

**Modeling the State Pension System and Pension Obligations in Germany**

**Masterarbeit**

zur Erlangung des akademischen Grades „Master of Science (M.Sc.)“ im Studiengang  
Wirtschaftswissenschaft der Wirtschaftswissenschaftlichen Fakultät der Leibniz Universität Hannover

vorgelegt von

Name: Rodríguez Cardona

Vorname: Davinia



Erstprüfer: Prof. Dr. Michael H. Breitner

Hannover, den 14.01.2016

**Content**

- 1. Introduction ..... 1
- 2. Research background ..... 3
- 2.1. Theoretical framework of the German retirement system ..... 3
  - 2.1.1. General description of the German pension system ..... 3
  - 2.1.2. Reforms of the German pension system ..... 4
  - 2.1.3. Key features of the current German state pension system ..... 6
    - 2.1.3.1. Contribution rate and contribution ceiling ..... 6
    - 2.1.3.2. Eligibility for pension benefits and retirement age ..... 6
    - 2.1.3.3. Pension type factors and actuarial adjustments ..... 7
    - 2.1.3.4. Earnings- related pension benefits ..... 8
    - 2.1.3.5. Sustainability factor ..... 9
    - 2.1.3.6. Financing ..... 9
  - 2.1.4. The German Retirement Benefit Formula ..... 9
  - 2.1.5. International benchmarking of the German pension system ..... 10
  - 2.1.6. Macro-level elements ..... 11
    - 2.1.6.1. The average age-wage profile in Germany ..... 11
    - 2.1.6.2. Labor market developments ..... 11
    - 2.1.6.3. The old-age poverty risk in Germany ..... 14
- 2.2. Demographic developments in Germany ..... 14
  - 2.2.1. Fertility ..... 15
  - 2.2.2. Life expectancy ..... 15
  - 2.2.3. Net migration ..... 16
  - 2.2.4. Population growth and the demographic transition of Germany ..... 17
- 3. Related work ..... 19
- 4. Overview of the projection methodology ..... 24
  - 4.1. Model approach and forecasting methodology ..... 24
  - 4.2. Autoregressive Integrated Moving Average (ARIMA) framework ..... 24
  - 4.3. Forecasting Methodology ..... 25
- 5. Construction of the database ..... 27

6.	Univariate modeling and projection results.....	27
6.1.	Descriptive statistics and graphical examination.....	28
6.2.	Testing for stationarity .....	30
6.2.1.	Testing.....	30
6.2.2.	Model identification .....	32
6.2.3.	Autocorrelation function (ACF).....	32
6.2.4.	Partial autocorrelation function (PACF).....	33
6.2.5.	Akaike's information criterion (AIC) .....	33
6.2.6.	Parameter estimation .....	35
6.2.7.	Diagnostic checking .....	36
6.2.8.	Time series projection .....	37
6.2.9.	Monte Carlo Simulation .....	41
7.	The pension projection model .....	43
7.1.	Assumptions underlying the pension model.....	43
7.1.1.	General underlying assumptions .....	43
7.2.	Demographic assumptions.....	44
7.3.	Fertility assumptions .....	44
7.4.	Life expectancy assumptions.....	45
7.5.	Migration assumptions .....	46
7.6.	Population assumptions .....	46
7.7.	Modeling of the German state pension system.....	47
7.7.1.	The development of wages.....	47
7.8.	Pension determination .....	50
7.9.	Determination of aggregate magnitudes and flows of income and expenditure.....	56
7.10.	The average wage .....	56
7.11.	The average pension benefit.....	57
7.12.	Pension indicators.....	59
7.13.	Scenario-based analysis.....	60
8.	Conclusions and final remarks .....	68
8.1.	Limitations and Future Research.....	68

9. Bibliography..... 70

## 1. Introduction

In 1889, Germany turned into the first country in the world to establish a state pension system in order to protect its population from old-age poverty and invalidity. From then on, the German state pension system introduced by German Chancellor Otto von Bismarck has not only granted German citizens the prospect of a secure existence in retirement, but also has consistently accomplished the objective of providing a retirement income at a level that allows German retirees to maintain a standard of living in retirement comparable to that achieved in working life (OECD, 2013), which has led it not only to be perceived by many German workers as an assurance of financial well-being and quality of life in old age, but also to be recognized worldwide as a generous and reliable state pension (Boersch-Supan & B. Wilke, 2004).

However, the effects of the demographic changes, triggered mainly by improvements in life expectancy and declining fertility rates, bring the sustainability and financial stability of the German state pension system into question (Allianz International Pensions, 2014), as the German population is expected to decline, in proportion to low and high assumed levels of net immigration, from 80.8 million in 2014 to between 68 million and 73 million people by 2060, and along with it, the working-age population is anticipated to decrease from 61% in 2013 to around 51% from the total population (Statistisches Bundesamt, 2015). While, on the other hand, one fourth of the population in Germany is estimated to be aged 65 and over by 2030, increasing the German old-age dependency ratio, which is already the second highest old-age dependency ratio in Europe and the third highest worldwide (Allianz, 2011), from 53 per cent to a projected 73 percent by 2040 (Statistisches Bundesamt, 2015).

The growing concern about the sustainability of the German state pension system is already reflected in the 2014 Melbourne Mercer Global Pension Index, in which Germany in terms of sustainability ranked 19th out of 25 countries and received an overall index grade of C+, highlighting the fact that although the German pension system has some good attributes in adequacy and integrity, it also faces significant risks and limitations in the area of sustainability that, if not addressed soon, endanger its efficiency and long-term future (Mercer, 2014). Likewise, the World Bank (World Bank, 1994) and the International Monetary Fund (International Monetary Fund, 1995) have remarked that the interplay of the rapidly ageing German population, the increasing old-age dependency ratio, the growing government debt and the current structure of the German pension system could lead the country to an old age crisis, which vast age-related government pension cost would represent a potential threat to the long-term sustainability of the German state pension system in less than a generation (Hughes & Stewart, 2000), bringing millions of elderly Germans to face the prospect of poverty in retirement.

Given the above, most of the research regarding to the development in the coming decades of the German state pension system has been mainly concentrated on the effect of population ageing on the public pension expenditures, thereby narrowing the analysis of long-term projections of pension

expenditure and the evaluation of the sustainability of the German state pension system to changes in the demographic structure of the population. Hence, this paper aims to contribute to a better understanding of the evolution of public pension expenditure in Germany, and to provide insights into the long-term sustainability of the German state pension system considering different demographic and macroeconomic scenarios. Therefore, based on existing literature, financial modeling and scenario-based analysis, the following research questions will be addressed:

*(RQ 1) How much will the German statutory pension system cost in the future?*

*(RQ 2) To what extent demographic and macroeconomic trends affect the sustainability of the German statutory pension system?*

The paper will be structured aiming to provide 1) an outline of the key characteristics, major reforms and present design of the German pension system, 2) an overview of the main macro-level elements and micro-level elements impacting the German retirement system, 3) a description of the general framework and theoretical properties of the Autoregressive Integrated Moving Average (ARIMA) modeling approach used to perform long-term projections of key macroeconomic variables for modeling the German state pension system 4) a description of the pension model and its main underlying general and demographic assumptions 5) a discussion and analysis of the long-term sustainability of the state pension system in Germany under diverse demographic and economic scenarios, and 6) a conclusion and proposal of areas for further research.

## 8. Conclusions and final remarks

The interplay of the rapidly ageing German population, the increasing old-age dependency ratio, the growing government debt and the current structure of the German pension system call into question the long-term sustainability and financial stability of the German state pension system. Hence, in order to contribute to a better understanding of the evolution of public pension expenditure in Germany, this paper followed an aggregated approach to analyze the evolution of the German public pension expenditure and determined the long-term sustainability of the state pension system under the presence of changes in certain demographic and economic variables. In this regard, the aggregated model implemented for this paper corresponds to a modified version of the models developed by (de la Fuente, 2011), (Jimeno, Rojas, & Puente, 2007), (Doménech & Melguizo, 2008) and (Eich, Gust, & Soto, 2012), which have been adapted in order to model the German state pension system based on a homogeneous multi-agent approach, characterized in this analysis, by the consideration of a female and a male “average agent”, with the intention of accounting for the effect of characteristic patterns of work, wage and retirement among men and women.

The underlying general and key demographic assumptions for the pension model are based on real data and on the current legislation on the Statutory State Pension (Gesetzliche Rentenversicherung, GRV) in Germany, while the long-term projections of key macroeconomic variables used for modelling the pension system, i.e. GDP growth, inflation rate, unemployment and employment rate (by age group), have been modelled for the time horizon examined in this paper (2015-2050) using an Autoregressive Integrated Moving Average (ARIMA) approach. The pension model results showed that the sustainability of the German state pension system in the coming decades will be mainly determined by those variables that have a direct effect on the contribution levels, such as the employment and wage levels. On this basis, the long-term sustainability of the German pension system can be improved through a greater incorporation of women into the labor force, a diminution of the current wage gap, or the incorporation of young migrant workers into the labor force. However, considering the profile of the historic German unemployment rate and employment to population ratios by gender and education, it becomes clear that the educational attainment will played a major role in the integration of new employees into the labor force.

### 8.1. Limitations and Future Research

There are also many other pension modeling strategies in the academic literature that enable different levels of analysis of the pension expenditure and could lead to finer representations of the socio-economic reality by considering heterogeneous interacting agents instead of homogenous agents defined in terms of an “average agent” as has been done in this analysis.

As well it is important to note that, the German public pension expenditure in this paper is modeled under a national perspective, and hence assumes a convergence between the average income level, old-

age dependency ratio, the eligibility ratio, replacement rate and employment rates of West and the East Germany. And therefore, it does not account for the impact of the existing economic and social differences between the Eastern and Western Germany on the state pension expenditure, which may lead to overlook additional threats to the sustainability of the German state pension system existing at a regional level.

Furthermore, another possible line of future research could be not only to incorporate heterogeneous agents into the pension model, but also to model the agents using the axioms of prospect theory and behavioral models in order to delineate strategic elements for the development of pension expenditures like the retirement behavior of individuals, the decision of individuals to participate in the labor force, or the inclination of women to reenter the workforce after maternity leave in view of how individuals form beliefs and preferences based on the prospect value of losses and gains in relation to diverse referent points and risk-attitudes. In this way, academic studies like (Smith Brothers, 2002 ) and (Mitchell & Utkus, 2003), to mention some examples, can be used to complement financial and demographic pension models by considering the behavior of the agents under uncertainty and risk.