Erasmus University Rotterdam

Erasmus School of Economics

MSc Economics & Business

Master Specialisation Financial Economics

Pension Funds' Assets and Economic Growth

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Finish date: 2013 August

Preface and acknowledgements

"Most of us end up with no more than five or six people who remember us. Teachers have thousands of people who remember them for the rest of their lives." (Andy Rooney)

First of all, I would like to thank my supervisor Prof. dr. Onno W. Steenbeek, who is inspiring, intelligent, honest, and the true embodiment of a mentor. I owe Prof. dr. O. W. Steenbeek a huge debt of gratitude for introducing me to an absolutely new field during the Pension Funds seminar and for his helpful suggestions, unfailing geniality and support before and throughout the research period. Next, I would like to sincerely thank J.A. (Jairo) Rivera Rozo who has provided me with the data on pension funds' assets and always found time for a friendly conversation. I really appreciate his welcoming attitude.

This work was not completed in a vacuum. I discussed my ideas with fellow students who broadened the value of the work and I am very grateful to Melle Bakker for his insightful comments at the first stage of the research, when I had only a tiny research proposal. I would also like to express my deepest appreciation to my friend Justina Ivanauskaitė for the long discussions about applied econometrics and to Michael Berlemann from Helmut Schmidt Universität Hamburg for confirming that I understand the procedure of capital stock calculation correctly. A very special thanks to Simonas Narušis and my family for their understanding and constant support. Last, but not least I am extremely grateful to all my friends and people I have had a chance to meet at a healthy lifestyle summer camp in Lithuania. Without them I would not have had an exceptionally good rest in between of the writing process.

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Abstract

This paper empirically explores the impact of funding on economic growth. Since assets held in autonomous pension funds across the OECD countries have been rapidly increasing a question whether such a growth affects economic wealth remains under debate. In order to examine the relationship statistically, we use a sample of OECD countries over the period 2001-2011 and employ a modified Cobb-Douglas function. Part of the research is a repetition of the analysis done by Davis and Hu (2004). Having said that our dataset covers the years of the crisis, the model suggested by the authors is improved by an inclusion of two dummy variables. The results of static panel data models let us state that more funding leads to an increased economic growth. Even though these models fit the actual data very well, no dynamics are captured and therefore we rely on a dynamic specification instead. Once a lagged GDP per capita is included in the regression, we cannot empirically prove that a *direct* link between funding of pensions and economic growth exists and such an outcome is in line with the results of the study conducted by (Zandberg and Spierdijk, 2010).

JEL classifications: C33, G23, J26, O16

Keywords: capital stock, economic growth, panel estimation, pension funding, pension funds.

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1 Introduction

Population ageing is a demographic revolution affecting the entire world (UNFPA, 2013). According to the World Health Organization (2013), between 2000 and 2050, the proportion of the world's population over 60 years will double from about 11% to 22%. This basically means that a crisis for pay-as-you-go pension systems is looming, as each pensioner will be supported by fewer workers (Willmore, 2004). To be able to cope with an increasing number of retirees countries across the world should re-think their pension systems. One of the possible solutions to improve financial sustainability is to switch to (partly) funded pension plans, where contributions made by participants are invested while they are young and paid out as pensions when they retire.

Since the mid 1980's, the World Bank has been working on the provision of the conceptual framework for a pension system, which assures adequate, affordable, sustainable and robust income (World Bank, 2008) and a shift from pay-as-you-go to funded or partly funded pension plans is not something new. As a result a steady increase in autonomous pension funds' assets is observed. Total assets across OECD coutries amounted to less than 11 trillion U.S. dollars in 2001, whereas in 2011 this figure reached $20 trillion. By looking at a country-specific data we can notice that such a sharp upward sloping trend is also present. For example, Dutch pension assets were equivalent to $411 billion in 2001 and it took less than a decade to increase assets in the country's autonomous pension funds to more than $1 trillion.

In terms of pension assets relative to GDP, the ratio has been also increasing, however not so drastically. The frontrunners in 2011 were Australia, Iceland, the Netherlands and Switzerland with the ratio of 92.8%, 128.7%, 138.2% and 110.8%, respectively. One explanation of the size of autonomous pensions relative to the country's gross domestic product being so large is that pension systems in these countries are very mature and fund managers had a long time horizon to collect and invest the money on behalf of future retirees.

There is no doubt that pension funds' assets are increasing and one may raise a question, whether such a fast growth can have an impact on economic wealth. Researchers advocate the idea of a positive pension funds' assets and economic growth nexus due to several reasons. Firstly, shifting from an unfunded to a (partly) funded system is very beneficial, because it may lead to a higher economic growth as aggregate saving rates increase (Börsch-Supan et al., 2004). Secondly, according to Zandberg and Spierdijk (2010) and Hu (2005a), increasing private pensions may reduce labor market distortions. Thirdly, more funding is expected to improve corporate governance as well as spur financial development. This means that a positive effect on the economy will be present, which is expected to increase GDP. Furthermore, Walker and Lefort (2002) conclude that increasing pension funds' assets positively influence transparency, integrity and improve fund allocation, which itself is very likely to lead to permanent positive effects on growth and welfare. Even though the listed assertions seem legitimate, some objections do also exist. For example, Blanchard and Fischer (1989) argue that if saving rates are already high, voluntary savings will simply be replaced by mandatory pension savings and the aggregate saving rate might stay the same not making any impact on economic growth. Zandberg and Spierdijk (2010) also fail to find a significant relationship. They arrive at a conclusion that once controlled for capital market returns of pension funds, the link between pension funds' assets and economic growth disappears.

The aim of this master thesis is to answer the question whether a *direct* link between pension assets and economic growth exists. This paper is a repetition of the research conducted by Davis and Hu in 2004, however instead of analysing only a sample of OECD members and selected emerging markets, we examine data on all OECD countries. Our dataset covers the years through 2001 to 2011 and we believe this particular time period is very interesting, since the world has experienced the financial crisis in 2007-2008.

The thesis is structured as follows. In Chapter 2 a detailed literature review on why pension funds' assets should or should not make an impact on economic growth is presented. Chapter 3 deals with a theoretical framework. We introduce the Cobb-Douglas production function and explain what modification have to be applied in order to construct a theory-based model. Chapter 4 stands for the introduction of panel data models. The description of the databases used and the stationarity testing procedure are also covered in this chapter. In Chapter 5 we analyse the changes in total pension funds' assets and GDP over time, whereas Chapter 6 is dedicated for econometrics. Using techniques described in Chapter 4, we estimate parameters of different models and compare the results. Finally, as expected, Chapter 7 concludes our research.

Summarising the results, a basic data analysis shows that movements in autonomous pension funds' assets and GDP across most of the countries are very similar. Correlations between these variables are extremely high and peaks as well as troughs are usually observed at the same time periods. By estimating static panel data models, we fit the actual data quite well and can firmly state that if the ratio of autonomous pension funds' assets to GDP increase by 1%, GDP per capita would grow by approximately 0.028%. Once a dynamic specification of the relationship is employed, no link between funding and economic growth can be proved statistically.

2 Literature review

Literature, examining the direct relationship between pension funds' assets and economic growth is quite scarce. Nonetheless a lot of information in the field of pension funds, their total assets as well as asset allocation and the effects of funding on capital formation is still available. Such information and research results are very valuable and are likely to provide substantial knowledge whilst examining the total pension funds' assets and economic growth nexus. Previously conducted analysis and research questions can be divided into a few subcategories. This chapter gathers and summarizes the main ideas and outcomes of several articles which mainly concentrated on the funding's effect (in most cases proxied by total pension funds' assets) on financial development and on economic growth.

2.1 General overview

There are three types of pension systems: unfunded, partly funded and funded. A system, where the outgoings to today's pensioners are paid for by the contributions of today's workers and employers, is called pay-as-you-go (PAYG). Such pension plans are unfunded pension plans, i.e. adequate money to meet future obligations are not set aside and the only responsibility plan managers accept is the responsibility to provide retirement benefits to participants today (World Bank, 2013d). An alternative to the PAYG approach is a funded pension. In this case contributions made by the participants are invested while they are young. Once the plan members retire, pension benefits are paid from this fund.

In many countries pension systems are a combination of a funded and a PAYG system. Since the population is rapidly ageing and contribution rates are not high enough, unfunded systems became financially unsustainable and therefore many countries worldwide are switching from unfunded to (partly) funded pension systems. According to Börsch-Supan et al. (2004), another reason why such a switch is beneficial, is the fact that shifting from an unfunded to a (partly) funded system may lead to a higher economic growth as aggregate saving rates increase. This happens, because pension premiums in a funded system are invested in capital markets and therefore are part of saving (Zandberg and Spierdijk, 2010). On the other hand, Blanchard and Fischer (1989) argue that this may not necessarily hold. For example, if people are already saving a lot, their voluntary savings will simply be replaced by mandatory pension savings and the aggregate saving rate might stay the same, meaning that economic growth will not be affected. Speaking about the other channels, it is very likely that capital markets become more efficient. Moreover, funding of pensions might also increase economic growth by reducing labor market distortions and by improving corporate governance (Zandberg and Spierdijk, 2010). Next two sub-chapters extensively discuss several studies investigating whether the link between funding and economic growth as well as financial development can be proved empirically.

2.2 Funding and economic growth

Davis and Hu (2004) in their research mention three aspects to the pension funds' assets and economic growth nexus: (1) the relationship between funding and saving, (2) the positive impact of funding on economic growth via positive externalities and (3) a direct impact. According to Davis and Hu (2004), the latter has not been analysed extensively and therefore the authors mainly concentrate on this research topic.

The theoretical model used by the authors starts with a standard Cobb-Douglas function. They modify the model by adding a few variables and after a couple of adjustments the model reads like this:

$$LnQ^*_{i,t} = \alpha_i + \gamma_i t + \lambda_i LnP_{i,t} + \beta_i LnK^*_{i,t} + \epsilon_{i,t} \quad (2.1)$$

where subscript t indicates time and i is a country index, $Q^*_{i,t}$ is the output per worker, $K^*_{i,t}$ is the capital per worker, t is the time trend and $P_{i,t}$ is pension funds proxied by pension funds' assets over GDP. The model is discussed more extensively in Chapter 3, where we elaborate further on the theory.

Application of various econometric techniques makes the research by Davis and Hu (2004) exceptional and therefore very interesting. By estimating regression coefficients with the dynamic OLS Davis and Hu (2004) find a strong and positive relationship between pension funds' assets, capital and output. The second estimation technique used by the authors is mean-group dynamic heterogeneous models. The results are also positive. Davis and Hu (2004) find evidence, supporting the idea that the long run positive relationship between pension funds' assets and output, especially for emerging economies, exists.

Similarly to Davis and Hu (2004), Hu (2005a,b) also analyses the direct relationship between pension funds' assets and economic growth. However, in contrast to Davis and Hu (2004), the empirical studies by Hu (2005a,b) extensively cover additional two aspects: (1) the analysis of the link between economic growth and pension reform towards the World Bank model[1] and (2) the relationship between pension funds' assets and financial development. The results of the latter are discussed in the next sub-chapter where the literature on the impact of pension funds' assets on financial development is summarized. In terms of the relationship between economic growth and pension reform towards the World Bank model, Hu (2005a) states that "panel estimation suggests a negative relationship in the short run and a positive relationship in the long run, although the results for OECD countries are not very statistically robust." Speaking about a direct link between pension funds' assets and economic growth, the author declares that there is a positive link between these two variables. Additionally, "there is evidence that pensions are a good predictor of economic growth." The results are also supported by panel Granger causality test (Hu, 2005a).

As discussed previously, there are not many research papers aiming to analyse the direct link between pension funds' growth and economic growth, however additionally to Davis and Hu (2004) and Hu (2005a,b) it is also worth mentioning the studies by Holzmann (1997a,b) and Davis and Hu (2008). Holzmann (1997a,b) concludes that pension reform positively affected total productivity in Chile. In terms of the research by Davis and Hu (2008), it goes along with Davis and Hu (2004). The structure of an updated study is very similar to their original article written in 2004. Davis and Hu (2008) also use a modified Cobb-Douglas function and find a positive and significant relationship between the ratio of pension assets to GDP and output per head.

Even though the research papers mentioned above support the idea of the positive total pension funds' assets and economic growth nexus, there are several articles arguing that such a relationship may not be present. One of the most recent studies was conducted by Zandberg and Spierdijk (2010). The sample used in their research covers 58 countries of which 29 are OECD countries. Sample period is 2001-2008. In contrast to Davis and Hu (2008), Zandberg

[1]For a brief introduction to the World Bank model refer to Appendix C.1.

and Spierdijk (2010) use total pension assets as a measure of funding and not the amount of pension assets of autonomous pension funds. For the analysis it should not matter who invests the money - whether it is a pension fund or any other institution and therefore it is advisable to use total pension funds' assets instead (Zandberg and Spierdijk, 2010). The model used by the authors also differs substantially from the one suggested by Davis and Hu (2004, 2008). Zandberg and Spierdijk (2010) suggest controlling for capital market returns of pension funds. The estimation procedure consists of two steps. Firstly, using OLS they estimate the following model:

$$\Delta(PA/GDP)_{it} = \beta_1 r_{it} + \beta_2 \Delta(OldDependencyRatio)_{it}^{-1} + \epsilon_{it} \quad (2.2)$$

where *PA/GDP* is pension assets divided by nominal GDP (and subsequently multiplied by 100), r is the rate of return on pension assets and *the inverse Old Dependency Ratio* is the number of people between 16 and 65 divided by the number of people over 65 (Zandberg and Spierdijk, 2010). The second step is to focus on the relationship between funding and growth during the transition from a PAYG system to a funded or partly funded system. In order to measure this effect, Zandberg and Spierdijk (2010) use the residual from equation (2.2) in a dynamic growth regression[2]. The authors believe that "funding of pensions might increase economic growth rates by increasing the aggregate saving rate, by the development of capital markets, by reducing labor market distortions, and by improving corporate governance", however it is interesting to note that after estimating the coefficients of several regressions, Zandberg and Spierdijk (2010) conclude that there is no direct link between pension funds' assets and economic growth. Such an outcome may be due to the fact that additional saving is not translated into a higher economic growth. Moreover pension funds may invest a significant amount of their assets abroad (Zandberg and Spierdijk, 2010).

It is worth mentioning that this is not the only study failing to empirically prove that the total pension funds' assets and economic growth nexus exists. For example, Davis (2002, 2004) examined the effect of institutionalisation on economic growth. This means that he analysed the proportion of equity held by insurance companies, pension and mutual funds

[2]For the regression and for a more detailed description of the model suggested by Zandberg and Spierdijk (2010) refer to Appendix C.2.

and not exactly the direct relationship between pension funds' assets and economic growth. In that case it was concluded that no link with economic growth was present.

2.3 Funding and financial development

In the previous sub-chapter we briefly mentioned that funding may have a positive impact on financial development, which itself may also stimulate growth. Quite a lot of researchers[3] were interested in the latter topic and asked similar questions (Walker and Lefort, 2002), however we suggest concentrating on a few studies and getting a deeper understanding of the relationship and rationale behind it. One of the most detailed analysis was conducted by Walker and Lefort (2002).

There are several reasons why pension fund growth should lead to financial development. Firstly, financial instruments in which pension funds can invest accumulated wealth have to be created. As a result, institutions, "issuing such instruments, will have to disclose the required information." This is expected to "improve transparency in terms of financial market practices and fund management"(Walker and Lefort, 2002). Secondly, it is also likely to increase levels of specialization and professionalism, because managing big volumes of assets requires substantial knowledge. And last, but of course not least, growing pension funds' assets are believed to stimulate financial innovation incentives (Walker and Lefort, 2002). Davis and Hu (2004) also support the ideas by Walker and Lefort (2002) by summarizing that "financial system's function of managing uncertainty and controlling risk could be strengthened with pension fund growth as pension fund managers as portfolio professionals have better expertise and knowledge."

In terms of the research and the results, Walker and Lefort (2002) use data of 33 emerging economies, and a subsample of seven Latin American countries. Length of the data varies depending on a country and sometimes is adjusted, however it mainly covers the period from early 80s until 2000. The authors analyse the impact of growing pension funds' assets (concentrating on the impact of pension reform) on capital markets by, as they say, considering evidence of anecdotal and casuistic nature as well as by using simple data and more advanced econometric techniques. Walker and Lefort (2002) conclude that transparency, in-

[3] e.g. Singh (1996); Blommestein (1997); Holzmann (1997a,b); Burtless (1998), etc.

tegrity and specialization in the investment decision-making process increase, however the "linkage between financial market integration and pension reform is somewhat weaker." The most important finding according to Walker and Lefort (2002) is that growing pension funds' assets improve fund allocation for investment purposes, which means that resources will probably be better allocated and as a result this should lead to "positive effects on growth and permanent welfare, even if total savings are not affected."

By using a dataset covering 51 EME countries and additionally 21 OECD countries, Hu (2005a), revisits the investigation of the relationship between pension assets and financial markets analysed by Walker and Lefort (2002). Analysis done by Hu (2005a) looks into the impact of pension assets from four different aspects: (1) financial intermediaries, (2) the banking industry, (3) the stock market and (4) the bond market. Overall, according to Hu (2005a), the results of his study are in line with Walker and Lefort (2002), meaning that growing pension funds' assets have a positive impact on financial development. Furthermore Demirgüç-Kunt and Levine (1996) and Levine and Zervos (1998) also agree that financial development stimulates growth and it is particularly the equity market development which makes the most positive impact.

2.4 Summary

To sum up, there are various channels through which pension funds' assets may affect economic growth. Firstly, increasing pension funds' assets may improve corporate governance and reduce labor market distortions. Secondly, it may also stimulate the development of capital markets (Zandberg and Spierdijk, 2010). Thirdly, funding of pensions may increase aggregate saving rates (Davis and Hu, 2004). All the above are more or less the indirect effects, however one may also consider the direct pension funds' assets and economic growth nexus. Literature examining the latter is quite scarce and the results are not consistent. Some economists conclude that there is evidence proving the link between pension funds' assets and economic growth (see Davis and Hu, 2004, 2008; Holzmann, 1997a,b; Hu, 2005a,b), however the others fail to find a significant relationship. One of the most insightful studies was conducted by Zandberg and Spierdijk (2010). They conclude that once controlled for capital market returns of pension funds, the relationship between pension funds' assets and economic growth disappears.

As a direct link may not be present analysing the effect of growing pension funds' assets on financial development is crucial. Many economists studied this relationship (see Singh, 1996; Blommestein, 1997; Holzmann, 1997a,b; Burtless, 1998, etc.) A very detailed analysis was conducted by Walker and Lefort (2002) where the authors arrive at a conclusion that increasing pension funds' assets positively affect transparency, integrity and improve fund allocation, which itself may lead to permanent positive effects on growth and welfare. The study by Walker and Lefort (2002) was revisited by Davis and Hu (2008) and their results are in line with the outcome of the initial research. Moreover, Demirgüç-Kunt and Levine (1996) and Levine and Zervos (1998) also agree that financial development stimulates growth and it is particularly the equity market development which makes the biggest positive impact.

The main question this thesis is going to research is whether the positive impact of pension funds' assets on economic growth exists. Most of the work is a repetition of the study conducted by Davis and Hu (2004), however additionally we look at the outcomes of static models. We also work on improving the dynamic model suggested by the authors by assessing the impact of the recent financial as well as the sovereign-debt crisis.

3 Theoretical framework

This chapter deals with a theoretical framework. The main model used in this thesis is obtained by adjusting the standard Cobb-Douglas production function, where the starting point is the classical function with two factors. The first sub-chapter introduces a basic model, in the second sub-chapter we discuss our variables, the third sub-chapter presents the final model suggested by Davis and Hu (2004, 2008), whereas the last sub-chapter is dedicated for the summary. The final model obtained in Chapter 3 is used as a base for our econometric analysis conducted in Chapter 6.

3.1 Introduction to the basic model

Derivation of the main model starts by modifying the classical Cobb-Douglas production function with two factors:

$$Q = AK^{\beta}L^{1-\beta}\text{[4]} \tag{3.1}$$

where Q is total production, A is total factor of productivity, L is labour input, K is capital input and β and $(1-\beta)$ are the output elasticities of capital and labour, respectively.

Adding extra variables, that may be relevant for the particular analysis, to a generalised Cobb-Douglas production function is very common practice and many economists advocate such adjustments (see McCoskey and Kao, 1999; Arestis et al., 2004; Davis and Hu, 2004, 2008; Haiss and Smegi, 2008, etc). By denoting cross-sectional and time-series dimensions and by including an additional parameter P to equation (3.1) we get a new specification:

$$Q_{it} = A_{i,t}(P_{i,t})^{\lambda_i}(K_{i,t})^{\beta_i}(L_{i,t})^{1-\beta_i} \tag{3.2}$$

where

- ⋆ Q is aggregate output, proxied by GDP;
- ⋆ A is state of technology;
- ⋆ P is pension funds' assets as percentage of GDP, i.e. pension funds' assets/GDP;
- ⋆ K is capital stock;

[4] It is assumed that production function has constant returns to scale. This basically means that $\alpha+\beta=1$ and therefore $\alpha = 1-\beta$. Such a relationship assures that if you double L and K, Q will also double.

- ⋆ L is labour supply, proxied by total population;
- ⋆ λ is elasticity of Q with respect to P;
- ⋆ β is elasticity of Q with respect to K;
- ⋆ i is a country index;
- ⋆ t is time dimension;

It can be seen from equation (3.2), that four factors make an impact on aggregate output: (1) state of technology, (2) pension funds' assets, (3) capital stock and (4) labour supply. Next sub-chapter and Appendix C.3 discuss the variables of the latter model in more detail.

3.2 Variable description

We assume that only the four factors listed in the equation (3.2) are making an impact on aggregate output. In order to be able to apply this model practically, a clear idea on how each of the variables (enodgenous and exogenous) are calculated should be present. Speaking about aggregate output, it is proxied by GDP and no additional calculations are required. Obtaining data for labour supply as well as for pension funds' assets is plain vanilla too as the estimates are listed on a few very well know databases. Two variables, whose calculation is a bit more sophisticated are technological progress (state of technology) A and capital stock K.

3.2.1 State of technology

According to Davis and Hu (2004) state of technology can be expressed using an intercept, a time trend and a residual term:

$$A_{i,t} = e^{\alpha_i + \gamma_i t + \epsilon_{i,t}} \tag{3.3}$$

It is suggested to specify state of technology as in equation (3.3) due to several reasons. Firstly, such a specification introduces a stochastic element ϵ in the model and secondly, it allows for heterogeneity across countries by including the country-specific intercept (Davis and Hu, 2004; McCoskey and Kao, 1999). By substituting equation (3.3) into equation (3.2) we get a new expression of our model:

$$Q_{it} = e^{\alpha_i + \gamma_i t + \epsilon_{i,t}} (P_{i,t})^{\lambda_i} (K_{i,t})^{\beta_i} (L_{i,t})^{1-\beta_i} \tag{3.4}$$

3.2.2 Capital stock

Calculation of the existing capital stock is a bit more complicated. In theory, capital stock should consist of machinery, buildings, computers, etc., however there is no agreed international standard on how exactly it should be derived. Even though it is possible to obtain data on capital stock for OECD countries from the OECD database, the organisation itself advises to use the provided data very carefully due to several reasons. Firstly, "the data is a mixture of data collected from the national statistics offices and own estimations of the OECD" (Berlemann and Wesselhöft, 2012). Secondly, there is not much consistency in techniques economists use for measuring capital stock and therefore data across countries is hardly comparable. An alternative approach is to find a proxy for physical capital accumulation. Most of the related literature has used this acceptable alternative and employed gross investment rates as a proxy. It is interesting to note that all attempts to generate capital stock datasets rely on the Perpetual Inventory Method (Berlemann and Wesselhöft, 2012), under which inventory is treated as the economy's capital stock. In this thesis, consistently with Luintel and Khan (1999) and Davis and Hu (2004), we use a steady state approach with a 3-year average and a depreciation rate of 8%. For a full description of the Perpetual Inventory Method and the derivation of capital stock please refer to Appendix C.3.

3.3 Final model

In the previous two sub-chapters and Appendix C.3 we discussed how all the variables in our model are calculated. This section explains a few additional steps needed to finalise and prepare the model for estimation. Firstly, equation (3.4) is normalised by dividing both sides of the equation by labour supply L:

$$\begin{aligned}\frac{Q_{it}}{L_{it}} &= \frac{e^{\alpha_i+\gamma_i t+\epsilon_{i,t}}(P_{i,t})^{\lambda_i}(K_{i,t})^{\beta_i}(L_{i,t})^{1-\beta_i}}{L_{it}} \\ \frac{Q_{it}}{L_{it}} &= e^{\alpha_i+\gamma_i t+\epsilon_{i,t}}(P_{i,t})^{\lambda_i}\left(\frac{K_{i,t}}{L_{i,t}}\right)^{\beta_i}\end{aligned} \tag{3.5}$$

Secondly, we label output per worker $\frac{Q_{i,t}}{L_{i,t}} = Q^*_{i,t}$ as well as capital stock per worker $\frac{K_{i,t}}{L_{i,t}} = K^*_{i,t}$ and take the logs of both sides of the equation (3.5) to get a log-linear expression:

$$lnQ^*_{i,t} = \alpha_i + \gamma_i t + \lambda_i lnP_{i,t} + \beta_i lnK^*_{i,t} + \epsilon_{i,t} \tag{3.6}$$

where

- ⋆ Q^* is GDP per capita;
- ⋆ P is pension funds' assets as percentage of GDP, i.e. pension funds' assets/GDP;
- ⋆ K^* is capital stock per capita;
- ⋆ t is a time trend;
- ⋆ subscript i and t indicate country and time, respectively;
- ⋆ ϵ is an error term.

The above model (equation (3.6)) is our final model. We will be using it to assess the impact of different factors on output. In terms of the estimation techniques applied to obtain the coefficients of this model, please refer to Chapter 4. Note, that for simplicity reasons when we speak about GDP per capita and capital stock per capita in the text as well as when we plot the data, these variables are labelled without asterisks, i.e. LnQ and LnK instead of LnQ* and LnK*. As logarithmised values of total GDP and total capital stock are never used in this thesis, we believe such a simplification of the names will not make any confusion. Variables in equations are not relabelled.

3.4 Summary

To conclude, the main task of this chapter is to design a theoretical model, describing the relationship between pension funds' assets and economic growth. We start with the basic Cobb-Douglas production function at the beginning of the chapter. The description and relevant calculations of our variables are represented in the second sub-chapter. Except for the capital stock most of the transformations are very simple. The detailed procedure on how to obtain values for the capital stock and the description of a steady state approach can be found in Appendix C.3. Finally, with the inclusion of pension assets as a shift factor we design a modified Cobb-Douglas function. Our final model is described by equation (3.6). This model does not differ from the one suggested by Davis and Hu (2004, 2008).

4 Data and methodology

In this chapter we present the availability of our data and define the methods used in Chapter 6 for parameter estimation. The first sub-chapter discusses the sources used to obtain the data, whereas in the second sub-chapter we concentrate on possible biases. In the later sections the issue of non-stationarity is described from a technical point of view and the introduction to the panel data estimators is included. Finally, in the last sub-chapter we provide the reader with a brief summary and discuss the main ideas of this chapter.

4.1 Presentation of the data

To examine the relationship between economic growth and pension funds' assets we use data on autonomous pension funds' assets as a share of GDP, aggregate output, labour supply and investments on a country level. The data comes from three different sources: (1) OECD database[5], (2) World Development Indicators, thereafter WDI, database[6] and (3) personal calculations[7]. For obtaining the data on labour supply and aggregate output we employ the WDI database. Investment data, needed for capital stock calculation, is also downloaded from the latter database. In terms of pension funds' assets, the OECD database is used.

The data about 34 OECD countries is collected from different sources and therefore the length of time-series is not the same for all the variables and across the countries. The shortest time-series is for pension funds' assets[8]. It is worth reminding, that our initial model requires not an actual data of total assets, but a ratio of total pension funds' assets to GDP[9]. The main concept of this ratio is to give an "indication of the maturity of the system and evidence of importance of private pensions relative to the size of the economy" (OECD, 2012a). For almost all the countries data is available from 2001 onwards, meaning that the maximum number of observations of pension funds' assets to GDP ratio is 11. Due to several

[5]OECD stands for the Organisation for Economic Co-operation and Development. As the institution publishes comparable statistics on a wide range of subjects it is also known as a statistical agency.

[6]WDI database is a collection of development indicators assembled by World Bank from various officially-recognised international sources.

[7]Refer to Chapter 3 and Appendix C.3 for more information on the formulas used.

[8]To measure total pension funds' assets Davis and Hu (2004) advise to use autonomous pension funds' data provided by OECD.

[9]Already calculated ratio (multiplied by 100) was retrieved from OECD database on 09/11/2012.

Table 1: Availability of the data. The table reports the years, for which data is collected and analysed. The column labelled Obs. counts how many observations are available for a particular country as well as lists the total at the bottom.

No.	Country	Sample period	Obs.
1	Australia	2001-2011	11
2	Austria	2001-2011	11
3	Belgium	2001-2011	11
4	Canada	2001-2011	11
5	Chile	2002-2011	10
6	Czech Republic	2001-2011	11
7	Denmark	2001-2011	11
8	Estonia	2001-2011	11
9	Finland	2001-2011	11
10	France	2005-2011	7
11	Germany	2001-2011	11
12	Greece	2007-2011	5
13	Hungary	2001-2011	11
14	Iceland	2001-2011	11
15	Ireland	2001-2011	11
16	Israel	2001-2011	11
17	Italy	2001-2011	11
18	Japan	2001-2011	11
19	Korea	2002-2011	10
20	Luxembourg	2004-2011	8
21	Mexico	2001-2011	11
22	Netherlands	2001-2011	11
23	New Zealand	2001-2011	11
24	Norway	2001-2011	11
25	Poland	2001-2011	11
26	Portugal	2001-2011	11
27	Slovak Republic	2001-2003 & 2005-2011	10
28	Slovenia	2003-2011	9
29	Spain	2001-2011	11
30	Sweden	2001-2011	11
31	Switzerland	2001-2011	11
32	Turkey	2004-2011	8
33	United Kingdom	2001-2011	11
34	United States	2001-2011	11
		Total:	**353**

missing data points instead of having 374 (34 countries × 11 years) observations, we analyse 353 data points in total. Please refer to Table 1 for more information on data availability and missing observations.

The data on output, investments and labour supply is obtained from the WDI database. The latter database includes a very long history of time-series, however as we managed to collect the data on pension funds' assets for the recent 11 years only, it makes sense to use the data for the the last 11 years on output, investment and labour supply too. There are no missing values in this dataset, meaning that for each variable we have 374 observations.

In Chapter 3 it was discussed that GDP would be used as a proxy for aggregate output. This variable in the WDI database is coded as NY.GDP.MKTP.CD[10]. Consistently with Davis and Hu (2004), labour supply is measured as total population and the code in the WDI database is SP.POP.TOTL[11]. Lastly, for investment data, needed to calculate capital stock, we use gross fixed capital formation. This is in line with Berlemann and Wesselhöft (2012), however they use real figures, whereas all variables in our research are expressed in nominal terms. Due to this reason for obtaining time-series data on gross fixed capital formation we use a NE.GDI.FTOT.CD[12] variable from the WDI database.

4.2 Possible biases and collection problems

Data design and collection problems is something every analyst experiences before proceeding to modelling. Depending on a dataset, different issues may be present, however the ones we would like to talk about are the following: (1) heterogeneity of the countries, (2) non-response and (3) usage of different sources of information. All these problems are interrelated and sometimes may be caused by each other. Firstly, it is apparent that even though all the countries in our sample are OECD members rules and regulations substantially differ among them. In some countries the laws, determining how much information autonomous pension

[10]World Bank (2013a) explains NY.GDP.MKTP.CD as the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. Data retrieved on 15/05/2013.

[11]World Bank (2013b) explains SP.POP.TOTL as total population, based on the de facto definition of population, which counts all residents regardless of legal status or citizenship–except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The values shown are midyear estimates. Data retrieved on 23/03/2013.

[12]World Bank (2013c) explains NE.GDI.FTOT.CD as gross fixed capital formation, which includes land improvements, plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Data are in current U.S. dollars. Data retrieved on 15/05/2013.

funds should disclose on semi-annual or annual basis, are very strict, whereas in the others disclosure of information regulations may be minimal. This means that for some countries relevant data may be missing due to the lack of strict laws. One of the selectivity problems called non-response is the second quite important issue. Non-response can also be very much related to regulations within a particular country. For example if a pension fund is performing poorly and if there is a gap in the law allowing to release only some information on the performance of the fund, then fund managers may want to hide certain details. This will automatically lead to biased estimates. The third reason, why comparing data may be a difficult task is the usage of different sources to obtain that data. For example when downloading the time-series of pension funds' assets for all OECD countries we used the OECD database. Even though we believe that this data was gathered with strong attention to detail, OECD itself collects data from various sources, for example local governments, which automatically means that some inconsistencies may be present. Finally, one has to remember that some countries have a very bad reputation and the estimates provided by their local governments should be examined with caution. It is well known how 'magically' Greek debt disappeared before it joined the EU (Little, 2012) and such a history should not be forgotten when thinking about the accuracy of the data.

4.3 Stationarity testing

Before proceeding to modelling one has to assure that data exhibits certain characteristics. Most methods are based on the assumption that time-series is stationary. Forecasting and modelling non-stationary data cannot provide meaningful results and therefore time-series has to be transformed to at least a weak stationary process, i.e. its mean, variance and auto-covariance structure should not change over time. It is very common that macro economic data has a stable long-run trend and is non-stationary, however this issue can be easily handled by de-trending.

One of the most popular ways of determining whether a series is stationary or non-stationary is to conduct a unit-root test. Next section introduces the theoretical background of unit-root tests and Appendix C.4 elaborates on them further. Statistical testing may be powerful in some cases and not in the others, therefore examining data graphically is something an analyst should also consider. Additionally, the Hodrick-Prescott filter can be used in order to extract (1) a trend and (2) a remainder part (i.e. short term fluctuations).

4.3.1 Unit-root tests

Since our panels are really small with a maximum of 11 observations per panel, certain assumptions required to run the tests may not be satisfied. This leads to a low power of the tests, suggesting that the results may not be of the highest relevance. We understand the limitation of our data, however examining whether unit-roots are present or not will not make any harm and may confirm our thoughts about the data being trend stationary.

Hall and Mairesse (2000) extensively investigated the properties of six unit-root tests in short panel data, however instead of analysing actual time-series, they applied the tests on simulated panel data. Examining different outcomes using fictitious data may be considered as the main drawback of their research. On the other hand, Davis and Hu (2004) applied only three tests to check panel data's stationarity. Consistently with Davis and Hu (2004) we rely on the Levin-Li-Chu (LLC), the Im-Pesaran-Shin (IPS) tests and also conduct the Fisher-type test to check whether logarithmised output per capita, capital stock per capita and total assets over GDP have unit-roots. The Fisher-type test is chosen instead of the Hadri LM test, because it can be applied to an unbalanced panel. Speaking about the IPS test, it can also handle unbalanced panels, however the latter test requires at least 10 observations per panel. In order to test stationarity of LnP we use the IPS test excluding 5 countries (France, Greece, Luxembourg, Slovenia and Turkey) for which we have less than 10 observations. The basic theory behind the testing procedure is straightforward. Consider the following model:

$$y_{i,t} = \rho_i y_{i,t-1} + X'_{i,t}\delta_i + \epsilon_{i,t} \tag{4.1}$$

where

- ⋆ y is the variable being tested;
- ⋆ X represents panel-specific means, panel-specific means and a time trend, or nothing, depending on the options specified;
- ⋆ i indexes country;

- ⋆ t indexes time;
- ⋆ ϵ is independently and identically distributed error term with zero mean and σ_ϵ^2 variance, i.e. $\epsilon_{i,t}$ iid $(0, \sigma_\epsilon^2)$.

Panel unit-root tests are used to test the null hypothesis $H_0 : \rho_i = 1$ for all i versus the alternative $H_a : \rho_i < 1$. Depending on the test H_a may hold for one i, a fraction of all i or all i. Moreover, equation (4.1) may be rewritten to equation (4.2) and this is a more commonly used expression:

$$\Delta y_{i,t} = \phi_i y_{i,t-1} + X'_{i,t}\delta_i + \epsilon_{i,t} \tag{4.2}$$

where $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$. In that case the null hypothesis is then $H_0 : \phi_i = 0$ for all i versus the alternative $H_a : \phi_i < 0$.

Of course, it is worth noting that different tests have a few similar options such as an option to include a time trend, suppress panel-specific means or subtract cross-sectional means, however they rely on different assumptions and the alternative hypothesis is also not the same. For example the LLC test makes a simplifying assumption that $\rho_i = \rho$ for all i, which basically means that all panels share the same autoregressive parameter (StataCorp, 2011). The IPS test, on the other hand, allows heterogeneity across the countries. In terms of H_a, the alternative hypothesis of the LLC test is that all panels are stationary, whereas if we reject H_0 after conducting the IPS or the Fisher-type test, we can only state that some panels are stationary. Additional information on the tests used can be found in Appendix C.4, whereas the results of the tests are discussed in Chapter 6.

4.4 Panel data

This sub-chapter stands for an introduction to static and dynamic panel data estimators, however before proceeding to the discussion about modelling we present the advantages and disadvantages of using panel data. Baltagi (2005), Greene (2004), Hsiao (2003, 2007), Klevmarken (1989), Verbeek (2004) and many other econometricians agree that sometimes neither time-series nor cross-sectional settings alone can provide valuable insights and the models based on panel data may be preferred. The main ideas particularly relevant to our research are briefly summarised below.

The biggest advantage of using panel data is that it allows controlling for heterogeneity. It is not surprising that countries in our sample are not the same and we touch upon this topic again in Chapter 5, where the basic analysis of each country is conducted. For the time being Figure 1 draws a compact picture from which we can see that data on GDP per capita in each country is not homogeneous. Heterogeneity is also present in the panels of capital stock per capita as well as in the panels of total pension funds' assets over GDP[13]. An analyst should understand that it is very important to have a model, allowing to control for heterogeneity, because there may be variables that are country-invariant or time-invariant and not taking them into account one runs the risk of obtaining biased and inconsistent results. Panel data is able to deal with this issue, whereas neither a time-series study nor a cross-sectional analysis is.

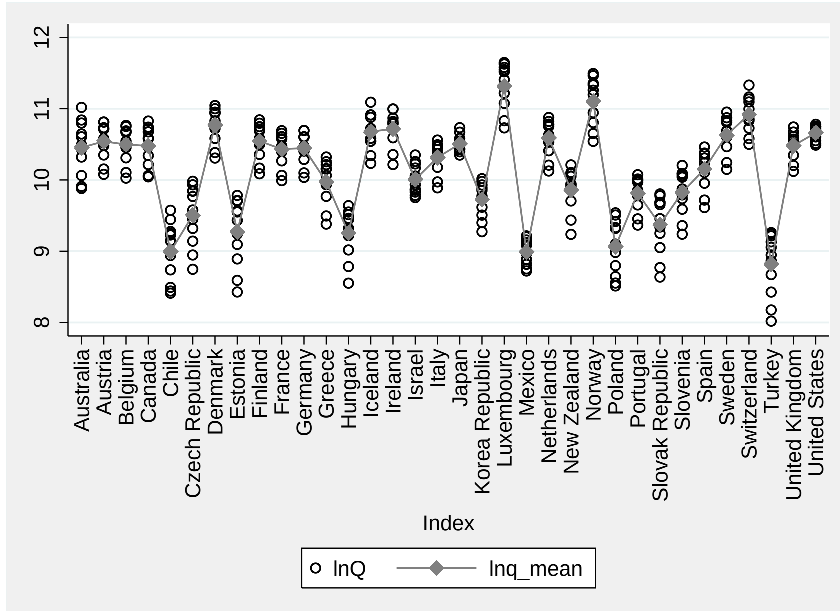

Figure 1: Heterogeneity of GDP across the OECD countries. The empty dots represent logarithmised values of output per capita (proxied by GDP per capita). Mean of this variable is plotted with a connected grey line. Data is obtained from OECD, calculations are done by the authors.

Explanatory variables in panel data sets vary over two dimensions (individuals and time) rather than one and therefore panel data sets are usually larger than cross-sectional or time-series data sets. This gives more informative data and more variability (Baltagi, 2005), making panels more attractive compared to one-dimensional sets. Moreover, in most cases estimators based on panel data are more accurate and efficient (Verbeek, 2004). The list of advantages of panel data may be continued by mentioning that panel data is better able to study the dynamics of adjustment and it also allows an analyst to construct and test more complicated behavioural models, however we believe that the most important ones to our

[13]See figures B1 and B2 in Appendix B.

research are the ability to control for heterogeneity and the higher efficiency of parameter estimators.

Speaking about the limitations of panel data, they are very similar to the ones that econometricians face while analysing cross-sectional data or time-series. Panels may have selectivity (self-selectivity, nonresponse, attrition), design and collection problems as well as distortions of measurement errors. Besides that, cross-sectional dependence can also be present in panel data sets. Furthermore, compared to cross-sectional or time-series, data collection of panel data is usually much more costly.

To conclude, since our time dimension is very small (maximum 11 observations per country), we believe that no other solution to estimate parameters can do a better job than panel data models. We understand that countries are very different and running regressions for each country separately might provide insightful and interesting results, however due to the lack of the data we do not pursue the analysis of separate regressions and rely on static and dynamic panel models discussed in the next section. The only time when the coefficients of individual regressions estimated by OLS are used is when we need to average out these coefficients in order to obtain the estimates of dynamic heterogeneous models.

4.4.1 Static panel data models

In this section we describe the rationale behind static panel data models, particularly concentrating on fixed effects and random effects. The impact of pension funds' assets and capital stock on gross domestic product is later measured in Chapter 6, where the summary and comparison of the outcomes of different models are presented.

When talking about the advantages of using panel data instead of a regular time-series or cross-sectional datasets we have already mentioned that panel data has two dimensions, i.e. it has a double subscript on its variables:

$$y_{i,t} = \alpha + X'_{it}\beta + u_{i,t} \quad i = 1, ...N;\ t = 1, ..., T \tag{4.3}$$

with i denoting countries or individuals and t denoting time. α is a scalar, β is $K \times 1$ and X_{it} is the itth observation on K explanatory variables. Most of the panel data applications utilize a one-way error component model for the disturbances, with

$$u_{it} = \mu_i + \nu_{it} \tag{4.4}$$

where μ_i denotes the *unobservable* effect and ν_{it} denotes the remainder *disturbance* (Baltagi, 2005). Note that any individual-specific effect that is not included in the regression is accounted by a time-invariant μ_i, which can be interpreted as the individual's unobserved ability. In our research it can, for example, be a political system of a particular country. The remainder disturbance ν_{it} varies across the countries and time and can be thought of as the usual disturbance in the regression.

By recalling our final model derived in Chapter 3:

$$lnQ^*_{i,t} = \alpha_i + \gamma_i t + \lambda_i lnP_{i,t} + \beta_i lnK^*_{i,t} + \epsilon_{i,t} \tag{4.5}$$

one can easily calculate that the number of parameters to be estimated is 136 (34 $\times$ 4) and with only 353 observations obtaining consistent estimates is not feasible. A simplification of equation (4.5) that is possible to estimate allows the intercepts for each country to vary, but restricts the slope parameters to be constant across all the countries. That is,

$$\gamma_i = \gamma, \quad \lambda_i = \lambda, \quad \beta_i = \beta \tag{4.6}$$

Equation (4.5) then can be rewritten to:

$$\begin{aligned} lnQ^*_{i,t} = \alpha_i + \gamma_i t + \lambda_i lnP_{i,t} + \beta_i lnK^*_{i,t} + \epsilon_{i,t} = \\ = \alpha_i + \gamma t + \lambda lnP_{i,t} + \beta lnK^*_{i,t} + \epsilon_{i,t} \end{aligned} \tag{4.7}$$

It can be seen that no lagged variables are included in equation (4.7) and therefore this model is called a static model.

Fixed Effects

Fixed effects, thereafter FE, examine the relationship between predictor and outcome variables within a particular entity, in our case within a particular country. If an analyst is interested in assessing the impact of variables that vary over time only, FE are an advisable solution. On the other hand, using FE does not mean that time-invariant effects will be ignored.

34 OECD countries in the sample are not the same and each of them has its own characteristics (for example a political system), which may or may not not influence the predictor variables. If these characteristics make an impact on the predictor variables, one has to control for them assuring that bias is not present in the estimates. The rationale behind FE is that an assumption of (1) the correlation between country's error term and the predictor variables is made and in order to assess the predictors' net effect FE remove the effect of time-invariant characteristics from the predictor variables.

Another important assumption made by the FE model is that (2) time-invariant characteristics are unique to the country and should not be correlated with other individual characteristics (Torres-Reyna, 2010) As all the countries are different, it is expected that the country's error terms and the constant, capturing individual characteristics, should not be correlated with the error terms and constants of other countries. If, however, the error terms are correlated, it is advised not to apply the FE model as its estimates will be biased and incorrect. An alternative in such a situation is to use a different methodology, e.g. random effects, which is discussed below.

Random Effects and the Hausman Test

In contrast to fixed effects, random effects, thereafter RE, model assumes that the individual effects are random and strictly uncorrelated with the regressors included in the model (Greene, 2004). Therefore, if an analyst believes that the differences across the countries have no influence on the predictor variables then RE should be used. An advantage of RE is that time-invariant variables can be included, whereas in the FE model these variables are absorbed by the intercept (Torres-Reyna, 2010).

In order to apply RE one has to assume that α_i can be divided into two parts: α and μ_i, meaning that equation (4.7) is rewritten to:

$$\begin{aligned} lnQ^*_{i,t} &= \alpha_i + \gamma t + \lambda lnP_{i,t} + \beta lnK^*_{i,t} + \epsilon_{i,t} = \\ &= \alpha + \gamma t + \lambda lnP_{i,t} + \beta lnK^*_{i,t} + \epsilon_{it} + \mu_i = \\ &= \alpha + \gamma t + \lambda lnP_{i,t} + \beta lnK^*_{i,t} + z_{i,t} \end{aligned} \tag{4.8}$$

Moreover, it is important to note that when using RE one has to specify which time-invariant variables may or may not make an impact on the predictor variables. According to Torres-Reyna (2010), the problem with this is that some variables may not be available therefore leading to an omitted variable bias in the model.

In order to choose between FE or RE it is advised to use the Hausman test. The original Hausman test was proposed in 1978 and is based on different assumptions of the random effects and fixed effects models (Wooldridge, 2002). One of the assumptions required to use the test is that errors in the model are uncorrelated and homoskedastic. A failure to meet this assumption means that the test has no systematic power. We are going to take into account the issues related to the errors of our model by estimating parameters using robust errors and because of this adjustment instead of the original Hausman test, a robust version programmed by Schaffer and Stillman (2006) has to be applied. The null hypothesis is that there should not be any difference whether FE or RE estimates are used, whereas the alternative states that the estimates produced by the RE model are inconsistent.

4.4.2 Dynamic panel data models

We have listed several advantages of panel data earlier in this chapter. One additional advantage, which has not been mentioned yet, is the ability to model individual dynamics. It is suggested by many economic models that past behaviour should make an impact on current behaviour of a particular variable and therefore one would like to estimate a dynamic model instead of a static one. The ability to do so is unique for panel data (Verbeek, 2004). Even though dynamic panel data models allow a researcher to better understand the dynamics of adjustment, one has to understand that the estimators used to estimate parameters of static models can no longer be applied, since a modeller is now dealing with a dynamic specification (i.e. static estimators should not be used as they become biased and inconsistent). Moreover, every additional lag included in the model reduces the number of observations and if panels are small it may be very costly. In order not to loose observations, one may have a lag of a dependent variable only and extend a dataset by using a longer history of this variable. The latter solution, however works only if additional data on the dependent variable is available. In Chapter 6 we estimate our dynamic model using the Arellano and Bond estimator[14] and compare the results with the ones produced by static models.

4.5 Summary

To sum up, our data is obtained from two well know databases: OECD and World Development Indicators database. We believe that all the data was collected with strong attention to detail, however we also understand that even in such a case our dataset is not perfect. Disclosure of information regulations in different countries are not the same and some pension funds may not publish all relevant details, required for analysis. Additionally, when presenting the data we stress that the length of time-series dimension is very short, which automatically means that analysing separate countries does not make much sense. Due to this reason we decide to use panel data models and introduce the rationale behind static and dynamic specifications. The results of these models are described in Chapter 6.

[14]For a brief introduction to the Arellano-Bond linear dynamic panel-data estimation refer to Appendix C.5. For a detailed technical note see Arellano and Bond (1991), Verbeek (2004) or Holtz-Eakin et al. (1988).

5 Overview of the developments in pension funds' assets

Before proceeding to a more extensive analysis of the total pension funds' assets and economic growth nexus we briefly discuss the changes in the latter variables over time. The whole study covers 34 OECD countries. The major markets according to the Global Pension Assets Study conducted by Towers Watson (2013) are the following: Australia, Canada, Japan, the Netherlands, Switzerland, the United Kingdom and the United States. Mercer (2012) in their research also analyse only a selection of countries[15], however we use a sample of all OECD countries. The first sub-chapter provides a brief overview of the developments in total pension funds' assets, the second sub-chapter compares the changes in total pension funds' assets with changes in GDP, the fourth sub-chapter stands for the analysis of the ratio of total pension funds' assets to GDP and in the summary sub-chapter we conclude and outline our main findings.

5.1 Total assets

In this section we look at the changes in total pension funds' assets throughout the time, however when going into further detail we discuss only a few countries, whose features, in our opinion, seem to be the most interesting. At the end of 2011 total pension funds' assets for 34 OECD countries amounted to more than 20 trillion US dollars. Compared to the year before, this figure grew by around 5%. Looking at a longer horizon and data listed in columns *2001* and *2011* in Table 2, one can notice that pension funds' assets were growing during the last decade quite rapidly. Ignoring Slovak Republic[16] the largest growth was for Estonia: in 2001 country counted its pension funds' assets only in millions (1.97 mln USD) whereas for 2011 this figure was far much higher. The total pension funds' assets in Estonia in 2011 exceeded 1.5 billion US dollars, with a compounding annual growth rate[17] of 95%. No other

[15] Australia, Brazil, Canada, Chile, China, France, Germany, India, Japan, the Netherlands, Poland, Singapore, Switzerland, the United Kingdom and the United States

[16] "The break in series in pension fund investment in 2006 is due to the inclusion of voluntary pension plans, not included in previous years" (OECD, 2012b) and therefore the figure is not comparable.

[17] Compounded annual growth rate is calculated using the following formula: n-year $CAGR = \sqrt[n]{\frac{X_t}{X_{t-n}}} - 1$

country has experienced such an extreme growth in the recent decade. The compounding total pension funds' assets growth rate for the rest of the countries varies from as small growth as 3.3% and 3.9% for Portugal and the United States, respectively, to two digit numbers for almost all the remaining countries. One may also discern Poland and Czech Republic. The 10-year CAGR in Poland is 32.6%. This may be due to the fact that in 1999 voluntary occupational pension plans were introduced. As a consequence such an establishment might have encouraged additional private savings in the country (Pension Funds Online, 2013).

Speaking about Czech Republic, the 10-year CAGR is 25.9%. Such a growth may be related to a strong economic situation in the country and a rapid increase in pension funds' assets in the first decade of the 21st century. Even though the country experienced the financial crisis in 2007-2010 it did not make a dramatic impact on the total pension funds' assets. The pace of the assets' growth in Czech Republic in 2009 decreased, however as it can be seen from Figure 2 the stability remained in place. One reason for that may be the fact that in the late 1990s Czech Republic experienced a banking crisis (Tang et al., 2000). This lead to various restructuring plans and made everyone in the country more aware of economic and financial instabilities.

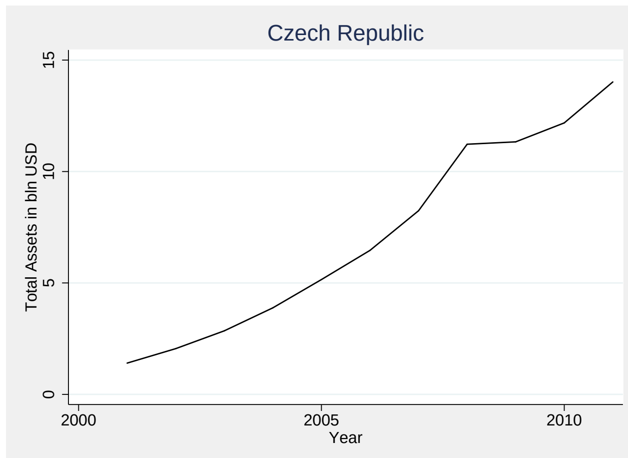

Figure 2: Autonomous pension funds' assets in Czech Republic. The line in the graph represents total assets held in autonomous pension funds in Czech Republic from 2001 to 2011. Data is obtained from OECD.

Looking at the recent 5-year growth rates listed in Table 2, one can notice that they also vary quite a lot. A few countries: Hungary, Iceland, Ireland and Portugal experienced a decrease during that period. There may be several reasons for a negative growth in total pension funds' assets and the causes differ across the countries. A very sharp decrease was noticed in Hungary in 2011, when pension funds' assets dropped drastically. This is a consequence of a pension reform introduced by the Hungarian government in 2010. A new

[18] Actual figure is 2270 U.S. dollars.

Table 2: Total assets and their growth rates. The first section of the table labelled Total Assets (in bln USD) reports total autonomous pension funds' assets in OECD countries in the following years: 2001, 2006, 2010 and 2011. Numbers are expressed in billions of U.S. dollars. On the right side of the table labelled CAGR (%) compounded annual growth rates (expressed in percentages) are reported for 1-year, 5-year and 10-year. Totals are listed at the bottom of the table. Data is obtained from OECD, calculations are done by the authors.

		Total Assets (in bln USD)				CAGR (in %)		
No.	Country	2001	2006	2010	2011	10-year	5-year	1-year
1	Australia	268.18	658.87	1066.17	1339.96	17.5	15.3	25.7
2	Austria	5.67	15.99	20.15	20.53	13.7	5.1	1.9
3	Belgium	12.77	16.77	17.63	21.74	5.5	5.3	23.3
4	Canada	375.57	807.81	1017.67	1106.09	11.4	6.5	8.7
5	Chile	.	88.99	136.25	145.51	.	10.3	6.8
6	Czech Republic	1.40	6.46	12.18	14.02	25.9	16.8	15.1
7	Denmark	43.64	89.57	154.38	165.74	14.3	13.1	7.4
8	Estonia	.002	.60	1.34	1.58	95.1	21.3	17.8
9	Finland	61.95	149.50	196.10	199.81	12.4	6.0	1.9
10	France	.	.95	5.30	6.68	.	47.5	26.0
11	Germany	65.13	122.76	178.60	195.36	11.6	9.7	9.4
12	Greece	.	.	.07	.10	.	.	45.0
13	Hungary	2.07	10.98	19.08	5.29	9.8	-13.6	-72.3
14	Iceland	6.64	21.67	15.61	18.09	10.5	-3.5	15.9
15	Ireland	45.79	110.09	100.00	100.56	8.2	-1.8	0.6
16	Israel	28.79	45.14	106.38	120.10	15.4	21.6	12.9
17	Italy	25.09	55.95	93.79	106.89	15.6	13.8	14.0
18	Japan	756.01	1151.36	1385.28	1470.35	6.9	5.0	6.1
19	Korea	.	26.62	40.15	49.72	.	13.3	23.8
20	Luxembourg	.	.44	1.06	1.16	.	21.1	9.3
21	Mexico	26.60	96.47	131.82	149.01	18.8	9.1	13.0
22	Netherlands	411.32	843.01	1006.77	1157.34	10.9	6.5	15.0
23	New Zealand	7.69	13.12	19.57	24.73	12.4	13.5	26.4
24	Norway	9.39	22.88	32.12	35.98	14.4	9.5	12.0
25	Poland	4.62	37.96	73.98	77.43	32.6	15.3	4.7
26	Portugal	13.27	26.58	26.13	18.41	3.3	-7.1	-29.5
27	Slovak Republic	0.0[18]	1.66	6.47	8.06	351.9	37.2	24.7
28	Slovenia	.	.62	1.44	1.67	.	22.0	15.9
29	Spain	35.06	92.53	111.24	116.13	12.7	4.6	4.4
30	Sweden	18.25	36.40	43.90	49.63	10.5	6.4	13.1
31	Switzerland	261.36	465.43	595.79	703.91	10.4	8.6	18.1
32	Turkey	.	3.97	17.24	8.57	.	16.7	-50.3
33	United Kingdom	1040.47	2002.06	1990.94	2129.54	7.4	1.2	7.0
34	United States	7205.81	10418.14	10586.13	10595.76	3.9	0.3	0.1
	Total:	**10732**	**17441**	**19211**	**20165**	**6.51**	**2.95**	**4.97**

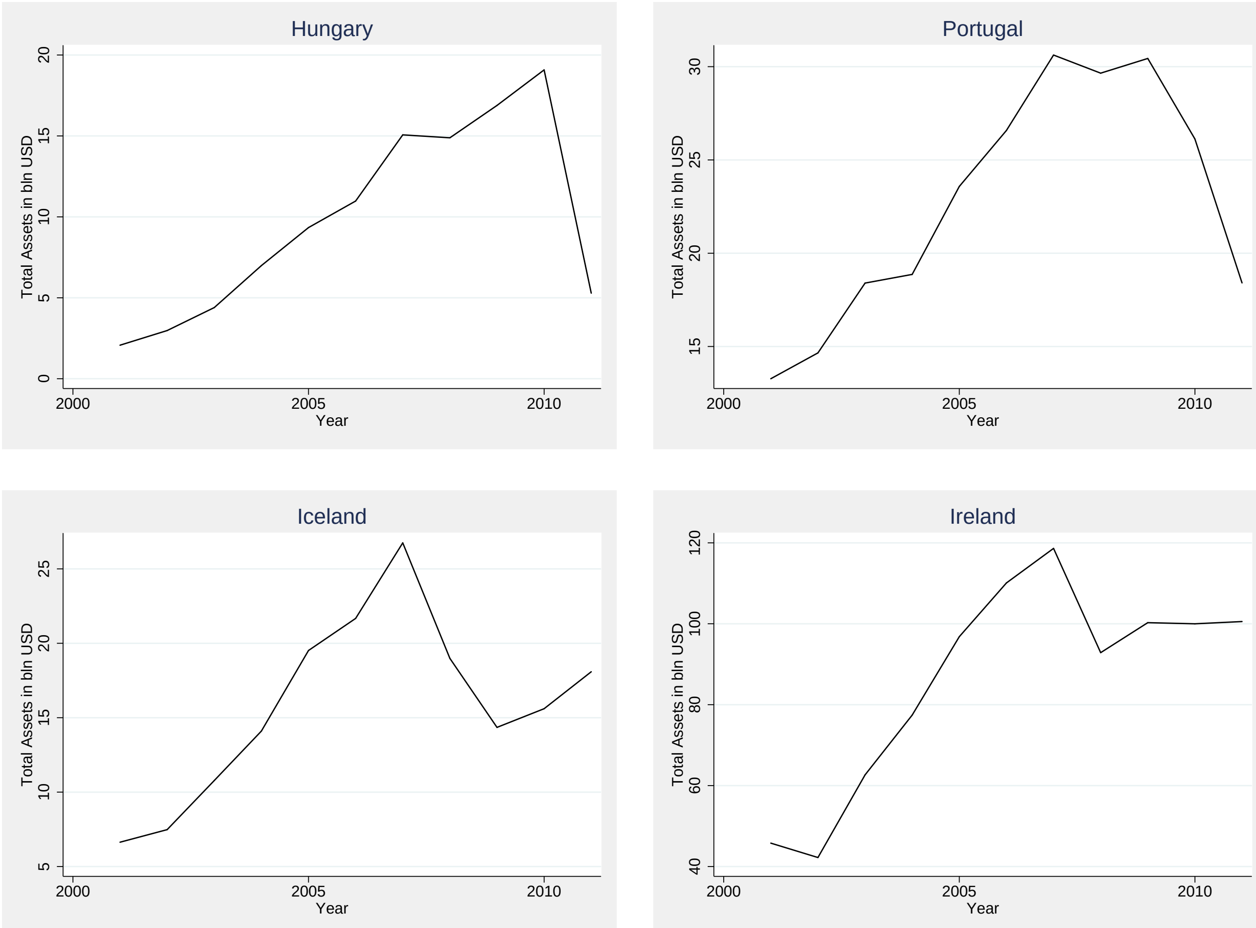

Figure 3: Autonomous pension funds' assets in selected OECD countries I. This figure represents total assets held in autonomous pension funds in selected OECD countries in 2001-2011. From left to right, top to bottom: Hungary, Portugal, Iceland and Ireland. Assets are expressed in billions of U.S. dollars. Data is obtained from OECD.

legislation obliged Hungarians to transfer a large portion of their pension assets back into the state state system in order to cut the budget deficit while avoiding austerity measures (Reuters, 2010). In Portugal situation was somehow similar. Even though the total assets decreased slightly in 2008, the largest drop was in 2011 when pension funds sponsored by banks were transferred to the public retirement system (Almeida, 2011). Speaking about autonomous pension funds' assets in Iceland and Ireland, movements in both of the countries in the last five years are quite similar and cannot be attributed to any pension reforms. The two bottom plots of Figure 3 show that the sharpest drop in assets was in 2008. Savings decreased by approximately 29% and 22% in Iceland and Ireland, respectively. Major explanation for this is the financial crisis. According to Allianz Global Investors (2009), in 2008 the crisis caused pension fund returns to fall by up to 35%, however losses differed greatly by country. Moreover, even though the 5-year CAG rates for the remaining countries in the sample are positive, looking at the changes in total pension funds' assets between the year 2007 and 2008, more than half of the countries experienced a negative growth. For more details refer to Table A1 in Appendix A.

Last, but not least we look at the growth in autonomous pension funds' assets between 2010 and 2011. The total pension funds' assets grew by around 5%, however if calculate an average of the growth among the countries it is more than 8%. Even though such a figure looks promising, we should take into account that the standard deviation of the growth is more than 21%, meaning that an average is not a very accurate statistic as the growth rates vary a lot depending on the country. The highest growth was in Greece (44.98%), New Zealand (26.37%), France (26.01%) and Australia (25.68%).

Speaking about the situation in Greece, we have several doubts about data accuracy. The country's pension system is very poorly organised (Hadjimatheou, 2012) and even the biggest pension funds operating in Greece have very high exposures to domestic assets (Sotiropoulos, 2013). Being aware of economic issues the country is facing and taking into account high rates of corruption, an almost 45% growth of autonomous pension funds' assets raise many concerns and looks very peculiar. An increase in total assets in other countries, on the other hand, seems plausible. For example, growth of autonomous pension funds' assets in Australia was very steady in the last 10 years and except the year 2008 and 2009 exceeded 20%. Not without a reason the country's retirement system was ranked as one of the best (Mercer, 2012) and most sustainable (Jackson, 2012) system in the world.

The countries, which did the worst are Hungary (-72.29%), Turkey (-50.30%) and Portugal (-29.53%). As discussed in the previous section, the drop in autonomous pension funds' assets in Hungary and Portugal were due to several reforms obliging to transfer lump sums of money to the public retirement systems. Situation in Turkey may also not be very representative as data for the year 2011 covers only personal plans. If the latter three countries are excluded from the sample, then there are no countries, which experienced a decrease in autonomous pension funds' assets in nominal terms. The smallest growth was for the United States (0.09%), Ireland (0.56%), Austria (1.88%) and Finland (1.89%).

5.2 Total assets versus GDP

The main question this thesis is trying to answer is whether GDP movements and growth of GDP can be directly explained by the changes in autonomous pension funds' assets. Before testing this relationship using econometric techniques we first assess data graphically and calculate correlation coefficients. As it can be seen from Table A2 in Appendix A the correlation coefficients are very high and exceed 75% for 33[19] out of 34 countries in our sample. What is even more interesting, for 14 countries[20] correlation is extremely high and breaches 95% level, suggesting that the relationship between autonomous pension funds' assets and GDP in the same country is particularly strong.

Graphical analysis also confirms our results. Figure 4 shows the movements that are almost perfect. One may say that such an ideal relationship may be due to the fact that Australian, Dutch, Danish and Swedish economies are mature and their retirement systems are also not in the early stage of development, but have a long history of improvements. However, if we look at the data representing other countries, for example Czech Republic, Poland, Spain or Mexico, where pensioners are not that well taken care of and where the retirement systems are still far from being perfect, the relationship still holds. Total pension funds' assets are also moving in parallel with GDP in Canada, Chile, Germany, Iceland, Israel, Japan, Korea, New Zealand, Norway, Switzerland, the UK and the US. For a graphical representation please refer to Figures B3- B5 in Appendix B.

There are several reasons why autonomous pension funds' assets may be growing line in line with GDP. Firstly, growing funded pensions may lead to a higher aggregate saving rate, which will automatically increase GDP. Secondly, according to Zandberg and Spierdijk (2010) and Hu (2005a), increasing private pensions may reduce labor market distortions. Thirdly, more funding is expected to improve corporate governance as well as spur financial development. This means that a positive and indirect impact on the economy will be present, which is also expected to increase GDP. Even though we believe that economic growth and funding should be related, data on Belgium, Finland, France, Greece, Luxembourg and Slovenia do not exhibit a clear relationship. For a graphical representation please refer to

[19] Correlation coefficient for Greece is -0.5491, however this may be due to the lack of the data.

[20] Australia, Austria, Canada, Chile, Czech Republic, Germany, Iceland, Israel, Mexico, the Netherlands, Norway, Poland, Spain, Switzerland.

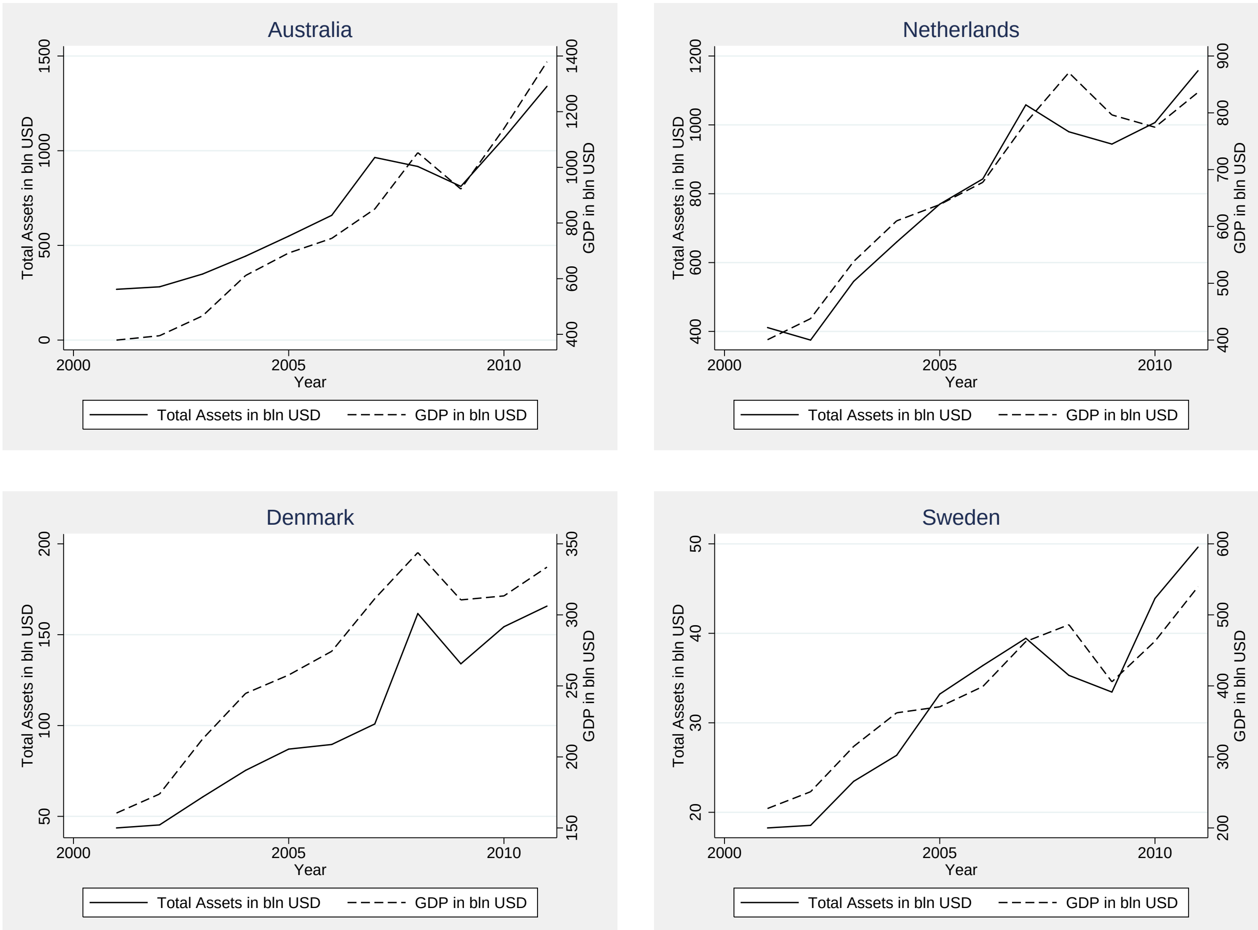

Figure 4: Autonomous pension funds' assets and GDP in selected OECD countries I. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Australia, the Netherlands, Denmark and Sweden. Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

Figure B6 in Appendix B. If we speak about the remainder countries (Austria, Estonia, Hungary, Italy, Ireland, Portugal, Slovak Republic and Turkey), movements are more or less going the same direction, but they are not too close nor too separate. Data is plotted in Figures B7- B8 in Appendix B.

5.3 Ratio of total assets to GDP

So far we have seen that the behaviour of pension funds' assets compared to the changes in GDP over time are different for OECD members. In some countries assets grow line in line with GDP, whereas the movements in these variables are discrepant for the others. It is not surprising that a single relationship between output and total assets is absent and this is due to the pension systems in 34 OECD countries being very different.

What is also very interesting to look at is the evolution of the ratio of total pension funds' assets to GDP, thereafter assets-to-GDP, ratio. Firstly, this ratio gives an indication of the maturity of the system (OECD, 2012a). If a system is very old, it basically means that funded pensions were introduced many years ago and fund managers had a long time horizon to collect contributions and invest the money on behalf of future pensioners. If return on investment on average was positive and if pension payments did not exceed contributions, it is very likely that a mature system has accumulated more assets in its autonomous funds than a younger one. In contrast, countries where funded pensions were introduced only recently, funds are immature and total assets are much smaller leading to a lower assets-to-GDP ratio. However one has not to forget the cases when a fund is in a transition period, i.e. it is not very young any more, but also not mature enough to pay pensions. This indicates that money have been collected for a decade or so, but no outlays were made. In such a situation the assets-to-GDP ratio can also be very high. Another aspect of assets accumulated relative to the size of the economy is to show the importance of private pension systems. "The larger the value of their investments, the greater will be their ability to provide high benefits to individuals" (OECD, 2012b).

Assets-to-GDP ratio for 2001, 2007, 2010 and 2011 is listed in Table 3. One can clearly see that the ratio varies a lot from less than 1% to 138%. This confirms that the the maturity and importance of private pension systems in OECD countries are very different. For example assets-to-GDP ratio in Australia, Iceland, the Netherlands and Switzerland is close or exceeds 100%. This let us firmly state that these countries are the frontrunners in the field and it is actually what we expected, because pension systems in the latter OECD member states are well developed.

Even though dissimilarities are present, one can also discern one common trend: for almost all the countries assets-to-GDP ratio is increasing. This may happen if (1) autonomous pension funds' assets are growing at a faster phase than GDP or if (2) pension funds' assets are diminishing at a slower phase than GDP. We know that in the last decade except for 2009 nominal GDP yearly growth rates were positive for many countries in our sample. This

Table 3: Ratio of total assets to GDP. The table reports autonomous pension funds' assets as a share of GDP in OECD countries in the following years: 2001, 2007, 2010 and 2011. The ratio is expressed in percentages. Average ratios listed at the bottom of the table are calculated by taking a mean of the ratio in all OECD countries and not by dividing total assets by total GDP. Data is obtained from OECD and WDI, calculations are done by the authors.

		Total Assets/GDP (%)			
No.	Country	2001	2007	2010	2011
1	Australia	75.3	110.4	89.0	92.8
2	Austria	2.9	4.8	5.4	4.9
3	Belgium	5.5	4.5	3.8	4.2
4	Canada	52.5	62.3	64.7	63.7
5	Chile	.	64.4	67.0	58.5
6	Czech Republic	2.3	4.7	6.3	6.5
7	Denmark	27.2	32.4	49.7	49.7
8	Estonia	0.0	4.6	7.4	5.3
9	Finland	49.5	71.0	82.1	75.0
10	France	.	0.1	0.2	0.2
11	Germany	3.4	4.7	5.4	5.5
12	Greece	.	0.0	0.0	0.0
13	Hungary	3.9	10.9	14.6	3.8
14	Iceland	84.0	134.0	123.9	128.7
15	Ireland	43.7	46.6	49.0	46.2
16	Israel	25.1	33.2	48.9	49.4
17	Italy	2.2	3.3	4.6	4.9
18	Japan	18.5	25.7	25.2	25.1
19	Korea	.	3.1	4.0	4.5
20	Luxembourg	.	1.0	1.9	1.9
21	Mexico	4.3	11.5	12.7	12.9
22	Netherlands	102.6	138.1	128.5	138.2
23	New Zealand	15.3	11.5	14.4	15.8
24	Norway	5.5	7.0	7.8	7.4
25	Poland	2.4	12.2	15.8	15.0
26	Portugal	11.5	13.7	11.4	7.7
27	Slovak Republic	0.0	3.7	7.4	8.4
28	Slovenia	.	1.8	2.5	2.9
29	Spain	5.8	8.2	7.9	7.8
30	Sweden	8.1	8.7	9.6	9.2
31	Switzerland	102.5	119.2	113.7	110.8
32	Turkey	.	1.2	2.3	1.1
33	United Kingdom	72.0	78.9	88.7	88.2
34	United States	71.5	79.4	72.6	70.6
	Average:	**29.5**	**32.8**	**33.8**	**33.1**

suggests that an increasing assets-to-GDP ratio is due to the assets increasing at a faster phase than GDP.

5.4 Summary

By examining autonomous pension funds' assets and by comparing their movements with changes in GDP we can draw several conclusions. Firstly, three largest pension markets are the US, the UK and Japan with 52.54%, 10.56% and 7.29% of total pension assets in the study, respectively. Secondly, there is a clear tendency for pension funds' assets to grow over time. If we look at the pooled data, the 10-year CAGR is 6.51%. This figure however does not tell all the story since the growth rates vary quite a lot among the countries and in many cases breaches 10%. Thirdly, we find that assets tend to move line in line with GDP for many OECD countries: Australia, Canada, Chile, Czech Republic, Denmark, Germany, Iceland, Israel, Japan, Korea, Mexico, the Netherlands, Norway Poland, Sweden, Switzerland, the UK and the US. This is something we expect as it is believed that increasing pension funds' assets should have a direct or/and indirect positive effect on output. In contrast, data on Belgium, Finland, France, Greece, Luxembourg and Slovenia do not exhibit a clear relationship. Finally, we look at the assets-to-GDP ratio. Inspection of the data confirms that this ratio is a good indicator of the maturity of a pension system.

6 Econometric analysis

This chapter stands for the analysis of the impact of funding on GDP. Methods discussed in Chapter 4 are applied in this part of the thesis and results are reported. At the beginning of the chapter we test stationarity of the variables. Later on, parameters of fixed and random effects models are estimated. Since the latter models are not able to capture dynamics, we report the results of a dynamic panel data model and compare them to the ones obtained by Davis and Hu (2004). We also update the model suggested by the authors by incorporating several dummies, however we understand that such an inclusion is relevant to our dataset only as we examine the time period of the crisis.

6.1 Stationarity testing

As already discussed in Chapter 4 in order to obtain meaningful estimates it is important to work with stationary data. There are several ways to examine whether a particular time-series is stationary or not. In this sub-chapter we analyse our data graphically, conduct several unit-root tests and run regressions for 34 countries so as to confirm that including a time trend as specified in the theoretical model described by equation (3.6) makes sense.

6.1.1 Graphical analysis

The most popular way of determining whether a series is stationary or non-stationary is to conduct a unit-root test, however before proceeding to statistical testing we firstly examine data graphically. From the four graphs plotted in Figure 5 it can be clearly seen that the existence of unit-roots is really unlikely. LnQ and LnK have an upward sloping trend and fluctuate minimally, suggesting that the data is probably trend stationary. Speaking about the movements in the remaining 30 OECD countries, they are very similar to the ones observed in Czech Republic, Switzerland, Norway and the United States. Figures B9 and B10 in Appendix B show that, except for Israel, logarithmised values of capital stock per capita exhibit a deterministic trend, whereas logarithmised GDP per capita fluctuates a bit more. The time-series of LnP, plotted in Figure B11 in Appendix B are quite volatile for some countries and stable for the others, however a slightly increasing trend can be noticed in almost all the panels.

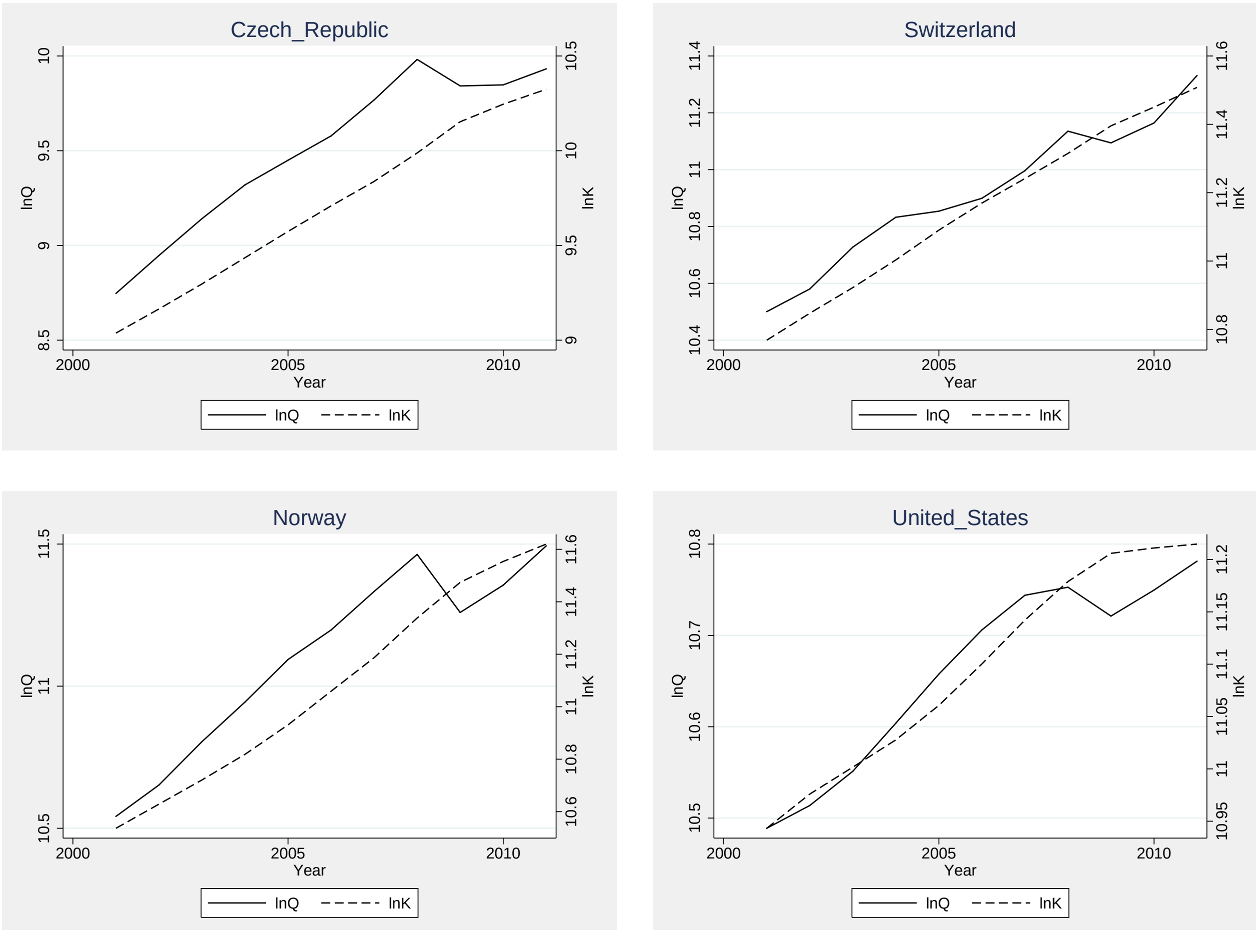

Figure 5: Inspection of a deterministic trend in selected OECD countries I. This figure represents logarithmised GDP per capita (lnQ - continuous line and left axis) and logarithmised capital stock per capita (lnK - dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Czech Republic, Switzerland, Norway and the United States. Data is obtained from WDI, calculations are done by the authors.

6.1.2 Regressions

Running a regression with a constant and a time trend on the right hand side of the equation only is also something that may help to see whether a trend should be included in a testing procedure. Therefore for each country and for each variable (LnQ, LnK and LnP) we run a simple regression to examine whether a trend is statistically significant (i.e. we estimate the following relationship using OLS: $y_t = \alpha + \beta t + \epsilon_t$). Situation with variables LnQ and LnK is already clear from the graphical analysis and we expect the trend to be statistically significant for all the countries. The time series of LnP fluctuate more, however we still believe that a slightly upward trend may be present. Table 4 summarises the results of 102 regressions (3 variables × 34 countries), listing in how many cases the trend was found to be statistically significant. The most interesting part of the table is the last row, from which we can see that 26 (21+3+2) panels out of 34 are trending. Additionally, even though it is not reported in 92 out of 93 cases where the trend is statistically significant it loads positively[21].

Table 4: Trend significance. The table reports the number of the cases when after estimating 102 simple regressions: $y_t = \alpha + \beta t + \epsilon_t$ using OLS we find the trend to be statistically insignificant or significant at 1%, 5% and 10% levels.

	Significance Level			Not
	1%	5%	10%	Significant
LnQ	31	2	0	1
LnK	33	1	0	0
LnP	21	3	2	8

6.1.3 Unit-root tests

So far both graphical analysis and simple regressions suggest that our data is definitely trending. Even though after de-trending[22] for most of the countries we are not able to see the issue of the data being non-stationary, we should understand that the first impression may be misleading and therefore it is advisable to check stationarity of the data statistically. The theoretical background of the testing procedure is described in Chapter 4 and Appendix C.4.

The results of unit-root tests can be seen in Table 5. In all three cases we include a trend component. Not surprisingly the outcomes differ. For example, the LLC test states that all panels of LnK are stationary, however the IPS test concludes that this is not the case. Luckily, according to the IPS and the Fisher-type tests, LnK can be stationarised by subtracting cross-sectional means and including one lag (p-values of these additional modified tests are not listed in the table, but they are 0.0005 and 0.0000 for the IPS and the Fisher-type tests, respectively). The same can be done with LnP. Even though the results of the

[21] In the equation for Belgium the trend is statistically significant at 10% level and loads negatively.
[22] The series of de-trended logarithmised GDP per capita and capital stock per capita are plotted in Appendix B, Figure B12.

Table 5: Results of unit-root tests. The table reports p-values of three different unit-root tests. The Levin-Li-Chu test can be applied for a balanced panel only and therefore it is not applicable for the ratio of total assets to GDP as this set of panels is unbalanced.

	Levin-Li-Chu	Im-Pesaran-Shin	Fisher-type
LnQ	0.0000	0.7946	1.0000
LnK	0.0000	1.0000	1.0000
LnP	N/A	1.0000	0.0000

conducted tests are different, we believe the latter inconsistencies are due to the lack of the power of the tests. Such an issue arises because neither the number of the panels (N) nor the length of the observations (T) available for each panel are very large.

To sum up, we examined data graphically, conducted unit-root tests and ran simple regression to see, whether LnQ, LnP and LnK are trend-stationary processes. Since the number of observations in each panel is very limited, we mainly rely on the graphical analysis and feel confident to state that the existence of unit-roots in our data is unlikely, however a slightly upward sloping trend can be observed in almost all the panels. This means that including a trend component to our final model as described by equation (3.6) makes sense.

6.2 Estimation of the parameters

This sub-chapter stands for the description and the estimation of regression coefficients using different methods described in Chapter 4. Our expectations about parameter signs are very simple and consistent with the theory. Growing ratio of pension funds' assets to GDP should mean that a country is probably doing better and this should be reflected in a growing GDP per capita. Increasing capital stock per capita also indicates an improving economic situation as it is very likely that higher investments will be made and therefore we believe that this variable should also load positively. Lastly, we have observed an upward sloping trend in almost all the panels and therefore a statistically significant and higher than zero parameter is something we expect. Next two sections summarize and compare the results of static and dynamic panel data models.

Table 6: Expectations of parameter estimates. The table lists what signs we expect next to each variable. A plus sign indicates that, according to the theory, a particular factor should load positively.

Variable	Sign	Explanation
trend	+	Due to positively trending panels
LnP	+	Indication of an improving economic situation
LnK	+	Indication of an improving economic situation

6.2.1 Fixed effects models

In this section we estimate model parameters using fixed effects with robust errors. It can be seen from Table 7 that our results are consistent with the theory. As expected, all variables load with a correct sign and are statistically significant. Interpretation of a log-linear model is straightforward. Regression output tells us that if total pension funds' assets relative to GDP grow by 1% GDP level per capita is expected to grow by 0.0288%. Parameter estimate for LnK has the same interpretation. GDP per capita should approximately increase by 0.4897% if capital stock per capita grows by 1%.

Table 7: Parameter estimates using a FE model. This table reports the outcome of the FE model. The dependent variable is GDP per capita (Q). The independent variables are trend, ratio of total assets to GDP (P) and capital stock per capita (K). Q, K and P are transformed to logarithms. Data is obtained from OECD and WDI, calculations are done by the authors.

	coef	robust s.e.	t-stat	P > |t|
trend	.0222	.0098	2.27	0.03
LnP	.0288	.0074	3.88	0.00
LnK	.4897	.0976	5.02	0.00
cons	4.8895	.9482	5.16	0.00

Speaking about the goodness-of-fit, the R^2-between is directly relevant and is equal to 0.9125. If, however, we use these estimates to predict the within model, we have an R^2 of 0.7923. And if the latter estimates are used to fit the overall data, our R^2 is 0.8467. For the differences between different definitions of R^2 please refer to Appendix C.6. It might also be interesting to look at the RMSE[23] to assess how well the model fits our data. Particularly for this estimation the RMSE is equal to 0.12086026. Having in mind that LnQ ranges in an interval of [8.018536, 11.6484] with an interval width of more than 3.6, the RMSE which is approximately 30 times smaller than the width of the interval suggests that the fitted values do not extremely deviate from the actual data.

Even though the parameter estimates are significant, signs are correct and the model fits the data quite well, we would like to stress that the current model, which was proposed by the theory, does not include any dynamics and therefore may not be the most representative one. However before moving to dynamic models, let us firstly see if there is any way to improve the static model.

Since the world has experienced the financial crisis very recently, it should make sense to include a dummy to account for the crisis year(s). Initially, we wanted to propose a dummy for a year 2007 and/or 2008, however before including one of these dummies we conducted a basic data analysis and noticed something very interesting. Even though LnQ is positively trending, if we take the observations of the last 5 years (from 2007 until 2011) and try to find in which year GDP per capita was at its lowest level, surprisingly it is not the year 2007 nor the year 2008. In 26 out of 34 countries the lowest GDP per capita level was reached either in 2009 or 2010. This suggests that having a dummy for one or both of these years makes much more sense than including a dummy for 2007 and/or 2008. Out of curiosity, of course, we tried to estimate parameters by including dummies for 2007 and 2008 into our regression, however the signs of the coefficients were positive, meaning that the financial crisis had a positive impact on GDP per capita which is unrealistic.

If we estimate the model with dummies for the year 2009 and/or 2010, the goodness-of-fit of the model improves slightly and parameter estimates do not change drastically. Moreover both dummies load negatively as expected. One explanation why 2009 and/or 2010 dummies improve the results may be that not the financial, but the sovereign-debt crisis, which widely spread in Europe in 2009 should be accounted for in our model. The comparison of different models and their goodness-of-fit measures are summarized in Tables 8 and 9 and it can be

[23]RMSE stands for the root mean squared error and is calculated using the following formula RMSE= $\sqrt{\frac{\sum \hat{\epsilon}_{i,t}^2}{M-b}}$, where M is the number of observations and b is the number of parameters to be estimated.

noticed that the model which includes a dummy for both years 2009 and 2010 does the best job having, even slightly, but still the highest R^2 and the lowest RMSE.

Table 8: Comparison: Parameter estimates using FE models with dummies. This table reports the outcome of three different FE models. The dependent variable is GDP per capita (Q). The independent variables are trend, ratio of total pension assets to GDP (P), capital stock per capita (K), dummy for 2009 and dummy for 2010. Q, K and P are transformed to logarithms. Data is obtained from OECD and WDI, calculations are done by the authors.

	I		II		III	
	coef	P > |t|	coef	P > |t|	coef	P > |t|
trend	.0218	0.05	.0274	0.01	.0285	0.01
LnP	.0279	0.00	.0287	0.00	.0274	0.00
LnK	.5268	0.00	.4866	0.00	.5366	0.00
dummy2009	-.1111	0.00			-.1528	0.00
dummy2010			-.1285	0.00	-.1688	0.00
cons	4.5208	0.00	4.9023	0.00	4.3994	0.00

Table 9: Comparison: Goodness-of-fit using FE models with dummies. This table reports the characteristics of three models summarised in Table 8. When comparing two or more models, a model with a higher R^2 and a lower root mean squared error fits the actual data better.

	I	II	III
RMSE	.11691028	.11585839	.10827462
R^2 within	0.8062	0.8097	0.8343
R^2 between	0.9145	0.9131	0.9160
R^2 overall	0.8617	0.8476	0.8685

6.2.2 Random effects model and the Hausman test

An alternative and a well known approach for estimating static panel data models is called random effects. The theory of this estimator is discussed in Chapter 4, whereas this section stands for the actual results. Parameter estimates using RE are listed in Table 10, however there are some concerns about their accuracy. First of all, the time trend is found to be statistically insignificant. Since we have seen that almost all the panels are trending, such a regression outcome seems to be very questionable. Moreover, we also have reasons to believe that country specific characteristics may influence predictor variables and therefore an assumption induced by RE that the variation across the countries is random may not hold. In order to check the validity of this assumption we use the Hausman test. After conducting the test we get a p-value of 0.00 and therefore the null hypothesis is strongly rejected meaning that the parameter estimates provided by the RE model are not accurate. Due to such the results we are in favour of the FE estimates.

Table 10: Parameter estimates using a RE model. This table reports the outcome of the RE model. The dependent variable is GDP per capita (Q). The independent variables are trend, ratio of total assets to GDP (P) and capital stock per capita (K). Q, K and P are transformed to logarithms. Data is obtained from OECD and WDI, calculations are done by the authors.

	coef	robust s.e.	z-stat	P > |t|
trend	-.0031	.0083	-.37	0.71
LnP	.0165	.0067	2.45	0.01
LnK	.7649	.0721	10.60	0.00
cons	2.2296	.6841	3.26	0.00

6.2.3 Dynamic panel data models

This section stands for the estimation of parameters of dynamic panel data models. Davis and Hu (2004) suggest using dynamic heterogeneous models as well as dynamic panel data estimators. It is worth mentioning that once the specification of the model is augmented with a lagged endogenous variable, including a trend becomes irrelevant.

Davis and Hu (2004) estimate a very simple model with one lag of GDP per capita and no trend. We replicate their procedure and discuss the differences between the results. We also estimate parameters using dynamic heterogeneous models, however both the results and a short introduction to these estimators are discussed in Appendix C.7. We believe that particularly for our sample, which includes only 11 observations per panel, these kind of estimators are not of the highest relevance and the results are likely to be biased. Finally, we update the specification of the model suggested by Davis and Hu (2004) by including several dummies and discuss the outcome.

Comparison to Davis and Hu (2004)

The only dynamic panel data model, whose parameter estimates are reported by Davis and Hu (2004) is specified as follows:

$$lnQ^*_{i,t} = \alpha + \theta lnQ^*_{i,t-1} + \lambda lnP_{i,t} + \beta lnK^*_{i,t} + u_{i,t}. \tag{6.1}$$

In order not to loose observations by augmenting the model with a lagged GDP per capita we extend our sample (i.e. add $lnQ^*_{i,2000}$). Since the data on this variable is available for a very long time period, inclusion of an additional year is not an issue. Additionally, note that a time trend is now omitted from the model. This is done because the lag of the endogenous variable is included to the right hand side of the equation. Parameter estimates and comparison with the outcome reported by Davis and Hu (2004) are listed in Table 11.

Table 11: Comparison: Parameter estimates using a dynamic model. This table reports parameter estimates of a simple dynamic model. The dependent variable is GDP per capita (Q). The independent variables are lagged GDP per capita, ratio of total pension assets to GDP (P) and capital stock per capita (K). Q, K and P are transformed to logarithms. The left side of the table stands for the results produced by the authors, whereas on the right side the outcome of the model estimated by Davis and Hu (2004) is presented. Data is obtained from OECD and WDI, calculations are done by the authors.

	Our Results		Results by Davis and Hu	
	coef	P > |t|	coef	P > |t|
LnP	.017	0.06	-.065	0.00
LnK	.068	0.06	.492	0.00
lnQ_{t-1}	.757	0.00	.462	0.00
cons	1.772	0.00	not reported	not reported
RMSE	.14304321		not reported	

From Table 11 it can be clearly seen that all the parameters we have estimated have a correct sign, whereas Davis and Hu (2004) report a negative coefficient for pension funds' assets. The authors understand that these results contradict the theory and therefore consider them with caution. Speaking about the long run impact[24] of pension funds' assets and

[24]Long run coefficients $\tilde{\lambda}$ and $\tilde{\beta}$ are calculated using the following formulas $\tilde{\lambda} = \hat{\beta}/(1-\hat{\theta})$ and $\tilde{\beta} = \hat{\beta}/(1-\hat{\theta})$, where $\hat{\lambda}$ and $\hat{\beta}$ stand for the estimated coefficients for the explanatory variables and $\hat{\theta}$ is the estimated coefficient for the lagged endogenous variable.

capital stock, we get 0.069 and 0.282 for lnP and LnK, respectively, whereas Davis and Hu (2004) report -0.121 and 0.915. Moreover, according to RMSE[25], this particular dynamic specification fits the data worse than the same static model where instead of the lagged LnQ on the right hand side of the equation we have a time trend (see section 6.2.1). Finally, it should be clear that even though Davis and Hu (2004) do not report any goodness-of-fit measures of the model, parameter estimates produced by us are much more realistic.

Dynamic panel data models with dummies

In this section the results of three dynamic panel data models are presented. Compared to the model specified by equation (6.1), our models additionally include dummies for the years 2009 or/and 2010. In all three cases an extended dataset, which includes GDP per capita for the year 2000 is used. Parameter estimates are reported in Table 12.

Table 12: Comparison: Parameter estimates using dynamic models with dummies. This table reports the outcome of three different dynamic models. The dependent variable is GDP per capita (Q). The independent variables are lagged GDP per capita, ratio of total pension assets to GDP (P), capital stock per capita (K), dummy for 2009 and dummy for 2010. Q, K and P are transformed to logarithms. Data is obtained from OECD and WDI, calculations are done by the authors.

	I		II		III	
	coef	P > |t|	coef	P > |t|	coef	P > |t|
LnP	.0127	0.17	.0169	0.05	.0134	0.12
LnK	-.0285	0.49	.0942	0.03	.0445	0.29
$\ln Q_{t-1}$	.9590	0.00	.7337	0.00	.8960	0.00
dummy2009	-.1972	0.00			-.2052	0.00
dummy2010			-.0177	0.28	-.0530	0.00
cons	.7697	0.00	1.7454	0.00	.6540	0.00
RMSE	.08768018		.14355469		.08809008	

Several things can be seen from our results. Firstly, the short-run impact of the ratio of total pension funds' assets to GDP varies from 0.0127% to 0.0169%, whereas if we look at the long run-elasticities they range quite a lot in an interval of [0.0636%; 0.3083%]. Secondly, as expected the lagged output per capita loads with a large coefficient which is positive

[25] RMSE is an adequate goodness-of-fit measure allowing to choose between alternative estimators, whereas R-squared can only provide guidance when choosing between different specifications of the model (Verbeek, 2004).

and statistically significant. Even though the first specification of the model has the lowest RMSE, capital stock per capita in that model loads negatively and therefore we believe that this model should not be considered. Thirdly, we find that the parameters produced by dynamic models are lower than the ones we get after estimating the model using fixed effects with robust errors. It is also not surprising that including a lagged endogenous variable to the model improves the fit. Moreover, speaking about the goodness-of-fit, RMSEs are smaller for the dynamic models with the dummies compared to the static ones, however not drastically. This may be due to the fact that GDP per capita has been steadily trending over time and an inclusion of a time-trend to the static model did quite a good job. We believe that specification III describes our data best, however it is crucial to note that lnP and lnK loose their significance and no relationship between pension funds' assets and GDP can be proved statistically. Practically, one may suggest excluding the latter variables from the specification of the model, however we prefer no to do so and stick to the model, which is in line with the theory. Additionally, it can been seen from Figure B13 in Appendix B that the predictions produced by model III fit the actual data very well. On the other hand, we want to stress that such a simply specified model should never be used for forecasting GDP per capita.

6.3 Summary

To sum up, the main purpose of this chapter is to examine the relationship between autonomous pension funds' assets and GDP. At the beginning of the chapter we test the presence of unit-roots and after concluding that our data is trend stationary we proceed to modelling. Firstly, parameters are estimated using a well known and widely used fixed effects model. The latter model is relevant only if the relationship between the variables under consideration is static. Although FE cannot be used to capture dynamics, the results produced by static models are very reasonable. We estimate four specifications of the model and in all cases variables load with a correct sign. The most accurate specification is the one which includes dummies for two years: 2009 and 2010. RMSE of the latter model is quite low and the fitted values are relatively close to the actual data. What is more, the results let us conclude that if the ratio of autonomous pension funds' assets to GDP increase by 1%, GDP per capita is very likely to grow by around 0.028%.

In the second part of this chapter, consistently with Davis and Hu (2004) we employ dynamic panel data models and dynamic heterogeneous models (more about them in Appendix C.7). Surprisingly, a simple dynamic panel data model, which includes only LnP, LnK and the lagged LnQ on the right hand side of the equation does a worse job than a static model where instead of the lagged GDP trend is used. On the other hand, once the model is augmented with the dummies for the years 2009 and 2010, the goodness-of-fit improves. However then LnP and LnK become insignificant, suggesting that it cannot be statically proved that an increasing ratio of pension funds' assets to GDP or an increasing capital stock per capita affect GDP per capita positively. Even though these variables are insignificant we prefer to keep them in the model as suggested by the theory. The fitted values plotted in Appendix B also confirm that the model specified in such a way produces very accurate predictions.

7 Summary and conclusions

Pension funds' assets in OECD countries hit a record USD 20.1 trillion in 2011 and a constant increase in the assets held in autonomous pension funds across the countries is something that has been observed for many years. This trend may be explained by the fact that policy makers, politicians and economists are rethinking pension systems and switching from pay-as-you-go to (partly) funded pension schemes in order to be able to meet obligations to future retirees. Since many countries have been doing so, a question, whether such a shift makes any impact on the economy attracted attention among the researchers. Some economists believe that a shift to (partly) funded pensions may be very beneficial to the whole economy as such a change may lead to higher savings rates and therefore to an increased economic wealth (Börsch-Supan et al., 2004). It is also very likely that more funding improves corporate governance, spurs financial development (Zandberg and Spierdijk, 2010; Hu, 2005a) and improves fund allocation (Walker and Lefort, 2002). Some of these links can be interpreted as an indirect effect of pension funds' assets on GDP.

The main purpose of this master thesis was to answer the question whether a *direct* impact of funding on economic wealth can be observed. Our sample included 34 OECD countries and data was available from 2001 onwards. We revisited the study by Davis and Hu (2004) and updated their model by including two dummies for the years 2009 and 2010, which improved the fit substantially. According to a static model, if the ratio of autonomous pension funds' assets to GDP increased by 1%, GDP per capita would grow by approximately 0.028%. Since the latter model was not able to capture any dynamics, we decided to rely on a dynamic model specification. The explanatory power of the model improved minimally, however the results did not let us conclude that funding *directly* affects economic growth. We agree with Zandberg and Spierdijk (2010) that such an outcome may be caused by the fact that a significant amount of pension funds' assets are invested abroad. As suggested by Blanchard and Fischer (1989), another reason may be that if savings are already high, shifting to (partly) funded pension plans will only mean a redistribution between the assets.

We believe this research can be broadened in two ways. Firstly, distinguishing between the assets that are held at a home country and abroad may help in explaining the effect of funding on growth. Additionally, extending a time-series dimension may also be very beneficial as analysing 11 observations per panel gives us less than 400 observations (11×34 countries). Moreover, even though all the countries are OECD members, the development of pension systems in these countries are very different. Therefore, a longer time horizon would allow a researcher to group them into relevant sub-samples with a sufficient amount of observations required for the analysis.

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Appendix A

Table A1: Growth of autonomous pension funds' assets between 2007 and 2008. This table reports growth rates (expressed in percentage) of total assets in OECD countries. Data is obtained from OECD, calculations are done by the authors.

No.	Country	Growth Rate (%)
1	Australia	-4.93
2	Austria	1.82
3	Belgium	-17.70
4	Canada	-13.08
5	Chile	-15.26
6	Czech Republic	36.22
7	Denmark	60.26
8	Estonia	3.78
9	Finland	-5.26
10	France	41.52
11	Germany	11.58
12	Greece	46.80
13	Hungary	-1.21
14	Iceland	-29.02
15	Ireland	-21.72
16	Israel	57.00
17	Italy	14.29
18	Japan	.03
19	Korea	-6.70
20	Luxembourg	11.18
21	Mexico	6.97
22	Netherlands	-7.39
23	New Zealand	-6.42
24	Norway	-.73
25	Poland	13.33
26	Portugal	-3.17
27	Slovak Republic	48.16
28	Slovenia	21.09
29	Spain	-3.57
30	Sweden	-10.51
31	Switzerland	-1.51
32	Turkey	38.05
33	United Kingdom	-22.30
34	United States	-24.83

Table A2: Correlation coefficients. This table reports correlation coefficients between autonomous pension fund's assets and GDP in OECD countries. Data is obtained from OECD and WDI, calculations are done by the authors.

No.	Country	Correlation
1	Australia	.9791
2	Austria	.9767
3	Belgium	.8787
4	Canada	.9779
5	Chile	.9845
6	Czech Republic	.9721
7	Denmark	.9358
8	Estonia	.9002
9	Finland	.9442
10	France	.6982
11	Germany	.9654
12	Greece	-.5491
13	Hungary	.7523
14	Iceland	.9815
15	Ireland	.9148
16	Israel	.9904
17	Italy	.8875
18	Japan	.8105
19	Korea	.9029
20	Luxembourg	.7719
21	Mexico	.9563
22	Netherlands	.9648
23	New Zealand	.9080
24	Norway	.9738
25	Poland	.9663
26	Portugal	.8267
27	Slovak Republic	.8776
28	Slovenia	.8560
29	Spain	.9862
30	Sweden	.9487
31	Switzerland	.9779
32	Turkey	.7562
33	United Kingdom	.8904
34	United States	.8354
	Total:	**.933**

Appendix B

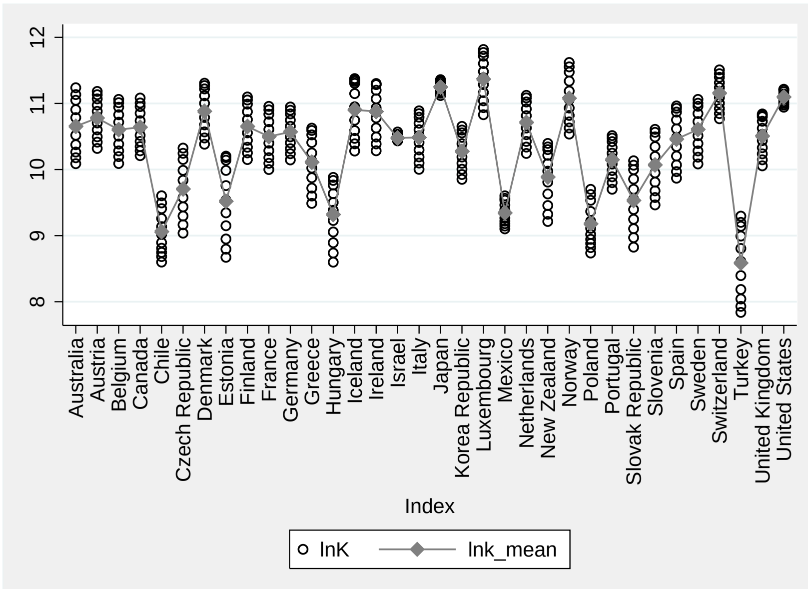

Figure B1: Heterogeneity of capital stock across the OECD countries. The empty dots represent logarithmised values of capital stock per capita. Mean of this variable is plotted with a connected grey line. Data is obtained from OECD, calculations are done by the authors.

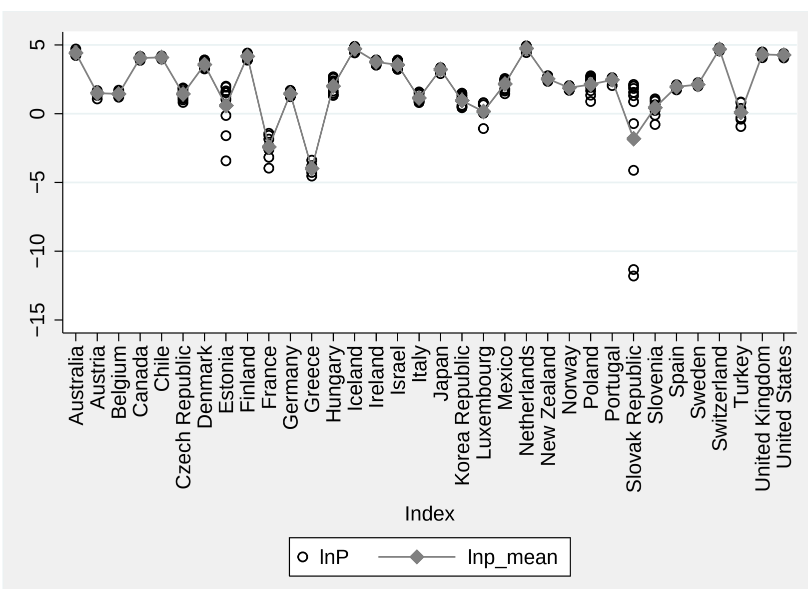

Figure B2: Heterogeneity of pension funds' assets across the OECD countries. The empty dots represent logarithmised values of the ratio of autonomous pension funds' assets to GDP. Mean of the logarithmised ratio is plotted with a connected grey line. Data is obtained from OECD, calculations are done by the authors.

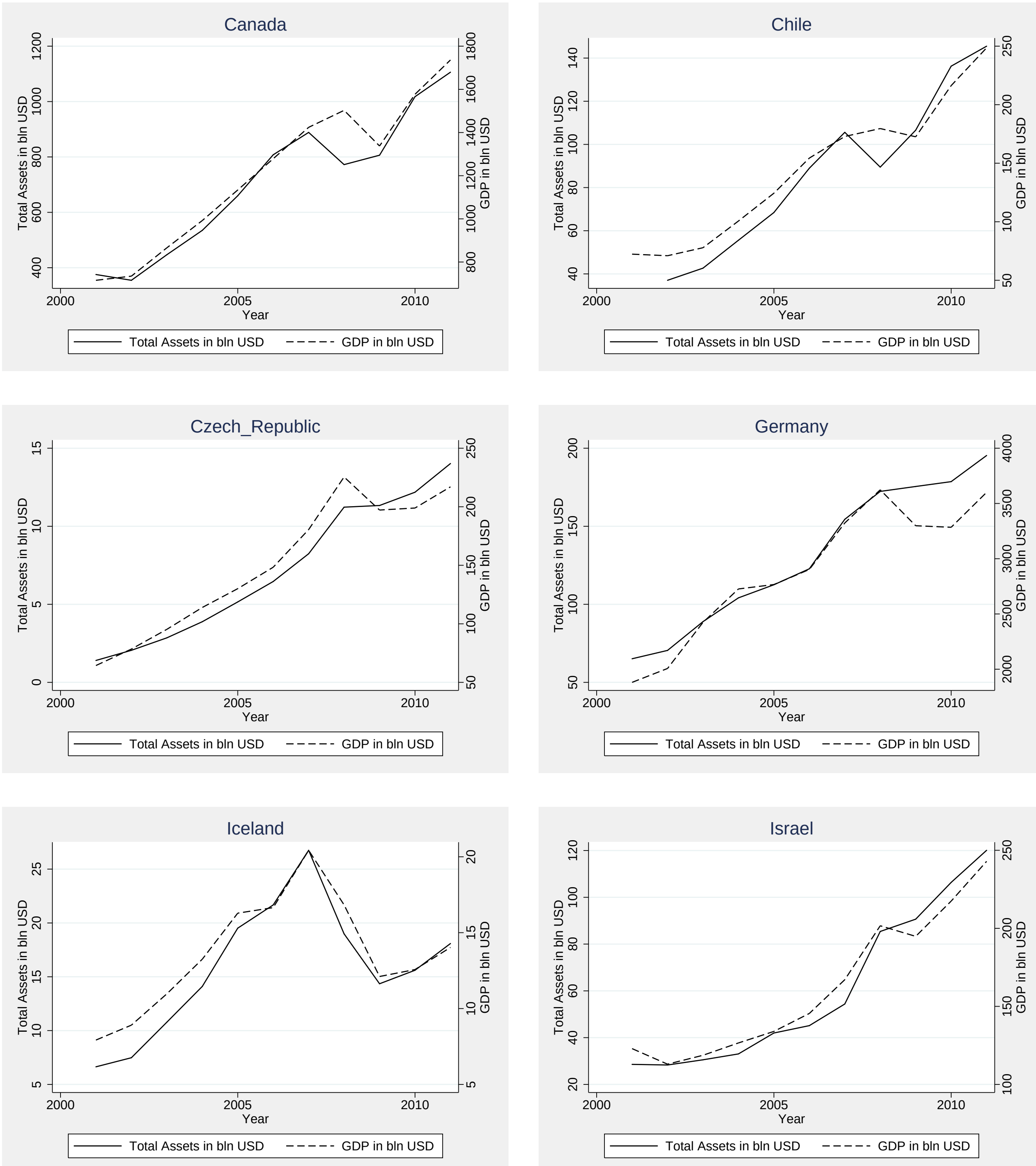

Figure B3: Autonomous pension funds' assets and GDP in selected OECD countries II. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Canada, Chile, Czech Republic, Germany, Iceland and Israel. Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

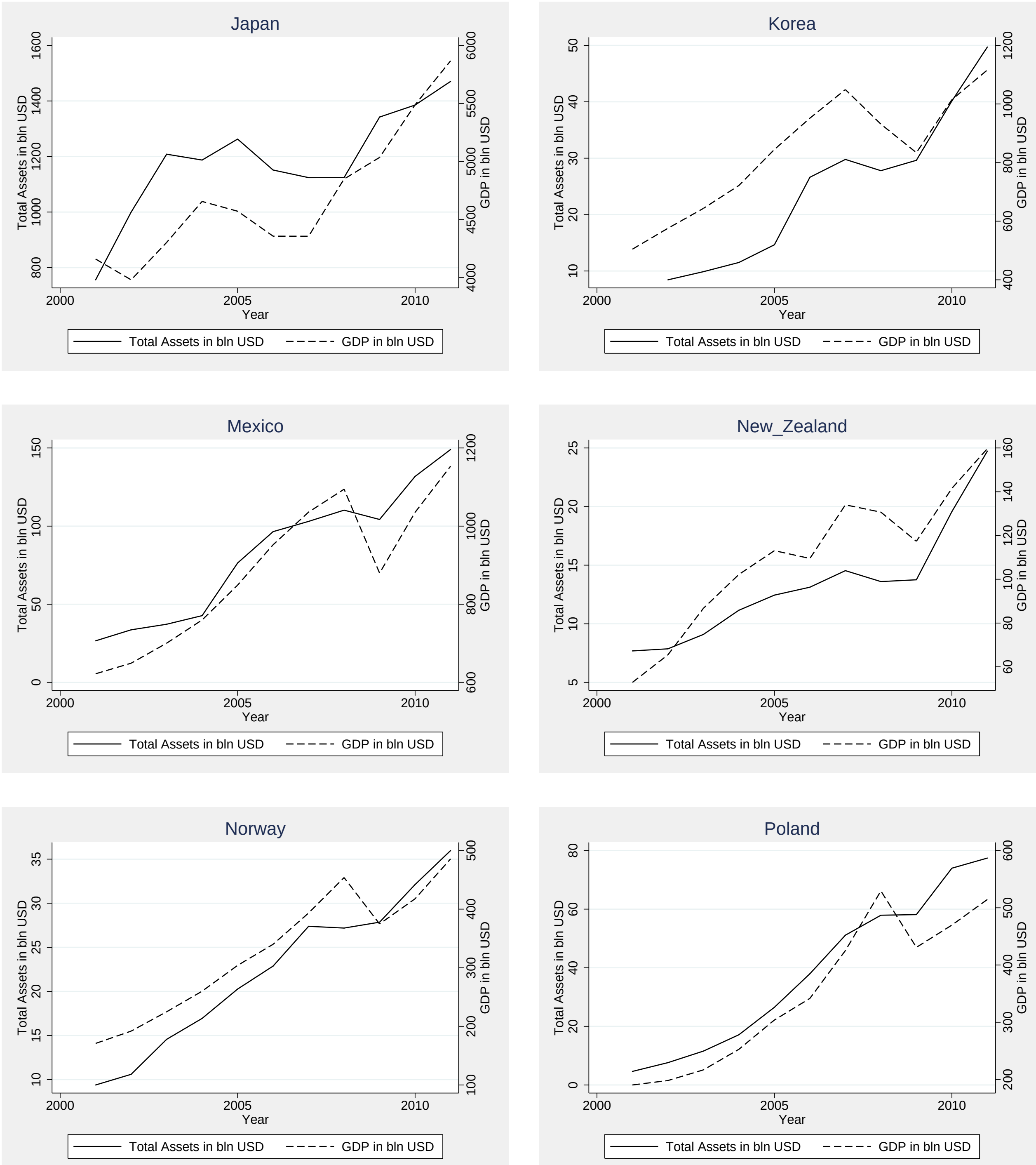

Figure B4: Autonomous pension funds' assets and GDP in selected OECD countries III. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Japan, South Korea, Mexico, New Zealand, Norway and Poland. Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

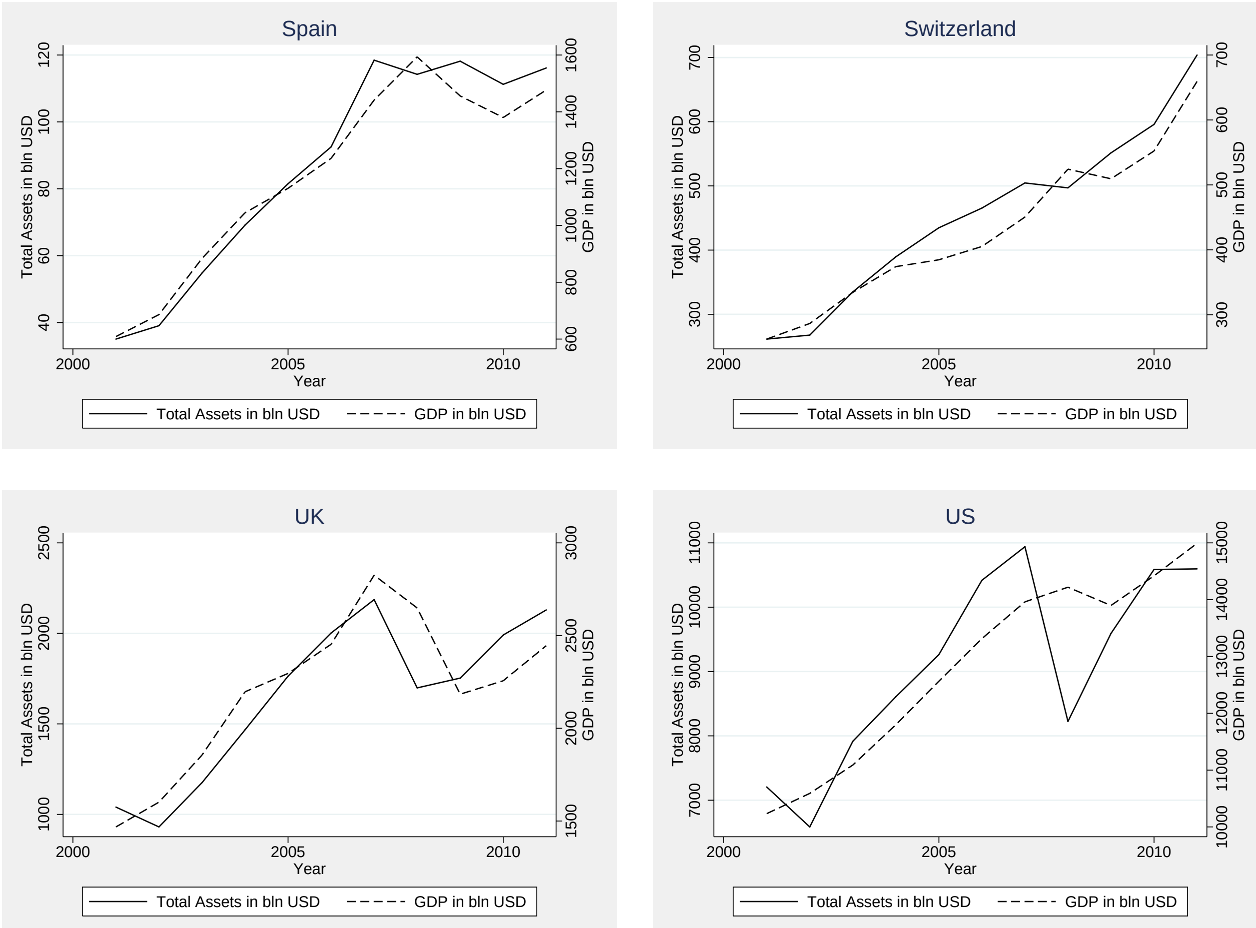

Figure B5: Autonomous pension funds' assets and GDP in selected OECD countries IV. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Spain, Switzerland, the United Kingdom, the United States. Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

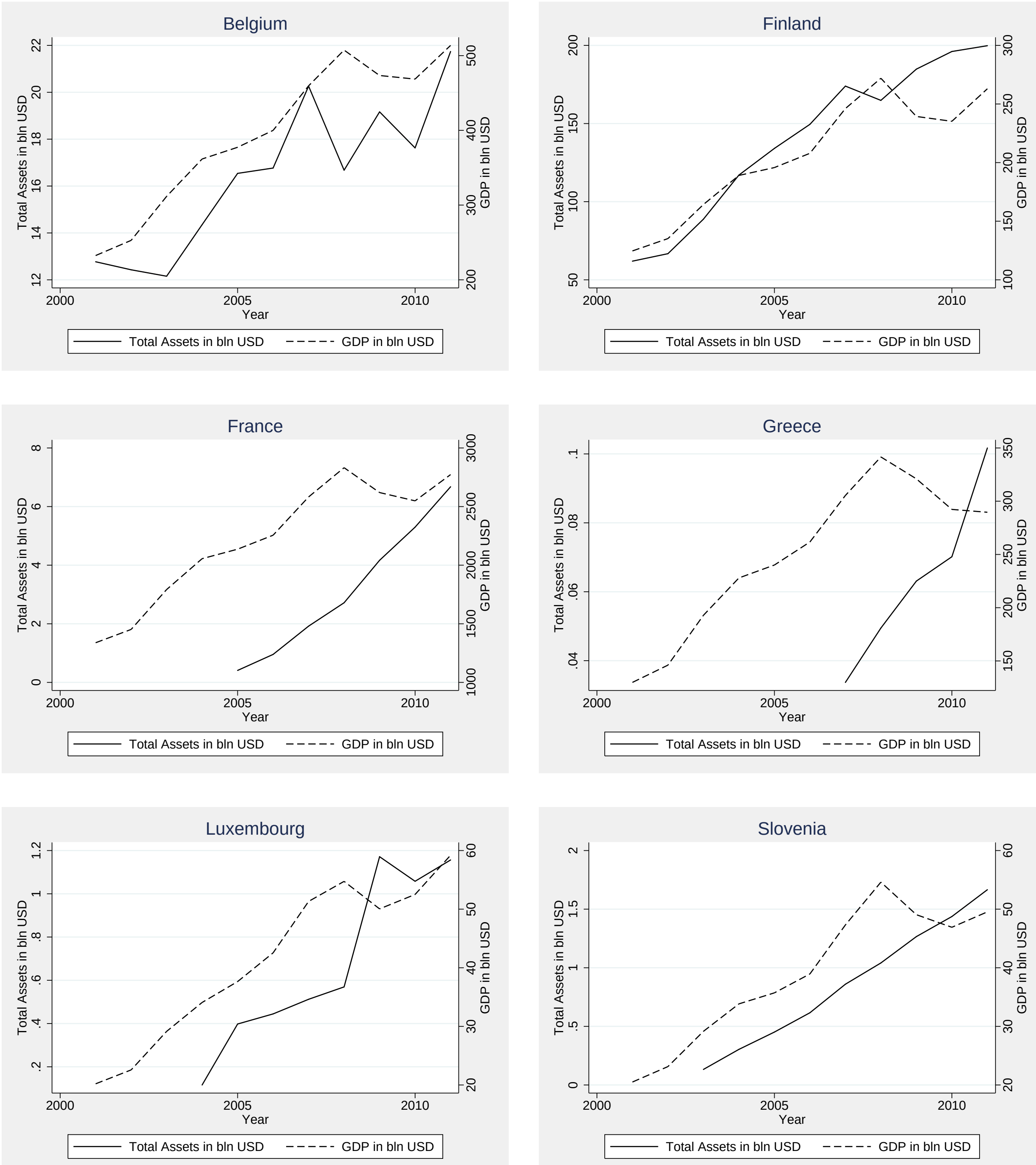

Figure B6: Autonomous pension funds' assets and GDP in selected OECD countries V. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Belgium, Finland, France, Greece, Luxembourg and Slovenia. Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

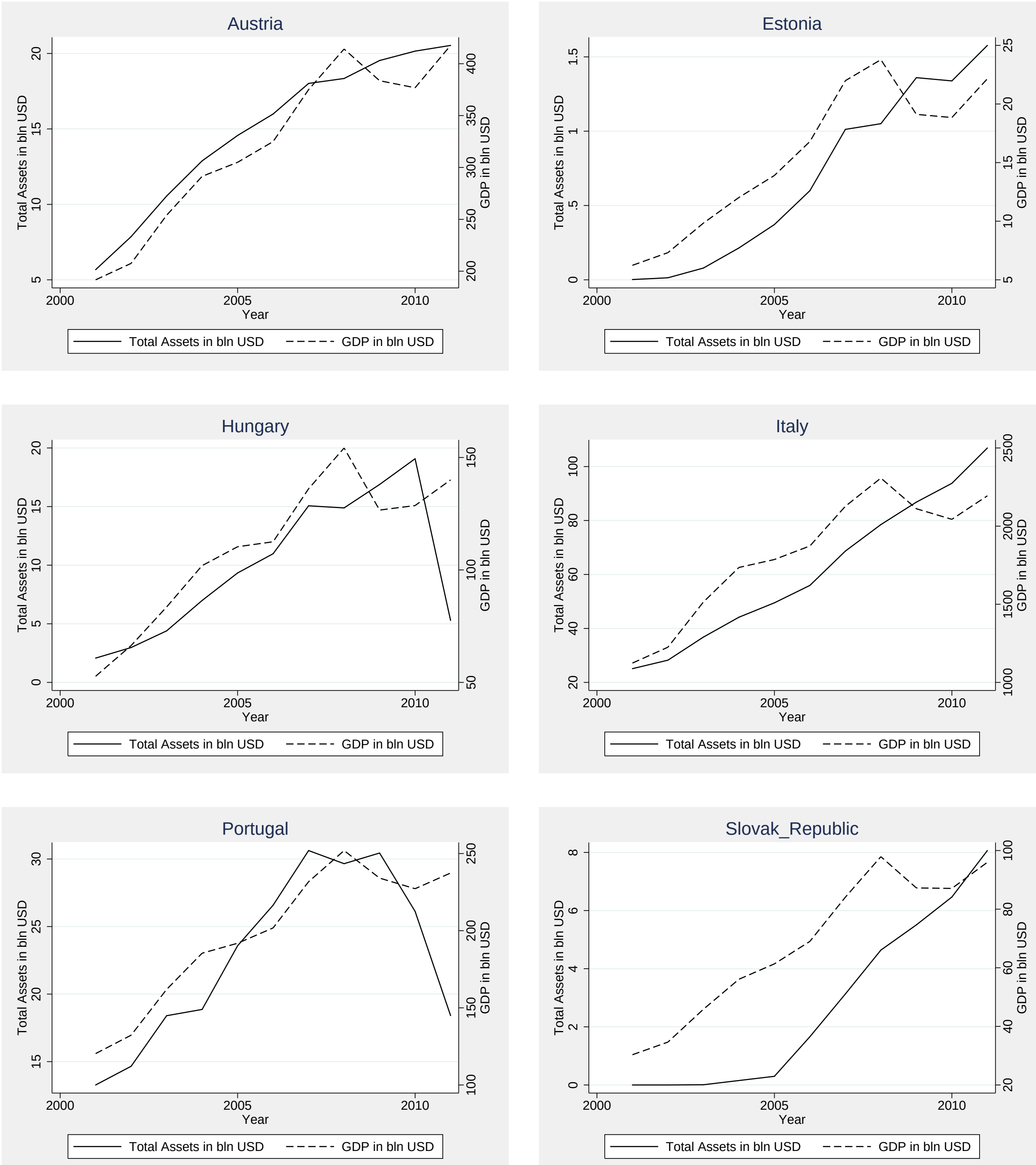

Figure B7: Autonomous pension funds' assets and GDP in selected OECD countries VI. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right, top to bottom: Austria, Estonia, Hungary, Italy, Portugal and Slovak Republic . Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

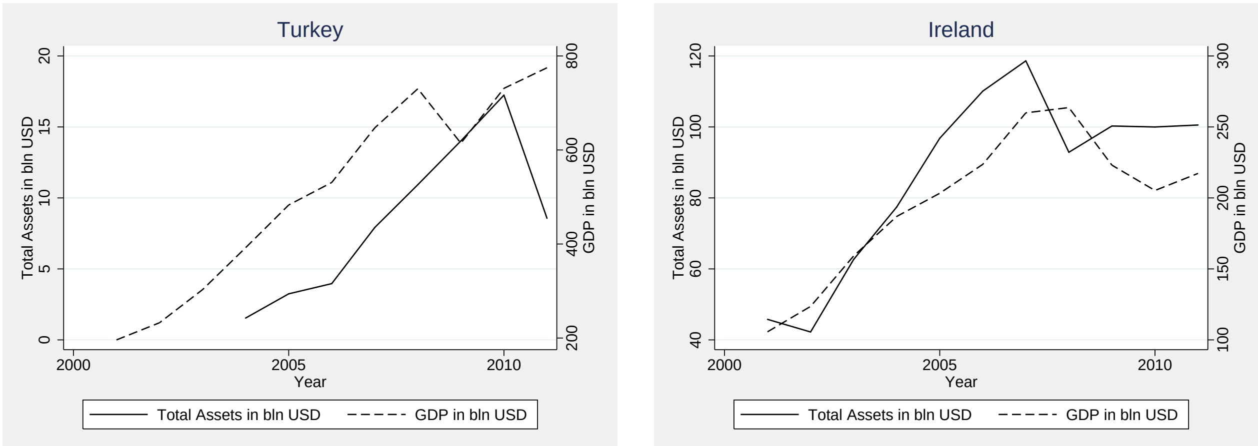

Figure B8: Autonomous pension funds' assets and GDP in selected OECD countries VII. This figure represents total assets (continuous line and left axis) held in autonomous pension funds and GDP (dashed line and right axis) in selected OECD countries in 2001-2011. From left to right: Turkey and Ireland. Both GDP and total autonomous pension funds' assets are expressed in billions of U.S. dollars. Data is obtained from OECD and WDI.

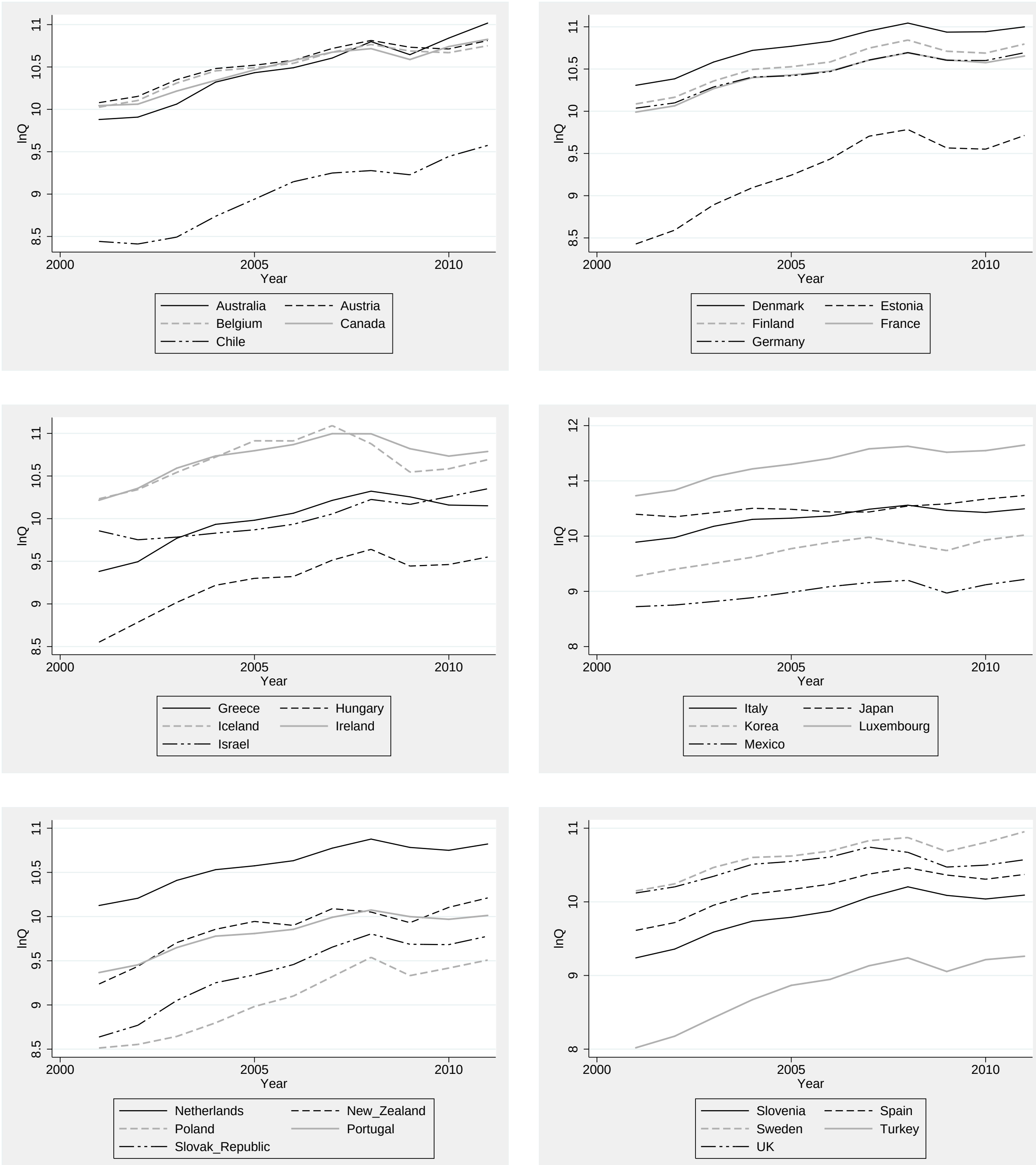

Figure B9: Inspection of a deterministic trend in selected OECD countries II. This figure represents logarithmised GDP per capita (lnQ) in selected OECD countries in 2001-2011. Data is obtained from WDI, calculations are done by the authors.

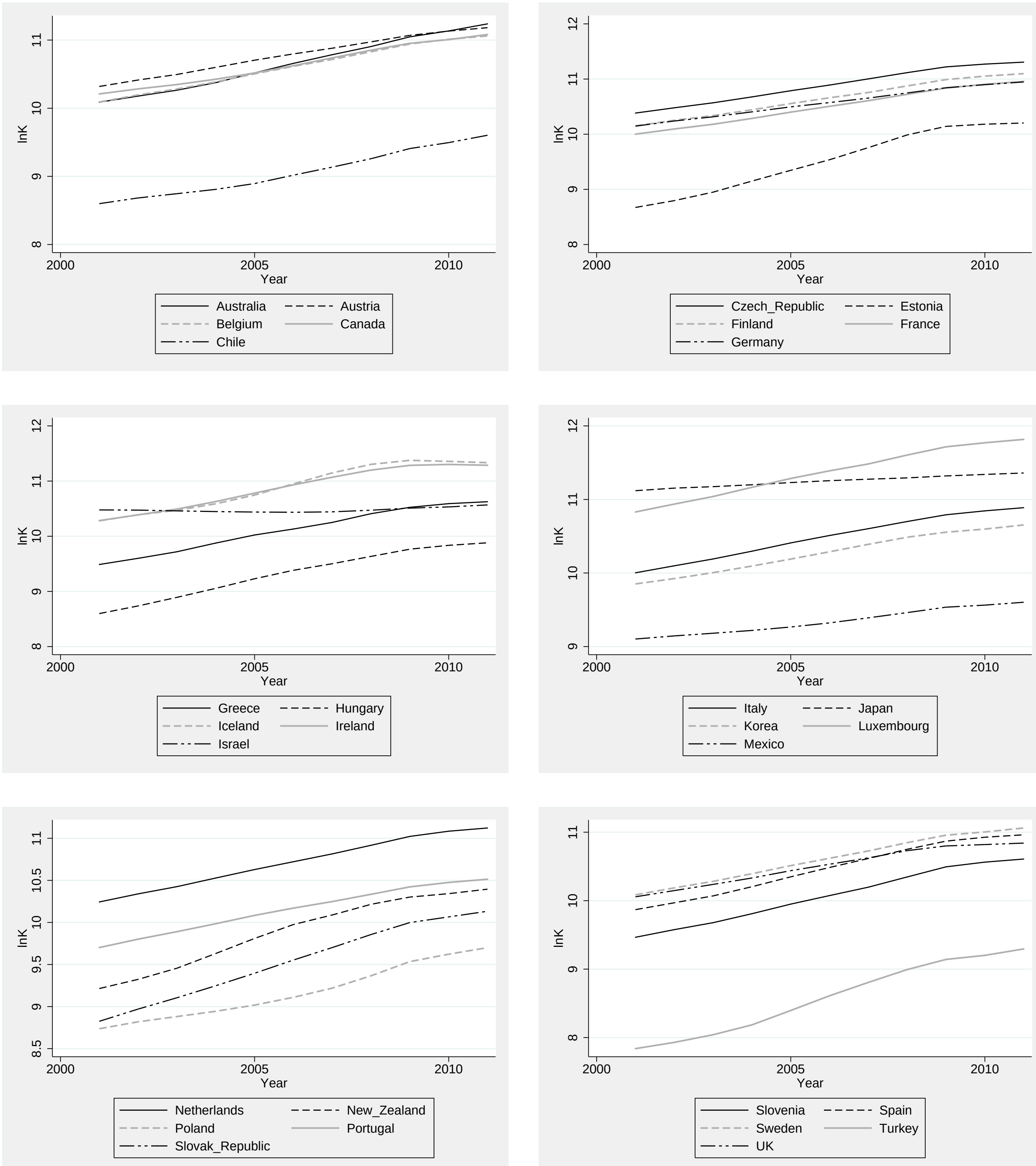

Figure B10: Inspection of a deterministic trend in selected OECD countries III. This figure represents logarithmised capital stock per capita (lnK) in selected OECD countries in 2001-2011. Data is obtained from WDI, calculations are done by the authors.

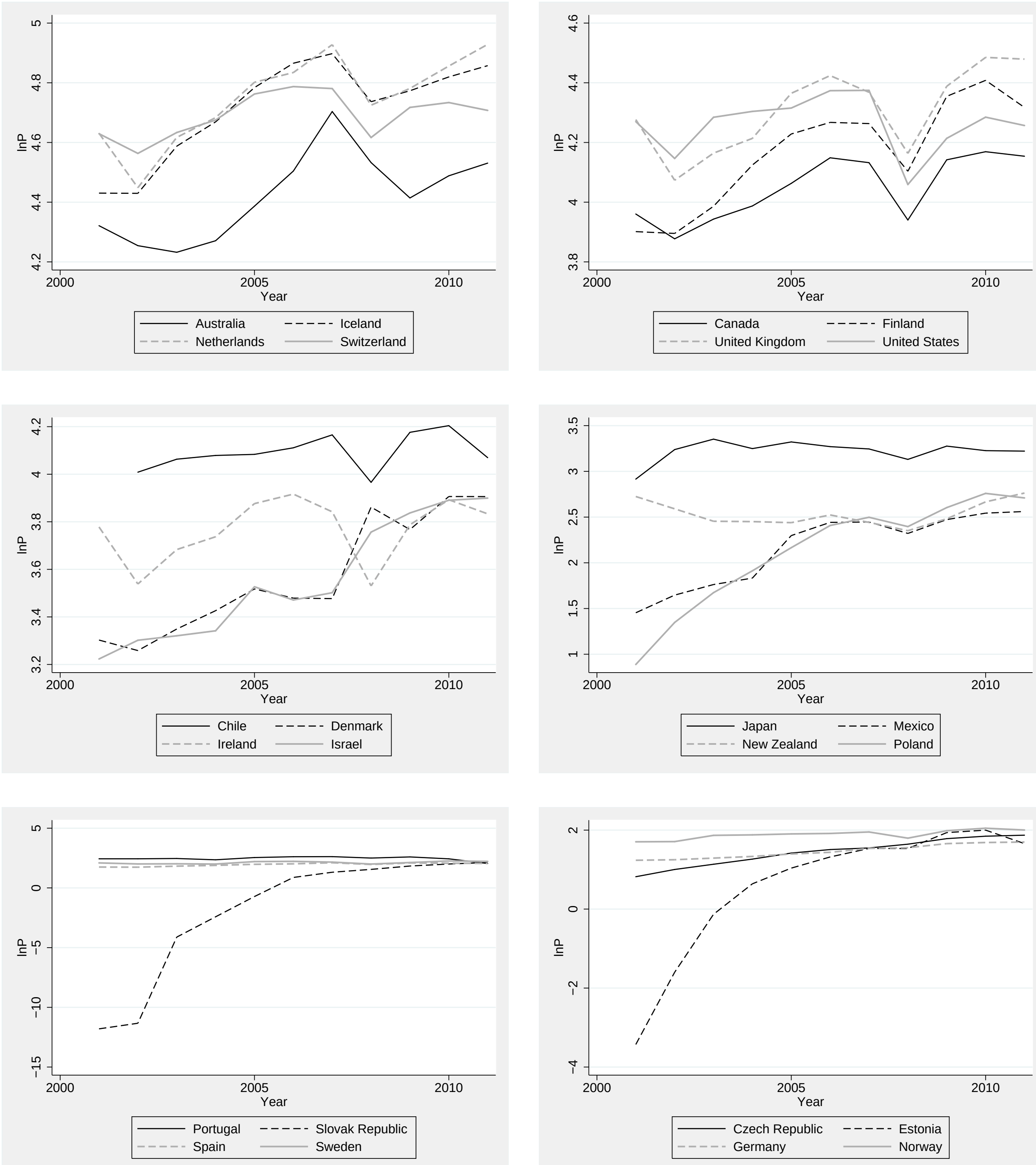

Figure B11: Inspection of a deterministic trend in selected OECD countries IV. This figure represents logarithmised ratio of autonomous pension funds' assets to GDP (lnP) in selected OECD countries in 2001-2011. Note, that instead of grouping the countries by the alphabet, we plot lnP depending on the size, so that the fluctuations can be better seen. Data is obtained from OECD and WDI, calculations are done by the authors.

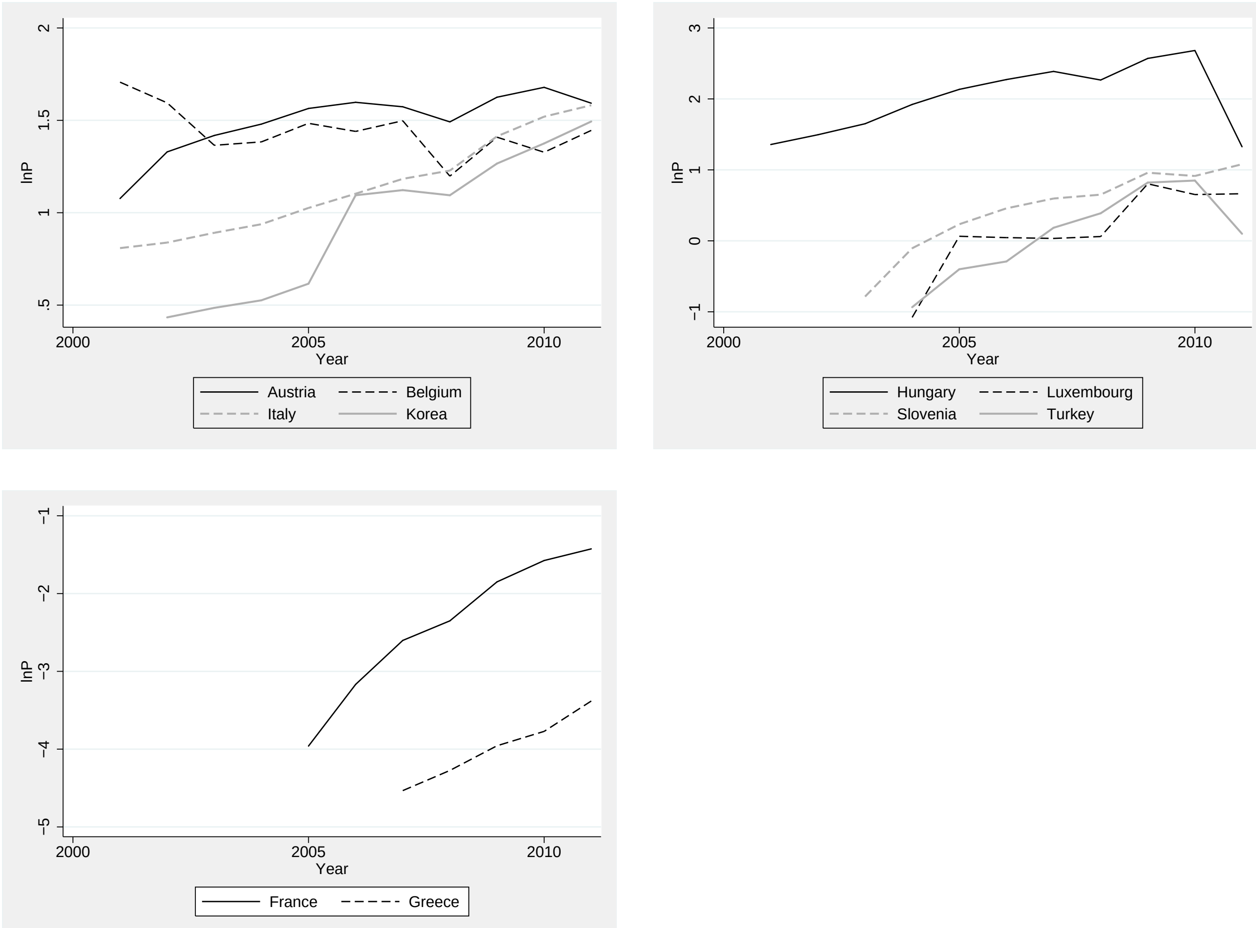

Figure B11: Inspection of a deterministic trend in selected OECD countries IV. (continued)

Figure B12: De-trended GDP and capital stock. This figure represents logarithmised output per capita (grey line) and logarithmised capital stock per capita (black line) in OECD countries in 2001-2011. The procedure applied is straightforward. Firstly, for each country and for each variable parameters are estimated using OLS: $y_t = \alpha + \beta t + \epsilon$. Secondly, the prediction is subtracted from the actual data: $z_t = y_t - \hat{\alpha} - \hat{\beta}t$. Data is obtained from WDI.

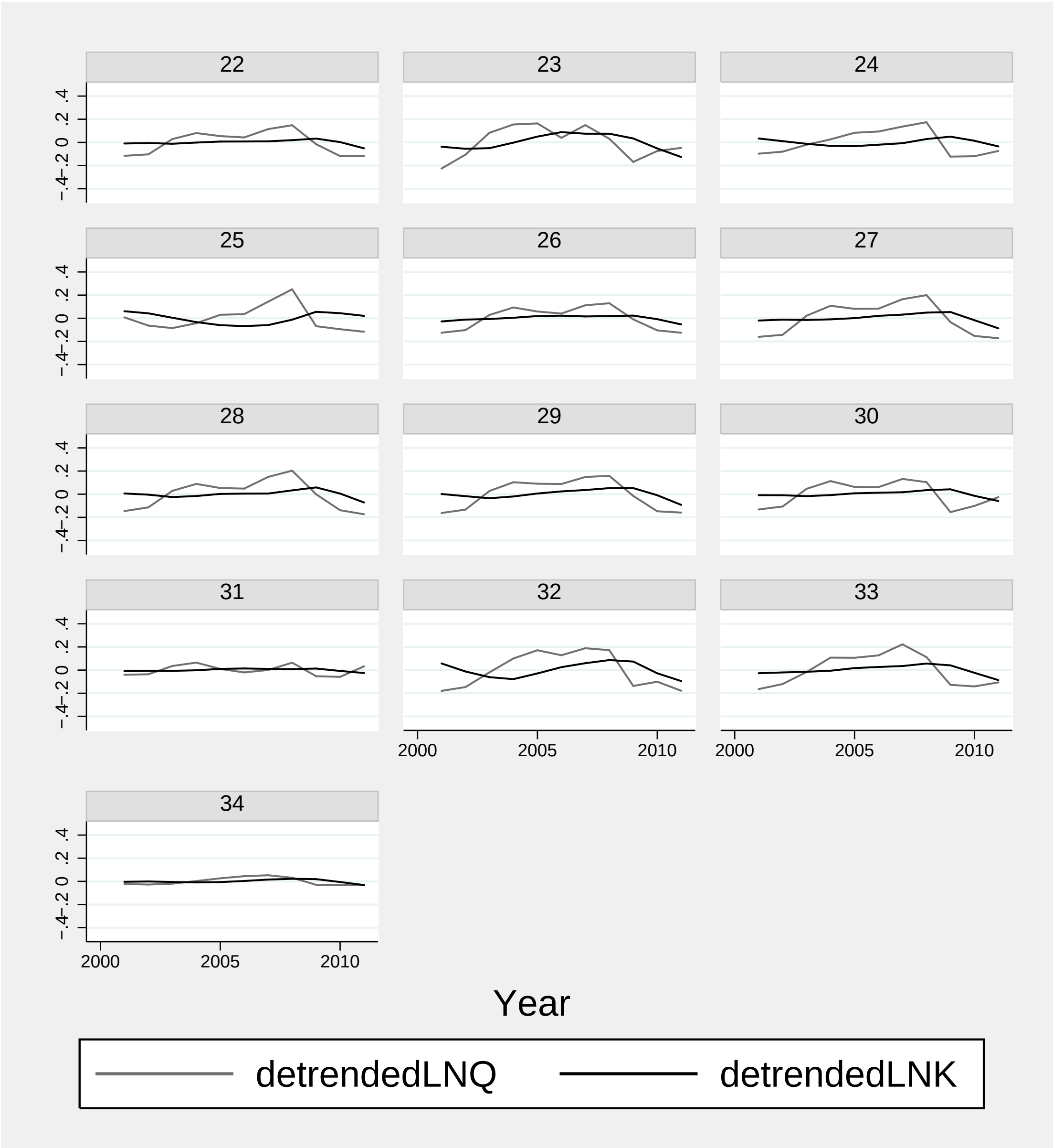

Figure B12: De-trended GDP and capital stock. (continued)

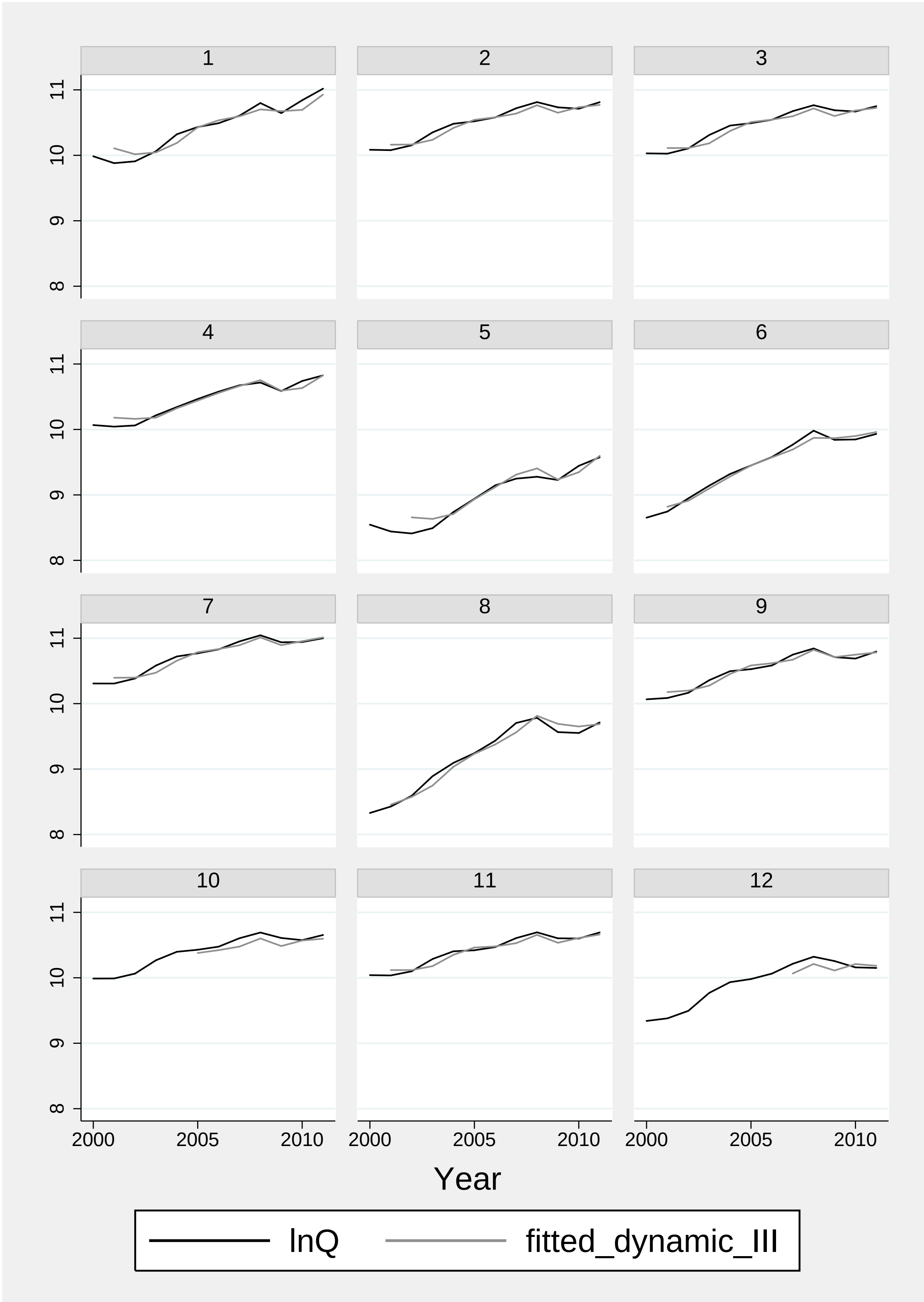

Figure B13: Comparison: Actual data versus model predictions. This figure represents how well the dynamic model which includes dummies for both 2009 and 2010 years (see Table 12 model III) fits the data. Actual data is plotted in black, whereas the grey line represents the fitted values.

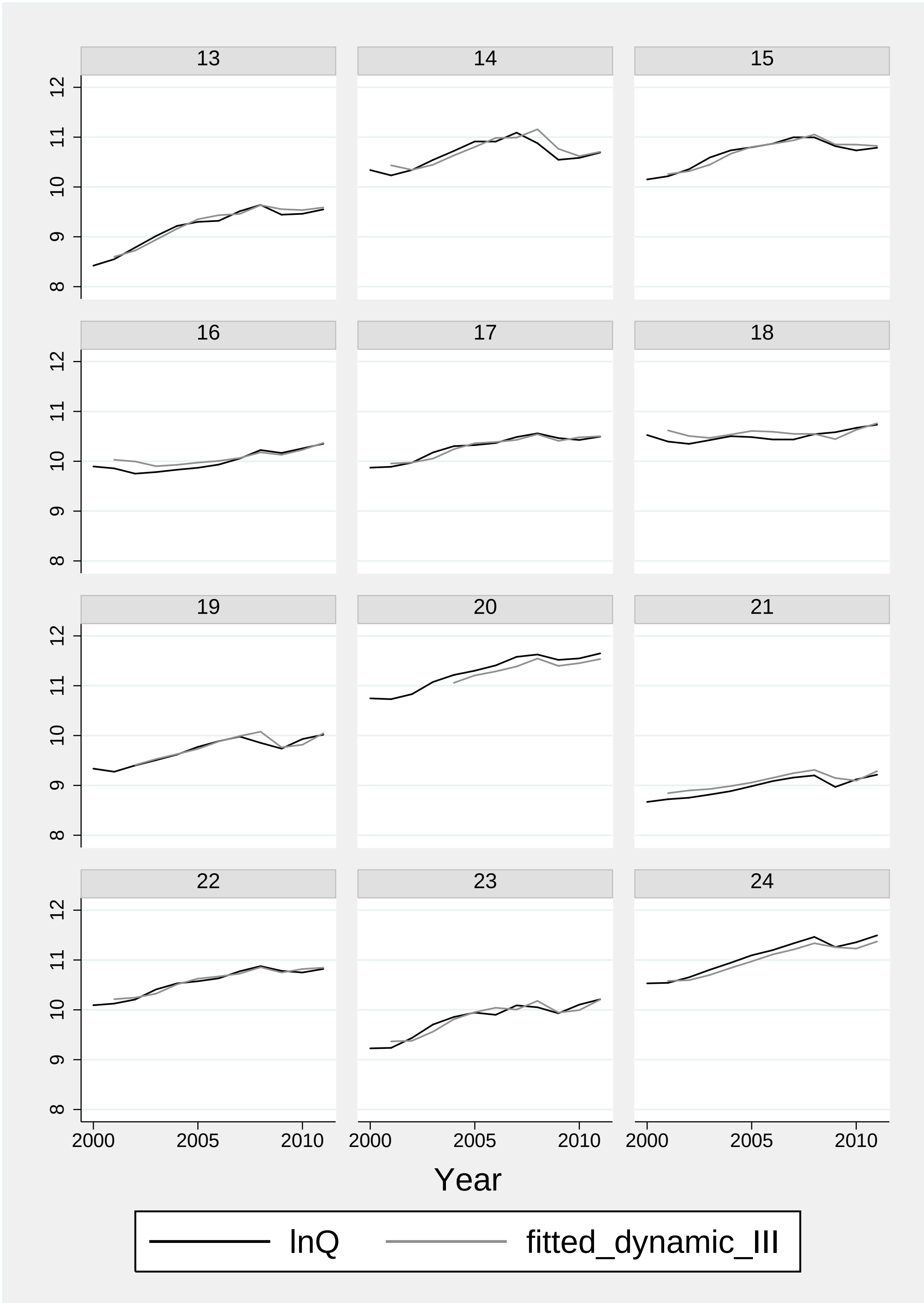

Figure B13: Comparison: Actual data versus model predictions. (continued)

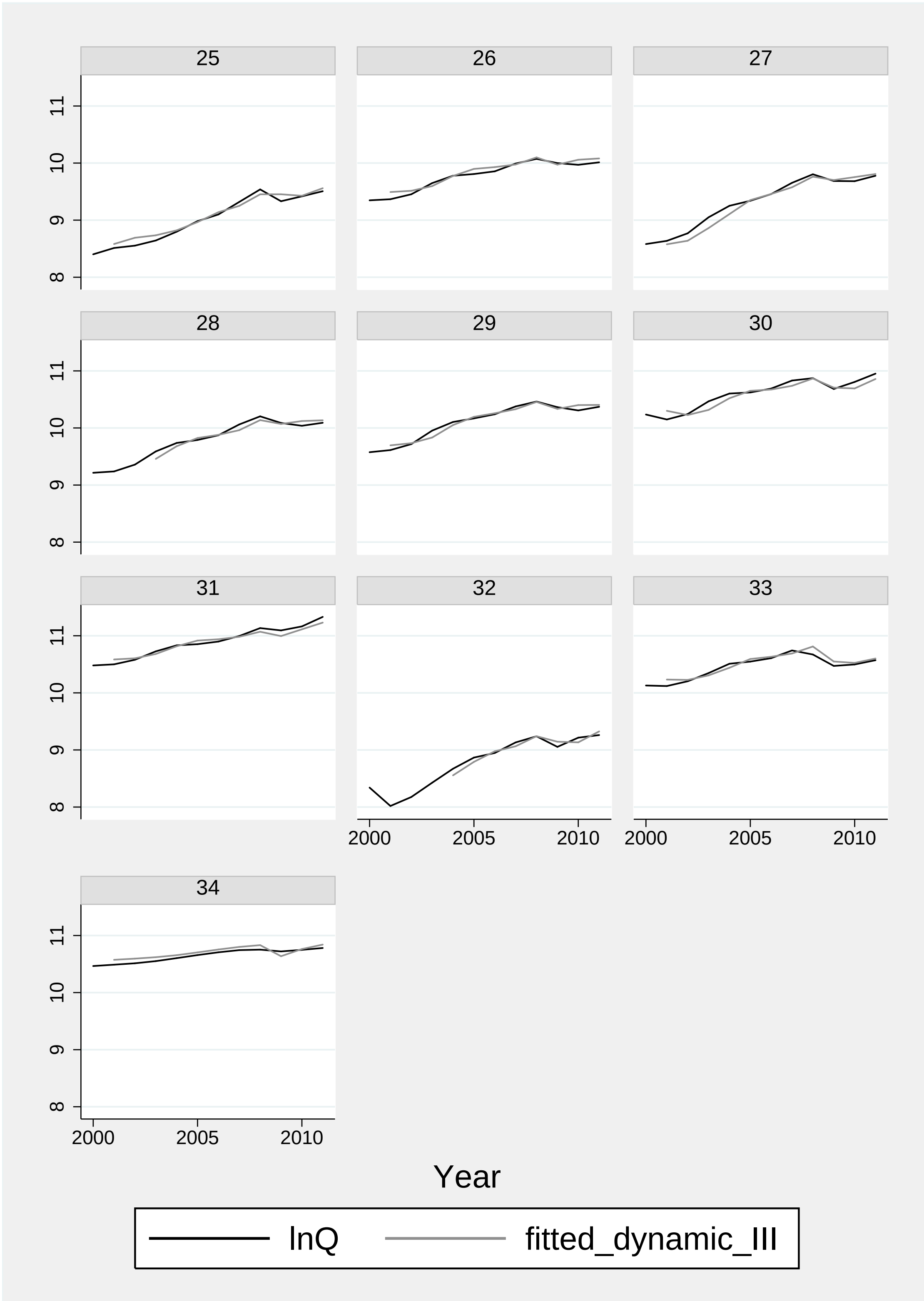

Figure B13: Comparison: Actual data versus model predictions. (continued)

Appendix C

C.1 The World Bank model

Since the population is rapidly ageing, traditional PAYG systems become financially unsustainable. Policy makers and economists worldwide are always seeking improvements and one of the suggestions is to reform a pension system towards the model proposed by World Bank. The model comprises five parts:

- ⋆ A non-contributory zero-pillar;
- ⋆ A mandatory first-pillar;
- ⋆ A mandatory second-pillar;
- ⋆ A voluntary third-pillar;
- ⋆ A non-financial fourth-pillar.

The main goal of the World Bank model is to provide the conceptual framework for a pension system, which assures adequate, affordable, sustainable, and robust income. Detailed guidelines on how this objective can be achieved are listed in the 2005 report called "Old Age Income Support in the 21st Century: An International Perspective on Pension Systems and Reform". In the report authors share their knowledge and experience in the field and provide insights into common challenges that countries are likely to face when reforming their pension systems (Holzmann and Hinz, 2005).

C.2 The model suggested by Zandberg and Spierdijk (2010)

Zandberg and Spierdijk (2010) suggest controlling for capital market returns of pension funds. The estimation procedure is quite simple and consists of two steps. Firstly, using OLS the authors estimate the following model and calculate robust standard errors:

$$\Delta(PA/GDP)_{it} = \beta_1 r_{it} + \beta_2 \Delta(OldDependencyRatio)^{-1}_{it} + \epsilon_{it} \tag{C.1}$$

where *PA/GDP* is pension assets divided by nominal GDP (and subsequently multiplied by 100), r is the rate of return on pension assets and *the inverse Old Dependency Ratio* is the number of people between 16 and 65 divided by the number of people over 65. The second step is to use the residual from equation (C.1) and estimate parameters of a dynamic growth regression:

$$log(y_{i,t}/y_{i,t-1}) = \mu_i + \delta_t + \gamma_1 log(y_{i,t-1}/y_{i,t-2}) + \gamma_2 \hat{\epsilon}_{i,t-1} + u_{i,t} \tag{C.2}$$

where y is real GDP per capita, $\hat{\epsilon}$ is the residual from estimating equation (C.1), μ_i is a country fixed effect, δ_t is a time fixed effect and u is the error term. The framework described above allows focussing on the relationship between funding and growth during the transition from a PAYG system to a funded or partly funded system (Zandberg and Spierdijk, 2010). For more information on the theoretical background and the results refer to the article by Zandberg and Spierdijk (2010).

C.3 Perpetual inventory method (PIM)

Under the Perpetual Inventory Method, thereafter PIM, inventory is treated as the economy's capital stock. Capital formation (investments) increases the stock of inventory and "once an investment enters the economy's inventory, it remains there forever and provides services to the inventory's owner" (Berlemann and Wesselhöft, 2012). The quantity of services provided by a particular investment reaches its maximum after the investment has been made. Throughout the time the value of that investment decreases by being depreciated, however it never falls to zero and therefore it is said to have a perpetual use (Berlemann and Wesselhöft, 2012).

According to Berlemann and Wesselhöft (2012), the net capital stock denoted by K can be calculated using the following formula:

$$K_t = K_{t-1} + I_{t-1} - D_{t-1} \tag{C.3}$$

where

- ⋆ K is net capital stock at the beginning of the period;
- ⋆ I is gross investment;
- ⋆ D is consumption of fixed capital;
- ⋆ t time dimension;

Assuming geometric depreciation at a constant rate ρ, the equation (C.3) can be easily rewritten to:

$$K_t = K_{t-1} + I_{t-1} - D_{t-1} = K_{t-1} + I_{t-1} - \rho K_{t-1} = (1-\rho)K_{t-1} + I_{t-1} \tag{C.4}$$

By employing a repeated substitution for the capital stock we get a generalised formula:

$$K_t = \sum_{i=0}^{\infty}(1-\rho)^i I_{t-(i+1)} \tag{C.5}$$

Equation (C.5) tells us that the net capital stock is a weighted sum of all historical capital stock investments. The weights are determined by the geometric depreciation function. Such a relationship is not of much use as having a complete time-series of past investments is impossible. However as long as we know the initial capital stock ($\tilde{K}$) at the beginning of the investment time-series, we can calculate the current capital stock K_t. Equation (C.5) then looks like this:

$$K_t = (1-\rho)^{t-1}\tilde{K} + \sum_{i=0}^{t-1}(1-\rho)^i I_{t-(i+1)} \tag{C.6}$$

The next question in a capital stock derivation is *how can we know the **initial** capital stock?* There are several methods to obtain the initial value (see e.g. Berlemann and Wesselhöft, 2012), however in this thesis, consistent with Luintel and Khan (1999) and Davis and Hu (2004), we use a steady state approach with a 3-year average and a depreciation rate of 8%.

Steady state approach

Steady state approach is based on Harberger (1978) and "relies on the assumption that the economy under consideration is at its steady state"(Berlemann and Wesselhöft, 2012). This means that capital stock grows at the same rate as aggregate output. Formally speaking, equation (C.7) is valid.

$$g_{GDP,t} = g_{K,t} = \frac{K_t - K_{t-1}}{K_{t-1}} = \frac{(1-\delta)K_{t-1} + I_{t-1} - K_{t-1}}{K_{t-1}} = \frac{I_{t-1}}{K_{t-1}} - \delta \tag{C.7}$$

Solving equation (C.7) for the capital stock we get:

$$K_{t-1} = \frac{I_{t-1}}{g_{K,t} + \delta} \tag{C.8}$$

Relying on the assumption that the economy is in a steady state (*i.e.* $I_t = I_{t-1}$) and assuming that the availability of the data covers a sample from a particular time period t onwards, we can rewrite equation (C.8) as follows:

$$K_{t-1} = \frac{I_t}{g_{K,t} + \delta} \tag{C.9}$$

It can be clearly seen from equation (C.9) that the initial capital stock is affected by the investment and the growth rate of output in a single year only. If the economy under consideration is in equilibrium, this relationship is not concerning, however "a short-term investment shock in the first period of the available time-series of investments would lead to a strongly biased initial capital stock estimates"(Berlemann and Wesselhöft, 2012). In order to cope with this issue, it is advised to use a 3-year average instead (see Harberger (1978); Davis and Hu (2004); Berlemann and Wesselhöft (2012)). By incorporating 3-year averages, we can update equation (C.9):

$$\tilde{K} = K_{t-1} = \frac{\overline{I}}{\overline{g_K} + \delta} = \frac{\frac{I_t + I_{t+1} + I_{t+2}}{3}}{\frac{g_{K,t} + g_{K,t+1} + g_{K,t+2}}{3} + \delta} = \frac{I_t + I_{t+1} + I_{t+2}}{g_{K,t} + g_{K,t+1} + g_{K,t+2} + 3\delta} \qquad \text{(C.10)}$$

Now when we know how to calculate the initial capital stock for each country, we can insert the values obtained using equation (C.10) to equation (C.6) or equation (C.4).

C.4 Stationarity tests

Levin-Lin-Chu test

The Levin-Lin-Chu (LLC) test adds the restriction that all panels share a common autoregressive parameter. This basically means that $\phi_i = \phi \; \forall i$ and then equation (4.2) is rewritten as follows:

$$\Delta y_{i,t} = \phi y_{i,t-1} + X'_{i,t}\delta_i + \epsilon_{i,t} \tag{C.11}$$

where

- ⋆ y is the variable being tested;
- ⋆ X represents panel-specific means, panel-specific means and a time trend, or nothing, depending on the options specified;
- ⋆ $\Delta y_{i,t} = y_{i,t} - y_{i,t-1}$;
- ⋆ i indexes country;
- ⋆ t indexes time;
- ⋆ ϵ is an error term.

It is very likely that $\epsilon_{i,t}$ from suffers from serial correlation and in order to mitigate this problem, the LLC augments the model with additional lags of the dependent variable (StataCorp, 2011):

$$\Delta y_{i,t} = \phi y_{i,t-1} + X'_{i,t}\delta_i + \sum_{j=1}^{p} \theta_{i,j}\Delta y_{i,t-j} + u_{i,t} \tag{C.12}$$

It is not required for $u_{i,t}$ to have the same variance across the panels, however in order to assure that $u_{i,t}$ is white noise, a sufficient number of lags (p) of $\Delta y_{i,t}$ has to be included. p can either (1) be specified manually or (2) an option, which minimizes a particular information criteria, can alternatively be chosen. In terms of the assumptions made by the test, it is assumed that $\epsilon_{i,t}$ is independently distributed across the panels and follows a stationary invertible autoregressive moving-average process for each panel (StataCorp, 2011). Under the null hypothesis all the panels contain a unit-root, whereas an alternative states that all panels are stationary.

Im-Pesaran-Shin test

In contrast to the LLC test, the Im-Pesaran-Shin (IPS) test developed by Im et al. (2003) does not assume that all panels share a common autoregressive parameter (i.e. ϕ is panel-specific). Additionally, the IPS test does not require balanced datasets. Testing procedure starts with with a set of Dickey-Fuller regressions of the form (StataCorp, 2011):

$$\Delta y_{i,t} = \phi_i y_{i,t-1} + X'_{i,t}\delta_i + \epsilon_{i,t} \tag{C.13}$$

where $\epsilon_{i,t}$ is independently distributed normal $\forall$ i and t with heterogeneous variances σ_i^2 across panels (StataCorp, 2011).

The main difference between the LLC test discussed previously and the IPS test is that in the latter test equation (C.13) is fit to each panel separately and the resulting t statistics are averaged, whereas in the procedure suggest by Levin et al. (2002) data is pooled (thus a common autoregressive parameter is imposed) before fitting an equation such as (C.12) and a test statistic is calculated (Maddala and Wu, 1999). Under the null hypothesis of the IPS test all panels contain a unit-root, whereas the alternative allows some (but not all) of the individuals to have unit roots (Baltagi, 2005).

Fisher-type test

A Fisher-type test can be interpreted as a more explicit approach of stationarity testing. Basically, p-values from independent tests are combined in order to obtain an overall test statistic and two options are allowed: (1) ADF unit-root test and (2) Phillips-Perron unit-root test. Similarly to the IPS test, a Fisher-type test can handle unbalanced panel data, however the disadvantage of the latter test is that the p-values have to be derived by Monte Carlo simulations (Baltagi, 2005). Under the null hypothesis all panels contain unit-roots, whereas the alternative states that at least one panel is stationary.

C.5 Arellano-Bond linear dynamic panel data estimation

A dynamic panel data model is specified as follows:

$$y_{i,t} = \sum_{j=1}^{p} \alpha_j y_{i,t-j} + \mathbf{x}_{i,t}\boldsymbol{\beta_1} + \mathbf{w}_{i,t}\boldsymbol{\beta_2} + \nu_{i,t} + \epsilon_{i,t} \quad i = 1, ..., N \;\; t = 1, ..., T_i \tag{C.14}$$

where

- ⋆ α_j are p parameters to be estimated;
- ⋆ $\mathbf{x}_{i,t}$ is a $1 \times k_1$ vector of strictly exogenous covariates;
- ⋆ $\boldsymbol{\beta_1}$ is a $k_1 \times 1$ vector of parameters to be estimated;
- ⋆ $\mathbf{w}_{i,t}$ is a $1 \times k_2$ vector of predetermined and endogenous covariates;
- ⋆ $\boldsymbol{\beta_2}$ is a $k_2 \times 1$ vector of parameters to be estimated;
- ⋆ ν_i are the panel-level effects (which may be correlated with the covariates);
- ⋆ $\epsilon_{i,t}$ are i.i.d. over the whole sample with variance σ_ϵ^2 and
- ⋆ it is assumed that ν_i and the $\epsilon_{i,t}$ are independent for each i over all t (StataCorp, 2011).

From equation (C.14) it can be clearly seen that $y_{i,t}$ will depend upon ν_i, irrespective of the way ν_i is treated. Correlation with unobserved panel-level effects basically means that standard errors become inconsistent (Verbeek, 2004). With many panels and few periods ($N > T$), Arellano and Bond (1991) derived a consistent generalized method of moments (GMM) estimator. The estimator is constructed by first-differencing, so that the panel-level effects are removed. Moment conditions are formed by using the differenced errors and instruments such as lagged levels of the dependent variable, the predetermined variables and the endogenous variables. The first differences of the strictly exogenous variables can also be used as standard instruments (StataCorp, 2011). For a technical note on the GMM estimator and GMM-type instruments, refer to Arellano and Bond (1991), Verbeek (2004) or Holtz-Eakin et al. (1988).

C.6 Different types of R-squared

Computation of goodness-of-fit measures in panel data applications is different. The usual $R^2 = (Var(\hat{y})/Var(y))^2$ is appropriate only if the model is estimated by OLS (Verbeek, 2004). For measuring how well a particular panel data model fits the actual data, three different types of R^2s are reported: overall, between and within. In order to understand how these R^2s are calculated, the easiest way is to consider three equations:

$$\hat{y}_{i,t} = \hat{\alpha} + \mathbf{x}_{i,t}\hat{\boldsymbol{\beta}} \tag{C.15}$$

$$\hat{\overline{y}}_i = \hat{\alpha} + \mathbf{x}_i\hat{\boldsymbol{\beta}} \tag{C.16}$$

$$\hat{\tilde{y}}_{i,t} = (\hat{y}_{i,t} - \hat{\overline{y}}_i) = (\mathbf{x}_{i,t} - \overline{\mathbf{x}}_i)\hat{\boldsymbol{\beta}} \tag{C.17}$$

Depending on which equation (C.15, C.16 or C.17) was chosen for the calculation of panel data R^2 we have either R^2-overall, R^2-between and R^2-within. "In fact, you can think of each of these three numbers as having all the properties of ordinary R^2s, if you bear in mind that the prediction being judged is not $\hat{y}_{i,t}$, $\hat{\overline{y}}_i$ and $\hat{\tilde{y}}_{i,t}$, but $\gamma_1\hat{y}_{i,t}$ from the regression $y_{i,t} = \gamma_1\hat{y}_{i,t}$; $\gamma_2\hat{\overline{y}}_i$ from the regression $\overline{y}_i = \gamma_2\hat{\overline{y}}_i$; and $\gamma_3\hat{\tilde{y}}_{i,t}$ from $\tilde{y}_{i,t} = \gamma_3\hat{\tilde{y}}_{i,t}$." (StataCorp, 2011) The three R^2s can be computed for any of the static panel data estimators, however one has to understand that these goodness-of-fit measures are not adequate to choose between alternative estimators. They can only provide guidance when choosing between alternative specifications of the model (Verbeek, 2004).

C.7 Dynamic heterogenous models

Consistently with Pesaran and Smith (1995), in order to look at the long run relationship Davis and Hu (2004) use two types of mean group estimators. The construction of these estimators is very simple. Firstly, separate regressions are estimated using OLS. Secondly, depending on the method parameters are averaged out. If one uses the first type estimator, long run coefficients have to be calculated and then averaged out, whereas the second method states that means of short run coefficients have to be taken before proceeding to the calculation of long run parameters. Basically for the model specified as follows $lnQ^*_{i,t} = \alpha + \theta lnQ^*_{i,t-1} + \lambda lnP_{i,t} + \beta lnK^*_{i,t} + u_{i,t}$ the formulas below have to be used:

Method I:

$$\hat{\lambda} = \frac{1}{N}\sum_{i=1}^{N}\hat{\lambda}_i/(1-\hat{\theta}_i) \text{ and } \hat{\beta} = \frac{1}{N}\sum_{i=1}^{N}\hat{\beta}_i/(1-\hat{\theta}_i) \tag{C.18}$$

Method II:

$$\hat{\lambda} = \frac{\frac{1}{N}\sum_{i=1}^{N}\hat{\lambda}_i}{1-\frac{1}{N}\sum_{i=1}^{N}\hat{\theta}_i} \text{ and } \hat{\beta} = \frac{\frac{1}{N}\sum_{i=1}^{N}\hat{\beta}_i}{1-\frac{1}{N}\sum_{i=1}^{N}\hat{\theta}_i} \tag{C.19}$$

where $\hat{\lambda}_i$, $\hat{\beta}_i$ and $\hat{\theta}_i$ are the parameters obtained from the individual regressions estimated using OLS and N is the number of the panels (in our case the number of the countries in the sample).

Davis and Hu (2004) also suggest augmenting the model with a time trend, however a lagged GDP per capita is already present in the model and therefore we believe that an inclusion of the trend is irrelevant. Consistently with the authors, we reduce our sample by excluding some countries due to the small number of observations. Speaking more specifically we drop the countries, for which more than 1 observation is missing. After estimating all the models with OLS, we reduce our sample further[26] as some parameter estimates are very unrealistic (i.e. either too high or extremely low). The results of both methods as well as

[26]For estimating parameters using dynamic heterogeneous models we use a sample of 17 countries: Australia, Austria, Canada, Denmark, Estonia, Finland, Hungary, South Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Sweden, the United Kingdom.

the coefficients reported by Davis and Hu (2004) are listed in Table C3.

Table C3: Comparison: Parameter estimates using dynamic heterogeneous models. This table reports parameter estimates of a simple dynamic model. The dependent variable is GDP per capita (Q). The independent variables are lagged GDP per capita, ratio of total pension assets to GDP (P) and capital stock per capita (K). Q, K and P are transformed to logarithms. The left side of the table stands for the results produced by the authors, whereas on the right side the outcome of the model estimated by Davis and Hu (2004) is presented. As Davis and Hu (2004) used two different sub-samples of the OECD countries, the coefficients are separated by semicolons. ***, ** and * stand for 1%, 5% and 10% statistical significance, respectively. Data is obtained from OECD and WDI, calculations are done by the authors.

	Our Results		Results by Davis and Hu	
	Method I	Method II	Method I	Method II
LnP	.152	.194**	.034**; .069***	.023**; .046***
LnK	.295*	.381***	.937***; .953***	.948***; .951***

We believe that particularly for our data set, where the maximum number of observations per panel is 11, it is very unlikely that an estimator constructed in such a way provides very precise estimates. On the other hand, it is good to note that both LnP and LnK load positively as suggested by the theory, however according to the first method the impact of growing pension funds assets on GDP per capita is statistically insignificant. In contrast, Davis and Hu (2004) conclude that 1% growth in the ratio of total pension funds' assets to GDP leads to an increase of around 0.023%-0.069% in GDP per capita.