# CHARLES UNIVERSITY

## FACULTY OF SOCIAL SCIENCES

Institute of Economic Studies


# Effects of Population Ageing on the Pension Systems in EU

Bachelor's thesis


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Year of defense: 2023

## Declaration of Authorship

I hereby declare that I compiled this thesis independently, using only the listed resources and literature, and the thesis has not been used to obtain any other academic title.

I also acknowledge the assistance of ChatGPT, an artificial intelligence language model, for providing guidance on grammar and academic English to enhance the writing skills necessary for the production of this thesis.

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Prague, May 2, 2023

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## Abstract

This bachelor's thesis comprehensively analyses the demographic and economic challenges of selected European countries due to an ageing population. The study involves a demographic projection for the period up to the year 2150, highlighting the anticipated increase in the old-age dependency ratio, thereby imposing a growing burden on the working-age population. The importance of individual demographic variables on the old-age dependency ratio is analysed in the panel data regression, indicating that life expectancy has the most significant impact. The demographic projection is further utilised to construct generational accounts to calculate generation-specific pension payments and expenditures. Generational accounts show that increasing payments from younger generations will not be enough to cover future pension expenditures, indicating the long-term unsustainability of the PAYG system.



**Keywords** pension system, PAYG, OLG, ageing population

**Title** Effects of Population Ageing on the Pension Systems in EU



## Abstrakt

Tato bakalářská práce komplexně analyzuje demografické a ekonomické výzvy vybraných evropských států v důsledku stárnutí populace. Studie zahrnuje demografickou projekci do roku 2150, která zdůrazňuje očekávaný nárůst míry závislosti starších osob na mladší pracující populaci. Význam jednotlivých demografických determinant na míru závislosti je zkoumán v regresní panelové analýze, kde nejsignifikantněji vychází očekávaná délka života. Demografická projekce je dále použita k sestavení generačních účtů pro výpočet generačně specifických penzijních příjmů a výdajů. Generační účty ukazují, že navyšování plateb mladších generací nebude dostatečné na pokrytí budoucích výdajů na důchody, což indikuje dlouhodobou neudržitelnost systému PAYG.



**Klíčová slova** penzijní systém, PAYG, OLG, stárnutí populace

**Název práce** Vliv stárnoucí populace na důchodové systémy v EU

## Acknowledgments

I am grateful especially to Mgr. Roman Kalabiška, for his guidance, insightful feedback, and patience throughout the completion of this thesis. Additionally, I extend a special thanks to my family for their endless support during my studies.

Typeset in FSV LaTeX template with great thanks to prof. Zuzana Havránková and prof. Tomáš Havránek of Institute of Economic Studies, Faculty of Social Sciences, Charles University.

**Bibliographic Record**
Kralova, Adela: *Effects of Population Ageing on the Pension Systems in EU.* Bachelor's thesis. Charles University, Faculty of Social Sciences, Institute of Economic Studies, Prague. 2023, pages 51. Advisor: Mgr. Roman Kalabiška

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# Acronyms

**AUT** Austria

**BEL** Belgium

**CB** contribution-based

**CZE** Czechia

**DB** defined-benefit

**DC** defined-contribution

**EU** European Union

**ESP** Spain

**FF** fully funded

**FIN** Finland

**GER** Germany

**HUN** Hungary

**LUX** Luxembourg

**OECD** Organisation for Economic Cooperation and Development

**OLG** overlapping generation model

**PAYG** pay-as-you-go

**POR** Portugal

**RB** residence-based

**SLO** Slovenia

**WB** World Bank

# Chapter 1

# Introduction

Economists have examined the relationship between demographics and the economy for decades. In the 1950s, economist Simon Kuznets conducted one of the earliest studies on this topic and concluded that population growth could have both positive and negative effects, depending on a country's level of economic development. However, as the population expands, demographic changes such as population ageing become increasingly pronounced.

Population ageing is a demographic phenomenon in which the proportion of older people in a population increases over time. A helpful indicator for assessing the impact of population ageing on public finances is the old-age dependency ratio, which measures the number of individuals above retirement age relative to those of working age. According to the Organisation for Economic Cooperation and Development (OECD), this ratio is expected to rise substantially in the coming years, posing a risk to European pension systems, which primarily operate on a pay-as-you-go (PAYG) system, where the current workforce pays the pensions of current pensioners. Because these systems rely primarily on demographic stability, any demographic changes can significantly influence their efficiency and sustainability.

This thesis aims to study and analyse the demographics and pension systems of selected European countries with PAYG systems, specifically: Austria, Belgium, Czechia, Finland, Germany, Hungary, Luxembourg, Portugal, Slovenia, and Spain. Firstly, a demographic projection for these ten European countries for 2000–2150 is constructed. Consequently, as the projection covers the entire life cycle of several generations, it is utilised to create so-called generational accounts. These accounts illustrate generation-specific pension insurance payments and pension expenditures, allowing for the measurement of intergenerational solidarity between currently living and upcoming generations. Lastly, given the importance of the old-age dependency ratio, the study examines the impact of different demographic variables on this ratio in the final section using panel data regression analysis.

The thesis is structured as follows: Chapter 2 provides a comprehensive classification of the pension schemes in the European Union (EU), Chapter 3 presents a summary of the existing literature related to the topic, Chapter 4 describes in detail the methodology used to construct the demographic projection, intergenerational accounts and panel data model, Chapter 5 presents the results of each part of the study, and finally, Chapter 6 summarises the findings of the study.

# Chapter 2

# Pension systems in the EU

This chapter provides an overview of the classification of pension schemes and examines their impact on macroeconomic and financial stability in the EU.

According to Sánchez Serrano & Peltonen (2020), a pension scheme is a system in which a sum of money is accumulated throughout the individual's working life to receive future payments once they retire. The essential components of such a scheme are the contributions made during the person's working years and the benefits they are eligible to receive once they reach retirement age. Pension schemes can be labelled as either defined-benefit (DB) or defined-contribution (DC), based on whether the benefits or contributions are fixed:

- **Defined benefit**

  Benefits under a DB plan are calculated based on a worker's pensionable earnings history. The calculation may consider a person's final salary, length of service, or salaries over a given period. The main advantage of DB plans is that they ensure the security of either a monthly payment or a lump sum payout upon retirement. Since pension payments are both insulated from market performance and adjusted to meet obligations, the risk of fluctuating rates of return on pension assets lies with the sponsor - government or employer (Barr & Diamond, 2009).

- **Defined contribution**

  By contrast, the benefits under DC plans are determined by the value of assets accumulated throughout one's life. Each participant has a separate account to which the sponsor, the individual, or both make fixed contributions regularly. These contributions are further invested in the stock market, depending on the individual's taste and setting of a pension system. Upon retirement, the individual's account is used to provide retirement benefits based on the amount credited to the account plus any investment earnings.

Compared to DB, since contributions are subject to investment risks and market volatility, there is no way to determine the final payout at retirement in advance. Further, the DC plan puts most of the responsibility for contributing money and managing investments on the individual. Therefore, if the plan evolves unfavourably, the sponsor is not required to make additional contributions.

Barr (2006) states that since the DC scheme is built upon an actuarially fair principle, it leads to more significant differences in retirement benefits, further contributing to the widening of an economic gap between the rich and poor. In addition, Štěpánek (2017) notes that while a temporary inability to contribute to the social system under DB has little impact on pension transfer, it can have severe consequences under DC, especially if people cannot contribute in early life.

Furthermore, pension schemes can be categorized as either pay-as-you-go (PAYG) or fully funded (FF) , depending on the relationship between contributors and pensioners:

- **PAYG system**

  The unfunded PAYG system is a pension system where the benefits of current retirees are financed by contributions levied from current workers. In other words, the system operates on the principle of intergenerational solidarity: tax revenues from future generations of workers will be used to pay pension transfers for the current generation of workers.

  Generally, pensions are paid out of current revenue, usually by the state, rather than out of accumulated funds, and all potential savings are voluntary only. Next, PAYG systems are generally immune to the volatility of financial markets since the contributions are not invested further. On the other hand, they are highly vulnerable to demographic changes because the relationship between the number of workers and the number of pensioners is essential. As the population ages and the old-age dependency ratio increases, the cost of pension benefits exceeds the revenue collected, leading to a pension budget deficit. To avoid this undesirable externality, taxes or retirement benefits may be adjusted. However, taxes are relatively rigid, and the level of pensions significantly influences public opinion. Thus, they should be shifted only within limits (Štěpánek, 2017).

- **Fully funded system**

  Apart from the unfunded system, which relies on continuous financing through contributions, the funded pension system has sufficient assets to satisfy all obligations to current and future retirees. The contributions made by employee and/or their employer are saved on individual accounts at the pension fund, and further invested in a diversified portfolio of stocks, bonds, and other securities, based on the individuals taste and needs. The accumulated assets on one's account later serve as basis for pension transfers to the same person upon reaching retirement age.

  Funded pension systems are mostly DC schemes, therefore highly influenced by the fluctuations of asset prices. On the other hand, they are more resilient to demographic, political, or legislative changes, since the eventual returns are typically based solely on the total savings accumulated at retirement age, rather than being tied to government-approved indexing (Štěpánek, 2017).

## 2.1 Multipillar system

To address the long-term sustainability of pension systems the World Bank (WB) suggested applying a multi-pillared approach. The WB's conception presented in Holzmann *et al.* (2008) aims to offer a general framework that shall be adjusted according to conditions of particular economies and core objectives – *protection against the risk of poverty in old age* and *smoothing consumption from one's work life into retirement.* The purpose of the five-pillar system is to separate these objectives of retirement plans into the following pillars:

- A **non-contributory zero pillar** provides minimal protection for those with low lifetime incomes or with only marginal participation in the formal economy. It is a general social assistance typically financed by governments.

- The **first pillar** follows the typical design of a PAYG DB scheme financed through mandatory employer and worker contributions. It is linked to varying degrees of earnings and seeks to replace some portion of lifetime pre-retirement income to maintain the standard of living after retirement. This pillar addresses, among others, the risks of individual myopia, low earnings, and inappropriate planning horizons due to the uncertainty of life expectancies and financial market risks. Further, due to its pay-as-you-go financing, it is subject to demographic risks.

- A mandatory **second pillar** is an individual savings account, i.e. DC FF scheme. It is administered by the state or private pension funds, which collect mandatory contributions above those into the first pillar and invest them in a diverse range of assets. Therefore, they subject participants to financial market volatility. On the other hand, if effectively designed and operated, they can better insulate individuals from political risk.
- The **third pillar** is complementary and comprises a set of voluntary private pension schemes. These are generally managed by private pension administrators and can take many forms (individual, employer-sponsored, DB, DC) but are essential and discretionary.
- Under the **fourth non-financial pillar** fall informal support (such as family), various social programs (such as health care or housing), and other individual assets (such as home ownership and reverse mortgages).

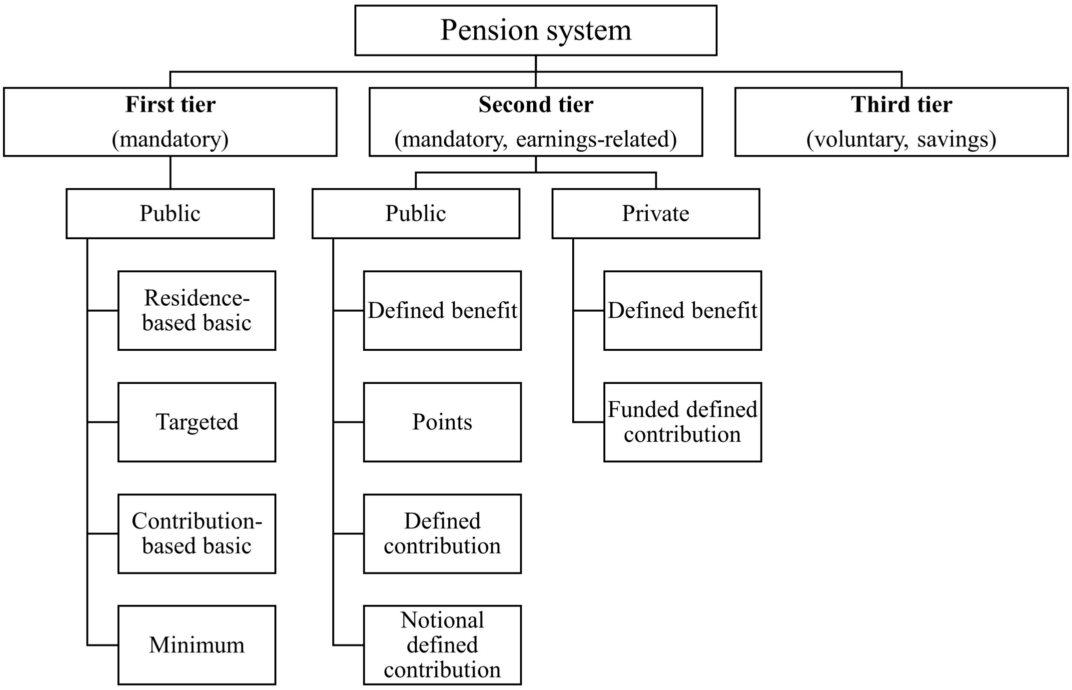
(Holzmann *et al.*, 2008)

Given the existing disparities across nations regarding social and labour law, obtaining a clear image of the exact set-up and composition of the pension systems in the EU is challenging. Whereas the World Bank's classification uses a pillar approach and is rather prescriptive, the OECD version avoids the pillar concept altogether and employs a more descriptive approach. Therefore, the OECD's taxonomy is generally considered a more suitable instrument when classifying pension systems. The following subsection will briefly discuss the OECD's taxonomy and provide examples from European states.

## 2.2 OECD framework

The OECD framework consists of two mandatory tiers, a redistributive part and a savings part, and one voluntary tier, comprised of individual private schemes. See Figure 2.1 and Table 2.1 (at the end of this subchapter).

Figure 2.1: Different types of retirement-income provision




*Source:* OECD (2021). Figure created by author.

- **Tier 1: Redistributive schemes**

  The redistributive part consists of elements created to guarantee a prescribed minimum standard of living for all pensioners. It includes programs that provide the initial level of social protection in old age and for which past earnings are neglected when calculating retirement income. The redistributive scheme can incorporate three components: basic, targeted, and minimum pensions.

  Basic pensions can be structured as a residence-based (RB) or contribution-based (CB) benefits. Years of contributions or residency required for eligibility to basic pensions vary substantially across countries but usually range between 35 to 40 years. RB basic pensions are present in three countries, with a maximum benefit of nearly 30 % of the gross average wage in the Netherlands. Seeven countries in the EU provide a CB basic pension, which lies on average at 16 % of average earnings.

Targeted redistribution refers to conditional provisions corresponding to the specific needs of individuals, and each country in the EU provides it to their residents. In these plans, the value of the benefit depends on income from other sources and possibly assets, i.e., the financial aid is dependent on current means rather than contributory history. Hence, poorer pensioners receive higher benefits than better-off retirees. Across the member states, 21 % of gross average earnings can be received from targeted schemes.

Minimum schemes are established in most EU countries and implemented to supplement the pension benefit if it does not reach the threshold for the minimum pension, i.e., the pension benefits of individuals whose contributions from working history are insufficient to provide an adequate pension are calculated as if the worker had earned at a higher income level. Low contributory pensions are topped up to a higher minimum pension level in approximately half of EU nations. These minimum pensions range from a low of about 7 % of the average wage in Hungary to a high of about 37 % in Luxembourg.

In Tier 1, it is prevalent for all three components to coexist. However, whereas in some nations, the benefits are cumulative, in others, there is some degree of substitution between them (OECD, 2021).

- **Tier 2: Insurance schemes**

  The second tier strives to guarantee that retired people have an adequate replacement rate, i.e. they maintain their standard of living in retirement relative to that while working. In contrast to the first tier, the retirement income generated by the second tier considers the level of past earnings and covers earnings-related components. There are four types of insurance scheme: defined benefit, points, notional defined contribution, and funded defined contribution.

  The public PAYG schemes follow a general DB format in most EU countries, providing more than 90 % of all benefits for full-career workers in Austria, Belgium, Finland, France, Germany, Hungary, Italy, Portugal, Slovenia, and Spain. Further, the DC system may also be introduced as a point system, which is the case of Slovakia, Estonia, and Lithuania.

Under the point scheme, the employees accumulate pension points based on their earnings for each year of contributions. These points are further multiplied by a pension-point value to convert them into a regular pension payment.

The second most prevalent form of pension-insurance provision is the DC plan, which can be organised in various ways. For instance, in Poland, employees independently select their pension provider without any employer involvement. In contrast, in Denmark, employees can choose their investment portfolio, but the national retirement savings plan investments are managed centrally. Further, on the same principle as DC, the notional accounts schemes work, constituting a pension plan in Sweden, Italy, Poland and Latvia. These schemes record each worker's contributions in an individual account and apply a notional rate of return to them. However, since the accounts are notional, the incoming contributions and the interest exist only on the books of the managing institution, i.e., the money collected from contributions is used to finance current pension benefits. Upon retirement age, the accumulated notional capital in each account is transformed into a series of pension payments (OECD, 2021).

- **Tier 3: Voluntary schemes**

  Beyond the pensions offered by the first and second tier, individuals can undertake a personal savings plan to contribute funds towards their retirement voluntarily. These plans are contracted privately between the individual and the financial institution and include various savings plans, such as individual retirement accounts, annuities, or other investment vehicles that provide tax benefits or other incentives for retirement savings (Lannoo & von Werder, 2014).

In addition to this primary classification, national pension plans differ in the accrual rate, valorisation method, ceilings on pensionable earnings, indexation of pensions in payments and others. Therefore, it must be again emphasised how arbitrary and limited in scope this classification for pension plans is.

To conclude, the extent to which a given system or scheme achieves the objectives of a specific pillar or tier depends solely on the implementation in each country.

The structure of retirement-income provision through Tier 1 and 2 in the EU countries is depicted in the Table 2.1 below.

Table 2.1: Structure of retirement-income provision through mandatory schemes

| | First tier | | | Second tier | |
|---|---|---|---|---|---|
| | Public | | | Public | Private |
| | Basic | Minimum | Targeted | Type | |
| Austria | | ✓ | ✓ | DB | |
| Belgium | | ✓ | ✓ | DB | |
| Bulgaria | | | ✓ | | |
| Croatia | CB | ✓ | ✓ | | |
| Cyprus | | ✓ | ✓ | | |
| Czechia | CB | ✓ | ✓ | DB | |
| Denmark | RB | | ✓ | DC | DC |
| Estonia | CB | | ✓ | points | DC |
| Finland | | | ✓ | DB | |
| France | | ✓ | ✓ | DB + points | |
| Germany | | | ✓ | DB + points | |
| Greece | RB | | ✓ | DB + NDC | |
| Hungary | | ✓ | ✓ | DB | |
| Ireland | CB | | ✓ | | |
| Italy | CB | | ✓ | DB + NDC | |
| Latvia | | ✓ | ✓ | DB + NDC | |
| Lithuania | CB | | ✓ | points | |
| Luxembourg | CB | ✓ | ✓ | DB | |
| Malta | CB | ✓ | ✓ | | |
| Netherlands | RB | | ✓ | | DB |
| Poland | | ✓ | ✓ | DB + NDC | |
| Portugal | | ✓ | ✓ | DB | |
| Romania | | ✓ | ✓ | | |
| Slovakia | | ✓ | ✓ | points | |
| Slovenia | | ✓ | ✓ | DB | |
| Spain | | ✓ | ✓ | DB | |
| Sweden | | | ✓ | DC + NDC | DC |

*Source:* OECD (2021). Figure created by author. Notes: CB = contribution based, RB = residence-based, DB = defined benefit, DC = defined contribution, NDC =notional defined contribution

# Chapter 3

# Literature review

Even though an aging population is a sign of a growing and advanced economy, it is regarded as a critical factor affecting the sustainability of pension systems. Nevertheless, since EU countries' population structures and pension systems differ, the impact of population ageing will vary from one to the next. To understand and accurately predict changes in demographic structure, statistical offices in each country publish demographic projections that depict the population age distribution. These projections, however, are typically disseminated in long intervals and only cover up to the year 2060, failing to capture the entire lifespan of today's young generations, who are expected to face a greater risk of inequality in old age than current retirees. Thus, this thesis aims to provide a population projection for ten European countries between 2000 and 2150 using the most recent data available.

Change in a demographic structure is expected to decrease economic growth and pose a particular threat to pension systems reliant heavily on intergeneration solidarity, such as the PAYG system. In response to this challenge, Langenus (2006) proposed a theory of pre-funding strategies to create sufficient budgetary surpluses in advance needed to finance rising costs associated with an ageing population. This approach would allow for more even distribution of the fiscal burden across generations compared to more gradual adjustment strategies. Unfortunately, due to the impacts of the Financial Crisis in 2008 and the COVID-19 pandemic, it has become inconceivable.

As proposed by Barr & Diamond (2006), any improvement to the finances of a pension system must involve one or more of the following: higher contribution rates, lower benefits, later retirement at the same benefit or policies designed to increase national output. However, these parameters are rigid, heavily influenced by public opinion and can be shifted only within limits. Moreover any reform is likely to cause hardship for either the old-aged beneficiaries or the young-aged contributors.

## 3.1 Retirement age

The effect of raising the retirement age was examined in Bielecki *et al.* (2016), concluding that for increasing longevity, raising the retirement age is beneficial for the well-being of all current and future generations, regardless of the pension system. According to his conclusion, as longevity increases, which stems from several reasons, including rising living standards and improved medical care, people are expected to be able to work for a more extended period of their life. And if productivity remains relatively high in old age, future welfare gains may be realised.

## 3.2 Contribution rates

Financing the PAYG system may also be improved by raising the contribution rates. Nevertheless, according to Castro *et al.* (2017), such policies might lead to adverse effects on the economic growth due to their potential to decrease labour supply and employment.

## 3.3 Multipillar system

The prevailing opinion in the literature is that limiting the PAYG system and at least partially introducing a FF system is recommended in the case of an ageing population. The World Bank strongly recommends implementing a combination of FF and PAYG elements, a multipillar system.

Like managing any portfolio, to mitigate risk, it is advisable to use a diversification strategy, which a multi-pillar system enables, as it consists of various elements characterized by its own level of risk. Together they can deliver income more effectively and efficiently because the factors affecting each pillar are not perfectly correlated; therefore, any expected retirement income is feasible at a lower risk. This concept can be easily illustrated in the relationship between public DB (first pillar) and funded individual accounts (second or third pillar). A DB system offers benefits based on wage growth and is thus exposed to the risk associated with individual and average wages, depending on the plan's design. On the other hand, individual accounts that are invested in financial assets are subject to the risks associated with the return on these assets. Since wage growth and financial returns are not perfectly correlated, the benefits of diversifying the two "asset categories" can be easily demonstrated (Holzmann, 2005).

Although the relative pillar size has not been determined, the predominance of either pillar one or pillar two has significant implications for households' saving and consumption decisions. According to Samwick (2000), countries with a dominant first pillar tend to have lower saving rates, primarily if the DB PAYG system covers a large portion of the population. On the other hand, the paper failed to deliver robust evidence that the transition to a pension system based more on DC automatically leads to higher savings.

## 3.4 Fully funded system

Alternatively, policymakers may want to adopt a fully funded system to make pension arrangements more sustainable. According to Barr & Diamond (2006), it is necessary to consider the fiscal costs of undertaking such a shift. The amount of transition costs depends on several factors, and therefore any reform has to be evaluated concerning each country's specific economic and demographic situations. In particular, shifting towards higher levels of mandatory funding imposes a double burden on those generations who continue to pay into the PAYG system for existing pensioners whilst having to accumulate their retirement savings. Additionally, as previously mentioned, fully funded pension plans might put household finances at risk in a scenario with low or negative asset returns. On the other hand, the transition towards a fully funded system would increase the transparency of pension deficits, promoting growth in domestic savings, which might also benefit the asset markets.

Fully funded systems still play only a limited role in the euro area. According to OECD (2021), pension payments derived from private pension funds account for only about 6 % of all pension expenditures in the euro area.

## 3.5 Alternative opinions

Besides the proposed structural and parametric changes, several economists have looked at the problem from a different perspective. For example, Loužek (2014), emphasizes that the fundamental problem the pension systems face is not financial or demographic, hence political. He believes the PAYG system can always be regulated by a combination of three parameters (retirement age, pension insurance rate, replacement ratio) even under unfavorable demographic development. Additionally, he concludes that how the ratio of public and private pensions will be established is a political question heavily influenced by public opinion.

## 3.6 Overlapping generation model

To analyze the long-term economic implications of the interactions between different generations of individuals within an economy, a growing body of literature suggests using the general equilibrium overlapping generation model (OLG). Samuelson (1958) and Diamond (1965) were the first to introduce it, and since then, OLG models have been significantly improved and now constitute a fundamental theoretical framework for analyzing pension systems. The basic OLG model by Diamond (1965) has the following characteristics: Time evolves discretely and is divided into successive periods of equal length. Individuals live for two periods; in each period, a new generation is born. Notably, in each period, two generations (Young and Old) are alive and interact with each other. During the first period of their life, individuals are referred to as Young. They supply their labour to firms and earn wages in return. They consume an endogenous fraction of their income and save the remainder for retirement. During the second period, individuals are referred to as Old, no longer represent a labour supply and live off all the savings they made when Young.

As indicated, the model can be viewed as an intergenerational optimization problem, as generations optimize their consumption-saving patterns over life. In the baseline of the Diamonds, pension schemes may be adjusted by introducing a government sector, which collects taxes from young individuals and redistributes invested returns to old individuals. Such a setup permits the model to project the accumulation and transfer of wealth over time and across generations. The extent to which a pension system is modelled, and the techniques used in the literature, vary substantially depending on the paper's intended purpose.

The pioneering large-scale numerical OLG model focusing on the dynamics of an ageing population is presented in Auerbach *et al.* (1989). It traces the life choices of each generation regarding labour supply, retirement, consumption, fertility, and bequest behaviour. As individuals are expected to be entirely rational, they base their decisions on current and future tax rates and pension benefits, which are assumed to be known. The model stimulated the general equilibrium effects of demographic changes in four OECD countries. With no surprise, their analysis indicated that rates of national saving, real wage rates, and current accounts all appear very sensitive to the forecast increases in dependency ratios. Thus, they have confirmed the intuition that significant changes in demographic structure will have a major impact on economic performance.

A substantial body of literature (e.g., Cremer *et al.* (2006), Ehrlich & Lui (1998), Cipriani (2014)) shares the conviction that PAYG pension schemes are especially vulnerable to a drop in fertility because it leads to the reduction of future workers who will provide support to retirees. However, this classical externality is refuted by Fanti & Gori (2012), who came up with a finding that a falling fertility rate may have a positive effect on the PAYG system. They justify their opinion by stating that the fertility drop may cause public pension payments to rise because of falling costs for raising children. Despite adopting a different point of view, Cigno (1993) reached the same conclusion, stating that a fall in the fertility rate causes the capital-labour ratio to increase, resulting in higher output per capita and higher pension payouts.

Cremer *et al.* (2011) extended his model to incorporate the impact of a parent's choice of the number and educational attainment of his children. He concluded that investments in education must be subsidized, as it increases the proportion of high-ability children in the economy and entails positive externalities, i.e., shifting the focus of child investment from quantity to quality leads to a higher proportion of high-ability individuals, resulting in higher future wages and higher tax revenues for the pension system.

# Chapter 4

# Methodology

A crucial first step in calculating the anticipated fiscal burden on future generations in the context of an ageing population and the current design of the pension systems is the preparation of demographic projections. Population projections offer insight into the size and age distribution of the future workforce, which is particularly important for pension funds, which need to accurately forecast the number of retirees and the amount of money required to cover their retirement benefits. Therefore, the projection of demographic development plays a vital role in the long-term sustainability of public finances.

Once the projection is complete, the intergenerational accounts method can be utilised to show the assumed generation-specific pension payments and expenditures. In this context, *payments* refer to pension contributions and *expenditures* refer to pension benefits. The difference between the two figures for each generation will indicate the pension system's anticipated fiscal burden.

Lastly, within the framework of this thesis, it is also relevant to examine the significance of demographic factors affecting the old-age dependency ratio. For this purpose, the relevance of fertility, mortality and migration rate on the old-age dependency ratio is investigated.

This chapter is divided into three sections. The first section outlines the steps used to project demographic development. The second depicts the calculation of the pension system's income and expenditures. The last section focuses on the analysis of panel data regression.

## 4.1 Population projection

Population projection is created using the cohort-component method, which employs the initial age and sex structure of the population as well as assumptions on the future components of population change: fertility, mortality, and migration to project the population by age and sex. The components of change are projected separately for each birth cohort (persons born each year).

The primary input data for the projection are the population size of a given country by sex and age as of 1. January 2022. Each year, this base population is advanced using expected survival rates and the net balance of migrants. Further, by applying the expected fertility rates to the female population, a new birth cohort is added to the population each year. Population trends are projected from 2022 to 2150 to capture the complete or nearly complete history of the generations alive today.

With this procedure, the projection calculations are carried out independently for each sex. The first step is to obtain data about the size and age structure of the population as of year $t$. The number of persons of completed age $x$ at the beginning of year $t+1$ is calculated from the number of survivors of the previous year and the net migration balance of persons in that age cohort:

$$S_{t+1,x+1} = S_{t,x} \cdot P_{t,x} + (\triangle_{t,x} \cdot P_{t,x}^{2/3} + \triangle_{t,x+1} \cdot P_{t,x}^{1/3}), \tag{4.1}$$

where $S_{t,x}$ is the number of persons alive at the beginning of year $t$ at completed age $x$ and $\triangle_{t,x}$ is the difference between the number of immigrants and emigrants that reached age $x$ in year $t$. Moreover, it is assumed that immigrants exhibit the same demographic traits as the "domestic" population. $P_{t,x}$ is the so-called projection coefficient in year $t$ for age $x$, which reflects the mortality rate for a given age cohort. In other words, it indicates what proportion of persons aged $x$ at the year $t$ will survive to the beginning of year $t+1$.

The method described above fails to calculate the number of 0-year-olds at the beginning of year $t+1$ because they were born during year $t$ and were not yet living at the start of year $t$. Thus, the population of newborns at the beginning of year $t+1$ is calculated as follows:

$$S_{t+1,0} = N_t \cdot P_t + \frac{1}{2} \cdot (\triangle_{t,0} \cdot P_t), \tag{4.2}$$

where $N_t$ is the number of births during year $t$ and $P_t$ is the projection coefficient for these newborns.

The number of births during year $t$, $N_t$, depends on the fertility rate in that year, $f_{t,x}$, in a given age cohort of women between 15 and 49 years of age, i.e. in the reproductive age:

$$N_t = \delta \cdot \sum_{x=15}^{49} \frac{S^w_{t,x} + S^w_{t+1,x}}{2} \cdot f_{t,x}, \tag{4.3}$$

where the parameter $\delta$ is the proportion of newborns of a given sex, $\delta = 0.515$ for males and $\delta = 0.485$ for females. Index $w$ is used to distinguish the female part of the population.

By following the steps outlined previously, an approximation of the population's age distribution at time *t+1* was obtained.

The same procedure is carried out to estimate the age structure of the population for each year within the period from 2022 to 2150. This projection's base year is 2022, represented as *t=0*. The time horizon for the projection extends until the year 2150, denoted as $t{=}T$, where $T$ represents the endpoint of the projection period. The age variable, $x$, ranges from zero to 100 years, which is considered to be the theoretical upper limit of human lifespan in this projection.

## 4.2 Pension scheme balance

Once the projection is completed, the pension scheme revenue and expenditure can be computed to depict the relationship between demographic structure and pension scheme balance.

### 4.2.1 Pension system revenues

The pension system revenues consist of pension insurance payments deducted from employees' wages.

The social insurance payment from age cohort $x$ in year $t$ is calculated by multiplying the expected number of employees (in cohort $x$ at time $t$), $L_{t,x}$, the average wage (in year $t$), $E_t$, and the pension contribution, $PC$:

$$\textit{payment of pension insurance}_{t,x} = L_{t,x} \cdot E_t \cdot PC \tag{4.4}$$

It is presumed that the rate of pension insurance, PC, remains unchanged throughout the projection and is the same for all workers regardless of occupation type and age group. The level of annual average wages, $E_t$, changes only with time and increases by constant rate.

The number of people working at age $x$ in year $t$, $L_{t,x}$, is determined by multiplying the number of people in the age cohort, $S_{t,x}$, by the corresponding employment-population ratio, which measures the proportion of a country's working-age population. Further, it is assumed that a generation becomes economically active when it reaches the age of 15 and remains so until the end ($x=100$).

#### Generational payments

The total pension payment of one generation can then be expressed as the sum of all payments of that generation, i.e.:

$$\sum_{t} \sum_{x=15}^{100} \textit{payment of pension insurance}_{t,x} \tag{4.5}$$

To illustrate, *total payment of the generation born in 2000 = payment of 15-year-olds in 2015 + payment of 16-year-olds in 2016 + ... + payment of 100-year-olds in 2100.*

### 4.2.2 Pension system expenditures

The pension system expenditures refer to the total amount spent on pension benefits. Since most pension beneficiaries receive old-age pensions, other types of pensions, such as invalidity or survivor's, are not considered.

To simulate the number of old-age pension beneficiaries, the projected number of workers of a given age, $L_{t,x}$, is subtracted from the size of the individual cohorts, $S_{t,x}$, projected by the demographic projection. Thus, it is assumed that those economically active beyond retirement age will not receive pensions and, conversely, all those not working beyond retirement age will receive pensions. The retirement age, $r$, remains constant throughout the projection period, and its value is determined by the actual retirement age in a given country in 2022.

The projected average wage, $E_t$, and the replacement ratio, $R$, determine the average retirement pension for a given year and age. The replacement ratio, which measures a retired person's pension as a percentage of their pre-retirement income, stays constant throughout the projection period and is the same for both men and women. The average old-age pension is obtained by multiplying this ratio by the projected average wage, which we assume is the same for all pensioners in a given year.

$$\textit{pension benefit}_{t,x} = (S_{t,x} - L_{t,x}) \cdot E_t \cdot R \quad \text{for all } x \geq r \tag{4.6}$$

#### Generational expenditures

The total expenditure on pension benefits on a generation can then be expressed as the sum of all pensions paid out, i.e.:

$$\sum_{t} \sum_{x=r}^{100} \textit{pension benefit}_{t,x} \tag{4.7}$$

To illustrate, if $r$ = *65*, then *total pension expenditure on the generation born in 2000 = pension benefit of 65-year-olds in 2065 + pension benefit of 66-year-olds in 2066 + ... + pension benefit of 100-year-olds in 2100.*

## 4.3 Panel data model

There is a prevailing view that the demographic changes in fertility, mortality and, to a lesser extent, migration profoundly affect the age structure in many developed countries. In order to determine the relative contribution of these factors to population ageing, a panel data analysis is conducted. The following regression equation expresses the panel data model:

$$Y_{it} = \beta_0 + \beta_1 MIG_{1it} + \beta_2 FR_{2it} + \beta_3 LE_{3it} + \epsilon_{it},$$

where the dependent variable $Y$, the old-age dependency ratio, captures the ratio of the number of individuals aged 65 and over per 100 people of working age, defined as those aged 15-64. *MIG* stands for net migration rate, defined as the difference between the number of immigrants and emigrants per 1000 population. *FR* represents the total fertility rate, characterized as the projected number of children a woman would have throughout her reproductive years, 15-49, assuming she survived until the end of that period and gave birth to children following the current age-specific fertility rates. Lastly, *LE* refers to life expectancy at age 65 years old, the average number of years a 65-year-old person can be expected to live, assuming that age-specific mortality levels remain constant.

# Chapter 5

# Data Description

## 5.1 Population projection

For the scope of this thesis, the currently available demographic projections generated by national statistical offices are insufficient for several reasons. Firstly, these projections are published in long, often five-year intervals. Secondly, they typically capture only a period up to 2060, thus failing to encompass the entire lifespan of currently living generations adequately. Moreover, since the last projections were released, the demographic structures and projected evolution have been significantly affected by two unexpected events: the COVID-19 pandemic and the war in Ukraine.

Therefore, the central core of this thesis is to deliver a population projection for the period 2000-2150 utilizing the most up-to-date data for ten European countries: Austria, Belgium, Czechia, Finland, Germany, Hungary, Luxembourg, Portugal, Slovenia and Spain. As described in the methodology, three main variables enter the projection: fertility, mortality, and migration. Assumptions for fertility rates by age and sex for 2022-2100 are collected from Eurostat. Assumptions on mortality and migration rates by age and sex for 2022-2100 are retrieved from the United Nations. For the years 2100-2150, the values of the three parameters remain unchanged, staying at the same level as in the year 2100.

The following tables present the data used for the demographic projection of Austria as an example. The population's age structure is estimated from 2023 onwards, with 2022 serving as the base year. Between 2000 and 2022, the projection relies on real-world data. To reiterate, fertility rates refer to the estimated number of live births per woman in her reproductive years, 15-49 years. Net migration reflects the difference between the number of immigrants and emigrants, and survival rates demonstrate the likelihood of survival to the following year. Similarly, the demographic data collected for Austria is obtained for the remaining countries.

Table 5.1: Fertility rates: Austria

| *Age/Year* | 2022 | 2023 | ⋯ | 2099 | 2100 | ⋯ | 2150 |
|---|---|---|---|---|---|---|---|
| 15 | 0.00026 | 0.00026 | ⋯ | 0.00043 | 0.00043 | ⋯ | 0.00043 |
| 16 | 0.00107 | 0.00108 | ⋯ | 0.00173 | 0.00173 | ⋯ | 0.00173 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 29 | 0.09691 | 0.09710 | ⋯ | 0.10762 | 0.10774 | ⋯ | 0.10774 |
| 30 | 0.10253 | 0.10273 | ⋯ | 0.11378 | 0.11390 | ⋯ | 0.11390 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 48 | 0.00042 | 0.00043 | ⋯ | 0.00086 | 0.00087 | ⋯ | 0.00087 |
| 49 | 0.00018 | 0.00018 | ⋯ | 0.00025 | 0.00025 | ⋯ | 0.00025 |

*Source:* EUROSTAT. Table created by author.

Table 5.2: Survival rates for men: Austria

| *Age/Year* | 2022 | 2023 | ⋯ | 2099 | 2100 | ⋯ | 2150 |
|---|---|---|---|---|---|---|---|
| 0 | 0.99731 | 0.99742 | ⋯ | 0.99947 | 0.99948 | ⋯ | 0.99948 |
| 1 | 0.99968 | 0.99969 | ⋯ | 0.99993 | 0.99993 | ⋯ | 0.99993 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 29 | 0.99951 | 0.99952 | ⋯ | 0.99988 | 0.99988 | ⋯ | 0.99988 |
| 30 | 0.99949 | 0.99950 | ⋯ | 0.999987 | 0.999988 | ⋯ | 0.99988 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 98 | 0.65394 | 0.65525 | ⋯ | 0.73493 | 0.73616 | ⋯ | 0.73616 |
| 99 | 0.62988 | 0.63105 | ⋯ | 0.70382 | 0.70497 | ⋯ | 0.70497 |
| 100 | 0.00000 | 0.00000 | ⋯ | 0.00000 | 0.00000 | ⋯ | 0.00000 |

*Source:* UN. Table created by author.

Table 5.3: Survival rates for women: Austria

| *Age/Year* | 2022 | 2023 | ⋯ | 2099 | 2100 | ⋯ | 2150 |
|---|---|---|---|---|---|---|---|
| 0 | 0.99771 | 0.99777 | ⋯ | 0.99971 | 0.99972 | ⋯ | 0.99972 |
| 1 | 0.99978 | 0.99978 | ⋯ | 0.99997 | 0.99997 | ⋯ | 0.99997 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 29 | 0.99977 | 0.99977 | ⋯ | 0.99996 | 0.99996 | ⋯ | 0.99996 |
| 30 | 0.99976 | 0.99977 | ⋯ | 0.99996 | 0.99996 | ⋯ | 0.99996 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 98 | 0.67352 | 0.67448 | ⋯ | 0.76796 | 0.76941 | ⋯ | 0.76941 |
| 99 | 0.64660 | 0.64747 | ⋯ | 0.73424 | 0.73563 | ⋯ | 0.73563 |
| 100 | 0.00000 | 0.00000 | ⋯ | 0.00000 | 0.00000 | ⋯ | 0.00000 |

*Source:* UN. Table created by author.

Table 5.4: Net number of male migrants: Austria

| *Age/Year* | 2022 | 2023 | ⋯ | 2099 | 2100 | ⋯ | 2150 |
|---|---|---|---|---|---|---|---|
| 0 | 1221 | 708 | ⋯ | 281 | 278 | ⋯ | 278 |
| 1 | 753 | 269 | ⋯ | 201 | 200 | ⋯ | 200 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 29 | 139 | 73 | ⋯ | 380 | 379 | ⋯ | 379 |
| 30 | 168 | 83 | ⋯ | 383 | 382 | ⋯ | 382 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 98 | -1 | -2 | ⋯ | 0 | 0 | ⋯ | 0 |
| 99 | 0 | -1 | ⋯ | 0 | 0 | ⋯ | 0 |
| 100 | 2 | -2 | ⋯ | 1 | 1 | ⋯ | 1 |

*Source:* UN. Table created by author.

Table 5.5: Net number of female migrants: Austria

| *Age/Year* | 2022 | 2023 | ⋯ | 2099 | 2100 | ⋯ | 2150 |
|---|---|---|---|---|---|---|---|
| 0 | 1157 | 646 | ⋯ | 308 | 306 | ⋯ | 306 |
| 1 | 764 | 278 | ⋯ | 250 | 250 | ⋯ | 250 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 29 | 1019 | 293 | ... | 398 | 397 | ... | 397 |
| 30 | 1025 | 258 | ... | 376 | 376 | ... | 376 |
| ⋮ | ⋮ | ⋮ | ⋱ | ⋮ | ⋮ | ⋱ | ⋮ |
| 98 | -3 | -35 | ... | 0 | 0 | ... | 0 |
| 99 | 1 | -2 | ... | 0 | 0 | ... | 0 |
| 100 | 5 | -4 | ... | 1 | 1 | ... | 1 |

*Source:* UN. Table created by author.

## 5.2 Pension scheme balance

The employment-population ratio, which represents the percentage of a nation's working-age population employed, was used to calculate the expected number of employees making pension insurance payments to the pension system. It is assumed that employment only includes individuals aged 15 and above. The actual employment-population ratio figures from 2000 to 2021 were retrieved from ILOSTAT. For the years 2022 and beyond, the average employment-population ratio from 2000 to 2021, shown in Table 5.6, was used and held constant.

Table 5.6: Age-specific employment rates by country (%)

| Age | AUT | BEL | CZE | FIN | GER | HUN | LUX | POR | SLO | ESP |
|---|---|---|---|---|---|---|---|---|---|---|
| 0-14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15-19 | 35 | 6 | 5 | 24 | 27 | 5 | 9 | 11 | 12 | 9 |
| 20-24 | 66 | 44 | 49 | 60 | 64 | 43 | 42 | 49 | 49 | 42 |
| 25-29 | 80 | 77 | 75 | 75 | 76 | 72 | 81 | 77 | 78 | 68 |
| 30-34 | 84 | 81 | 78 | 80 | 81 | 76 | 86 | 83 | 88 | 74 |
| 35-39 | 85 | 82 | 85 | 83 | 83 | 79 | 84 | 84 | 89 | 75 |
| 40-44 | 86 | 81 | 89 | 85 | 84 | 81 | 83 | 83 | 89 | 74 |
| 45-49 | 85 | 79 | 90 | 85 | 84 | 80 | 81 | 81 | 86 | 71 |
| 50-54 | 79 | 72 | 86 | 82 | 80 | 74 | 75 | 75 | 77 | 66 |
| 55-59 | 59 | 54 | 70 | 71 | 71 | 56 | 53 | 62 | 50 | 55 |
| 60-64 | 20 | 21 | 30 | 41 | 42 | 21 | 17 | 42 | 18 | 34 |
| 65+ | 4 | 5 | 5 | 5 | 5 | 2 | 2 | 15 | 6 | 2 |

*Source:* ILOSTAT. Table created by author.

The retirement ages, $r$, presented in Table 5.7 were held constant throughout the entire projection period and were based on the actual retirement age in each country in 2022.

Table 5.7: Retirement ages by country

| | AUT | BEL | CZE | FIN | GER | HUN | LUX | POR | SLO | ESP |
|---|---|---|---|---|---|---|---|---|---|---|
| $r$ | 65 | 65 | 65 | 65 | 65 | 62 | 65 | 65 | 60 | 65 |

*Source:* EUROSTAT. Table created by author.

The data on average annual gross wages from 2000 to 2021 were obtained from OECD in 2021 constant prices and national currency units. To project future wage growth, the wages for each year were adjusted by multiplying them with an annual wage growth rate. This growth rate equals an average of the annual growth rates from 2000 to 2021. Next, the contribution rate, which represents the social security contribution, is also held constant for the whole projection and was obtained from the OECD. Lastly, the replacement ratio used for the entire projection is an average of the period 2000-2021 and was obtained from EUROSTAT.

The following Table 5.8 summarizes the above-described retirement parameters, which were used for the projection of generation-specific pension payments and expenditures.

Table 5.8: Annual wage growth rate, contribution rate and replacement ratio by country (%)

| Country | Annual Wage Growth Rate | Contribution Rate | Replacement Ratio |
|---|---|---|---|
| AUT | 0.63 | 22.80 | 51.00 |
| BEL | 0.39 | 16.50 | 45.55 |
| CZE | 2.93 | 28.00 | 51.00 |
| FIN | 1.00 | 16.50 | 50.00 |
| GER | 0.78 | 18.60 | 46.29 |
| HUN | 2.31 | 26.50 | 59.71 |
| LUX | 1.00 | 24.00 | 74.72 |
| POR | 0.19 | 23.80 | 59.33 |
| SLO | 1.92 | 24.40 | 45.00 |
| ESP | 0.05 | 28.30 | 58.83 |

*Source:* EUROSTAT, OECD. Table created by author.

## 5.3 Panel data model

The panel data set is balanced and contains information on selected 25 countries: Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden over the period 1970-2021.

Fertility rates (FR) and life expectancy (LE) data are retrieved from EUROSTAT, migration rates (MIG) are retrieved from the United Nations and data on old-age dependency ratio (Y) are obtained from the World Bank. To provide insight into the data set, Table 5.9 summarizes minimum, maximum, and median values for all variables included in the model. In the last column of the table, the anticipated outcome is presented, indicating whether the independent variable is expected to have a positive (+) or negative (−) effect on the old-age dependency ratio.

Table 5.9: Summary of variable statistics and expected relationships

| **Variable** | **Minimum** | **Maximum** | **Median** | **Expected Relationship** |
|---|---|---|---|---|
| $Y$ | 12.67 | 37.19 | 21.44 | |
| $MIG$ | − 24.68 | 22.68 | 0.90 | − |
| $FR$ | 1.09 | 3.98 | 1.63 | − |
| $LE$ | 12.65 | 21.85 | 16.00 | + |

*Source:* EUROSTAT, UN, World Bank

It is worth noting that the data set for panel data regression was intentionally extended and thus contains information not only on the ten European countries examined before, but also on other countries (listed above). This was done to improve the accuracy of the results.

# Chapter 6

# Discussion of Results

## 6.1 Population projection

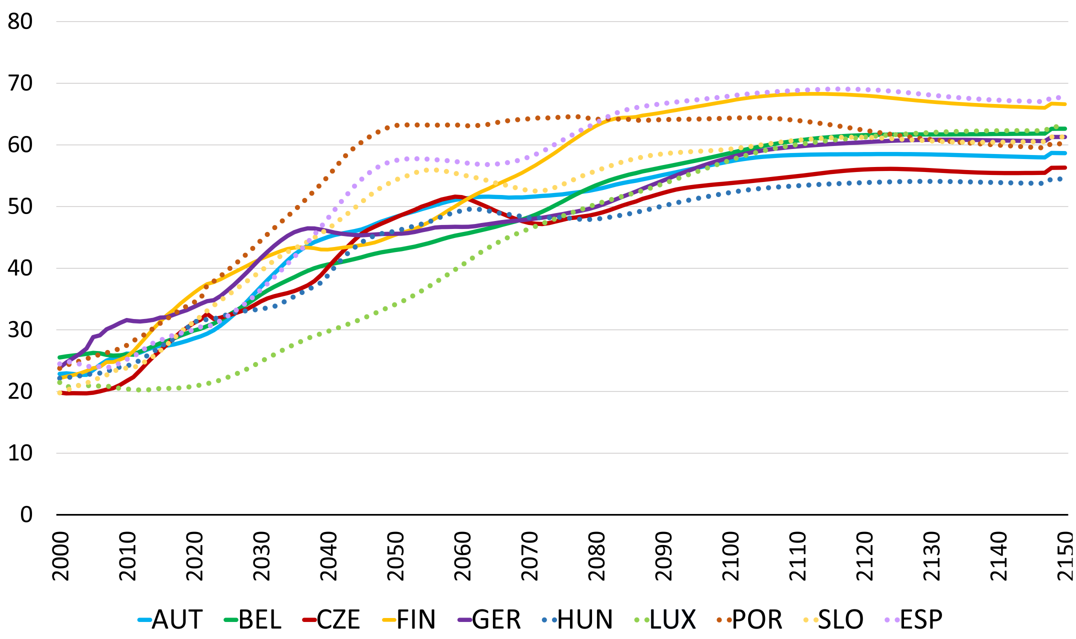
After finishing the projection, it is evident that the old-age dependency ratio is expected to double in less than 50 years in every country, as illustrated in Figure 6.1.

Portugal will experience the fastest increase in the old-age ratio in the first 40 years of the projection, with Spain following closely behind. Both will be the first to reach the 50 % milestone between 2030 and 2040. A possible explanation for the accelerated growth of the ageing rate in these countries is that a significant portion of these countries' territories is remote, rural, or mountainous. The younger generations might tend to leave these areas to study or work elsewhere, which results in a higher concentration of elderly individuals in these regions. Additionally, high unemployment rates, job insecurity, and deteriorating working conditions may contribute to the emigration of younger generations, usually highly skilled, further exacerbating the ageing population trend in these remote areas. The Portuguese old-age dependency ratio is predicted to peak at around 64 % in 2050 and fluctuate around that level until 2150. In other words, there will be two or more elderly people for every working-age person, making Portugal one of the "oldest" countries in the EU.

Belgium and Luxembourg are expected to experience moderate growth in their old-age dependency ratios, with growth slowing down around 2100 and peaking at around 60 % by the end of the projection period. Remarkably, Czechia will experience a sharp rise in its old-age dependency ratio by up to 30 percentage points by 2055, followed by a fall. This sharp rise is generally attributed to the shift of the strong generation born in the 1970s to the retirement age.

For a more comprehensive overview of old-age ratios by country and year, please refer to the Table A.1 in Appendix A.

Figure 6.1: Old-age dependency ratio (%)




## 6.2 Pension scheme balance

The demographic projections from the previous chapter and the economic assumptions presented in Section 5.2 form the basis for the projection of the generation-specific revenues and expenditures.

Utilizing the generational accounts methodology, the level of intergenerational solidarity has been quantified, i.e. an assessment of contributions (*payments*) made by each generation to the pension system and the benefits (*expenditures*) they are entitled to receive from it. The projected generational accounts in 2021-constant prices and national currency units are displayed in graphs B.1 - B.10 in the Appendix B.

Because the demographic projection described in the previous section is used for the generational methodology, the generational accounts in this study are built for the years 2000 to 2150, with actual figures for the years up to 2021.

The earliest generation for which it is possible to identify its contributions throughout their entire working life is the generation born in 1985, which enters the labour market in the first year of the projection, 2000. Conversely, the latest generation for which their most economically active years are captured is born in 2090. Focusing on this time frame, 1985–2090, nearly all graphs demonstrate that, given anticipated demographic and economic trends, each younger generation's payments will gradually rise. However, the generational accounts of Spain and Portugal deviate from this trend, as total payments stagnate at the level of the generation born in 1990.

The total pension expenditure is first documented for the generation that reached the retirement age in 2000, born between 1930 and 1940 (depending on the country's specific retirement age). The latest generation for which the total expenditures are recorded is the one born in 2050. As a result, the expenses related to the ageing of the younger generations are absent. It is evident from examining the individual generational accounts that although some generations contribute nearly identical amounts to the system, their claimed pension varies considerably. This disparity can be attributed to the rising life expectancy across generations, implying that they will draw upon their pensions for an extended time, resulting in higher generational expenditures, as indicated in the graphs.

All selected countries have to some extent, a PAYG system, where retirement benefits are financed by contributions levied from current workers. Since the projected payments and expenditures for each age cohort and year are already available, the annual balance of the pension system for the years 2000-2150 can be calculated in addition to the generational balance. However, in such a case, evaluating the pension system's annual balance to GDP is most appropriate.

Unfortunately, current macroeconomic forecasts do not provide sufficient data for such an analysis, and projecting GDP data into the future is fraught with error. This, combined with the already existing limitations of the projection of generational accounts, such as demographic and economic assumptions, would undoubtedly limit the accuracy of any results. Nevertheless, generational accounts can be used to some extent to partially assess the pension balance if we assume that the pensions of each generation will be paid by the generation born approximately 30 years later – that is, while the first generation is retired and drawing from the system, the second generation is of economically active age. Given our timeline, we can compare, for example, the projected expenditures of the generation born in 2000 with the payments of the 2030 generation, which will gradually enter the labour market and whose payments will directly pay the pension benefits of the generation born in 2000.

## 6.3 Panel data model

Five different models with various time-lagged variables were estimated to guarantee the robustness of the results. The Hausmann test suggested that the fixed effects model was more appropriate than the random effects model, leading to the use of the Within estimator. However, the outcomes of the Durbin-Watson and Breush-Pagan tests revealed that the models exhibit both autocorrelation and heteroskedasticity. To address these issues, the models were estimated using the robust variance-covariance estimator.

Additionally, one of the independent variables, FR, was intentionally lagged for 15 years in three models. This was done to align with the definition of FR, which specifies that only individuals aged 15 or older affect the dependent variable. In Model 4 and 5, FR was lagged for 20 years.

Table 6.1 presents the outcomes of five estimated models. The lagged periods of independent variables are indicated in the brackets next to their variable names. Additionally, the standard errors are reported in brackets below the corresponding coefficients.

Consistent with the anticipated outcome, the coefficient for fertility rate is negative, and the coefficient for life expectancy is positive, suggesting that declining fertility and increasing life expectancy contribute to a higher old-age dependency ratio.

Despite expectations, the coefficient estimate for the fertility rate is only statistically significant after lagging the variable for 20 years. The absence of a significant relationship between these two variables in the first three models could be explained by the large robust standard errors caused by using the robust variance-covariance estimator to correct for both autocorrelation and heteroskedasticity. Nonetheless, based on the panel data models in which fertility rate was found to be a statistically significant predictor of the old-age dependency ratio, a one-tenth unit increase in FR can be expected to lead to a 0.18 percentage point decrease in the ratio.

On the other hand, life expectancy was found to be statistically significant across all models at the 0.001 level, indicating a strong relationship between life expectancy and the old-age ratio. Based on the estimates, a one-year increase in

Table 6.1: Results of panel data analysis

| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** |
|---|---|---|---|---|---|
| *MIG* | $-0.19^{**}$ (0.06) | | | $-0.05$ (0.06) | |
| *FR (15)* | $-1.30$ (0.97) | $-1.28$ (0.93) | $-1.21$ 0.9 | | |
| *LE* | $2.10^{***}$ (0.23) | $2.13^{***}$ (0.22) | $2.17^{***}$ (0.21) | $1.93^{***}$ (0.26) | $1.96^{***}$ (0.25) |
| *MIG (1)* | | $-0.23^{***}$ (0.06) | | | $-0.10^{*}$ (0.05) |
| *MIG (2)* | | | $-0.27^{***}$ (0.06) | | |
| *FR (20)* | | | | $-1.84$ . (1.06) | $-1.80$ . (1.04) |

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, . $p < 0.1$

life expectancy can raise the ratio by 1.93 to 2.17 percentage points, depending on the model.

Last, the migration rate appears to have a statistically significant negative relationship with the old-age dependency ratio. This can be explained by migrants being more likely to be of working age, lowering the ratio.

To summarize, this regression analysis and data set show that life expectancy is the most critical factor. As a result, there is no doubt that as life expectancy rises, the proportion of the elderly will rise, affecting the pension system and healthcare systems in general, as older people may require more medical care and resources. It is, therefore, crucial to consider the long-term implications of rising life expectancy and plan accordingly to ensure the sustainability of social security and healthcare systems.

# Chapter 7

# Conclusion

This thesis comprehensively analyses several European countries' demographic and economic challenges due to population ageing. The initial section of the study involved a demographic projection for the period up to the year 2150, utilizing the most recent data available. Based on this projection, the selected countries will likely experience substantial changes in their population structures, primarily reflected in an increase in the old-age dependency ratio. The findings indicate that by 2090, all countries examined will surpass the 50% old-age ratio threshold, with Spain and Portugal being the first countries to reach this milestone. Due to the expected need for the economically active segment of society to pay for the pension and social security benefits of the non-working population, either directly through family support or indirectly through taxation, this demographic trend implies a growing burden on the working-age population.

The demographic projection enabled estimating generation-specific pension insurance payments and projected pension expenditures, employing intergenerational accounts methodology. This approach allowed for the measurement of intergenerational solidarity between currently living and the upcoming generations. While the OLG model used in this study has limitations due to specific demographic and economic assumptions, the analysis still offers insights that shed light on the problematic aspects of the PAYG pension system. For instance, the findings indicate that the anticipated increase in payments will not keep pace with escalating pension costs, attributed to more extended retirement periods resulting from increasing life expectancy and demographic trends. Given the projected increase in pension benefits that each successive generation is expected to demand, it is inevitable that the pension system deficit will rise over time.

The third section of the study involved a panel data regression analysis to investigate the determinants of population ageing, such as life expectancy, migration, and fertility rates. The results suggest that increasing life expectancy significantly affects the demographic shift towards an ageing population in the selected countries. A one-year increase in life expectancy leads to an approximately two percentage point increase in the old-age ratio. Some degree of significance was also observed for the migration rate.

In conclusion, the analysis in this thesis emphasizes the urgent need for policymakers in several European countries to address the issues raised by an ageing population, particularly in the context of pensions and intergenerational solidarity. As the results from demographic and generational projections indicate, the PAYG system is unsustainable in the long term. Utilizing the outcomes of panel data regression, some of the proposed solutions to at least partially lessen the extent of the system's anticipated fiscal burden might include incorporating working-age migrants in the system or improving conditions for working mothers. Finally, policymakers need to promote individual savings to address the limits of pension system financing.

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# Appendix A

# Population projection

Table A.1: Old-age dependency ratio by country and year (%)

| | AUT | BEL | CZE | FIN | GER | HUN | LUX | POR | SLO | ESP |
|---|---|---|---|---|---|---|---|---|---|---|
| 2000 | 22.86 | 25.53 | 19.83 | 22.17 | 23.88 | 22.15 | 21.46 | 23.76 | 19.78 | 24.47 |
| 2005 | 23.48 | 26.26 | 19.80 | 23.80 | 28.84 | 22.93 | 21.04 | 25.71 | 21.82 | 24.17 |
| 2010 | 26.16 | 26.03 | 21.71 | 25.63 | 31.58 | 24.12 | 20.43 | 27.48 | 23.80 | 25.21 |
| 2015 | 27.43 | 27.84 | 26.65 | 31.33 | 31.99 | 27.18 | 20.50 | 31.05 | 26.59 | 28.30 |
| 2020 | 28.59 | 29.89 | 31.11 | 35.97 | 33.70 | 31.19 | 20.86 | 34.46 | 31.27 | 29.97 |
| 2025 | 31.57 | 32.28 | 32.31 | 38.75 | 36.37 | 32.45 | 22.27 | 39.60 | 35.54 | 32.18 |
| 2030 | 36.95 | 35.70 | 34.62 | 41.48 | 41.63 | 33.38 | 24.83 | 44.48 | 39.51 | 36.48 |
| 2035 | 42.20 | 38.55 | 36.30 | 43.31 | 45.84 | 35.41 | 27.64 | 49.36 | 43.20 | 41.81 |
| 2040 | 45.05 | 40.60 | 40.10 | 43.02 | 46.03 | 38.80 | 29.75 | 54.86 | 46.35 | 48.04 |
| 2045 | 46.27 | 41.76 | 45.55 | 43.74 | 45.34 | 44.16 | 31.72 | 60.40 | 50.66 | 54.37 |
| 2050 | 48.29 | 42.93 | 48.16 | 45.37 | 45.59 | 45.98 | 34.07 | 63.13 | 54.23 | 57.45 |
| 2055 | 49.88 | 44.04 | 50.34 | 47.41 | 46.34 | 47.48 | 36.96 | 63.22 | 55.93 | 57.69 |
| 2060 | 51.26 | 45.48 | 51.53 | 50.70 | 46.70 | 49.33 | 40.47 | 63.17 | 55.17 | 57.16 |
| 2065 | 51.55 | 46.72 | 49.31 | 53.44 | 47.31 | 49.04 | 43.93 | 63.54 | 53.85 | 56.87 |
| 2070 | 51.56 | 48.26 | 47.36 | 56.08 | 47.93 | 48.20 | 46.37 | 64.23 | 52.62 | 58.03 |
| 2075 | 51.97 | 50.79 | 47.83 | 59.54 | 48.76 | 48.25 | 48.44 | 64.47 | 53.54 | 60.74 |
| 2080 | 52.77 | 53.43 | 48.77 | 63.06 | 49.95 | 47.98 | 50.37 | 64.16 | 55.78 | 63.55 |
| 2085 | 54.02 | 55.19 | 50.52 | 64.45 | 52.02 | 48.83 | 51.96 | 64.13 | 57.54 | 65.82 |
| 2090 | 55.11 | 56.36 | 52.20 | 65.27 | 54.20 | 50.09 | 53.68 | 64.10 | 58.54 | 66.69 |
| 2095 | 56.25 | 57.47 | 53.26 | 66.20 | 56.27 | 51.28 | 55.62 | 64.19 | 58.95 | 67.31 |
| 2100 | 57.32 | 58.66 | 53.78 | 67.15 | 57.95 | 52.26 | 57.49 | 64.34 | 59.31 | 67.92 |
| 2105 | 58.07 | 59.83 | 54.33 | 67.91 | 59.11 | 52.97 | 59.03 | 64.36 | 60.05 | 68.48 |
| 2110 | 58.37 | 60.69 | 54.92 | 68.23 | 59.73 | 53.36 | 60.04 | 63.97 | 60.75 | 68.82 |
| 2115 | 58.47 | 61.27 | 55.57 | 68.25 | 60.14 | 53.67 | 60.72 | 63.27 | 61.16 | 69.05 |
| 2120 | 58.49 | 61.58 | 56.01 | 68.01 | 60.43 | 53.88 | 61.25 | 62.39 | 61.23 | 68.98 |
| 2130 | 58.45 | 61.69 | 55.89 | 67.00 | 60.82 | 54.08 | 62.01 | 60.88 | 60.63 | 68.08 |
| 2135 | 58.32 | 61.72 | 55.61 | 66.60 | 60.82 | 54.01 | 62.22 | 60.37 | 60.44 | 67.59 |
| 2140 | 58.17 | 61.77 | 55.45 | 66.31 | 60.73 | 53.89 | 62.30 | 59.97 | 60.44 | 67.26 |
| 2145 | 58.02 | 61.82 | 55.45 | 66.08 | 60.64 | 53.78 | 62.31 | 59.63 | 60.51 | 67.06 |
| 2150 | 58.67 | 62.62 | 56.31 | 66.61 | 61.28 | 54.46 | 62.94 | 60.12 | 61.28 | 67.64 |

# Appendix B

# Generational accounts

Figure B.1: Pension payments and expenditures by generations: AUT

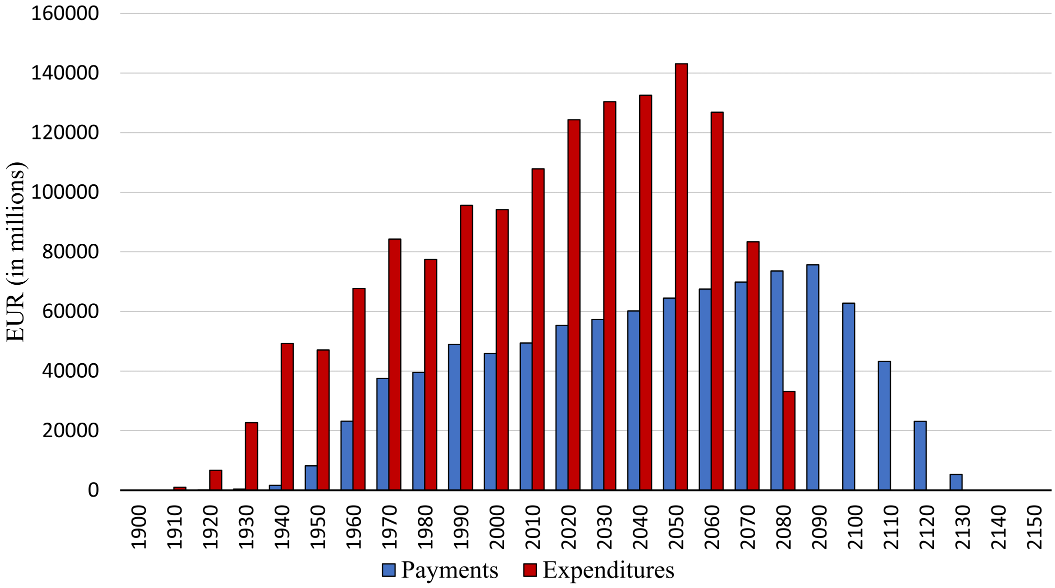

Figure B.2: Pension payments and expenditures by generations: BEL

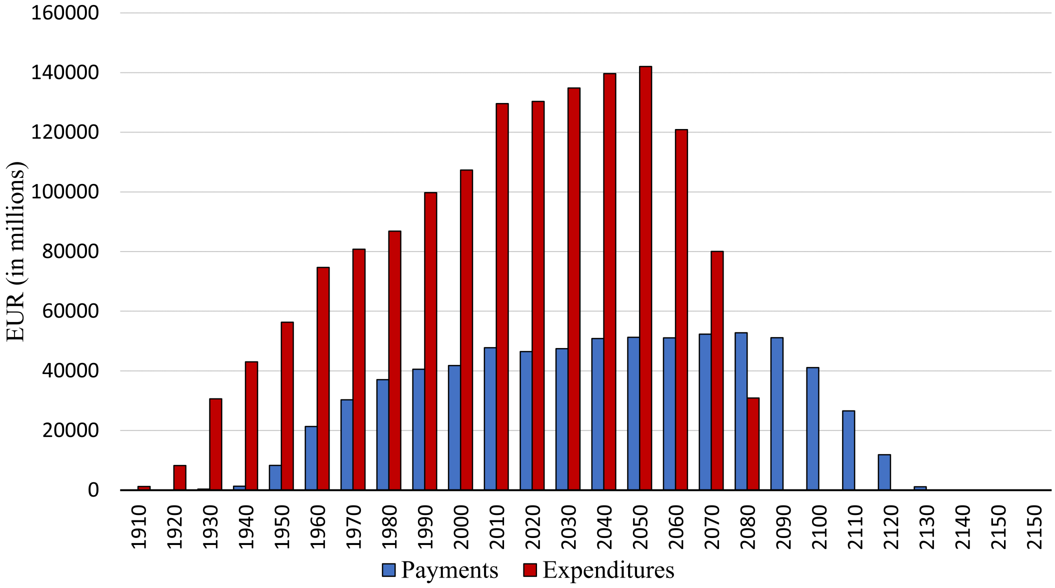


Figure B.3: Pension payments and expenditures by generations: CZE

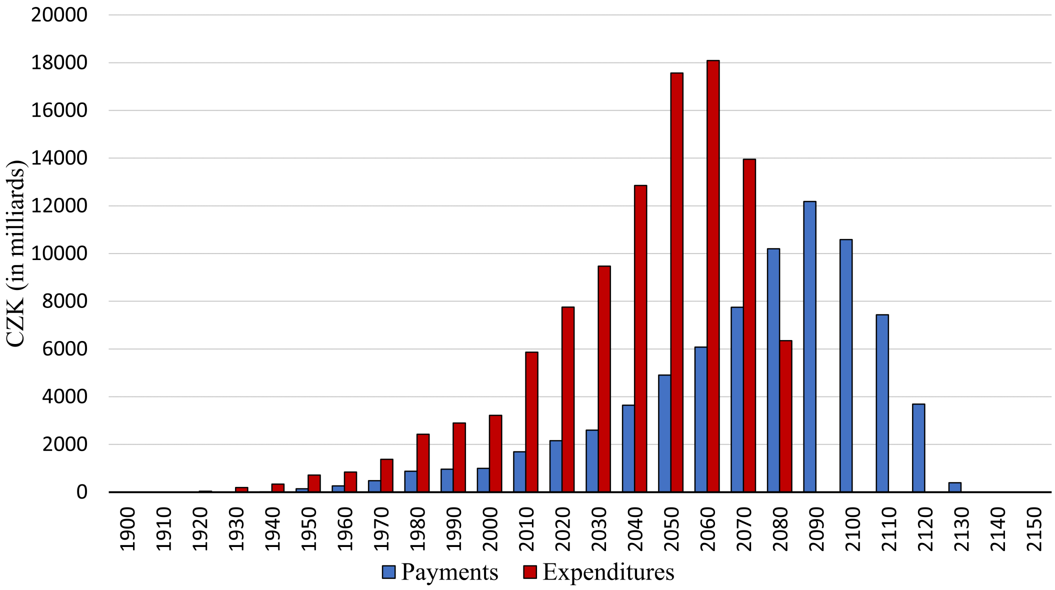

Figure B.4: Pension payments and expenditures by generations: ESP

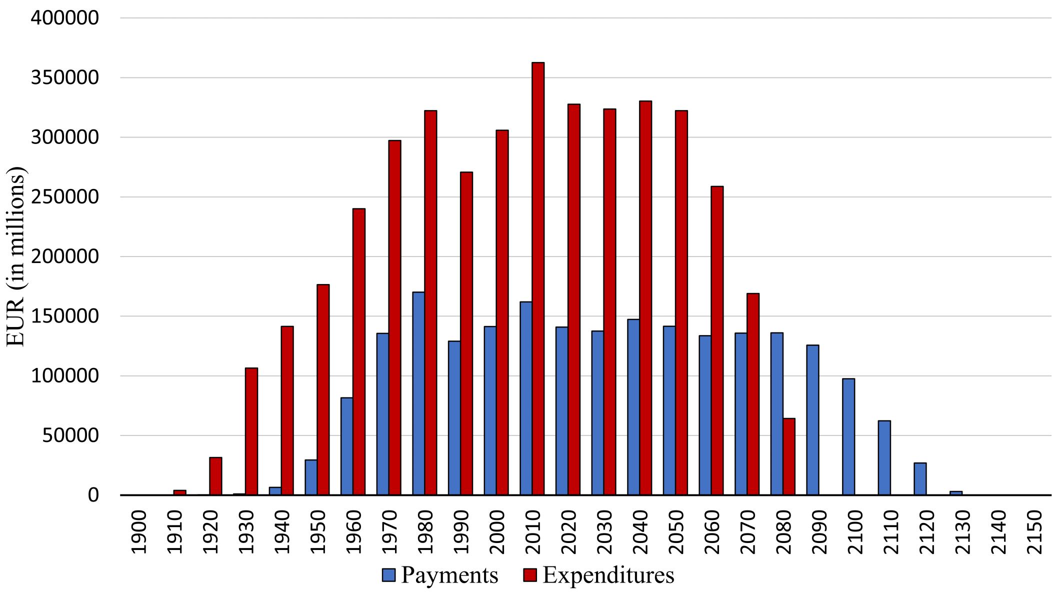


Figure B.5: Pension payments and expenditures by generations: FIN

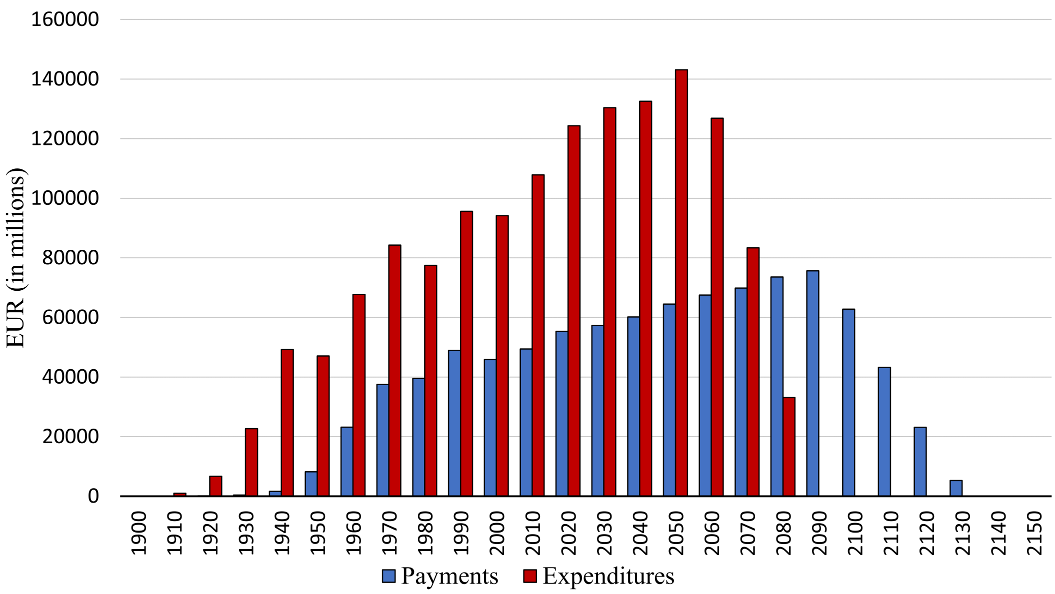

Figure B.6: Pension payments and expenditures by generations: GER

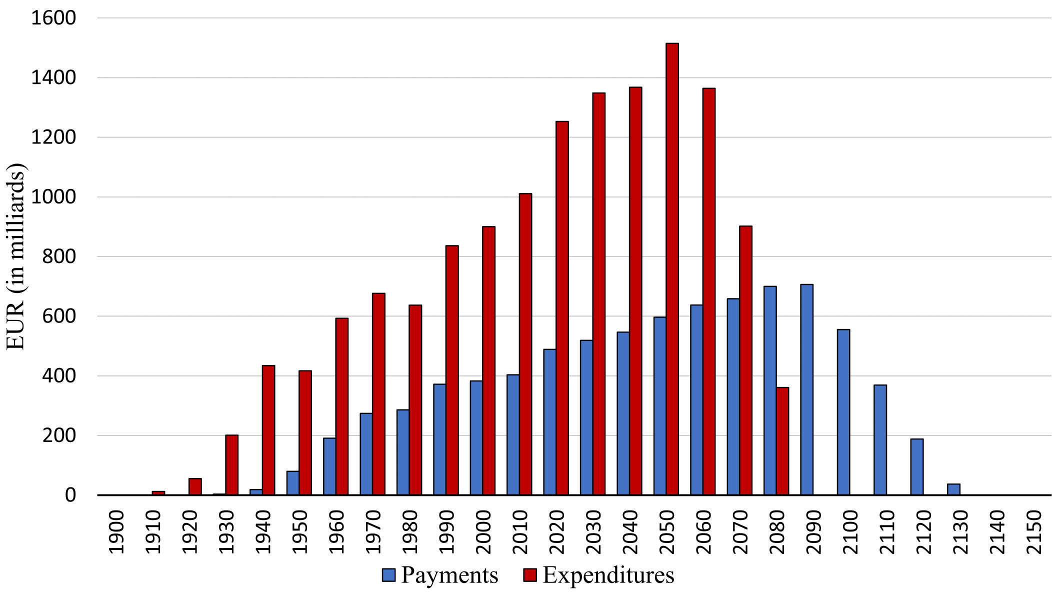


Figure B.7: Pension payments and expenditures by generations: HUN

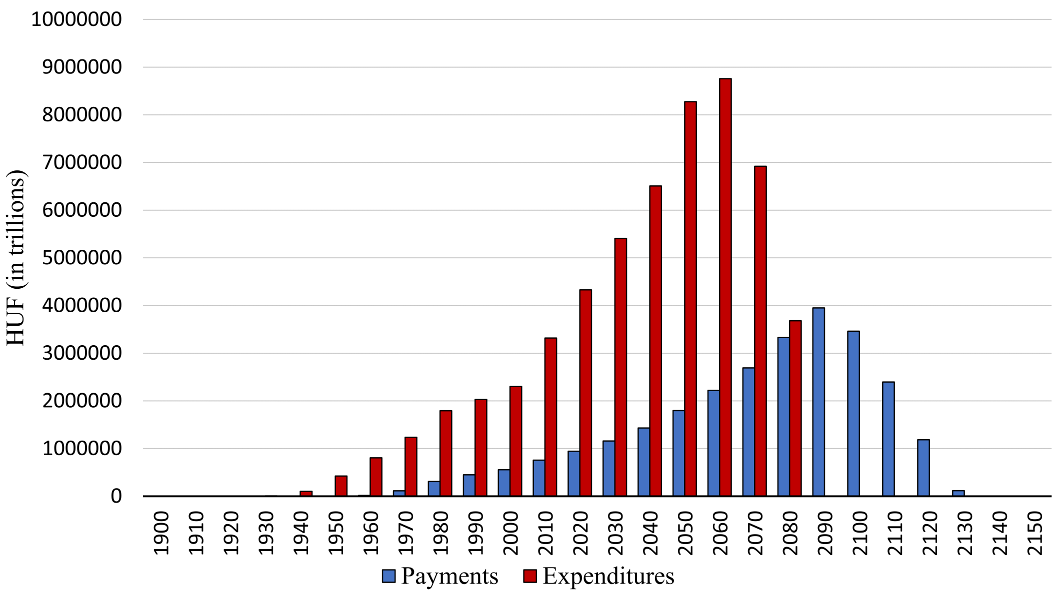

Figure B.8: Pension payments and expenditures by generations: LUX

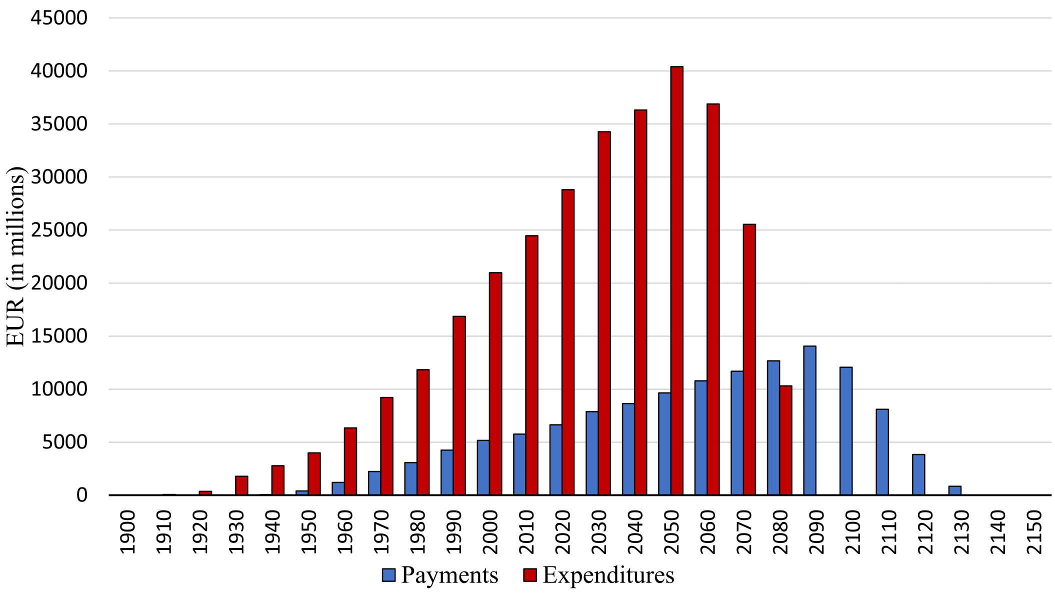


Figure B.9: Pension payments and expenditures by generations: POR

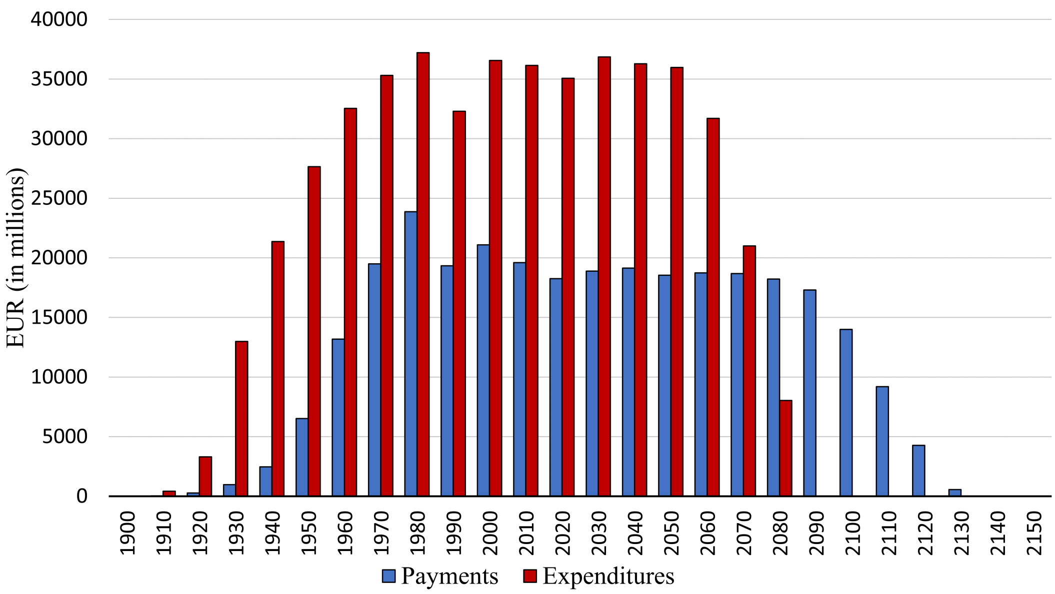

Figure B.10: Pension payments and expenditures by generations: SLO