 | 84610 | 89601 | 100235 | 106638 | 121795 | 124990 | 116956 | 113135 | 116649 | 122343 | 126659 | 121985 |
| | VR: Arts, entertainment and recreation | | Stagnant | 17504 | 22651 | 27247 | 24524 | 23433 | 22985 | 24520 | 24033 | 25714 | 29073 | 27647 | 25968 | 21482 | 21542 | 22104 | 23766 | 28307 |
| | VS: Other service activities | | Stagnant | 23918 | 25740 | 28856 | 30408 | 29762 | 33760 | 30547 | 30505 | 34708 | 37445 | 37166 | 32691 | 29846 | 27521 | 26855 | 27329 | 31623 |
| Data extracted on 03 May 2018 07:06 UTC (GMT) from OECD.Stat | | | | | | | | | | | | | | | | | | | | |
| | | Millions | Progressive | 1180755 | 1318955 | 1416249 | 1395108 | 1361311 | 1430816 | 1597075 | 1775477 | 1837461 | 1782899 | 1585450 | 1305485 | 1330339 | 1394063 | 1537543 | 1676232 | 1789807 |
| | | Millions | Stagnant | 824183 | 862043 | 936379 | 966440 | 970645 | 1020378 | 1086383 | 1189479 | 1314565 | 1409113 | 1499061 | 1349686 | 1352751 | 1435386 | 1513541 | 1507695 | 1618553 |
| | | | Progressive% | 0,59 | 0,60 | 0,60 | 0,59 | 0,58 | 0,58 | 0,60 | 0,60 | 0,58 | 0,56 | 0,51 | 0,49 | 0,50 | 0,49 | 0,50 | 0,53 | 0,53 |
| | | | Stagnant% | 0,41 | 0,40 | 0,40 | 0,41 | 0,42 | 0,42 | 0,40 | 0,40 | 0,42 | 0,44 | 0,49 | 0,51 | 0,50 | 0,51 | 0,50 | 0,47 | 0,47 |
| | | Millions | Progressive.G | 138200 | 97294 | -21141 | -33797 | 69505 | 166259 | 178402 | 61984 | -54562 | -197449 | -279965 | 24854 | 63724 | 143480 | 138689 | 113575 | 167723 |
| | | Millions | Stagnant.G | 37860 | 74336 | 30061 | 4205 | 49733 | 66005 | 103096 | 125086 | 94548 | 89948 | -149375 | 3065 | 82635 | 78155 | -5846 | 110858 | -16426 |
| | | Billions | Progressive.G | 138,2 | 97,294 | -21,141 | -33,797 | 69,505 | 166,259 | 178,402 | 61,984 | -54,562 | -197,449 | -279,965 | 24,854 | 63,724 | 143,48 | 138,689 | 113,575 | 167,723 |
| | | Billions | Stagnant.G | 37,86 | 74,336 | 30,061 | 4,205 | 49,733 | 66,005 | 103,096 | 125,086 | 94,548 | 89,948 | -149,375 | 3,065 | 82,635 | 78,155 | -5,846 | 110,858 | -16,426 |

**Table can be found at stats.oecd.org:**

**National Accounts --> Annual National Accounts --> Detailed Tables and Simplified Accounts --> 8A. Capital formation by activity ISIC rev4**

**Regression output of Business Profits on Investments**

```
. reg dInvestP2 dProfitP

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(1, 15)        =      8.43
       Model |  96639.4962         1  96639.4962   Prob > F        =    0.0109
    Residual |  172037.854        15  11469.1903   R-squared       =    0.3597
-------------+----------------------------------   Adj R-squared   =    0.3170
       Total |   268677.35        16  16792.3344   Root MSE        =    107.09

------------------------------------------------------------------------------
   dInvestP2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    dProfitP |   1.182607    .407408     2.90   0.011     .3142375    2.050977
       _cons |  -123.3367   63.76097    -1.93   0.072      -259.24    12.56655
------------------------------------------------------------------------------

. reg dInvestS2 dProfitS

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(1, 15)        =      9.06
       Model |  26454.7514         1  26454.7514   Prob > F        =    0.0088
    Residual |  43813.8076        15   2920.9205   R-squared       =    0.3765
-------------+----------------------------------   Adj R-squared   =    0.3349
       Total |  70268.5589        16  4391.78493   Root MSE        =    54.046

------------------------------------------------------------------------------
   dInvestS2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    dProfitS |   .5851724   .1944428     3.01   0.009     .1707274    .9996175
       _cons |   .7073742   19.89825     0.04   0.972    -41.70474    43.11949
------------------------------------------------------------------------------
```

# Appendix XII

### Long term interest rate data

| Interest Rate | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Long term interest rate, percentages % | 5,30 | 5,60 | 6,00 | 5,00 | 4,60 | 4,00 | 4,30 | 4,30 | 4,80 | 4,60 | 3,70 | 3,30 | 3,20 | 2,80 | 1,80 | 2,40 | 2,50 |
| Inflation, percentages % | 1,60 | 2,20 | 3,40 | 2,80 | 1,60 | 2,30 | 2,70 | 3,40 | 3,20 | 2,90 | 3,80 | -0,40 | 1,60 | 3,20 | 2,10 | 1,50 | 1,60 |
| Real long term interest rate, percentages % | 3,70 | 3,40 | 2,60 | 2,20 | 3,00 | 1,70 | 1,60 | 0,90 | 1,60 | 1,70 | -0,10 | 3,70 | 1,60 | -0,40 | -0,30 | 0,90 | 0,90 |
| Real long term interest rate, percentages %/100 | 0,0370 | 0,0340 | 0,0260 | 0,0220 | 0,0300 | 0,0170 | 0,0160 | 0,0090 | 0,0160 | 0,0170 | -0,0010 | 0,0370 | 0,0160 | -0,0040 | -0,0030 | 0,0090 | 0,0090 |
| Real long term interest rate, percentages growth % | -0,30 | -0,80 | -0,40 | 0,80 | -1,30 | -0,10 | -0,70 | 0,70 | 0,10 | -1,80 | 3,80 | -2,10 | -2,00 | 0,10 | 1,20 | 0,00 | 1,10 |
| Real long term interest rate, percentages growth %/100 | -0,0030 | -0,0080 | -0,0040 | 0,0080 | -0,0130 | -0,0010 | -0,0070 | 0,0070 | 0,0010 | -0,0180 | 0,0380 | -0,0210 | -0,0200 | 0,0010 | 0,0120 | 0,0000 | 0,0110 |

Data can be found at:

https://data.oecd.org/interest/long-term-interest-rates.htm#indicator-chart

https://data.oecd.org/price/inflation-cpi.htm

### Regression output of Interest Rate on Investments

```
. reg dInvestP3 dInterestL

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(1, 15)        =      1.17
       Model |  15045.0527         1  15045.0527   Prob > F        =    0.2966
    Residual |  193007.698        15  12867.1799   R-squared       =    0.0723
-------------+----------------------------------   Adj R-squared   =    0.0105
       Total |  208052.751        16  13003.2969   Root MSE        =    113.43

------------------------------------------------------------------------------
   dInvestP3 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  dInterestL |  -2141.706   1980.636    -1.08   0.297    -6363.333     2079.92
       _cons |   24.70335   27.58289     0.90   0.385    -34.08819    83.49489
------------------------------------------------------------------------------

. reg dInvestS3 dInterestL

      Source |       SS           df       MS      Number of obs   =        17
-------------+----------------------------------   F(1, 15)        =     15.67
       Model |  23381.2221         1  23381.2221   Prob > F        =    0.0013
    Residual |  22382.3204        15  1492.15469   R-squared       =    0.5109
-------------+----------------------------------   Adj R-squared   =    0.4783
       Total |  45763.5424        16   2860.2214   Root MSE        =    38.628

------------------------------------------------------------------------------
   dInvestS3 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  dInterestL |   -2669.91   674.4814    -3.96   0.001    -4107.534   -1232.287
       _cons |   20.66903   9.393015     2.20   0.044     .6482933    40.68977
------------------------------------------------------------------------------
```

**Investment data (constant prices with 2009 as national base year)**

| Dataset: 8A. Capital formation by activity ISIC rev4 | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Country | United States | | | | | | | | | | | | | | | | |
| | | | Transaction | Gross fixed capital formation | | | | | | | | | | | | | | | | |
| | | | Measure | Constant prices, national base year | | | | | | | | | | | | | | | | |
| | | | Unit | US Dollar, Millions, 2009 | | | | | | | | | | | | | | | | |
| | | | Year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Activity | | | i | | | | | | | | | | | | | | | | | |
| VTOT: Total activity | | | i | 2436794 | 2636585 | 2793790 | 2774416 | 2729024 | 2833911 | 3007248 | 3176191 | 3246225 | 3211744 | 3054763 | 2655170 | 2681730 | 2778190 | 2950197 | 3034627 | 3180167 |
| VTOT: Total activity | VA0: Agriculture, forestry and fishing | | Stagnant | 34475 | 28885 | 31035 | 32100 | 35048 | 36671 | 40285 | 41672 | 38742 | 38306 | 44222 | 42617 | 44820 | 49190 | 62403 | 68699 | 76186 |
| | VB: Mining and quarrying | | Stagnant | 109030 | 99595 | 104596 | 113859 | 81131 | 96178 | 102449 | 113445 | 130805 | 134357 | 144618 | 106778 | 122920 | 155684 | 175447 | 177466 | 184089 |
| | VC: Manufacturing | | Progressive | 349369 | 349234 | 365736 | 363182 | 325965 | 312392 | 318166 | 344925 | 363123 | 406600 | 410787 | 351689 | 356960 | 384417 | 405418 | 423071 | 427467 |
| | VD: Electricity, gas, steam and air conditioning supply | | Stagnant | 61003 | 64582 | 88205 | 98353 | 82927 | 79368 | 69498 | 73108 | 82592 | 102503 | 103963 | 106734 | 94357 | 98565 | 117366 | 104817 | 118818 |
| | VE: Water supply, sewerage, waste management and remediation activities | | Stagnant | 4064 | 4319 | 4830 | 4406 | 3861 | 4431 | 5120 | 5379 | 6732 | 5679 | 4605 | 4201 | 4824 | 6425 | 5142 | 5576 | 5894 |
| | VF: Construction | | Stagnant | 35197 | 39451 | 36134 | 31908 | 34903 | 31589 | 40808 | 42772 | 44990 | 48162 | 44662 | 19242 | 22986 | 26850 | 30602 | 36674 | 37705 |
| | VG: Wholesale and retail trade, repair of motor vehicles and motorcycles | | Stagnant | 117931 | 124989 | 139275 | 131233 | 129432 | 147344 | 160976 | 176398 | 176405 | 157546 | 151257 | 114835 | 125326 | 146317 | 155580 | 144387 | 170195 |
| | VH: Transportation and storage | | Stagnant | 88570 | 86560 | 90160 | 85230 | 62996 | 57269 | 63818 | 71637 | 81681 | 78528 | 83658 | 61248 | 67212 | 78205 | 85715 | 96787 | 120049 |
| | VI: Accommodation and food service activities | | Stagnant | 35859 | 37147 | 35658 | 34692 | 31612 | 32790 | 30281 | 35149 | 39958 | 45731 | 53838 | 37881 | 23733 | 26224 | 29390 | 33487 | 33498 |
| | VJ: Information and communication | | Progressive | 147427 | 183366 | 223182 | 212647 | 179932 | 183888 | 193662 | 204144 | 227713 | 242226 | 235004 | 221625 | 242913 | 242806 | 242516 | 266778 | 288896 |
| | VK: Financial and insurance activities | | Progressive | 99887 | 115369 | 120287 | 119696 | 119105 | 123869 | 143066 | 146794 | 155900 | 167944 | 143749 | 111569 | 119791 | 128999 | 149977 | 158012 | 178790 |
| | VL: Real estate activities | | Progressive | 652698 | 690841 | 689932 | 686021 | 732740 | 780225 | 870623 | 920167 | 860213 | 721984 | 563929 | 438335 | 419482 | 415405 | 473229 | 529744 | 551525 |
| | VM: Professional, scientific and technical activities | | Progressive | 65692 | 79363 | 83889 | 81650 | 93143 | 98277 | 96678 | 110822 | 104663 | 117034 | 129959 | 121444 | 119810 | 121090 | 133359 | 132898 | 126991 |
| | VN: Administrative and support service activities | | Progressive | 55111 | 85539 | 89350 | 77642 | 65497 | 76201 | 82032 | 94189 | 111855 | 96571 | 75673 | 60823 | 73000 | 85247 | 102548 | 102612 | 113567 |
| | VO: Public administration and defence, compulsory social security | | Stagnant | 455668 | 482164 | 497971 | 521163 | 553731 | 572890 | 583262 | 583148 | 601810 | 618643 | 639103 | 645210 | 644610 | 615014 | 580097 | 550955 | 543562 |
| | VP: Education | | Stagnant | 21946 | 22096 | 25755 | 27468 | 30472 | 30039 | 31627 | 28860 | 31739 | 33463 | 36618 | 35325 | 32423 | 32168 | 32751 | 31392 | 32166 |
| | VQ: Human health and social work activities | | Stagnant | 67267 | 68284 | 70218 | 72075 | 86522 | 90548 | 94555 | 103411 | 107428 | 121001 | 123076 | 116956 | 114888 | 117517 | 122709 | 126563 | 120977 |
| | VR: Arts, entertainment and recreation | | Stagnant | 23185 | 28981 | 33891 | 29779 | 28147 | 27092 | 28052 | 26398 | 27149 | 29695 | 27614 | 25968 | 21675 | 21500 | 21735 | 22990 | 26787 |
| | VS: Other service activities | | Stagnant | 28686 | 30498 | 33527 | 34934 | 34164 | 38564 | 34030 | 32705 | 35929 | 37757 | 36844 | 32691 | 30221 | 27447 | 26449 | 26575 | 30255 |
| Data extracted on 28 May 2018 08:58 UTC (GMT) from OECD.Stat | | | | | | | | | | | | | | | | | | | | |
| | | Millions | Progressive | 1370184 | 1503712 | 1572376 | 1540838 | 1516382 | 1574852 | 1704227 | 1821041 | 1823467 | 1752359 | 1559101 | 1305485 | 1331956 | 1377964 | 1507047 | 1613115 | 1687236 |
| | | Millions | Stagnant | 1082881 | 1117551 | 1191255 | 1217200 | 1194946 | 1244773 | 1284761 | 1334082 | 1405960 | 1451371 | 1494078 | 1349686 | 1349995 | 1401106 | 1445386 | 1426368 | 1500181 |
| | | | Progressive% | 0,56 | 0,57 | 0,56 | 0,56 | 0,56 | 0,56 | 0,57 | 0,57 | 0,56 | 0,55 | 0,51 | 0,49 | 0,50 | 0,50 | 0,51 | 0,53 | 0,53 |
| | | | Stagnant% | 0,44 | 0,42 | 0,43 | 0,44 | 0,44 | 0,44 | 0,43 | 0,42 | 0,43 | 0,45 | 0,49 | 0,51 | 0,50 | 0,50 | 0,49 | 0,47 | 0,47 |
| | | Millions | Progressive.G | 133528 | 68664 | -31538 | -24456 | 58470 | 129375 | 116814 | 2426 | -71108 | -193258 | -253616 | 26471 | 46008 | 129083 | 106068 | 74121 | 139314 |
| | | Millions | Stagnant.G | 34670 | 73704 | 25945 | -22254 | 49827 | 39988 | 49321 | 71878 | 45411 | 42707 | -144392 | 309 | 51111 | 44280 | -19018 | 73813 | -20538 |
| | | Billions | Progressive.G | 133,528 | 68,664 | -31,538 | -24,456 | 58,47 | 129,375 | 116,814 | 2,426 | -71,108 | -193,258 | -253,616 | 26,471 | 46,008 | 129,083 | 106,068 | 74,121 | 139,314 |
| | | Billions | Stagnant.G | 34,67 | 73,704 | 25,945 | -22,254 | 49,827 | 39,988 | 49,321 | 71,878 | 45,411 | 42,707 | -144,392 | 0,309 | 51,111 | 44,28 | -19,018 | 73,813 | -20,538 |

**Table can be found at stats.oecd.org:**

**National Accounts --> Annual National Accounts --> Detailed Tables and Simplified Accounts --> 8A. Capital formation by activity ISIC rev4**

# Appendix XIII

**Productivity data**

| Productivity | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Productivity per Industry** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** |
| BNEXCL: Non-agriculture business sector excluding real estate | 1,7 | 3,2 | 2,3 | 3,4 | 1,9 | 1,4 | 0,5 | -0,5 | 1,8 | 3,9 | 0,3 | 0,8 | 0,5 | 0,7 | 1,8 |
| BDE: Mining and Utilities | -0,2 | 0,1 | -0,2 | 0,1 | -0,3 | 0,3 | 0,2 | -0,1 | 0,5 | -0,0 | 0,2 | 0,2 | 0,1 | 0,3 | 0,2 |
| C: Manufacturing | 0,3 | 1,6 | 1,5 | 1,9 | 0,7 | 0,9 | 0,8 | -0,2 | 0,2 | 1,2 | -0,2 | -0,3 | 0,2 | -0,0 | 0,0 |
| F: Construction | -0,4 | -0,0 | -0,0 | -0,5 | -0,5 | -0,8 | -0,4 | 0,2 | 0,4 | 0,4 | 0,0 | 0,3 | -0,2 | -0,5 | 0,2 |
| G_I: Wholesale retail trade accommodation food services, transportation and storage | 0,1 | 0,3 | 0,4 | 0,8 | -0,2 | 0,5 | 0,0 | -0,6 | -0,5 | 1,1 | 0,1 | -0,2 | 0,6 | -0,2 | 0,3 |
| J: Information and Communication | 0,4 | 1,1 | 0,5 | 1,3 | 0,7 | 0,1 | 0,8 | 0,5 | 0,1 | 0,5 | 0,2 | 0,4 | 0,3 | -0,1 | 0,8 |
| K: Financial and Insurance activities | 1,2 | -0,1 | -0,0 | -0,2 | 1,0 | 0,3 | -0,4 | -1,4 | 2,2 | 0,3 | 0,1 | 0,4 | -0,8 | 0,6 | -0,2 |
| MN: Professional, scientific and technical activities, Administrative and support service activities | 0,3 | 0,3 | 0,2 | 0,0 | 0,4 | 0,0 | -0,5 | 1,1 | -1,0 | 0,3 | 0,0 | 0,1 | 0,3 | 0,6 | 0,5 |
| ** Excluding: Agriculture & Real Estate* | | | | | | | | | | | | | | | |
| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Progressive sector growth % | 2,23 | 2,88 | 2,17 | 3,00 | 2,78 | 1,37 | 0,73 | -0,00 | 1,52 | 2,33 | 0,04 | 0,51 | 0,03 | 1,05 | 1,14 |
| Stagnant sector growth % | -0,49 | 0,28 | 0,09 | 0,39 | -0,94 | 0,05 | -0,17 | -0,40 | 0,35 | 1,53 | 0,24 | 0,31 | 0,50 | -0,37 | 0,71 |
| Progressive sector growth %/100 | 0,0223 | 0,0288 | 0,0217 | 0,0300 | 0,0278 | 0,0137 | 0,0073 | -0,0000 | 0,0152 | 0,0233 | 0,0004 | 0,0051 | 0,0003 | 0,0105 | 0,0114 |
| Stagnant sector growth %/100 | -0,0049 | 0,0028 | 0,0009 | 0,0039 | -0,0094 | 0,0005 | -0,0017 | -0,0040 | 0,0035 | 0,0153 | 0,0024 | 0,0031 | 0,0050 | -0,0037 | 0,0071 |

**<u>Table can be found at stats.oecd.org:</u>**

**Productivity --> Productivity and ULC by industry, Annual --> Productivity and ULC by main economic activity (ISIC Rev.4) --> Industry contribution to business sector productivity growth**

## Investment data (constant prices with 2009 as national base year)

| Dataset: 8A. Capital formation by activity ISIC rev4 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Country | United States | | | | | | | | | | | | | | |
| | | Transaction | Gross fixed capital formation | | | | | | | | | | | | | | |
| | | Measure | Constant prices, national base year | | | | | | | | | | | | | | |
| | | Unit | US Dollar, Millions, 2009 | | | | | | | | | | | | | | |
| | | Year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Activity | | i | | | | | | | | | | | | | | | |
| VTOT: Total activity | | i | 2774416 | 2729024 | 2833911 | 3007248 | 3176191 | 3246225 | 3211744 | 3054763 | 2655170 | 2681730 | 2778190 | 2950197 | 3034627 | 3180167 | 3293714 |
| VTOT: Total activity | VA0: Agriculture, forestry and fishing | Stagnant | 32100 | 35048 | 36671 | 40285 | 41672 | 38742 | 38306 | 44222 | 42617 | 44820 | 49190 | 62403 | 68699 | 76186 | 59015 |
| | VB: Mining and quarrying | Stagnant | 113859 | 81131 | 96178 | 102449 | 113445 | 130805 | 134357 | 144618 | 106778 | 122920 | 155684 | 175447 | 177466 | 184089 | 135878 |
| | VC: Manufacturing | Progressive | 363182 | 325965 | 312392 | 318166 | 344925 | 363123 | 406600 | 410787 | 351689 | 356960 | 384417 | 405418 | 423071 | 427467 | 436208 |
| | VD: Electricity, gas, steam and air conditioning supply | Stagnant | 98353 | 82927 | 79368 | 69498 | 73108 | 82592 | 102503 | 103963 | 106734 | 94357 | 98565 | 117366 | 104817 | 118818 | 119162 |
| | VE: Water supply, sewerage, waste management and remediation activities | Stagnant | 4406 | 3861 | 4431 | 5120 | 5379 | 6732 | 5679 | 4605 | 4201 | 4824 | 6425 | 5142 | 5576 | 5894 | 6130 |
| | VF: Construction | Stagnant | 31908 | 34903 | 31589 | 40808 | 42772 | 44990 | 48162 | 44662 | 19242 | 22986 | 26850 | 30602 | 36674 | 37705 | 46183 |
| | VG: Wholesale and retail trade, repair of motor vehicles and motorcycles | Stagnant | 131233 | 129432 | 147344 | 160976 | 176398 | 176405 | 157546 | 151257 | 114835 | 125326 | 146317 | 155580 | 144387 | 170195 | 173432 |
| | VH: Transportation and storage | Stagnant | 85230 | 62996 | 57269 | 63818 | 71637 | 81681 | 78528 | 83658 | 61248 | 67212 | 78205 | 85715 | 96787 | 120049 | 127278 |
| | VI: Accommodation and food service activities | Stagnant | 34692 | 31612 | 32790 | 30281 | 35149 | 39958 | 45731 | 53838 | 37881 | 23733 | 26224 | 29390 | 33487 | 33498 | 36670 |
| | VJ: Information and communication | Progressive | 212647 | 179932 | 183888 | 193662 | 204144 | 227713 | 242226 | 235004 | 221625 | 242913 | 242806 | 242516 | 266778 | 288896 | 310743 |
| | VK: Financial and insurance activities | Progressive | 119696 | 119105 | 123869 | 143066 | 146794 | 155900 | 167944 | 143749 | 111569 | 119791 | 128999 | 149977 | 158012 | 178790 | 196011 |
| | VL: Real estate activities | Progressive | 686021 | 732740 | 780225 | 870623 | 920167 | 860213 | 721984 | 563929 | 438335 | 419482 | 415405 | 473229 | 529744 | 551525 | 615117 |
| | VM: Professional, scientific and technical activities | Progressive | 81650 | 93143 | 98277 | 96678 | 110822 | 104663 | 117034 | 129959 | 121444 | 119810 | 121090 | 133359 | 132898 | 126991 | 138097 |
| | VN: Administrative and support service activities | Progressive | 77642 | 65497 | 76201 | 82032 | 94189 | 111855 | 96571 | 75673 | 60823 | 73000 | 85247 | 102548 | 102612 | 113567 | 130374 |
| | VO: Public administration and defence, compulsory social security | Stagnant | 521163 | 553731 | 572890 | 583262 | 583148 | 601810 | 618643 | 639103 | 645210 | 644610 | 615014 | 580097 | 550955 | 543562 | 552934 |
| | VP: Education | Stagnant | 27468 | 30472 | 30039 | 31627 | 28860 | 31739 | 33463 | 36618 | 35325 | 32423 | 32168 | 32751 | 31392 | 32166 | 37175 |
| | VQ: Human health and social work activities | Stagnant | 72075 | 86522 | 90548 | 94555 | 103411 | 107428 | 121001 | 123076 | 116956 | 114888 | 117517 | 122709 | 126563 | 120977 | 125811 |
| | VR: Arts, entertainment and recreation | Stagnant | 29779 | 28147 | 27092 | 28052 | 26398 | 27149 | 29695 | 27614 | 25968 | 21675 | 21500 | 21735 | 22990 | 26787 | 26639 |
| | VS: Other service activities | Stagnant | 34934 | 34164 | 38564 | 34030 | 32705 | 35929 | 37757 | 36844 | 32691 | 30221 | 27447 | 26449 | 26575 | 30255 | 33336 |
| Data extracted on 28 May 2018 08:58 UTC (GMT) from OECD.Stat | | | | | | | | | | | | | | | | | |
| | BDE: Mining and Utilities | Stagnant | 216618 | 167919 | 179977 | 177067 | 191932 | 220129 | 242539 | 253186 | 217713 | 222101 | 260674 | 297955 | 287859 | 308801 | 261170 |
| | F: Construction | Stagnant | 31908 | 34903 | 31589 | 40808 | 42772 | 44990 | 48162 | 44662 | 19242 | 22986 | 26850 | 30602 | 36674 | 37705 | 46183 |
| | G_I: Wholesale retail trade accommodation food services, transportation and storage | Stagnant | 251155 | 224040 | 237403 | 255075 | 283184 | 298044 | 281805 | 288753 | 213964 | 216271 | 250746 | 270685 | 274661 | 323742 | 337380 |
| | C: Manufacturing | Progressive | 363182 | 325965 | 312392 | 318166 | 344925 | 363123 | 406600 | 410787 | 351689 | 356960 | 384417 | 405418 | 423071 | 427467 | 436208 |
| | J: Information and Communication | Progressive | 212647 | 179932 | 183888 | 193662 | 204144 | 227713 | 242226 | 235004 | 221625 | 242913 | 242806 | 242516 | 266778 | 288896 | 310743 |
| | K: Financial and Insurance activities | Progressive | 119696 | 119105 | 123869 | 143066 | 146794 | 155900 | 167944 | 143749 | 111569 | 119791 | 128999 | 149977 | 158012 | 178790 | 196011 |
| | MN: Professional, scientific and technical activities, Administrative and support service activities | Progressive | 159292 | 158640 | 174478 | 178710 | 205011 | 216518 | 213605 | 205632 | 182267 | 192810 | 206337 | 235907 | 235510 | 240558 | 268471 |
| | | Progressive | 854817 | 783642 | 794627 | 833604 | 900874 | 963254 | 1030375 | 995172 | 867150 | 912474 | 962559 | 1033818 | 1083371 | 1135711 | 1211433 |
| | | Stagnant | 499681 | 426862 | 448969 | 472950 | 517888 | 563163 | 572506 | 586601 | 450919 | 461358 | 538270 | 599242 | 599194 | 670248 | 644733 |
| | | Total | 1354498 | 1210504 | 1243596 | 1306554 | 1418762 | 1526417 | 1602881 | 1581773 | 1318069 | 1373832 | 1500829 | 1633060 | 1682565 | 1805959 | 1856166 |
| | | Progressive% | 0,63 | 0,65 | 0,64 | 0,64 | 0,63 | 0,63 | 0,64 | 0,63 | 0,66 | 0,66 | 0,64 | 0,63 | 0,64 | 0,63 | 0,65 |
| | | Stagnant% | 0,37 | 0,35 | 0,36 | 0,36 | 0,37 | 0,37 | 0,36 | 0,37 | 0,34 | 0,34 | 0,36 | 0,37 | 0,36 | 0,37 | 0,35 |
| | | Progressive.G | -71175 | 10985 | 38977 | 67270 | 62380 | 67121 | -35203 | -128022 | 45324 | 50085 | 71259 | 49553 | 52340 | 75722 | 44677 |
| | | Stagnant.G | -72819 | 22107 | 23981 | 44938 | 45275 | 9343 | 14095 | -135682 | 10439 | 76912 | 60972 | -48 | 71054 | -25515 | -48771 |
| | Billions | Progressive.G | -71,175 | 10,985 | 38,977 | 67,27 | 62,38 | 67,121 | -35,203 | -128,02 | 45,324 | 50,085 | 71,259 | 49,553 | 52,34 | 75,722 | 44,677 |
| | Billions | Stagnant.G | -72,819 | 22,107 | 23,981 | 44,938 | 45,275 | 9,343 | 14,095 | -135,68 | 10,439 | 76,912 | 60,972 | -0,048 | 71,054 | -25,515 | -48,771 |

**Table can be found at stats.oecd.org:**

**National Accounts --> Annual National Accounts --> Detailed Tables and Simplified Accounts --> 8A. Capital formation by activity ISIC rev4**

## GDP data (constant prices with 2009 as national base year)

Dataset: 1. Gross domestic product (GDP)

Country: United States
Measure: V: Constant prices, national base year
Unit: US Dollar, Millions, 2009

| Transaction | | Year: 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1_GA: Gross domestic product (output approach) | i | 12.682.240,0 | 12.908.761,0 | 13.271.081,0 | 13.773.490,0 | 14.234.243,0 | 14.613.817,0 | 14.873.734,0 | 14.830.359,0 | 14.418.738,0 | 14.783.809,0 | 15.020.565,0 | 15.354.627,0 | 15.612.175,0 | 15.982.255,0 |
| B1_GA: Gross domestic product (output approach) – B1G_P119: Gross value added at basic prices, excluding FISIM | i | 12.403.723,0 | 12.625.739,0 | 12.949.757,0 | 13.405.237,0 | 13.843.599,0 | 14.214.121,0 | 14.429.652,0 | 14.356.272,0 | 13.990.475,0 | 14.295.260,0 | 14.491.282,0 | 14.776.408,0 | 15.017.249,0 | 15.341.092,0 |
| B1G: Gross value added at basic prices, total activity | | 12.403.723,0 | 12.625.739,0 | 12.949.757,0 | 13.405.237,0 | 13.843.599,0 | 14.214.121,0 | 14.429.652,0 | 14.356.272,0 | 13.990.475,0 | 14.295.260,0 | 14.491.282,0 | 14.776.408,0 | 15.017.249,0 | 15.341.092,0 |
| B1GVA: Agriculture, forestry and fishing (ISIC rev4) | | 113.760,0 | 113.649,0 | 125.157,0 | 130.346,0 | 141.912,0 | 143.994,0 | 122.539,0 | 130.381,0 | 147.777,0 | 149.828,0 | 141.713,0 | 130.205,0 | 155.453,0 | 154.391,0 |
| B1GVB_E: Industry, including energy (ISIC rev4) | | 1.972.893,0 | 1.994.461,0 | 2.055.404,0 | 2.171.764,0 | 2.196.584,0 | 2.319.296,0 | 2.401.520,0 | 2.354.656,0 | 2.250.999,0 | 2.351.000,0 | 2.375.297,0 | 2.416.003,0 | 2.474.272,0 | 2.527.672,0 |
| B1GVB_E: Industry, including energy (ISIC rev4) – B1GVC: of which excluding: | | 458.462,0 | 462.617,0 | 446.645,0 | 458.049,0 | 444.745,0 | 479.595,0 | 501.668,0 | 508.973,0 | 548.404,0 | 556.221,0 | 575.222,0 | 609.844,0 | 630.774,0 | 663.912,0 |
| B1GVB_E: Industry, including energy (ISIC rev4) – B1GVC: of which: Manufacturing (ISIC | | 1.514.431,0 | 1.531.844,0 | 1.608.759,0 | 1.713.715,0 | 1.751.839,0 | 1.839.701,0 | 1.899.852,0 | 1.845.683,0 | 1.702.595,0 | 1.794.779,0 | 1.800.075,0 | 1.806.159,0 | 1.843.498,0 | 1.863.760,0 |
| B1GVF: Construction (ISIC rev4) | | 755.368,0 | 731.459,0 | 744.421,0 | 770.455,0 | 772.756,0 | 753.462,0 | 725.127,0 | 662.195,0 | 577.295,0 | 551.604,0 | 548.635,0 | 569.172,0 | 584.912,0 | 594.747,0 |
| B1GVG_I: Distributive trade, repairs; transport; accommod., | | 2.072.063,0 | 2.099.530,0 | 2.201.360,0 | 2.297.751,0 | 2.383.711,0 | 2.449.313,0 | 2.443.353,0 | 2.380.192,0 | 2.183.185,0 | 2.255.202,0 | 2.289.782,0 | 2.336.148,0 | 2.397.413,0 | 2.463.151,0 |
| B1GVJ: Information and communication (ISIC rev4) | | 546.142,0 | 586.473,0 | 609.245,0 | 679.078,0 | 723.086,0 | 751.021,0 | 830.031,0 | 873.991,0 | 851.627,0 | 893.068,0 | 910.514,0 | 940.846,0 | 992.023,0 | 1.005.736,0 |
| B1GVK: Financial and insurance activities (ISIC rev4) | | 846.859,0 | 849.659,0 | 854.988,0 | 851.479,0 | 928.663,0 | 969.011,0 | 942.749,0 | 817.519,0 | 950.344,0 | 950.242,0 | 958.995,0 | 1.009.349,0 | 961.490,0 | 1.009.733,0 |
| B1GVL: Real estate activities (ISIC rev4) | | 1.436.227,0 | 1.466.793,0 | 1.501.165,0 | 1.551.683,0 | 1.641.981,0 | 1.647.718,0 | 1.740.464,0 | 1.763.353,0 | 1.758.370,0 | 1.812.870,0 | 1.863.056,0 | 1.883.400,0 | 1.917.307,0 | 1.952.074,0 |
| B1GVM_N: Prof., scientific, techn.; admin., support serv. | | 1.469.124,0 | 1.494.152,0 | 1.511.773,0 | 1.530.420,0 | 1.580.278,0 | 1.637.738,0 | 1.651.727,0 | 1.727.389,0 | 1.587.152,0 | 1.622.577,0 | 1.678.326,0 | 1.740.162,0 | 1.766.958,0 | 1.835.792,0 |
| B1GVO_Q: Public admin.; compulsory s.s.; education; human | | 2.769.241,0 | 2.842.642,0 | 2.901.948,0 | 2.957.756,0 | 2.994.691,0 | 3.049.478,0 | 3.083.368,0 | 3.184.144,0 | 3.233.122,0 | 3.257.689,0 | 3.275.930,0 | 3.296.384,0 | 3.309.687,0 | 3.327.679,0 |
| B1GVR_U: Other service activities (ISIC rev4) | | 467.200,0 | 483.061,0 | 476.293,0 | 486.417,0 | 487.819,0 | 493.238,0 | 485.870,0 | 472.334,0 | 450.603,0 | 450.710,0 | 451.496,0 | 462.781,0 | 464.133,0 | 475.889,0 |
| Data extracted on 28 May 2018 09:44 UTC (GMT) from OECD.Stat | | | | | | | | | | | | | | | |
| | Progressive | 5.812.783,0 | 5.928.921,0 | 6.085.930,0 | 6.326.375,0 | 6.625.847,0 | 6.845.189,0 | 7.064.823,0 | 7.027.935,0 | 6.850.088,0 | 7.073.536,0 | 7.210.966,0 | 7.379.916,0 | 7.481.276,0 | 7.667.095,0 |
| | Stagnant | 6.636.094,0 | 6.732.958,0 | 6.895.824,0 | 7.100.774,0 | 7.225.634,0 | 7.369.080,0 | 7.361.925,0 | 7.338.219,0 | 7.140.386,0 | 7.221.254,0 | 7.282.778,0 | 7.404.534,0 | 7.542.372,0 | 7.679.769,0 |
| | Progressive.G | 116.138,0 | 157.009,0 | 240.445,0 | 299.472,0 | 219.342,0 | 219.634,0 | -36.888,0 | -177.847,0 | 223.448,0 | 137.430,0 | 168.950,0 | 101.360,0 | 185.819,0 | 218.105,0 |
| | Stagnant.G | 96.864,0 | 162.866,0 | 204.950,0 | 124.860,0 | 143.446,0 | -7.155,0 | -23.706,0 | -197.833,0 | 80.868,0 | 61.524,0 | 121.756,0 | 137.838,0 | 137.397,0 | 178.930,0 |
| | B.Progressive.G | 116,138 | 157,009 | 240,445 | 299,472 | 219,342 | 219,634 | -36,888 | -177,847 | 223,448 | 137,43 | 168,95 | 101,36 | 185,819 | 218,105 |
| | B.Stagnant.G | 96,864 | 162,866 | 204,95 | 124,86 | 143,446 | -7,155 | -23,706 | -197,833 | 80,868 | 61,524 | 121,756 | 137,838 | 137,397 | 178,93 |

**Table can be found at stats.oecd.org:**

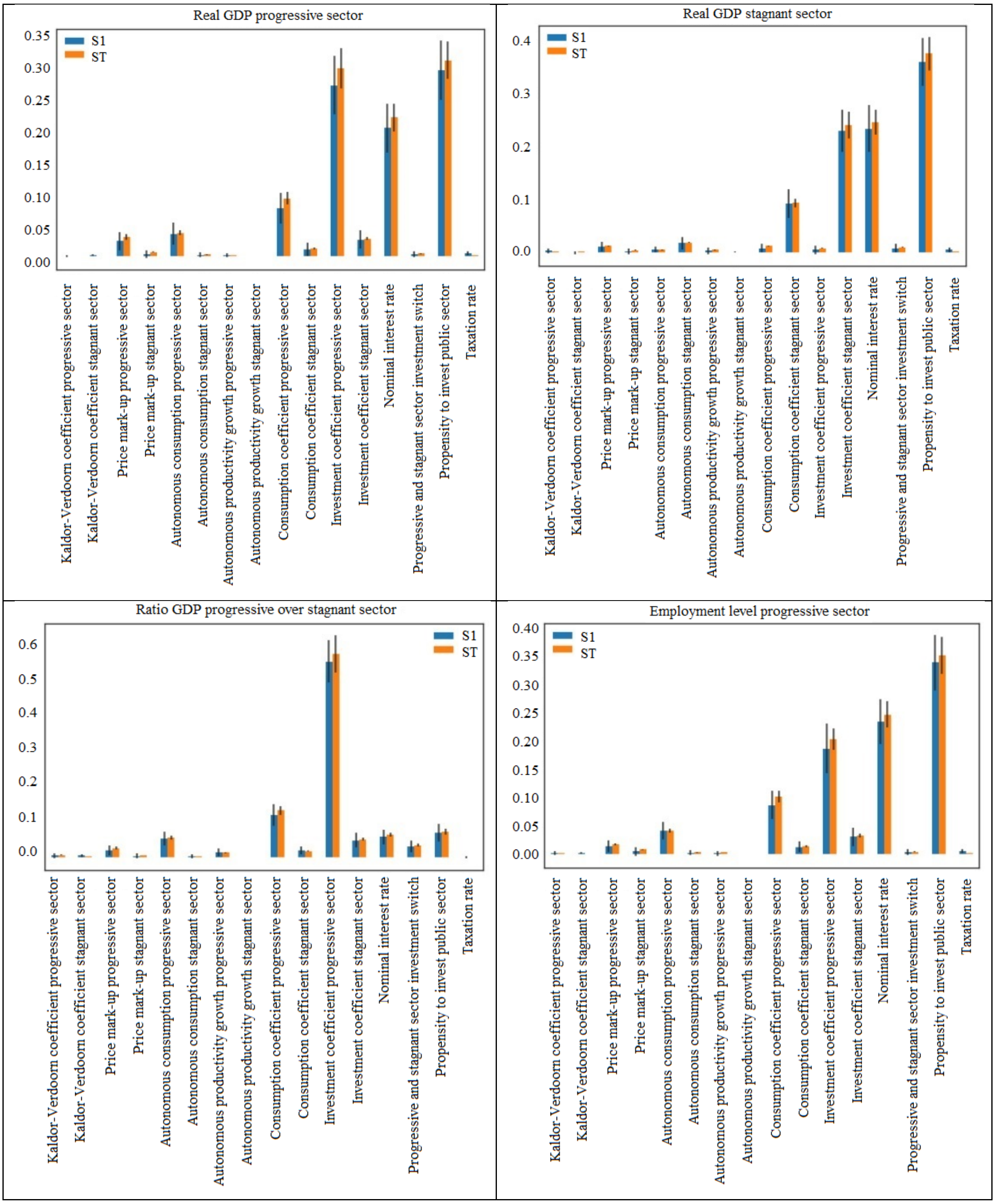
**National Accounts --> Annual National Accounts --> Main Aggregates --> 1. Gross domestic product (GDP) --> 1. Gross domestic product (GDP)**

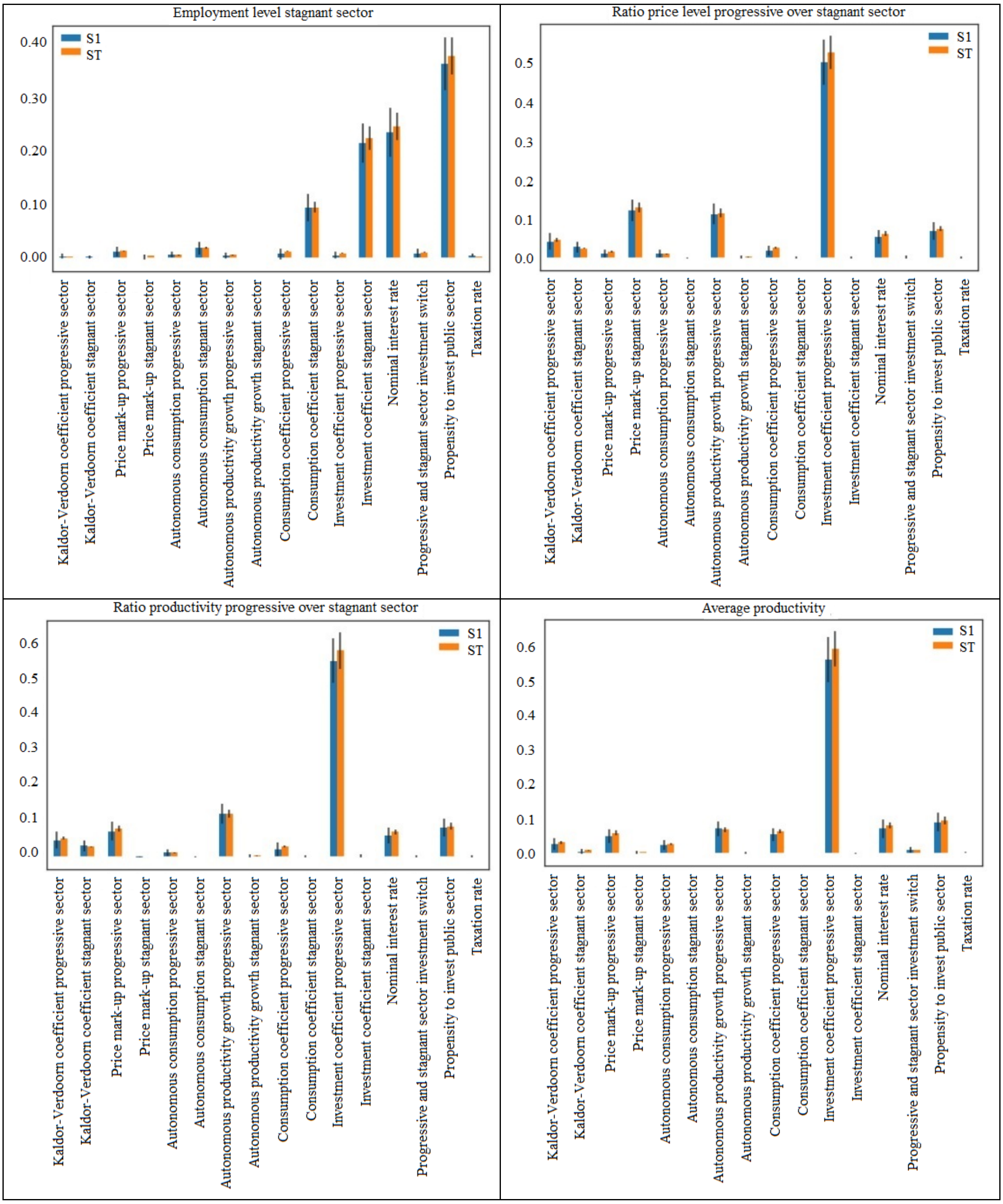
**Regression output of Investments/GDP on Productivity**

```
. reg dProducP dGDPP

      Source |       SS           df       MS      Number of obs   =        14
-------------+----------------------------------   F(1, 12)        =      4.38
       Model |  .000422143         1  .000422143   Prob > F        =    0.0583
    Residual |  .001157295        12  .000096441   R-squared       =    0.2673
-------------+----------------------------------   Adj R-squared   =    0.2062
       Total |  .001579438        13  .000121495   Root MSE        =    .00982

------------------------------------------------------------------------------
    dProducP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        dGDPP |   .0000462   .0000221     2.09   0.058    -1.91e-06    .0000943
       _cons |   .0078971   .0041911     1.88   0.084    -.0012346    .0170288
------------------------------------------------------------------------------

. reg dProducP dInvestP1

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(1, 13)        =      0.46
       Model |  .000053959         1  .000053959   Prob > F        =    0.5110
    Residual |  .001536039        13  .000118157   R-squared       =    0.0339
-------------+----------------------------------   Adj R-squared   =   -0.0404
       Total |  .001589997        14  .000113571   Root MSE        =    .01087

------------------------------------------------------------------------------
    dProducP |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   dInvestP1 |   .0000332   .0000491     0.68   0.511    -.0000728    .0001391
       _cons |   .0136222   .0030984     4.40   0.001     .0069285    .0203158
------------------------------------------------------------------------------

. reg dProducS dGDPS

      Source |       SS           df       MS      Number of obs   =        14
-------------+----------------------------------   F(1, 12)        =      0.15
       Model |  5.4984e-06         1  5.4984e-06   Prob > F        =    0.7042
    Residual |  .000436448        12  .000036371   R-squared       =    0.0124
-------------+----------------------------------   Adj R-squared   =   -0.0699
       Total |  .000441946        13  .000033996   Root MSE        =    .00603

------------------------------------------------------------------------------
    dProducS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dGDPS |   6.22e-06    .000016     0.39   0.704    -.0000286    .0000411
       _cons |   .0004297    .002133     0.20   0.844    -.0042178    .0050771
------------------------------------------------------------------------------

. reg dProducS dInvestS1

      Source |       SS           df       MS      Number of obs   =        15
-------------+----------------------------------   F(1, 13)        =      2.99
       Model |  .000089277         1  .000089277   Prob > F        =    0.1074
    Residual |  .000388059        13  .000029851   R-squared       =    0.1870
-------------+----------------------------------   Adj R-squared   =    0.1245
       Total |  .000477336        14  .000034095   Root MSE        =    .00546

------------------------------------------------------------------------------
    dProducS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   dInvestS1 |   .0000439   .0000254     1.73   0.107    -.0000109    .0000987
       _cons |   .0011016   .0014201     0.78   0.452    -.0019662    .0041695
------------------------------------------------------------------------------
```

# Appendix XIV

These graphs show the SOBOL sensitivity analysis results for the eight outcomes of interest. In total 16 uncertain input parameters are used in the analysis and each uncertain input parameter has a first-order effect (S1) and total effect (ST) score per outcome of interest. The higher the score, or the bar, the more sensitive the uncertain input parameter is with respect to the specific outcome of interest.

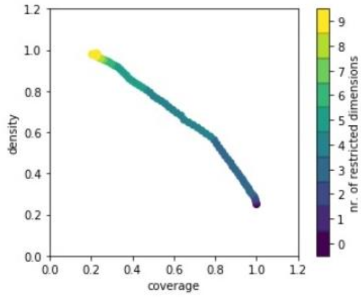



Employment level stagnant sector
0.40
0.30
0.20
0.10
0.00
S1
ST
Ratio price level progressive over stagnant sector
0.5
0.4
0.3
0.2
0.1
0.0
Ratio productivity progressive over stagnant sector
0.6
Average productivity
Kaldor-Verdoorn coefficient progressive sector
Kaldor-Verdoorn coefficient stagnant sector
Price mark-up progressive sector
Price mark-up stagnant sector
Autonomous consumption progressive sector
Autonomous consumption stagnant sector
Autonomous productivity growth progressive sector
Autonomous productivity growth stagnant sector
Consumption coefficient progressive sector
Consumption coefficient stagnant sector
Investment coefficient progressive sector
Investment coefficient stagnant sector
Nominal interest rate
Progressive and stagnant sector investment switch
Propensity to invest public sector
Taxation rate

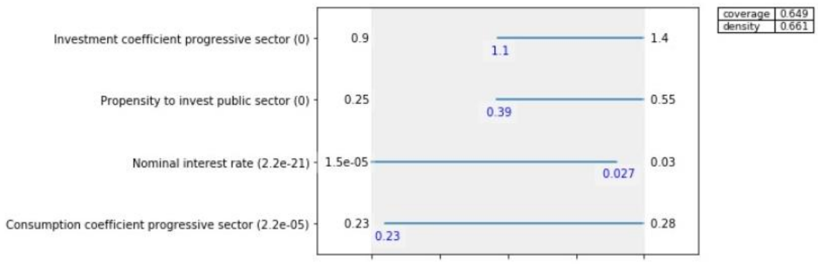
# Appendix XV

The PRIM results are shown for the eight outcomes of interest.

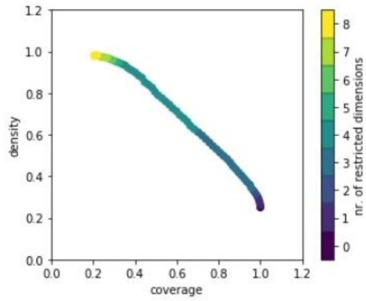
## Real GDP progressive sector



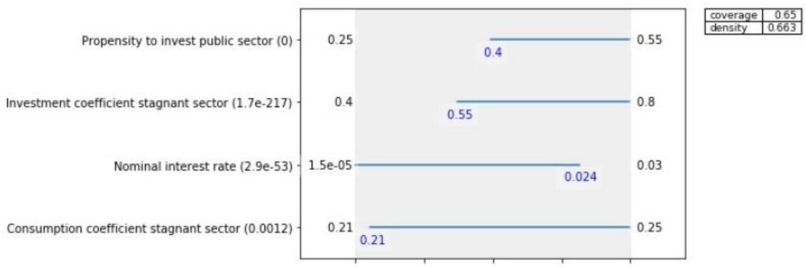

```
coverage    0.649141
density     0.660563
mass        0.245735
mean        0.660563
res dim            4
Name: 27, dtype: object

                                          box 27           \
                                             min       max
Investment coefficient progressive sector  1.132422  1.399756
Propensity to invest public sector         0.385586  0.549851
Nominal interest rate                      0.000015  0.026982
Consumption coefficient progressive sector 0.232576  0.279976

                                                        qp values
Investment coefficient progressive sector                   [0.0]
Propensity to invest public sector                          [0.0]
Nominal interest rate                      [2.2362369838159383e-21]
Consumption coefficient progressive sector [2.1757141776982846e-05]
```



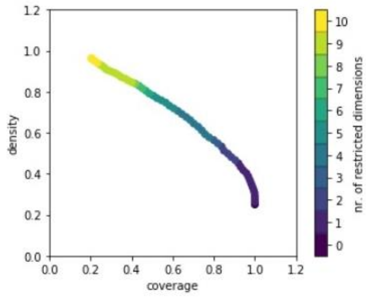

## Real GDP stagnant sector



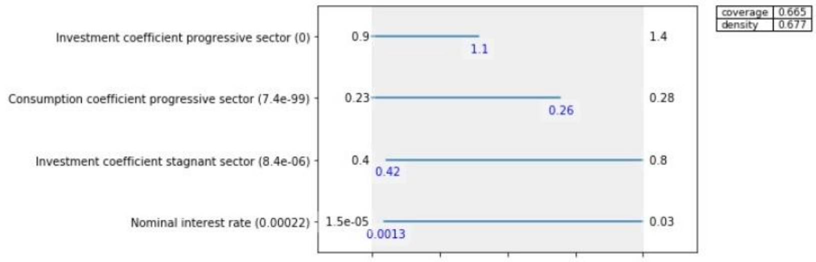

```
coverage    0.650282
density     0.662911
mass        0.245353
mean        0.662911
res dim            4
Name: 27, dtype: object

                                       box 27           \
                                          min       max
Propensity to invest public sector      0.395117  0.549851
Investment coefficient stagnant sector  0.548828  0.799805
Nominal interest rate                   0.000015  0.024375
Consumption coefficient stagnant sector 0.212207  0.249980

                                                     qp values
Propensity to invest public sector                       [0.0]
Investment coefficient stagnant sector  [1.6698985974609129e-217]
Nominal interest rate                    [2.8594204538947895e-53]
Consumption coefficient stagnant sector   [0.0011616979657651588]
```



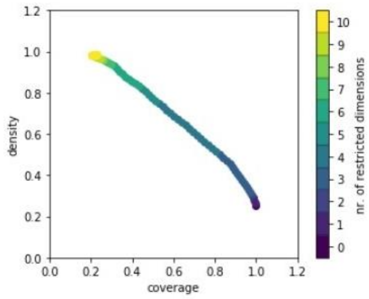
Ratio GDP progressive over stagnant sector



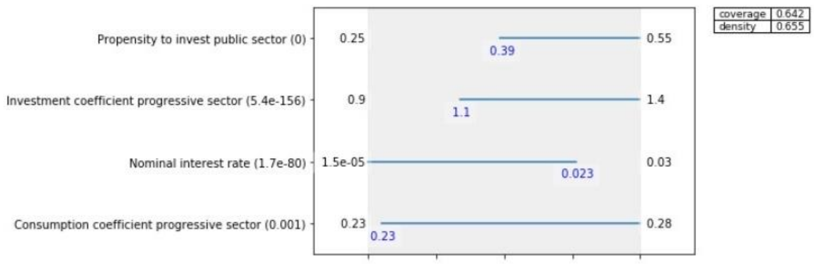

```
coverage    0.665136
density     0.676932
mass        0.245441
mean        0.676932
res dim            4
Name: 27, dtype: object

                                         box 27            \
                                            min       max
Investment coefficient progressive sector  0.900244  1.095801
Consumption coefficient progressive sector 0.230024  0.264668
Investment coefficient stagnant sector     0.420703  0.799805
Nominal interest rate                      0.001318  0.029985

                                                   qp values
Investment coefficient progressive sector              [0.0]
Consumption coefficient progressive sector [7.449627249673553e-99]
Investment coefficient stagnant sector      [8.44245351307565e-06]
Nominal interest rate                      [0.00022489613283532288]
```



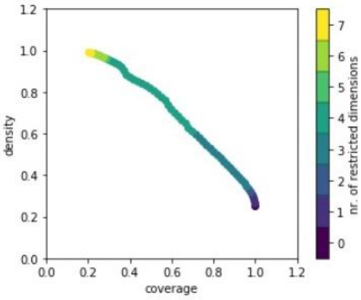

Employment level progressive sector



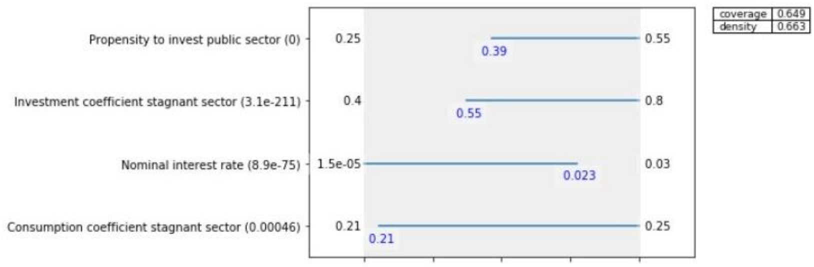

```
coverage       0.642
density     0.654709
mass        0.245147
mean        0.654709
res dim            4
Name: 27, dtype: object

                                         box 27            \
                                            min       max
Propensity to invest public sector         0.393032  0.549851
Investment coefficient progressive sector  1.068457  1.399756
Nominal interest rate                      0.000015  0.022910
Consumption coefficient progressive sector 0.232490  0.279976

                                                   qp values
Propensity to invest public sector                     [0.0]
Investment coefficient progressive sector  [5.38491361476297e-156]
Nominal interest rate                     [1.6667828814201276e-80]
Consumption coefficient progressive sector [0.0010397809098110543]
```



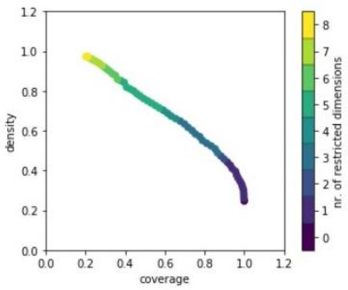
Employment level stagnant sector



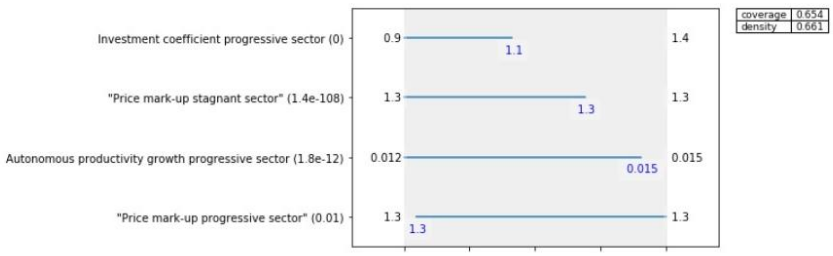

```
coverage    0.648725
density     0.663382
mass        0.244735
mean        0.663382
res dim            4
Name: 27, dtype: object

                                         box 27           \
                                            min      max
Propensity to invest public sector     0.387075  0.549851
Investment coefficient stagnant sector 0.549609  0.799805
Nominal interest rate                  0.000015  0.023262
Consumption coefficient stagnant sector 0.212266  0.249980

                                                     qp values
Propensity to invest public sector                       [0.0]
Investment coefficient stagnant sector  [3.1045076874182564e-211]
Nominal interest rate                      [8.906288441066546e-75]
Consumption coefficient stagnant sector   [0.0004598152478398131]
```



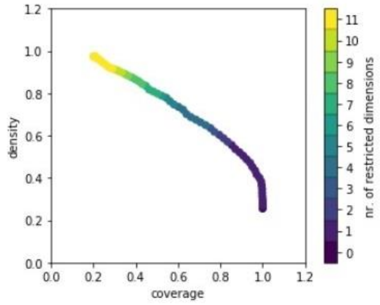

Ratio price level progressive over stagnant sector



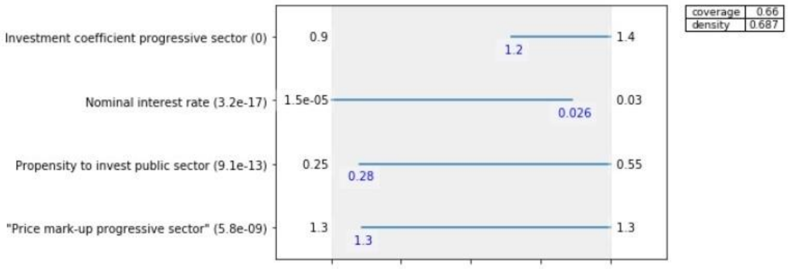

```
coverage    0.654057
density     0.660839
mass        0.243941
mean        0.660839
res dim            4
Name: 27, dtype: object

                                              box 27           \
                                                 min      max
Investment coefficient progressive sector   0.900244  1.106543
"Price mark-up stagnant sector"             1.270029  1.311484
Autonomous productivity growth progressive sector 0.012241  0.014700
"Price mark-up progressive sector"          1.272900  1.329971

                                                          qp values
Investment coefficient progressive sector                     [0.0]
"Price mark-up stagnant sector"              [1.3685066368630049e-108]
Autonomous productivity growth progressive sector [1.7973637311631235e-12]
"Price mark-up progressive sector"              [0.010145262977893357]
```



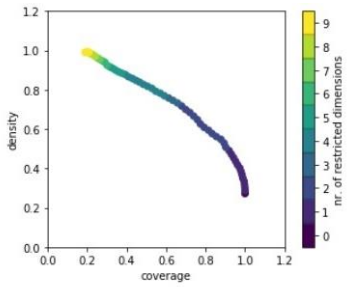
Average productivity




```
coverage     0.66041
density     0.687485
mass        0.245353
mean        0.687485
res dim            4
Name: 27, dtype: object

                                           box 27              \
                                              min       max
Investment coefficient progressive sector  1.223242  1.399756
Nominal interest rate                      0.000015  0.025928
Propensity to invest public sector         0.275679  0.549851
"Price mark-up progressive sector"         1.276621  1.329971


                                                       qp values
Investment coefficient progressive sector                  [0.0]
Nominal interest rate                      [3.231188019900841e-17]
Propensity to invest public sector         [9.069470121902816e-13]
"Price mark-up progressive sector"         [5.844804050601204e-09]
```




Ratio productivity progressive over stagnant sector




```
coverage    0.657627
density     0.732844
mass        0.244294
mean        0.732844
res dim            3
Name: 27, dtype: object

                                                  box 27              \
                                                     min       max
Investment coefficient progressive sector         0.900244  1.077246
Autonomous productivity growth progressive sector 0.012241  0.014229
"Kaldor-Verdoorn coefficient progressive sector"  0.000004  0.000005


                                                              qp values
Investment coefficient progressive sector                         [0.0]
Autonomous productivity growth progressive sector [1.0017101399625615e-121]
"Kaldor-Verdoorn coefficient progressive sector"     [0.0008001618930809662]
```