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UNIVERSITY OF TARTU
Press
1632

School of Economics and Business Administration, University of Tartu, Estonia

The dissertation is accepted for the defence of the degree of Doctor Philosophiae (in Economics) on March 10th, 2022 by the Council of the School of Economics and Business Administration, University of Tartu.

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The public defence of the dissertation is on May 9th, 2022 at 14.00 in room 1018, Narva mnt 18, University of Tartu

The publication of this dissertation is granted by the Doctoral School of Economics and Innovation of University of Tartu created under the auspices of European Social Fund and by University of Tartu School of Economics and Business Administration.

European Union
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Language editor: Andrew Rozeik (English)

ISSN 1406-1309
ISBN 978-9949-03-856-5 (print)
ISBN 978-9949-03-857-2 (pdf)

Tartu University Press
www.tyk.ee

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LIST OF ABBREVIATIONS

ABM	Agent-based model
CPI	Consumer price index
CSD	Central Register of Securities
DB scheme	Defined benefit scheme
DC scheme	Defined contribution scheme
EHIS	Estonian Education Information System
EuroPop2019	Eurostat population projections 2019
FF	Fully funded
GRPL	Gross relative pension level
GRR	Gross replacement rate
IHS	Inverse hyperbolic sine
ILO	International Labour Organization
IRR	Internal rate of return
MoF	Ministry of Finance
MSM	Microsimulation model
NDC scheme	Notional defined contribution scheme
NPV	Net present value
NRPL	Net relative replacement rate
NRR	Net replacement rate
PAYG	Pay-as-you-go
PF	Partially funded
PPP	Personal private pension
RNPV	Ratio of net present values
SIB	Social Insurance Board
SILC	Statistics on Income and Living Conditions
SPA	Statutory pension age

LIST OF AUTHOR'S PUBLICATIONS

Articles related to the thesis:

1) **Piirits, M.,** Võrk, A. (2019). The effects on intra-generational inequality of introducing a funded pension scheme: A microsimulation analysis for Estonia. *International Social Security Review*, 72(1), 33–57.
2) **Piirits, M.** (2021). The Inequality of Public Pension Benefits for the Elderly Using Estonian Data. In *Challenges to the Welfare State: Family and Pension Policies in the Baltic and Nordic Countries*, edited by Aidukaite, J., Hort, S. E. O., and Kuhnle, S., 248–266. Edward Elgar Publishing.
3) Nijman, T., Määttänen, N., Võrk, A., **Piirits, M.,** Gal, R. (2015). Analysis of the Standardized Pan European Personal Pension (PEPP) product and its impact in four European Countries: the Netherlands, Estonia, Finland and Hungary. *Netspar Discussion Papers*, 11.
4) Määttänen, N., Võrk, A., **Piirits, M.**, Gal, R. I., Jarocinska, E., Ruzik, A., and Nijman, T. (2014). The Impact of Living and Working Longer on Pension Income in Five European Countries: Estonia, Finland, Hungary, the Netherlands and Poland. *Netspar Discussion Papers*, 36.
5) **Piirits, M.,** Võrk, A. (2015). Eesti pensionisüsteemi reformide mõju pensionide põlvkonnasisesele jaotusele. *Riigikogu Toimetised*, 32, 133−142.
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INTRODUCTION

Motivation for the research

Pensions are an important source of income for a considerable share of the population in many countries around the globe. Although the vested interests of large population groups prevent abrupt changes in retirement income systems, these systems have been evolving over time. Demographic changes have triggered pension reforms. To cope with population ageing, countries have raised the pension age. More generally, some of the risks covered earlier by the state are transferred back to individuals. Beyond demographic developments, the changing world of work is motivating additional reforms in the world of pensions (OECD 2017b).

Traditionally, pension systems have aimed at preventing old-age poverty and reducing the transposition of labour market income inequalities to retirement age incomes (European Commission 2018; Immervoll and Richardson 2011; Frick and Grabka 2010; Wang and Caminada 2011). However, reforms, which transfer responsibilities from the state back to the individuals, tend to have some significant side-effects – reducing redistribution and increasing inequalities. Differences in employment, labour income and health across individuals influence their capacities to accumulate pension rights in public pension systems, but also to collect savings in private schemes. Inequalities of labour income are transposed into inequalities of pensions if pensions are more linked to former income. This warrants a need to analyse the redistributive effects of a pension system and the evolution of these effects with pension reforms.

The Estonian case deserves closer scrutiny for several reasons. Inequality of old-age pensions in Estonia has been relatively low compared to other European countries, characterised by below EU-average income quintile share ratio[1] of 65+ population – 3.7 in Estonia, against the EU average of 4.2 in 2019 (Eurostat 2021g). On the other hand, the at-risk-of-poverty rate of 65+ persons in Estonia is one the highest in Europe – 44.6% in Estonia against the EU average of 18.5% in 2019 (Eurostat 2021i). Hence the income structure of older persons in Estonia may be characterised by relatively low incomes with relatively low inequalities. However, the pension reforms undertaken from the late 1990s – which introduced an earnings-related component of the state old-age pension and a mandatory funded defined-contribution scheme – will affect the income distribution in old age. The income quintile share ratio of the 65+ population increased by 0.4 during the period 2008–2019. This trend is expected to continue over the next 20–30 years due to higher income inequalities among the population under 65 years of age. Piirits and Võrk (2019) demonstrated that for

[1] The **income quintile share ratio** or the **S80/S20 ratio** is a measure of the inequality of income distribution. It is calculated as the ratio of total income received by the 20% of the population with the highest income (the top quintile) to that received by the 20% of the population with the lowest income (the bottom quintile). (Eurostat 2018)

a person earning the average wage over the full working career, the earnings-related component of his/her old-age pension would comprise about 70% once the pension reforms of 1999–2002 take full effect. Nonetheless, changes in the old-age pension formula enacted at the end of 2018 will reduce the relative share of the earnings-related component of old-age pension from 2021 onwards.

While it is possible to discuss in which direction each reform could affect inequality in the coming decades, in the end there have been several reforms one after the other that will change inequality in different directions. In addition, other factors in the country (wage inequality in working age, individual features of the pension system, ageing population) also play a role, and the time horizon for reforms is different (some reforms have made changes more quickly and others in several decades). In this case, it is necessary to simulate a possible future to get an idea of what the inequality could become with the assumptions of the model. In the assessment of inequality, a better picture can be obtained by using the individual data of people living in the country.

The aim and research tasks of the thesis

The focus of the current thesis is on the impact of pension reforms driven by demographic and labour market changes on old-age pension inequalities. More specifically, the core aim of the thesis is to assess the effects of pension reforms undertaken in Estonia, from pay-as-you-go towards funded schemes and back, on old-age pension outcomes for the whole population. This has been done using the analytical tools of microsimulation and typical agent models. The scrutiny is on the extent to which inequalities of labour market income over the working career are being transformed into inequalities of old-age pensions upon retirement and the extent to which the Estonian three-pillar pension system will alleviate pension inequalities. The time horizon of model projections is until 2100.

The thesis addresses the following three research questions:

- To what extent would the inequality of old-age pensions change until the end of the projection of the model?
- What is the role of different pension pillars – separately and jointly – in reducing labour market income inequalities?
- Whether the results of the typical agent and microsimulation models differ and in what direction?

Methods

The analysis is based on a typical agent pension simulation model and a semi-dynamic microsimulation model to simulate future pensions. The development of these models and their calibration for the evaluation of the Estonian pension system is one of the core contributions of the thesis.

The typical agent pension model is used to assess the intergenerational effects of the pension system based on different wage levels. In contrast, the microsimulation model covers the whole population and is therefore more suitable for the assessment of inequalities and both intra- and intergenerational effects.

Scenarios

The current thesis analyses Estonian pension reforms from the late 1990s onwards. At the end of the 1990s, there was only a pay-as-you-go (PAYG) service years-based scheme. Initially, the length of service scheme was changed into an income-based component and, in addition, a voluntary funded pillar was created. In the following years, a mandatory funded pillar was established. The latest reforms relate to the modification of the PAYG scheme, e.g. raising the statutory pension age (SPA) and linking the life expectancy to SPA or returning to length of service component. The work assesses previous reforms and reforms that have already been accepted, but which will be implemented in the future. The scenarios are described in more detail in chapter 3. The most recent reform made the compulsory pension voluntary; a hypothetical scenario has been created to describe this reform, in which all people give up the funded scheme, to see the maximum impact of this reform.

Novelties of the study

The microsimulation pension models developed in other countries have either been based on a sample population or covered only some parts of the overall pension system (Li and O'Donoghue 2013). Norway uses a microsimulation model called MOSART which is one of the longest-running and actively used models (Andreassen *et al*. 2020). In contrast, the microsimulation pension model developed in the framework of the current thesis is novel in the field of economic analysis of pensions in that it covers the entire population of the country and includes a multi-pillar pension system.

The concurrent application of two pension models – typical agent model and microsimulation model – permits the comparison of some of the results of these models and develop a better understanding of the analytical differences and relative advantages of these tools in the assessment of effects of pension reforms on pension inequalities. When assessing the inequality of income at retirement, people's assets are also important, so in the future it would be important to take into account a person's total income and assets.

Models can provide a longer-term view. Since there is no common long-term view of the inequality of pensions at the European Union level, but there are some countries views on this issue. This work includes Estonia among these countries and helps to understand possible future developments in the inequality of pensions in countries with similar backgrounds and systems (multi-pillar). In addition, the Estonian view gives a light idea that a large-scale state pension does not automatically mean a low level of inequality (although it has been the case so far in Estonia). The share of funded pensions will increase in the future, but at one point the aggregate inequality will begin to decrease. Thus, Estonia's experience adds its contribution to the literature on this issue.

This work shows that the financial sustainability of the state pension depends to a large extent on two aspects: demography and SPA (particularly the SPA associated with the life expectancy). When there is much talk of baby booms, it turns out in this work that a period of low fertility is important because it affects the working-age population for a long period, but when this generation reaches the SPA, it will significantly improve the sustainability of the pension system. The time horizon of this work will be 2100 because pension reforms will take a long time before they are fully implemented. At the same time, this work shows that reforms that require an increase in the own share of an individual's contribution will take a much longer period than increases in the role of the state.

Estonia is an interesting country because it has been a user of the Bismarck system – a separate social security tax, which is earmarked, and the future pension depends on the contribution of a person. This work contributes to the literature, showing that the Estonian pension system is becoming more and more a Beveridge system – the state pension does not depend significantly on the contribution and is more likely to prevent poverty. But at the same time, the contributions are according to the Bismarck system. One of the reasons for such a situation (Bismarckian contributions and Beveridge benefits) is the low level of pension costs because there are not enough financial resources to differentiate pensions above the minimum level.

Structure of the study

The doctoral thesis includes four chapters. Following the introduction, the first chapter presents a conceptual and theoretical approach towards pension systems, illustrates the variation of pension systems around the world and synthesises recent pension reforms in other countries. The third part of the first chapter describes the key aspects of the Estonian three-pillar pension system both from the financing and benefits side, including pension formulas. The last section of this chapter introduces pension reforms in other countries – mostly pension reforms in European countries.

The second chapter explores the notions of equality and inequality, including the horizontal/vertical and intra-/intergenerational aspects of these notions as regards distributions of income from pensions and work earnings. The chapter also addresses assessment methods and measurement issues as regards income inequalities and includes a literature review of relevant earlier studies on pension inequalities. In addition, the last subchapter of that chapter describes models that have been used in pension-related works.

Given the focus of the current thesis on the use of econometric models for assessment pension inequalities, the entire third chapter is devoted to the methodology for designing the two types of models used in this thesis. Firstly, used data in the typical agent and microsimulation model is described and the analysed pension reform scenarios (implemented or hypothetical) are presented, which are simulated by the models in this study. Secondly, the typical agent model is described, including the stages of modelling, assumptions and indicators, and how the model can be used to assess pensions and intergenerational inequality. Thirdly, the microsimulation model is described, stages of model development, and comparisons with other estimates or known information.

The fourth chapter presents the results of both models – the typical agent model and the microsimulation model. Intergenerational inequalities in pensions by gender and age are analysed by using the typical agent model. This is followed by the analysis of the results of the microsimulation model as regards pension inequalities and other important aspects. Thereafter, the results of the two models are compared and the policy implications discussed. In the final part, the work undertaken in this study is summarised and conclusions drawn.

The delineation

In the current thesis, the retirement income generated by the Estonian pension system (including all three pillars) is assessed. The analysis also evaluates inequalities of work incomes (which are subject to social tax) during working life. All other sources of income are excluded from the analysis. The unit of the analysis is the individual, implying any household level transfers are disregarded. The analysis does not take into consideration imputed incomes, nor does it consider expenditures or in-kind benefits (e.g. medical care).

Practice relevance

The entire analysis of this thesis is based on the entire Estonia population individual-level registry data and the reform scenarios assessed are those which have been implemented or may hypothetically happen in Estonia. Hence the study has relevance for policy evaluation and critical assessment. The work undertaken permits to estimate the prospective evolution of pension inequalities, replacement rates (adequacy), pension gap, poverty, and sustainability of the Estonian pension system. The results of the study provide inputs into the policy debates on the future of the pension system in Estonia, whereas the analytical tools elaborated in the framework of the current thesis – the two models, can be further calibrated to analyse different policy alternatives.

Acknowledgements

I would like to thank my supervisors – Raul Eamets, Lauri Leppik and Andres Võrk. Raul was the one who told me to start my doctoral studies and I am glad that he was ready to become a supervisor on a topic that is not part of his usual topics. I am thankful that Lauri was ready to jump on board just before the pre-defence, which of course did not mean that there would be a short distance to the defence (only three years). It can be said that Lauri is a living lexicon of social protection, and his precision of detail is a great example to me. I would like to express my deepest gratitude to Andres, thanks to whom I started to study this topic for my master's thesis.

In addition to the supervisors, I would like to thank the co-thinkers who have given feedback to the dissertation and articles. Many thanks to the language editor, Andrew Rozeik, who has been very collaborative throughout this long work, as well as pre-defence opponents, Dmitry Kulikov and Jaanika Meriküll, who helped to see the points that were no longer noticed by me.

I am very appreciative of the people at the School of Economics and Business Administration in the University of Tartu, who have helped me on this long journey and helped me to figure out how I could extend my studies. I would also like to thank the Archimedes Foundation (DoRa+ programme) for giving me the opportunity to present my research abroad and get feedback from the people in my field.

I am grateful to the Ministry of Finance and especially to Tõnu Lillelaid for the data on which this work is based. Many thanks also to Eesti Pank, notably to Tairi Rõõm and Karsten Staehr and the rest of the team, where I had the opportunity to be a visiting researcher and where I continued to model a microsimulation model which is the base of this work.

I appreciate my previous employer, the think tank Praxis, especially Märt Masso who was understanding and helped find time between the different project for me to focus on my thesis. A great support was given by Alari Paulus, who helped to unravel the different models. I also acknowledge my current employer the Foresight Centre, and Tea Danilov, where I also got much support to finish my doctoral thesis. The entire teams at both Praxis and the Foresight Centre have helped me to think about different topics in the thesis.

I am thankful to my friends and relatives, who have kept me on track by asking with their enthusiasm "oh, but how is it going with your thesis?"

I am most grateful to my wife, Maike, who has supported me throughout these years and given me good advice (to ask Lauri to be my supervisor, for example). She has listened to my ideas and learned facts about the Estonian pension system, so these late-night discussions with her helped me to make my thoughts clearer. And of course I am thankful to my children, Paul and Helene. They had their own benefit, because they knew I tend to eat chocolate and biscuits during the writing nights and in the end I had no hiding places in my home office they did not know.

1. PENSION SYSTEMS IN THEORY AND IN PRACTICE

When inequality gets too extreme, then it becomes useless for growth, and it can even become bad because it tends to lead to high perpetuation of inequality over time and low mobility.

Thomas Piketty

1.1. Theoretical and conceptual framing of old-age pension systems

Old-age pension systems serve two basic goals: 1) consumption smoothing over the lifespan, and 2) prevention of old-age poverty (Nisticò 2019; Blake 2006). The relative importance of these goals is reflected in the parameters of a pension system. In Beveridgian pension systems the core aim is to alleviate poverty by the provision of either universal or means-tested pension benefits. In Bismarckian pension systems, the core aim is to smooth consumption and replace the previous earnings by the provision of earnings-related pension benefits. Beveridgian pension systems are normally financed from general taxes by the state budget. Bismarckian pension systems are ordinarily financed from earmarked contributions (Schludi 2005).

Pension schemes may be categorised on different grounds, e.g. on the basis of financing or benefit calculation. Barr and Diamond (2006) categorise pension schemes on the basis of the financing mechanism into fully funded schemes and pay-as-you-go (PAYG) schemes. On the other hand, Lindbeck and Persson (2003) categorised pension schemes along three dimensions or policy choices (see Figure 1): financing (is the system fully funded or not), pension accrual (is the future pension defined-benefit or defined-contribution), and lastly, the link between contributions and benefits at the individual level (is the pension system actuarial or non-actuarial).

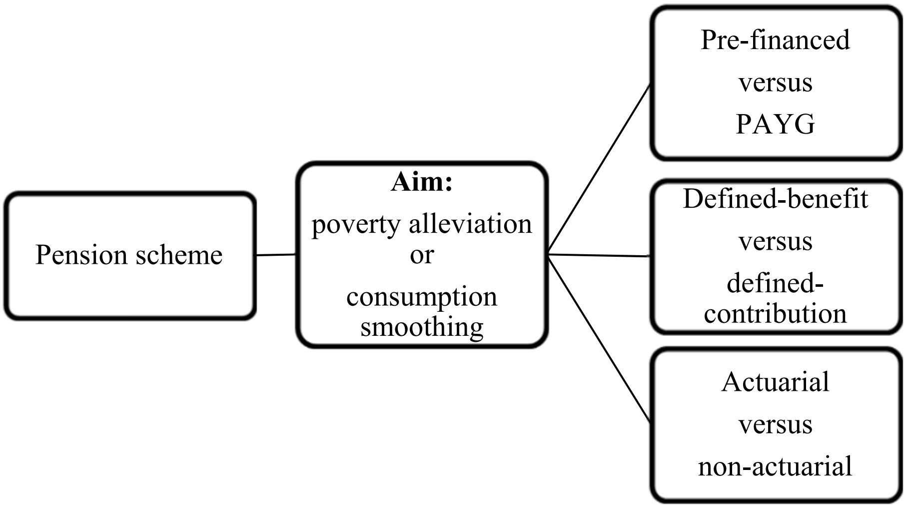

Figure 1. Pension policy choices
Source: modified from Lindbeck and Persson 2003; Nisticò 2019.

In a funded (pre-financed) pension scheme each person collects savings to use them in retirement. In a pure pre-financed scheme there is no public redistribution, but in a more realistic setting there are still some redistributions (Orenstein 2013). The PAYG scheme is usually managed by the government sector and operates as an intergenerational transfer system between cohorts, based on a trust in a social contract (Clements *et al.* 2014). Working-age cohorts pay taxes or social security contributions, which finance retirement benefits to current retirees. Upon the retirement of those cohorts their pensions are financed by taxes or contributions of the following working-age cohorts. PAYG schemes include several mechanisms of intragenerational and intergenerational redistribution (Barr and Diamond 2006). The growth rates of the PAYG scheme pension and interest rate of the pre-financed scheme are important for subsequent cohorts. If the entire life span of an aggregate interest rate is lower than the growth rate of the PAYG pension[2], the cohort will win with the PAYG pension scheme, but if the vice versa holds, then the cohort will lose. If they are equal, then the following cohort will be in equal standing. (Lindbeck and Persson 2003) Auerbach and Kotlikoff (1987) showed in their work that the PAYG pension scheme increased wealth for the favoured generation by 0.5 per cent, but reduced wealth by 4–5 per cent for later generations (Auerbach and Kotlikoff 1987).

A pension scheme can be established by fixing either the contributions or benefits (see Figure 1). In a defined-benefit scheme (DB scheme), the benefit rate is regulated, while the contribution rate may change.

[2] It should be noted that Lindbeck and Persson (2003) refer to the growth rate of the aggregate wage sum or to the growth rate of the tax base, but the question is whether the PAYG pensions are indexed on their referred basis or in any other way.

In a DB scheme, the benefit rate often depends on the length of service and wage. The reference wage may be the final salary before retirement, the wage over a reference period of some years or the (indexed) wage over the entire period of employment. (Nisticò 2019) There is normally a qualification period to qualify for the right to a pension, which may be, for example, 15 or 30 years of employment or payment of contributions. In real settings, the DB schemes may include certain flexibilities as to the determination of benefit rates, e.g. linking the benefits in payment to the macroeconomic situation. For example, when unemployment increases and wages decrease, the government will collect less taxes and as a result, will not be able to raise a defined benefit level; rather, it is maintained or reduced.

Alternatively, a DB pension scheme may be based on residence (rather than employment). Such a scheme is called a non-contributory universal pension scheme (Barr and Diamond 2009). A full residence-based pension is paid if a person has been a resident for a fixed number of years (frequently 40 years or from the age of 16 to the age of retirement), or if the length of residence is shorter, the pension is proportionally reduced. Such public pension schemes are in use in the Netherlands, Australia, New Zealand, South Africa, Chile, Denmark and Finland (Barr and Diamond 2009; Kangas *et al*. 2010).

A special form of the DB scheme is a point scheme – insured persons earn annual pension points, calculated by dividing person earnings or contributions to the base value, which is mostly either the average wage or the average contributions. At the time of retirement, the points accumulated over the employment period are converted to the amount of pension.

In a defined-contribution scheme (DC scheme) the contribution rate is fixed as a percentage of wages. In the funded scheme, the eventual benefit depends on the accumulated assets purchased for contributions and the rate of return earned on these assets over the entire employment period. Upon retirement, in general, an annuity is determined for the value of accumulated pension assets, considering the cohort life expectancy at the age of retirement. A DC scheme with a mandatory annuity pays lifelong pensions until death but does not protect against the decline in the asset value and the variation in the benefit rate across and within cohorts. Depending on the structure of the scheme pay-outs it is also possible to have programmed withdrawals or receive them as a lump sum.

A variation of the DC scheme is the notional defined-contribution scheme (NDC scheme). The NDC scheme is a PAYG (rather than funded) scheme with a fixed contribution rate. In such a scheme, employed persons have notional pensions accounts, where the amounts of contributions are recorded and notionally indexed (increased) by the government, e.g. based on the growth of the wage bill (Barr and Diamond 2006; Lindbeck and Persson 2003). The scheme is notional as no real assets are acquired. Upon retirement, the benefit is determined similarly to the other DC schemes, by dividing the value of the notional account with the cohort life expectancy at the age of retirement.

Lindbeck and Persson (2003) also categorise pension schemes based on whether the scheme is actuarial or non-actuarial (see Figure 1). In the pension system, actuarial fairness can be assessed from a macroeconomic and microeconomic point of view. Macroeconomic actuarial fairness refers to the long-term financial stability of the pension system. Macroeconomic actuarial fairness means a situation where the costs of paying pensions are covered by long-term social security taxes paid by working-age persons and the government sector does not have to use other tax revenues or loans to pay pensions. Microeconomic actuarial fairness refers to the balance between total contributions and benefits at the individual level (Lindbeck and Persson 2003). In a microeconomic actuarial pension scheme, there is no inter-cohort or intra-cohort redistribution of pensions. For example, one person contributes 10 units and the other 30 units during working time, in which case the second person receives three times the pension as the first during retirement time.

Holzmann and Hinz (2005) describe a multi-pillar pension system comprising of five parts. In their framework, the zero pillar should not depend on personal contributions, rather, it should protect against poverty. National pensions or flat-rate base parts can be considered as a zero pillar. The second part of their system is ordinary PAYG and should bear demographic and political risks. The third part is the mandatory saving and should allow a person to have a greater amount of savings for the future, while also decreasing political risks if it is effectively designed and operated (Holzmann and Hinz 2005). However, it increases financial market, transactions cost, income, inflation and longevity (if it is turned into annuity) risks (Takayama 2014; Holzmann and Hinz 2005). The private sector can reduce the inflation risk for a fee. There are also bonds indexed with inflation but this market is rather small and cannot cover all of the pension wealth market (Jousten 2007). The fourth part of the pension system consists of personal savings or occupational pension, or both. It can be a DC or DB scheme. This pillar's most important characteristic is flexibility for the contributor. The fifth part according to Holzmann and Hinz (2005) is non-formal or family support.

One main aim of any pension system is to protect retirees against poverty – replacing a sufficient amount of a person's income when that person retires (Holzmann and Hinz 2005; Holzmann 2013). World Bank experience shows that the average replacement rate from the mandatory pension system is needed to be around 40% for a typical full-career worker to provide subsistence levels of income in retirement (Holzmann and Hinz 2005). Of course, the pension systems' aim is also to distribute people's purchasing power over the course of their lives more equally.

Similar to the World Bank's pension system taxonomy, the OECD has divided the pension system into three major levels (see Figure 2). The first tier is mandatory and should ensure an adequate minimum level, either through a universal basic pension, means-tested (social assistance) pension or income-tested guaranteed minimum pension. The second tier is also mandatory and should ensure consumption smoothing through savings. The second level may take two forms: 1) a public or national system, which may be a DB scheme, a point scheme or an NDC scheme; or 2) a privately managed scheme, which may be a

DB or a DC scheme. The third tier is voluntary and should further help to smooth consumption over the lifetime. This tier is generally managed by the private sector and can be a DB or a DC scheme.

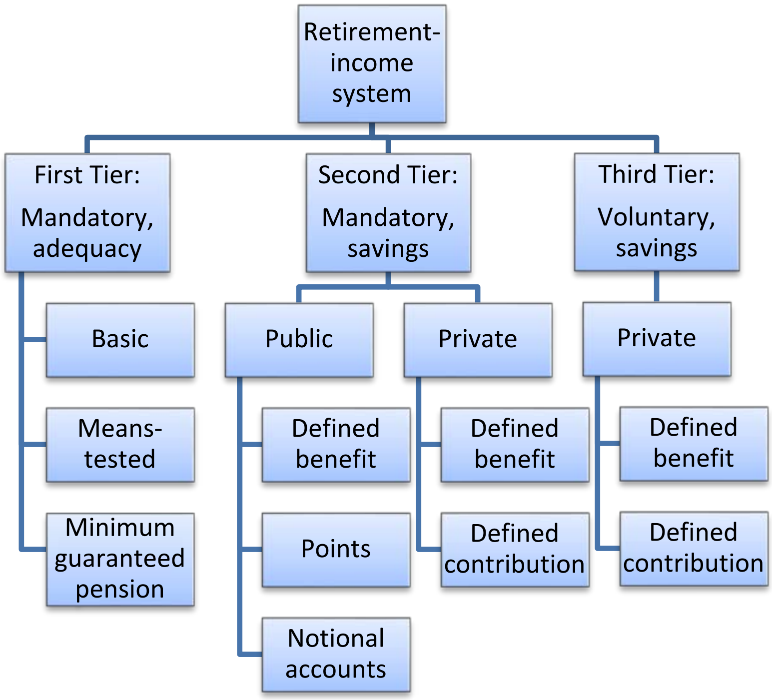

Figure 2. Pension system taxonomy by OECD
Source: OECD 2017a.

The theoretical approach and taxonomies of international organisations (e.g. the World Bank and the OECD) describe different pension policy options in a broader framework where each scheme has clearly distinctive qualities and aims. However, in the real-life settings pension systems often combine different elements.

There is no best pension system for all countries and at all times. The quality and efficiency[3] of pension systems (PAYG, fully funded or their combination) vary between countries and eras.

1.2. Pension systems around the globe

Most of the countries around the globe have some kind of public old-age pension system. By 2004, 167 countries had a pension system (Ney 2005).[4]

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[3] Quality and efficiency could be defined as the capacity to meet the established social aims in an equitable and sustainable manner (Clements *et al*. 2014).

Many developed pension systems are multi-pillar systems, which include several complementary pension schemes. A number of countries use the multi-pillar pension system proposed by the World Bank (Holzmann and Hinz 2005; Sørensen *et al*. 2016; Häusermann and Schwander 2012). In addition, Germany, which had the first formal pension system in the world, has moved towards a multi-pillar system (Wilke 2018).

The multi-pillar pension system is in use in a number of countries, for example Latin America[5], Central and Eastern Europe and Central Asia[6] and countries from East Asia, Middle East and North Africa, Sub-Saharan Africa and South Asia, but in each country these have been implemented differently (Holzmann and Hinz 2005). Some of the countries using an advanced multi-pillar are Canada, Denmark, the Netherlands and Sweden (Sørensen *et al.* 2016), while Germany and Switzerland also use the multi-pillar system (Wilke 2018; Häusermann and Schwander 2012).

A high number of countries have a DB scheme as the first pillar (see Figure 3). The clean DC scheme is available in a couple of countries, like Indonesia, Kenya, Malaysia or Nepal. Estonia, Lithuania, Germany, Slovakia and Russia use the point scheme in the first pillar. The NDC scheme, which has some similarities to the point scheme, is used in Italy, Liechtenstein, Norway, Poland and Sweden. Latvia and China use a combination of the NDC and DC schemes. Mixed systems in the first pillar are also used in India, Denmark (DB and DC) and France (DB and point scheme).

The DC scheme is mostly used in the second pillar, while Switzerland, Iceland and the Netherlands use the DB scheme (see Figure 4). Croatia and Liechtenstein combine DB and DC schemes. Several countries use private pension plans (PPP) – ordinarily those are voluntary savings schemes.

Based on the OECD average wage-based typical agent[7] pension calculation, 22 out of 49 of the OECD and selected countries rely on the first pillar (see Figure 5). For countries with a multi-pillar pension system, the average proportion of the first pillar is 45%, the second pillar 40% and the third pillar 15%. Although there is a multi-pillar system in several countries, the OECD calculations do not always cover pensions from all pillars. The OECD does not include a voluntary scheme in their calculations when the mandatory funded scheme is available. There are also exceptional countries – the whole pension depends on the second pillar or the entire pension depends on the third pillar.

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4 Having a pension system does not necessarily entail a full coverage of the system.

5 Chile, Peru, Colombia, Argentina, Uruguay, Mexico, Bolivia, El Salvador, Costa Rica, Nicaragua, Ecuador, and Dominican Republic.

6 Hungary (cancelled in 2010), Kazakhstan, Latvia, Croatia, Bulgaria, Slovakia, Estonia, Lithuania, Romania, Macedonia, Russia, Ukraine, and Kosovo.

7 This typical person works 40 years and without unemployment with average wage and retires at age 65.

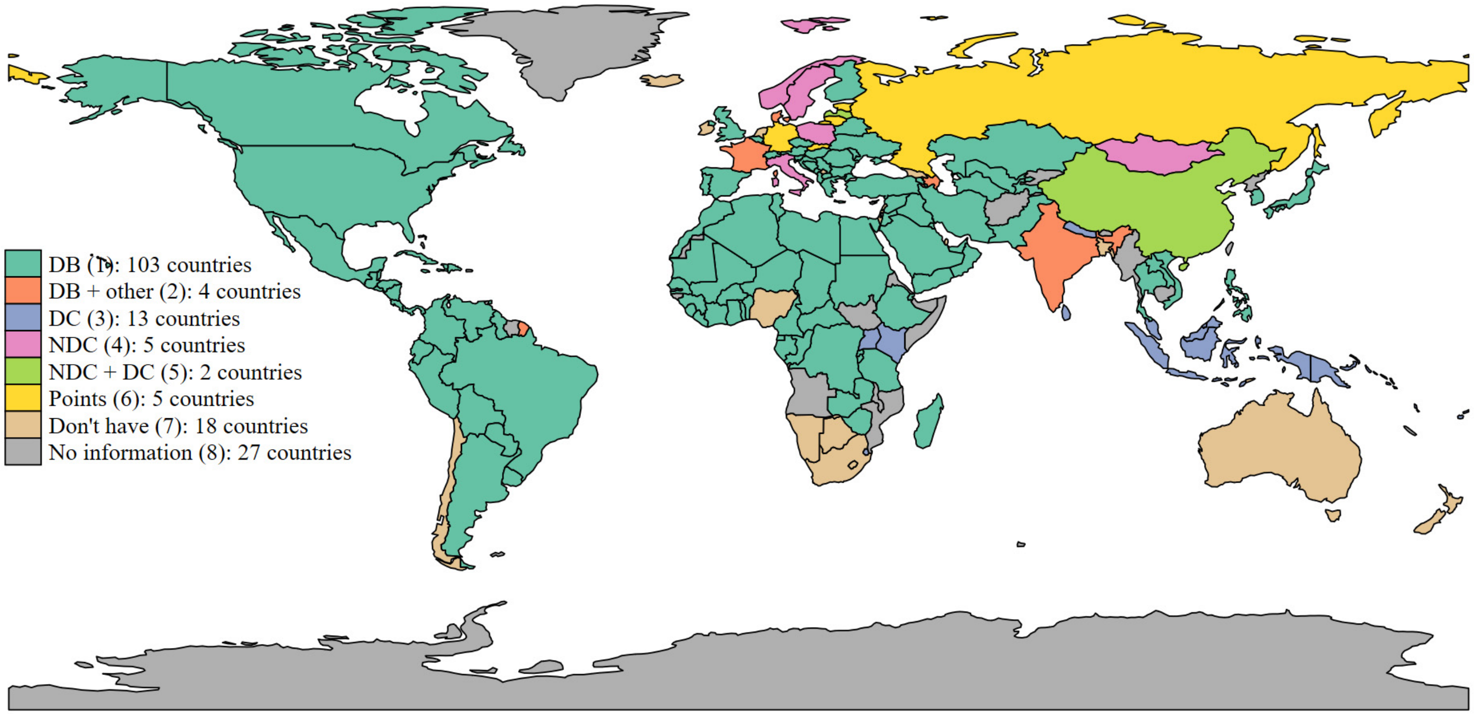

Figure 3. World countries by the type of first pillar pension schemes
Source: compiled by the author based on OECD 2017a; Whitehouse 2007; MISSOC 2018; World Bank 2014.

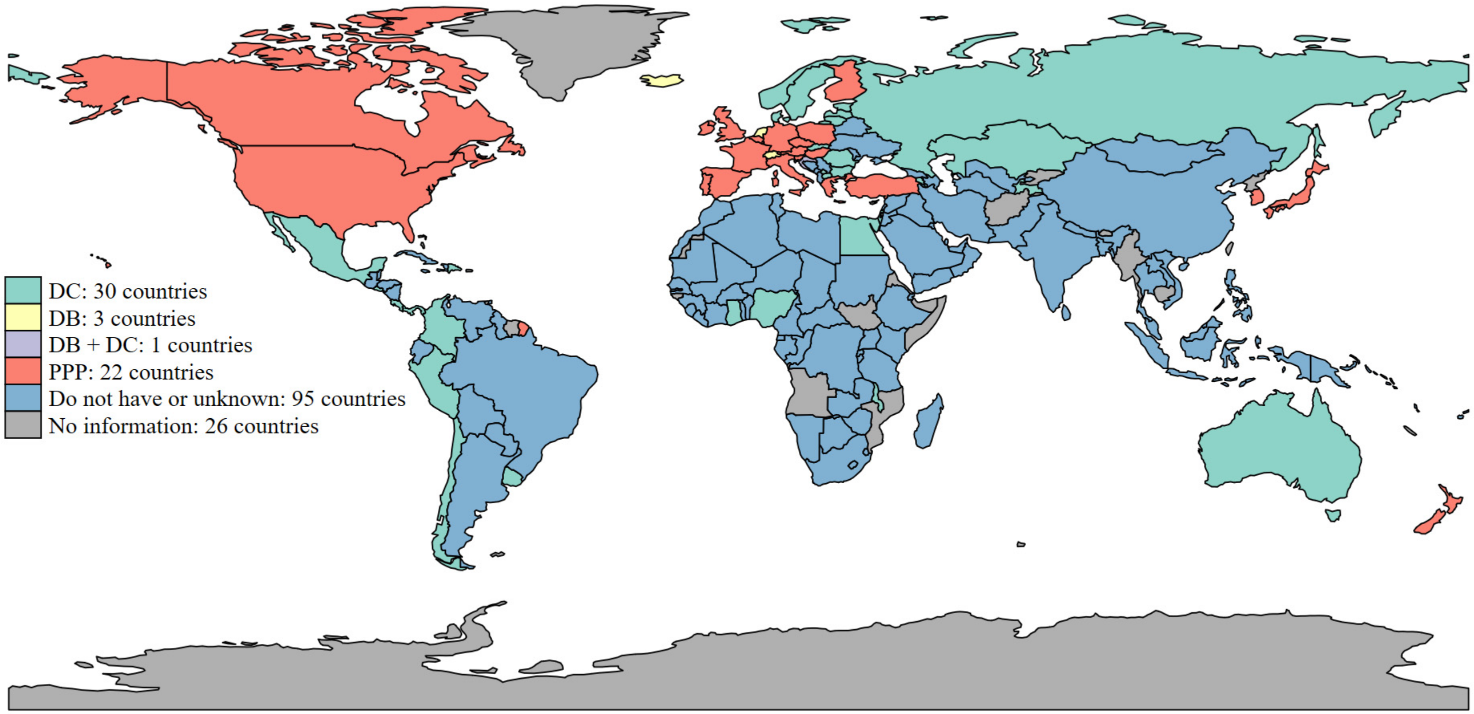

Figure 4. World countries by the type of second pillar
Source: compiled by the author based on OECD 2017a; Whitehouse 2007; MISSOC 2018; World Bank 2014.

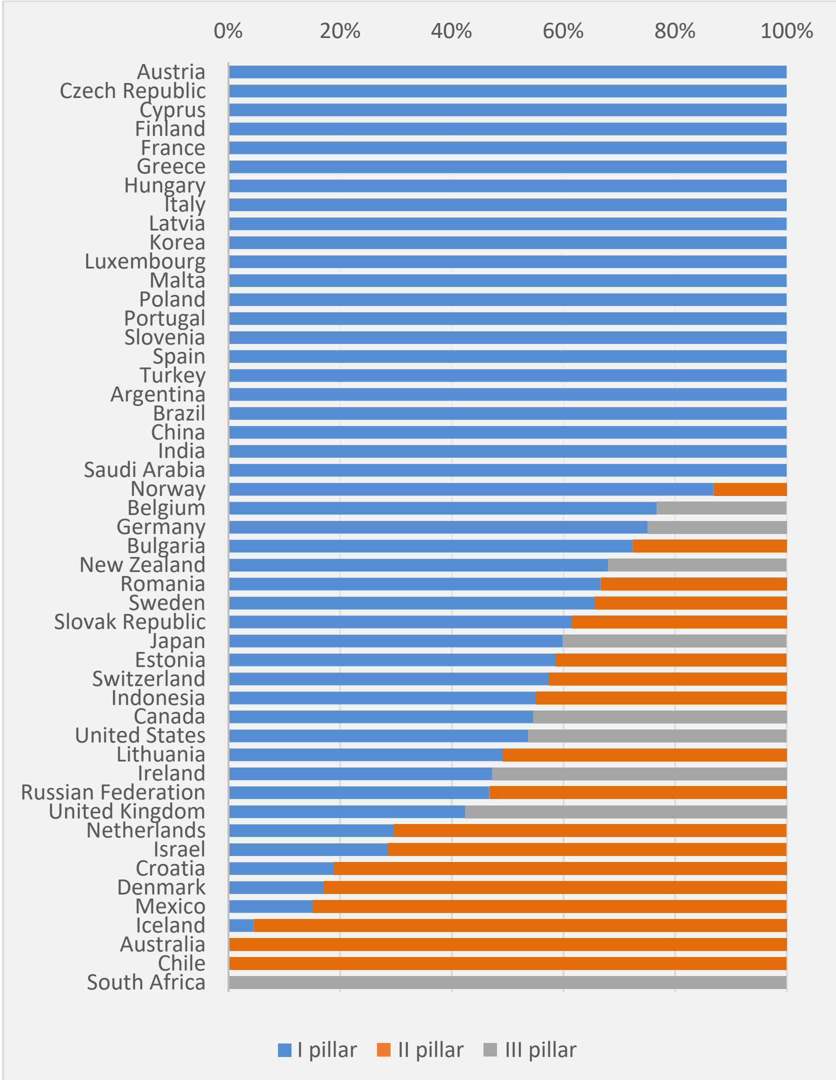

Figure 5. The proportion of pillars in the theoretical gross pension replacement rate for a typical beneficiary with an average wage
Source: OECD 2017a.

In Croatia and the Netherlands, the theoretical gross pension replacement rate is about 100%, entailing that a person who has worked for 40 years on an average wage would maintain the same income level during retirement as during employment (see Figure 6). In other countries, the replacement rate is lower, between 30% and 90%. As may be observed, there is no clear link between the

[8] In the interests of accuracy, it should be said that the first pillar may, in turn, consist of different components.

replacement rate and the structure of the pension system. The average gross pension replacement rate in these selected countries is around 60%. It should be noted that the average replacement rate does not indicate the coverage of the system, for example, the replacement rate may be high, but only a small proportion of the population will receive it.

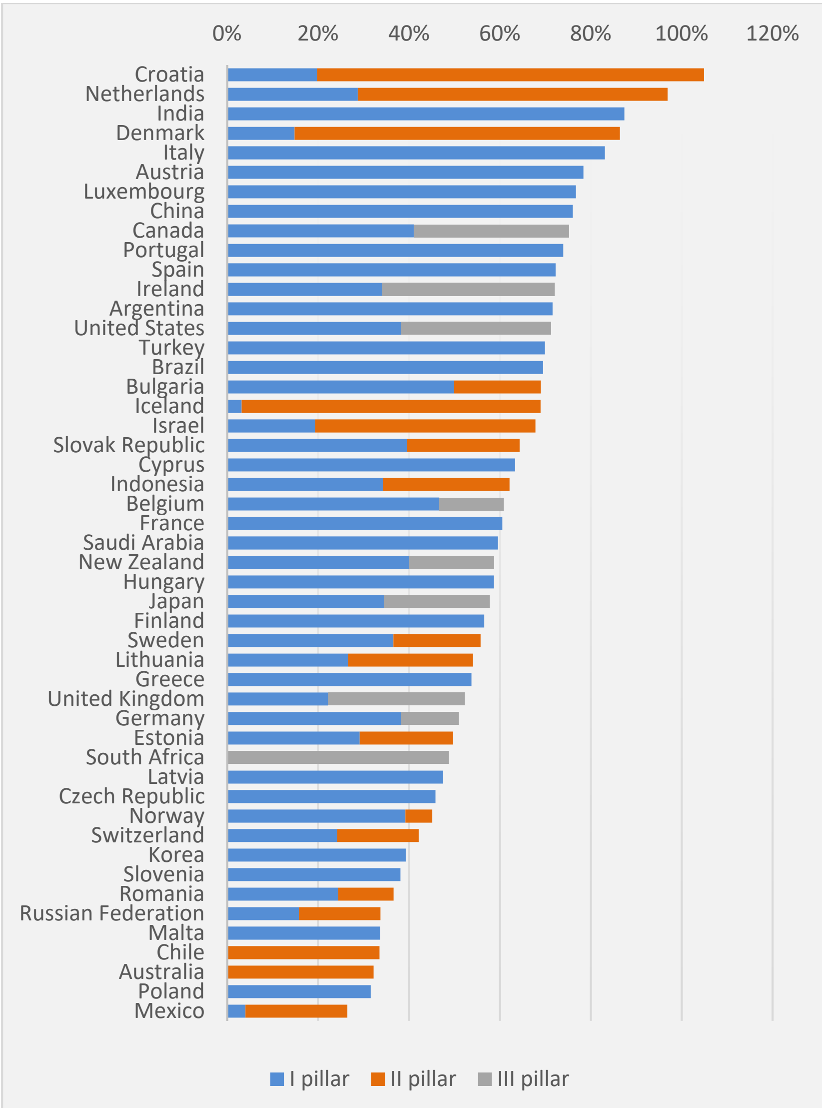

Figure 6. Theoretical gross pension replacement rates for average wage earners by pillars calculated by the OECD
Source: OECD 2017a.

The design of pension systems cannot be directly transferred from one country to another and have the same results because the demographic situation or labour market can be different. Different national systems are closely interwoven with the pension system. Therefore, the pension system is influenced by several exogenous factors and other public policies. For example, taxation, inequality of labour market income, and structure of the health care system can be quite different. The pension system also depends on the country's historical background. All decisions affecting the system have been taken in their context and time. Given that pension systems have path dependency (Pierson 2000; Ney 2005), the system simply cannot be transferred to another country on the grounds that if it functions in one country it will also be operational in another country (Holzmann *et al*. 2008). While the countries which use the World Bank's recommended multi-pillar systems share some similarities (all have two or three pillars), on the other hand, each country's system is still unique. This description corresponds to Estonia's pension system, which is representative of the World Bank's multi-pillar pension system. However, the first pillar, i.e. state old-age PAYG scheme, is different and the second pillar, i.e. mandatory funded pension, has increased people's own contribution to the funded pension (Holzmann and Hinz 2005).

1.3. The Estonian pension system

In the real world, countries rarely use pure systems, but rather the real pension systems combine different types of elements (Lindbeck and Persson 2003). The same applies to Estonia too – a three-pillar pension system is used in Estonia at the end of 2021 (see also Figure 7):

1. First pillar – compulsory PAYG point scheme with a flat-rate component (equal for all recipients of old-age pension) (more specifics can be found in subchapter 1.3.1);
2. Second pillar – compulsory fully funded defined contribution scheme (more specifics can be found in subchapter 1.3.2);
3. Third pillar – voluntary fully funded defined contribution scheme (more specifics can be found in subchapter 1.3.3).

Pensions are funded from the pension insurance part of the social tax (20%), a payroll tax, and additional contributions by employees (see Figure 7). Part of the social tax (4%) is transferred to the compulsory funded scheme if the person has joined the scheme (Riigi Teataja 2019c), and every person adds an additional 2% from his gross wage (Riigi Teataja 2019a). Additional contributions are possible to the voluntary pension scheme (third pillar).

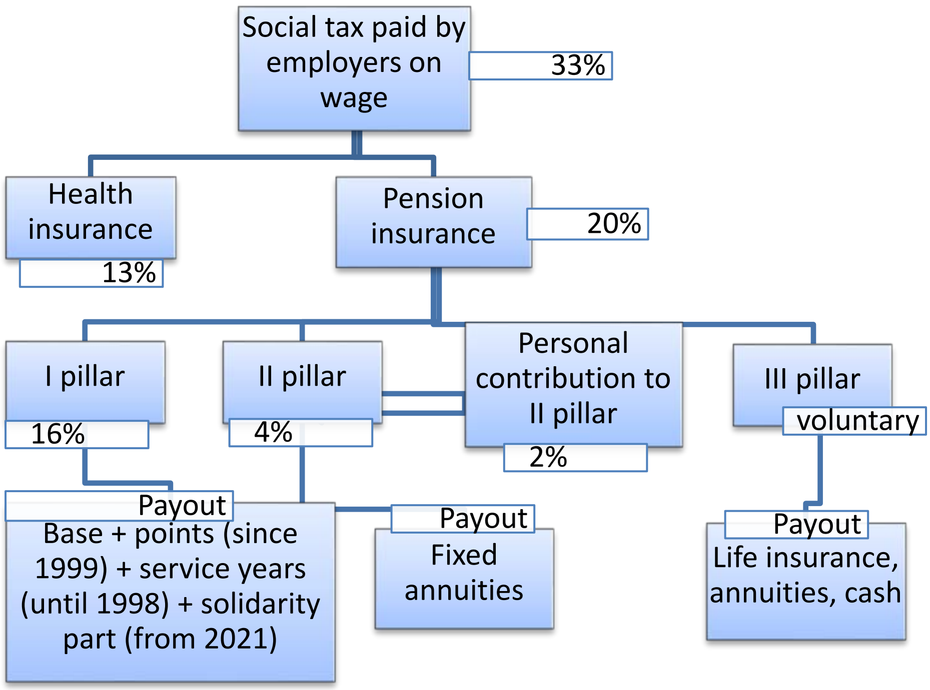

Figure 7. The Estonian pension system in 2019
Source: compiled by the author based on Riigi Teataja 2019d; 2019a.

The Estonian pension system's first pillar consists of a combination of pillars 0 and 1 according to Holzmann and Hinz's (2005) approach. The national pension or flat-rate base part of the first pillar can be considered as a zero pillar. The first pillar point scheme in Estonia is the second part of their system. Their third part is the second pillar in the Estonian pension system, which is mandatory. The fourth part of the pension system in Estonia is a voluntary third pillar.

The three-pillar system has been developed stepwise. Estonia has undertaken several important pension reforms from 1999 to 2021 (see Table 1). Since 1999, individual pension rights of the state pension scheme are more dependent on individual payments of social tax, i.e. Estonia introduced a points scheme. The next important reform established the compulsory funded pension scheme (the second pillar) in 2002, which is mandatory for all persons born after 1 January 1983. The third reform made the indexation of the first pillar more generous and increased the growth of the flat-rate component. Reforms also involved equalising and increasing the retirement age first to 63 by 2016 and then to 65 by 2026. From 2027 the retirement age is linked to life expectancy. There was also the introduction of a voluntary pension scheme in 1998.

Table 1. Estonian pension reforms

Time	Pension reforms
Until 1998	PAYG DB, pensions depended on the flat-rate base component and length of employment (I pillar)
1998	Voluntary pension scheme (DC, FF) (III pillar)
1999	Personalised contributions (point scheme) in the PAYG scheme (I pillar)
2002	Partial replacement of PAYG with compulsory FF DC scheme (II pillar)
2002	Indexation of pension (50% from CPI and 50% from growth of social tax revenues) in the first pillar
Since 2009	PAYG flat-rate component increases faster and change of indexation (20% from CPI and 80% from growth of social tax revenues) in the I pillar
Legislated 2018	From 2021 I pillar points are earned from two parts: 1) 50% from personalised contributions; 2) 50% service years. From 2027 retirement age is linked to life expectancy
Since 2021	Possibility of suspending the contributions to compulsory FF DC scheme and withdrawing assets

Source: compiled by the author based on Riigi Teataja 2019d; 2019e; 2019f; 2019a; 2021.

The ILO Convention No. 102 on social security minimum standards and the European Code of Social Security establish certain minimum standards on the rate of old-age pensions, specifying that the old-age pension for standard beneficiaries should be at least 40% of their previous earnings (in schemes where pensions are calculated on the basis of former salary) or at least 40% of the wage of the ordinary adult labourer (in schemes where pensions are not related to previous earnings). (Ortiz *et al.* 2018; Council of Europe 1964) Estonia has not ratified ILO Convention No. 102, but has ratified the European Code of Social Security.

In the following subchapters, the first pillar refers to the mandatory public pension scheme, the second pillar to the mandatory funded scheme and the third pillar to the voluntary funded scheme.

1.3.1. The Estonian state pension

The state pension insurance scheme provides protection against the risks of old age, invalidity and survivorship. In the current thesis, the focus is on employment-based old-age pensions. In addition to common old-age pensions, there are rules for special pensions and pensions under favourable conditions (e.g. pensions for the police, military, judges, artists, miners, etc.), which allow retirement under special conditions. (Piirits and Võrk 2019)

The coverage of the state pension insurance scheme (first pillar) is practically universal. Old-age pensions (*P1*) are comprised of three components (see Equation 1): the flat-rate base amount at year τ (B_τ), the pensionable length of service component (s), covering periods up to 1998, the insurance component that is based on individual social tax payments to the state pension scheme ($\sum I$), covering periods from 1999 onwards and the pensionable length of service component (ls), covering periods from 2021 onwards. (Riigi Teataja 2019e) Each year individual social tax payment is converted into points using a comparison with the average payment of the pension insurance part of the social tax. All three parts – the length of service components and points are multiplied by the cash value at year τ (V_τ). The cash value is equal for every component as every earned point has the same value.

$$P1_\tau = B_\tau + s \times V_\tau + \sum I \times V_\tau + \sum ls \times V_\tau \quad (1)$$

The old-age pension is redistributive through the flat-rate base amount (B_τ), which comprised about 40% of the average old-age pension in 2018. In addition, the length of service component (s) is strongly redistributive, but as this takes into account only employment periods up to 1998, its role is gradually diminishing for new pensioners. The proportion of the redistributive part will increase again from 2022 as half of the new pension rights are earned on a service base. Redistribution is also achieved through crediting pension rights for some non-active periods (including caring for children and military service), either adding values to s when people retire or by paying social tax (i.e. contributing to $\sum$I) on behalf of some socio-economic groups.

Both the base amount (B_τ) and the cash value (V_τ) of one year of pensionable service and the pension insurance coefficient are indexed annually. The pension index (*PI*) is a weighted average of past consumer price indices (*CPI*) and past growth of social tax revenues (*STR*) to the pension insurance scheme (in a 20:80 proportion since 2008). (Riigi Teataja 2019d)

$$PI_\tau = 0.2 \times CPI_{\tau-1} + 0.8 \times STR_{\tau-1} \quad (2)$$

The index is 10% higher for the base component and 10% lower for the cash value (V_τ) of one year of pensionable service and the pension insurance coefficient.

$$B_\tau = B_{\tau-1} \times [(PI_\tau - 1) \times 1.1 + 1] \quad (3)$$

$$V_\tau = V_{\tau-1} \times [(PI_\tau - 1) \times 0.9 + 1] \quad (4)$$

The following table describes the types of pension that have been calculated as a retirement pension. All invalidity pensioners and most of the recipients of superannuated pensions are transferred to the old-age pension at retirement age.

Table 2. The types of pensions and the formula of each type

Type of pension	Formula	Notes
Old-age pension	(5) $P1_\tau = B_\tau + s \times V_\tau + \sum I \times V_\tau + \sum ls \times V_\tau$	
Old-Age Pensions under Favourable Conditions Act	(6) $P1_\tau = B_\tau + s \times V_\tau + \sum I \times V_\tau + specific\ service\ years \times 0.031 \times V_\tau$	List number 1, specific service years should be at least 20
Old-Age Pensions under Favourable Conditions Act + other favourable conditions	(7) $P1_\tau = B_\tau + s \times V_\tau + \sum I \times V_\tau + \sum ls \times V_\tau$	List number 2 and others have the possibility of earlier retirement without a reduction in their pension. Specific service years should be at least 25
Early retirement old-age pension	(8) $P1_\tau = (B_\tau + s \times V_\tau + \sum I \times V_\tau + \sum ls \times V_\tau) * (1 - m * 0.04)$	*m* – how many months before retirement age person retired (1–36)

Source: compiled by the author based on Riigi Teataja 2019d.

1.3.2. The Estonian mandatory fully funded pension

The mandatory funded pension scheme was introduced in July 2002. Following its introduction, the PAYG scheme is being partially replaced by a fully funded defined contribution scheme. As regards the financing, four percentage points of the social tax were referred to the second pillar to which the person also adds two per cent from his/her gross wage. Therefore, the individually accounted contribution for a person who has joined the second pillar is 16% to the first pillar and 6% to the second pillar.

The persons born in 1983 and later are bound to join the second pillar. The preceding cohorts had an opportunity to join the second pillar, but once they joined the decision may not be reconsidered. The last year to join was 2010, while the window of time for joining depended on the birth year. (Riigi Teataja 2019a) The second pillar covers 52% of people born in 1942–1982[9] and 65% of people born in 1956–1982[10].

The person has a choice between funds with different investment strategies and risk levels. There are conservative funds (0% of shares), balanced funds (up to 25% of shares), progressive funds (up to 50% of shares) and aggressive funds (up to 75% of shares)[11]. There are two possibilities for changing the fund:

[9] People who did not have to join with the second pillar.

[10] People who did not have to join the second pillar, but people born in 1942–1955 are a separate group because they had special rules during financial crisis and their collection period is shorter (under 20 years).

[11] Maximum proportion of shares in pension funds changed in 2019. Conservative funds can also invest 10% into shares and aggressive funds 100% (Riigi Teataja 2019b). Until financial crisis the maximum proportion of investments in shares was 50%.

1) Directing contributions to a new fund; 2) changing the pension fund units. These changes can be made several times a year. (Riigi Teataja 2019a)

Before 2021 a person can start to receive payments only after reaching the retirement age; the second pillar retirement age is the same as in the first pillar. The following three options are for payments (PII_τ): lump sum, fund pension and annuity.

Table 3. Second pillar payments options

Payment options	Formula
Lump sum	$Value_t \leq 10\ NP_t$
Fund pension	$10\ NP_t < Value_t \leq 50\ NP_t$
Annuity	$Value_t > 50\ NP_t$

* $Value_t$ – the value of assets collected; NP_t – national pension[12].
Source: compiled by the author based on Riigi Teataja 2019a.

Since 2021, the mandatory funded scheme has been substantially changed. First, it is possible to suspend contributions regardless of age and to resume contributions in 10 years' time. Second, the assets collected can be withdrawn before SPA. Third, all payment options are possible, regardless of the amount of assets, but the rate of income tax depends on the choice. (Riigi Teataja 2021)

Insurance companies must use unisex lifetables to calculate the annuities by the law. The following equation is used to calculate the annuity:

$$PII_\tau = \frac{Value_{ry}}{\frac{1}{i/m} * [1 - \frac{1}{(1 + \frac{i}{m})^{m*LE}}]} \qquad (9)$$

Where,
PII_τ – annuity at year τ;
$Value_{ry}$ – second pillar value at retirement year;
i – yield of annuity;
m – payments in a year (every month, 12);
LE – cohort unisex life expectancy at retirement age.

Social tax (4%) transfers and individual contributions were suspended during the global financial crisis (in the middle of 2009), while individuals had the opportunity to continue to pay a personal contribution on the basis of the application from 2010 (see Table 4). During the crisis and post-crisis years, the government contribution was dependent on the birth year of the person. The older generation also received the government contribution if they continued to pay the individual contribution. The government promised to increase their part

12 The national pension (NP_t) was €205.21 at 01.04.2019. Therefore, a person had to use annuity when he/she retired 2019 and had over €10,261 in his/her second pillar account.

(from 4% to 6%) for 2014–2017 if the nominal growth of the economy was over 5%.

Table 4. People's second pillar contribution opportunities during the global financial crisis by birth year

	Birth year 1942–1954		Birth year 1955–…	
Decision in 2010	Continued	Not continued	Continued	Not continued
2010	2+4	0+0	2+0	0+0
2011	2+4	1+2	2+2	1+2
2012–2013	2+4			
2014–2017	2+4	2+4	2+6	2+4
2014–2017 (Second decision)	-	3+6		

Source: compiled by the author based on Riigi Teataja 2012.

Around one-third of people decided to continue paying contributions during the crisis (see Table 5). In addition, 10% of joiners who did not continue contributions during the crisis made an application to increase contributions from the 2% + 4% scheme to the 3% + 6% scheme for the period 2014–2017.

Table 5. Second pillar participants (number of persons) by their choices as regards payment of contributions during the financial crisis and increase of contributions after the crisis

Did the person increase contributions during 2014–2017?	No	Yes	Total
Did the person continue to contribute in 2010–2011?			
No	359,929	65,730	425,659
Yes	179,943	40,410	220,353
Total	539,872	106,140	646,012

Source: compiled by the author based on Ministry of Finance 2012; 2013.

1.3.3. The Estonian voluntary fully funded pension

The voluntary fully funded defined contribution pension scheme was established in 1998. As it is a DC and voluntary scheme, people themselves can decide their own contribution and if necessary, modify it as appropriate. It is possible to temporarily suspend the contributions. The difference between the collection phase of the third pillar and other investments is the income tax incentives. An investor in the third pillar can choose between pension funds and pension insurance. (Riigi Teataja 2019a)

The third pillar fund is an ordinary mutual fund where its owners are the fund investors. Insurance contracts may take two forms: 1) insurance with guaranteed interest which is classical saving insurance, and 2) insurance with investment risk where a person has more options but also bears the risk. (Riigi Teataja 2019a)

Until the financial crisis, the number of investors in the third pillar increased, reaching 80,000 people in 2009, i.e. 15% of employed persons (Ministry of Finance 2012). In recent years, the decline in the number of contributors has stabilised and quietly risen. In 2017, 64,000 people, i.e. 10% of employed persons, made contributions to the third pillar. The average percentage of contributions from the wage is varied between 3% and 5%. (Ministry of Finance 2013; 2018)

The employer may also make contributions to the third pillar of the employee. From 2012 contributions can be made at no additional taxation. However, maximum limits for tax incentives have been set (15% of a person's gross income or 6,000 euros a year). (Riigi Teataja 2020)

A person can choose the way in which he/she wants to receive payments from the third pillar (see Table 6). There are tax advantages for those who have pay-outs after the age of 55 and an extra tax incentive for using the annuity.

Table 6. Third pillar payments options

Payment options	Tax before the age of 55	Tax after the age of 55
Lump sum	20% (10%*)	10%
Fund pension or withdrawal	20% (10%*)	10%
Annuity	20% (0%*)	0%

Source: compiled by the author based on Riigi Teataja 2020.
* In the case of permanent incapacity for work

1.4. Pension reforms

Pension system reforms may be driven by various reasons. Reforms may be triggered by internal or external factors of the pension system, or by a combination. Internal driving factors may be, for example, a too fragmented pension system or too universal system – which may not provide all the needs if the needs are different. External drivers may be changes in the demographic situation or changes in the labour market – contract types, unemployment or wage gap. Ageing is not only a phenomenon of developed countries, but worldwide – the median age of the population was 22.4 years in 1975, projected to increase to 38.4 by 2050 (Higo and Khan 2015).

One of the main objectives of reforming the pension system is to make the system sustainable in the changing situation. Another objective is to broaden the pension system's intentions. Demographic changes have forced many developed countries to increase individual contributions for retirement and reduce the country's risks and costs. As a result, pension systems in several countries are being transferred from DB schemes into DC schemes. One example is the mandatory funded pension, as the second pillar in Estonia. This should help to alleviate the problems of population ageing and to reduce budgetary pressure in the future.

In the period 1981–2007, over 30 countries have partially or completely transformed the PAYG scheme into a funded scheme. The financial crisis has slowed this trend (Orenstein 2011). Countries will no longer be able to pay such large pensions under PAYG schemes, as there are fewer working-age people per pension age and therefore the importance of the DC schemes is growing (van Vliet *et al.* 2012; OECD 2014). The occupational and compulsory funded pension share will increase significantly during 2006–2046 (European Commission 2010).

Some countries have started to use behavioural or nudging funded schemes. People are automatically enrolled on the scheme and have tax incentives but they can opt-out from those schemes (Orenstein 2011). The first national auto-enrolment saving scheme was introduced in New Zealand in 2007 (called KiwiSaver), with the United Kingdom following a similar idea (O'Connel 2009).

Poland is one of the countries that stopped its second pillar during the financial crisis. As the first pillar alone does not provide sufficient adequacy in the future, a new occupational pension savings scheme with behavioural and nudging aspects in Poland was legislated at the end of 2018 (Chłoń-Domińczak 2019). Other countries are also improving saving schemes, for example Turkey requiring automatic enrolment in the voluntary funded scheme (Sayan 2017) and Germany legislated new regulations on its occupational scheme (Bäcker 2017). The Danish government proposed a mandatory funded scheme for individuals who are not saving enough for old age (Kvist 2016).

In addition to setting up and improving funded schemes, a number of changes have been made to deal with demographic changes – for example, an increased retirement age or trying to raise the effective retirement age (Bezovan 2018; Ólafsson 2018; Palme 2018; Jessoula and Raitano 2019; Kvist 2017; Kangas 2014; Piirits and Masso 2017). As risks are more directed towards people, there is also a need to increase the minimum base or increase the non-contributory part of the pension system. European countries like Italy, Sweden, Iceland, Germany, Slovenia and Estonia have planned or already legislated the increase of the basic pension or non-contributory size part (Jessoula and Raitano 2019; Palme 2018; Ólafsson 2018; Schmitz 2018; Majcen 2017; Piirits and Masso 2017).

All pension reforms have advantages and disadvantages. As Barr and Diamond (2009) have pointed out, the administrative costs and changing of risks entailed in a switch from one system to another should not be forgotten. Replacing a DB scheme with a DC scheme transfers some risks from the state to the individual. Introducing a mandatory funded scheme or funded schemes with incentives has transition costs[13]. For example, the net annual transition

[13] A transition cost is an extra cost going from one system to another or adding an additional aspect to the pension system, although its amount depends on the system design.

costs have been below the inflow of revenues to the second pillar due to high economic growth during 2002–2008 in Estonia (Leppik and Võrk 2008). From 2002 to 2012 the transition costs are found to be 6.2% of GDP and this is also the average transition costs of Central and Eastern European countries (Bielawska *et al*. 2017).

In conclusion, pension reforms can be triggered by internal or external factors. One of the major objectives has been the sustainable pension system. In order to have a sustainable pension system and to achieve other objectives, the retirement age has been raised, more risks are transferred to the future retiree and there is a move towards greater savings. As the pension system is complex, improving one aspect may lead to new problems.

2. PENSION INEQUALITY AND REDISTRIBUTION

Income inequality is troubling because, among other things, it means that many people in our society don't have the opportunities to advance themselves.

Ben Bernanke

The focus of the current thesis is on income inequalities in the pension system. As pension entitlements are earned during the working life, pension inequalities result from labour market inequalities, in particular from differences in employment and earnings. The question is whether the allocation mechanisms of the pension system maintain or mitigate these inequalities, and in the latter case to what extent?

Disposable income consists of earnings from work or self-employment, capital income and public cash transfers, while income taxes and social security contributions are deducted (OECD 2016). Disposable income excludes non-cash income. As pensions are cash transfers, non-cash income is not taken into account in this thesis. Disposable income can be measured at an individual or household level. In this thesis, incomes are assessed at individual level.

Equality is a normatively loaded and contested concept, which is often associated with egalitarianism. Economic egalitarianism is concerned with distributive justice and fairness of resource allocation mechanisms (Roemer 1998). Le Grand and Robinson (1976) point to the trade-off between income equality and work incentives, whereby full equality undermines the motivation to work. In turn, this would deteriorate the income position of everyone. Similarly, Lindbeck (1993) and Barr (1998) address the dilemma of the welfare state – how to advance equality without losing incentives. On the issue of how reducing inequality affects economic growth, Garrec (2012: 55) has noted that "greater progressivity results in less lifetime inequality but also less growth". On the other hand, Stiglitz (2013) suggests that destructively high levels of inequality lead to markets being neither efficient nor stable.

Income inequality may be conceptualised as the extent of uneven distribution of income in a society or among a category of people (Van Lancker and Van den Heede 2021). Obviously, differences in income may have several grounds. Income differences may reflect different individual choices (Barr 2012). Persons with similar backgrounds and skills may have different earnings if they prefer more free time. A time dimension should also be considered, as annual differences and fluctuations of earnings may be smoothened out cumulatively over a longer period (Atkinson and Stiglitz 1980). Hence a distinction can be made between temporary and more permanent income inequality.

It is also well established that income distribution depends on the age structure of the society (von Weizsäcker 1988). Faggio *et al*. (2010) have shown that income inequality is linked to technology-driven company-level productivity dispersion, whereby an increase in individual wage inequality is largely due to an increase in productivity inequality between companies.

The notion of equity, within the meaning of fairness and social justice, is closely linked to the equality-inequality debate (Barr 1998). According to Barr (2012), in welfare economics equity is a policy goal relating to the manner of distribution or sharing of resources between individuals. Barr (1998) considers the reduction of inequality as predominantly an equity issue. A distinction may be drawn between two forms of equity: vertical equity and horizontal equity. Vertical equity refers to the extent of redistribution of income from rich to poor. Horizontal equity refers to the distribution in accordance with the principle of equal treatment of equals, for example by taking into account objective factors like age, family size, etc. (Barr 2012; Atkinson and Stiglitz 1980; Clements *et al.* 2014).

For the purposes of the current thesis, it is also relevant to assess inequalities from the perspective of generations, i.e. to analyse inequality inside and between generations. Intragenerational income inequality is captured by income differences between groups within the same generation, whereas intergenerational inequality refers to income differences across generations.

The pension system, being generally the largest element of public social protection cash transfers, has a major influence on income distribution. The capacity of pension systems to mitigate intragenerational and intergenerational income inequalities largely depends on the relative weight given to different pension policy objectives as reflected in the design and specific parameters of pension schemes. Pension schemes with income- or means-tested benefits, but also Beveridgian non-means-tested schemes with flat-rate benefits or flat-rate parts of pension redistribute towards individuals with lower incomes, aiming at vertical equity (Barr 1998). On the other hand, pension schemes where benefits are strongly linked to former contributions, such as earnings-related Bismarckian PAYG schemes or DC funded schemes, smoothen income over an individuals' lifetime. Actuarial pension schemes with a strong link between contributions and benefits at the individual level pursue the objective of horizontal equity (Lindbeck and Persson 2003; Mattil 2006).

Compared to intragenerational inequality, income inequality between generations has received somewhat less scholarly attention in the past. However, already in the 1980s Musgrave (1981) formulated the principle of intergenerational fairness of a pension system, stating that for the system to be fair across generations the ratio of per capita benefits to retirees to per capita earnings of workers (net of social security contributions) should remain constant over time. The topic of intergenerational equality has gained relevance in the framework of sustainability of pension systems in the context of population ageing (Mattil 2006). Roemer (2011) points to the argument that intergenerational equality is desirable as the fairest way of sharing scarce resources.

Pension reforms may have an impact on the intragenerational and intergenerational distribution of resources. Lindbeck and Persson (2003) indicate that a transition from a non-actuarial PAYG pension scheme to benefit rules with strong actuarial elements reduces redistribution within generations, while on the other hand, as the return to the average individual is not affected by such a transition of benefit rules, there would be no direct effects on the intergenerational distribution of income. In contrast, the transition to a funded pension scheme, increase of contribution rate, reduction of the replacement rate and increase of pension age affect intergenerational inequality. Along with the argument developed by Roemer (2011), a fair approach to attain sustainability of the system in the context of scarcity of resources could be to opt for a distribution of resources with equal outcomes across generations, as a way to ensure equal welfare for all future generations (see also Padilla 2002; Tisdell 2010). Takayama (2014: 101) claims that the issue of intergenerational pension equity arises "if younger generations were forced to bear excess burdens created by preceding generations". Such a situation would emerge, for example, in the case of increasing contribution rates in DB schemes. Takayama (2014) also points out that intergenerational equity considerations vary depending on the type of the pension scheme: PAYG DB, NDC, funded DB or funded DC.

It is important to consider that as generations live at different times, the economic level of the country and the living standards of people change over time. This must be taken into account when choosing appropriate measurements for the assessment of inequality between generations.

2.1. Measuring inequality

The first stage of the assessment of inequality is to identify the entity to be assessed. Whether it is an individual, a family or a household. It is easier and problem-free to address inequality at the level of individuals. Another aspect is to determine which inequalities are assessed, whether they are income, wealth or influential inequalities. (Barr 2012)

Barr (2012) divided the assessment of inequality into two: 1) frequency distributions; 2) measurement of inequality (see Figure 8), but there are also simple difference indicators. Range *R* is the simplest indicator of inequality and shows the distance between two points but does not say anything about what is going on between two end points. The primary version can use maximum and minimum differences, but the upper 5% and lower 5% differences can also be used. (Cowell 2011)

The easiest way to use the frequency division is the histogram. This is good for average values but not for endpoints (Cowell 2011). Something else is needed for the aggregated indicator, as the histogram values do not allow comparison. One option is to use dispersion, the disadvantage being the sensitivity to absolute values of income. This problem is solved by the coefficient of variation, which is normalised to average income. If a greater weight to lower incomes and even better alignment of end points is desired, a logarithm can be used (Cowell 2011). (Barr 2012)

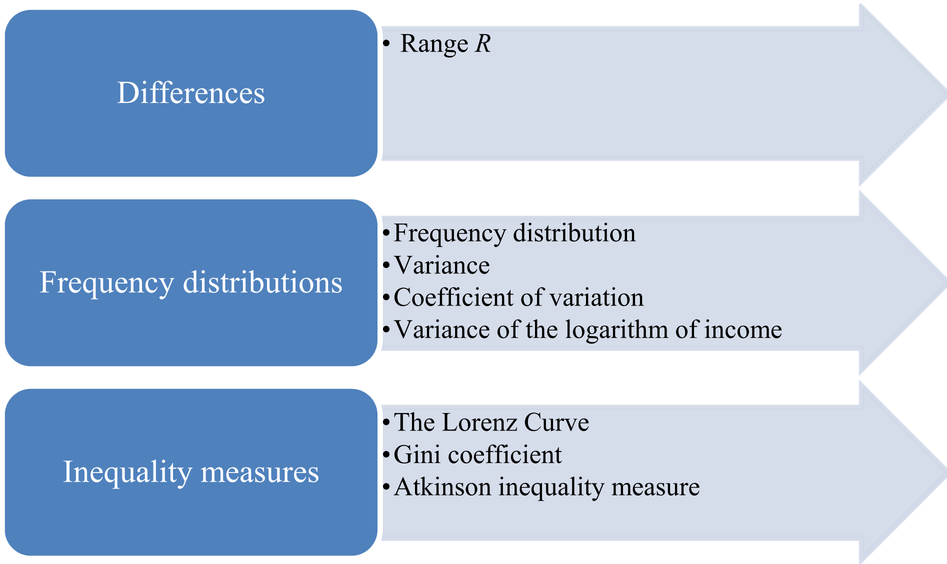

Figure 8. Inequality measures
Source: compiled by the author based on Barr 2012; Cowell 2011.

The Lorenz curve was created in 1905 to assess inequalities. The horizontal axis indicates the proportion of the population and the vertical axis indicates the proportion of income (see Figure 9). In the figure below, point (a) shows that 60 per cent of the employed people earn less than 30 per cent of all income. The straight line from point 0 to 1 represents a situation where all people receive exactly the same salary. (Barr 2012; Cowell 2011)

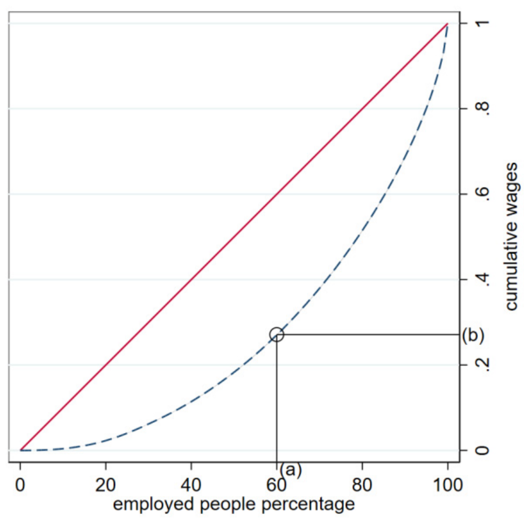

Figure 9. The example of the Lorenz curve
Source: author's calculations using Estonian wages; based on Barr 1998.

The Gini coefficient is the proportion of the area between two lines of the Lorenz curve from the total triangle area. Gini is 0.46 with the Lorenz curve presented in Figure 9. If all incomes are equal, the value of the Gini coefficient is 0. If the total income belongs to one person, then the value would be 1. The Gini coefficient is defined as half of the average of the absolute differences between all income pairs. The total is then normalised by the average income (Barr 2012):

$$G = \frac{1}{2n^2\mu}\sum_{i=1}^{n}\sum_{j=1}^{n}\left|y^i - y^j\right| \tag{10}$$

Where,

G – Gini coefficient;
y – Individual level of income;
μ – Mean income.

A positive aspect of the Gini coefficient is the absence of the problem of absolute values. The Gini value compares each value with each other, not just with the average value. If the lines of inequality should cross in the Lorenz curve, the result of the Gini coefficient does not indicate it, or if the two Gini indicators are equal, it does not mean that the Lorenz curve is accurately covered. (Barr 2012)

Another indicator is the Atkinson inequality indicator, which has the advantage of being able to set different "weights" to income groups. It is understood which income groups have different inequalities and therefore, different weights are used in calculations. For example, if there is less inequality with higher "weights", this means that greater equality is for people with lower incomes. Atkinson's inequality indicator removes the negative aspect of the Gini coefficient – crossing Lorenz curve lines are not indicated. (Barr 2020) There are therefore a number of approaches to assessing inequalities, whether to estimate the top one per cent of the wealthiest, such as Piketty and Saez (2003) or to look at the bottom percentile, such as Atkinson (2016), by investigating poverty or general inequalities in Gini.

While the previous indicators mainly take into account the current situation and compare absolute figures or their adjustments to mean values, the next step is to compare equality over a longer period and using well-known indicators from the financial world, such as net present value (NPV) and Expected Utility (Auerbach and Lee 2011) as well as individual internal rate of return (IRR) of different career patterns (Nisticò and Bevilacqua 2013; 2017). The indicators known in the financial world do not directly assess inequalities and therefore need to be re-evaluated with the indicator of inequality.

There are even more measurements and indicators, even at the macro level, to assess inequalities. As entire population individual-data are used in this work, the Gini coefficient has been selected which has been evaluated according to the absolute size of pensions.

2.2. Overview of previous works

2.2.1. Overview of previous works around the globe

This subchapter deals with pension articles focusing on distribution, inequalities and, in particular, inequalities within or between generations. In addition, it partly covers the poverty issue, but only in as much as this is connected to the inequality. A large amount of literature deals with the macroeconomic impacts[14] and with the sustainability of pension systems, but those are excluded from this subchapter because those topics are not on focused in this work.

PAYG and DB schemes are usually redistributive inside a generation but moving over to a DC scheme where distributional opportunity inside a cohort disappears because the size of the pension depends on the pension contributions. This might not be a concern because higher income groups have more savings opportunities and they also have the opportunity to use the base amount of the PAYG scheme or guaranteed pension (Lindbeck and Persson 2003).

For example, Davies (2009) found that contribution-based pensions have a lower equalising effect than the previous DB pension scheme. Similarly, but from another viewpoint, Goudswaard and Caminada (2010) found a strong positive relationship between public social expenditures and income distribution across OECD countries and a weak negative relationship with private social expenditures. Similar results are found by Bönke *et al.* (2010) but in different aspects – they found that the Gini coefficient elasticity is negative in PAYG pensions and positive to income and investments, i.e. funded DC schemes. Different authors have reached the same conclusions, but using different methods, such as time-series studies (Hughes and Stewart 2004; Oshio and Shimizutani 2005; Milligan 2008; Schirle 2009) and cross-sectional studies (Brown and Prus 2004; Weller 2004; Fukawa 2006) – private pensions increase inequality or inequality is lower in pension systems where public pensions have a greater role to play.

In contrast, van Vliet *et al.*, who examined the pension indicators of 15 European countries in 1995–2007, found that the reforms did not increase the risk of poverty or inequality among the elderly (van Vliet *et al.* 2012). The same authors found in the repeat study involving more countries, expanding the time frame and using revised OECD data, similar results as previous authors, but opposite results to their previous research (Been *et al.* 2016). As can be seen from recent pension reforms in European countries (see Chapter 1.4), some countries are increasing the minimum pension or a non-wage component. Fox and Palmer (2001) also pointed out that, so far, a strong first pillar has been maintained in the multi-pillar systems.

Intragenerational redistribution. There are major differences between countries in terms of redistribution, but these differences are also explained by national pension systems. In general, the redistribution does not work the same

[14] For example, Kuznets (1955) examined the links between economic growth and the growth of inequality.

way for all subgroups, but differently. (Lefèbvre 2007) A separate subgroup can be gender. The redistribution has been found to be beneficial to women within a generation (Lefèbvre 2007; Bonenkamp 2009; Klazar and Slintáková 2012).

Lefebre (2007) believed that this was due to poorer participation in the labour market and to a significantly longer life expectancy. However, Bonenkamp (2009) tested this in the Dutch example – an important reason is the longer life expectancy of women. Differences in income and participation in the labour market are also important, but their impact is not high. He anticipated that this trend would decrease in the future, as the difference in life expectancy between men and women is declining according to population projections. One of the reasons still lies in the rights granted for raising children, as they generally go to women, and so it equates men and women. For example, in Germany, the share of children's rights was increased and, as a result, retirement income was more widely redistributed to women within the generation (this does not mean that a woman would receive a higher pension but redistribution is in favour of women). (Klos *et al*. 2022)

The following subgroups are made on the basis of income, skills and education. Intragenerational redistribution occurs from high-income to low-income people (Klazar and Slintáková 2012). Beetsma and Bucciol (2015) controlled redistributions in the case of collective risk-reallocation defined contribution fully funded pension contracts and found that a highly qualified pensioner wins the most and a highly qualified worker loses most of this scheme. It has been found that in the Dutch occupational schemes an intragenerational distribution occurs from lower education to those with higher education (Bonenkamp 2009).

In the case of extending employment, based on the French example two options have also been made: 1) extension of seniority requirement for retirement; and 2) extension of statutory retirement age. Although increasing the duration period is a better option than statutory retirement age (just from the point of view of inequality), the French example shows that lengthening the duration period had a worse effect on men with lower salaries and life expectancy than men with higher salaries and high life expectancy. (Aubert *et al*. 2013)

Spain has had to deal significantly with the financial sustainability of the pension system due to the global financial crisis. The retirement age was increased and pension replacement rates were reduced. Interestingly, the reduction in substitution rates increased the redistribution, as the pension index was linked to a 100 per cent CPI. (Conde-Ruiz and González 2016) The index of pensions is also important at old age, as older women may not be in the favoured pension system because of the index (Lefèbvre 2007).

If, in general, there are no significant reallocations in the fully funded scheme, this would be possible in the modified fully funded scheme. Frassi *et al.* (2019) found that their proposed new scheme would increase the welfare and also increase the redistribution. The scheme would be the same as the old fully funded scheme, but before the retirement age, a small part of all accounts would be taken away, which would be invested jointly and would be redistributed if the same people become retirees.

Korpi and Palme (1998) wrote that the more benefits are channelled to the poor, the less it reduces poverty and inequality – which they called the paradox of redistribution. Jacques and Noël (2018) re-tested this paradox with new data and a better methodology. The result remains in the 21st century that universality is the best political solution to reduce inequalities.

Therefore, it is important to analyse inequality in such conditions like Europe has and countries that have a similar system like the World Bank has recommended.

Intergenerational redistribution. Although we still lack studies that would offer a clear insight into intergenerational equality in Estonia, such studies have been conducted abroad. Geyer and Steiner (2014) studied how achieving long-term pension system fiscal stability will affect different generations' replacement rates. They concluded that pensioners would fall into poverty if they rely only on the state pension. For older generations, the reasons for falling into poverty might be a longer period of unemployment and pension reform. Fehr *et al*. (2012) also found that increasing the normal retirement age increases the risk of falling into poverty, as well as the contributions of future generations.

The price and availability of crude oil and natural gas play an important role in the Norwegian economy and the sustainability of the country's pension system. Norway reduced its generosity of the pension index and implemented a flexible retirement age in 2011. Hagist *et al.* (2011) found that as a result of these reforms the pension system sustainability is maintained and there are no intergenerational effects. They added a Norway-specific recommendation – the country needs to continue with reforms to minimise intergenerational effects in the future in case they run out of natural resources.

Similarly, Catalán *et al*. (2010) analysed the effects of increasing the retirement age in Spain and in one part they also examined intergenerational distribution. They found that while the younger cohorts would reap the benefits and the older cohorts would be unlikely to notice any effects of the reforms in question, it is the middle cohorts that stand to suffer from the 2008 decision to increase the retirement age by two years.

Italy too could not equally distribute the effect of rising retirement age by five years in the 1990s (Lockwood and Manoli 2012). In the case of men in West Germany, the increase in retirement age increases the inequalities, as low-educated and blue collars are unable to achieve a higher retirement age (Etgeton 2018).

If the government wants to move to a funded pension scheme, the solution is a step-by-step transition through the NDC scheme. Such a solution has been suggested for China. (Barr and Diamond 2009) In addition to raising the retirement age, Italy also switched to an NDC scheme in 1995. Belloni and Maccheroni (2013) investigated intergenerational effects of NDC reform and found that it made generations actuarially more equal. They also pointed out the use of untenable life expectancy values; ordinary people live longer than the life expectancy assigned to them in the calculations.

Although countries have different economic backgrounds and pension systems, it is generally found that the younger cohort or cohorts who have just started to retire would have an advantage if the retirement age is increased. However, future cohorts need to contribute more to have a proper replacement rate. Pension systems are made more actuarially fair, but this might lead to the risk of poverty. Most pension system reforms have intergenerational effects and although countries are aware of it, they do not always find a way to distribute the effects equally.

2.2.2. Overview of previous works in Estonia

Several overviews of the Estonian pension system have been made available in recent years. The OECD publishes a biannual "Pensions at a Glance" report which offers pension indicators of all OECD and G20 countries, including, for example, the replacement rate and pension wealth values. Estonia was first included in the report in 2011. Each publication has a slightly different focus; for example, pension reforms and their effects were under review in 2013 (OECD 2013) or flexible retirement was discussed in 2017 (OECD 2017a). The OECD does not give recommendations; rather, its aim is to compare countries and bring out some potential reasons for the differences. Other authors have also carried out comparable analyses involving Estonia.

Leppik (2006) wrote a doctoral dissertation on the transformation of the Estonian pension system over the period 1990–2005. He focused on the details of the reform process, key factors and actors that triggered the transformation and the choice of the particular reform paths. He also tested the explanatory power of three theoretical frameworks (historical institutionalism, actor-centred institutionalism and ideational approach) to explain the choices taken during the transformation. However, he did not specifically analyse the intra- and intergenerational effects of the reforms.

The mandatory funded pension scheme was launched in 2002. Since then, several articles have been published about it. Kulu and Reiljan concluded that a multi-pillar pension system is not a solution to the challenges posed by an ageing population because this would increase the at-risk-of-poverty rate and the switch to a new system would itself carry more risks. In addition, a multi-pillar system has shaken the principle of solidarity between generations. (Reiljan and Kulu 2002; Kulu and Reiljan 2004)

The question of whether a three-pillar pension system fulfils its purpose was also discussed in Raudla's (2004) master's thesis. She found that a limited intragenerational distribution is induced by the three-pillar system and this leads to intergenerational inequality for people with different income levels. A higher tax gain might be a positive side of the pension reform if this has an affirmative effect on the labour market and economic growth. Another positive effect might be less tax evasion due to a stronger connection between wage and pension. (Raudla and Staehr 2003)

Specific issues relating to the second pillar have also been studied including Estonia, such as the impact of a state decision on second pillar financial assets during a crisis (Chłoń-Domińczak 2018). The sustainability of the pension system from the perspective of trust has also been studied (Rajevska 2015). From the poverty viewpoint – Estonia has been assessed as one of the European countries where the number of people living in relative poverty is increasing dramatically (Zaidi *et al*. 2006).

Although the pensions of the first pillar are indexed there is no automatic stabilisation mechanism. The pensions of the future retirees do not depend on the fact that 20% of total social tax (earmarked for pensions) goes straight to the second pillar and this leads the social security budget into deficit in the near future. In theory, present workers should have higher pensions due to higher contributions to the pension system. However, as Leppik and Võrk (2006) show, in practice, this will not be the case. In addition, as the replacement rates do not take into account the contributions, we have to use alternative methods which capture that factor.

After Estonian re-independence in 1991, the retirement age was 55 for women and 60 for men but has been continuously increasing. By 2016, the retirement age of men and women reached 63 years (Võrk 2009), and by 2026 it will reach 65. Puur *et al.* have examined the effect of the statutory retirement age on the effective retirement age – they found that the exit from employment has moved proportionally to later ages (Soosaar *et al*. 2021; Puur *et al*. 2015; Võrk 2009). In comparison with Finland, Hungary, the Netherlands and Poland, so far there have been strong incentives to continue working or to postpone retirement in Estonia (Määttänen *et al.* 2014).

Previous studies about the Estonian pension system have been written based either on one typical person or a national perspective. Therefore, intra- and intergenerational effects are less studied in Estonia. Piirits and Võrk (2019) published the first article on the intergenerational effects of the reforms of the Estonian pension system.. The authors found that while pension distribution is widening, the distribution of the replacement rates to the last wage is diminishing. Those who are contributing more are going to receive a higher pension.

2.2.3. Overview of pension models

Modelling or simulations are needed to imitate real-world processes, requiring a set of assumptions regarding the behaviour of a simulated system (Banks 2010). Models can be categorised by various dimensions like theoretical or statistical model, general equilibrium or semi-equilibrium, static or dynamic model, deterministic or stochastic, typical or heterogeneous agents' model. Depending on data availability and the aim, whether to consider the economy as a whole or from the individuals' perspective, different models are used. This subchapter only deals with pension models.

Econometric or regression models are used if historical pension and income data are available and the aim is to compare countries over time (Goudswaard and Caminada 2010; van Vliet *et al.* 2012; Been *et al.* 2016). Decomposition methods are used to separate the role of different factors (Bönke *et al*. 2010; Schirle 2009; Lockwood and Manoli 2012).

Macro models are typically used to study welfare, sustainability or aggregate impacts, like labour force participation, wages, and return on capital (Beetsma and Bucciol 2015; Conde-Ruiz and González 2016; Frassi *et al.* 2019; Etgeton 2018; Catalán *et al*. 2010). Different types of macro models are used: general equilibrium framework (Frassi *et al.* 2019), dynamic general equilibrium model (Catalán *et al*. 2010) and overlapping generations model (Beetsma and Bucciol 2015; Fehr *et al*. 2012; Conde-Ruiz and González 2016; Buyse *et al*. 2017). The generational accounting method is used to study sustainability and intergenerational inequality issues (Bonenkamp 2009; Hagist *et al.* 2011).

Another approach is to simulate changes at the individual level. There are three relevant approaches: 1) cellular automata; 2) agent-based models (ABM); and 3) microsimulation models (MSM) (Williamson 2007). ABM and MSM are commonly used for the pension reform issues.

The representative agent model is one branch of ABM. Representative agent models are sophisticated to use for estimating replacement rates. The main challenges with these models are sustainability estimates and modelling individual behaviour. Another branch is a cohort model which is easier to use for aggregated results but problematic in the creation of more detailed subgroups. (Gal *et al.* 2009) As distributional effects are difficult to estimate with ABM, those models are rarely used for that purpose.

MSM are increasingly used to assess the effects of policies on income distribution. They can be static, dynamic, stochastic or behavioural and are used for distributional analyses. (Figari *et al*. 2015) MSM input data can be based on surveys or administrative datasets. They can estimate intra- and intergenerational distributive effects (Gal *et al.* 2009). Models are usually specific to a given country though some models also cover several countries in Europe[15], for example the dynamic MSM MIDAS for Belgium, Germany and Ital, which is used to assess the impact of ageing and pension system reforms on sustainability, adequacy, poverty, inequality and for (re)distribution (Dekkers *et al.* 2010).

MSM are often criticised for being a “black box” because models are usually complex and incorporate many processes (O’Donoghue and Dekkers 2018). Dekkers (2010) validated a dynamic MSM with a simplified model and aggregated results were comparable but base inequality was different. Inequality trends were comparable between the simple and dynamic MSM. (Dekkers 2010)

There are some cases where a MSM and a macro model are combined (e.g. Peichl 2009; Holmøy and Strøm 2013; Fredriksen *et al.* 2019). Holmøy and

[15] See the list of MSM, cohort models and typical agent models in the Gal *et al.* 2009 report.

Størm (2013) and Fredriksen *et al.* (2019) estimated the impact of a pension reform on the long-run fiscal sustainability in Norway. The aim of a micro-macro model is to assess the effects of macroeconomic changes on income distribution (Bourguignon and Bussolo 2013; Figari *et al*. 2015). Micro-macro models can also be described as a "black box" inside the "black box" and therefore, it is even more essential to describe every step made in the model and validate results with external data or another model.

Dynamic models are mainly used when it is essential to model processes over time, like with pensions (Figari *et al*. 2015). A dynamic model is needed in particular when a Bismarckian pension system is being simulated because the future benefits depend on the previous earnings and therefore, it is necessary to simulate potential employment changes in the future (Dekkers 2015). As the Estonian pension system is mostly a Bismarckian system in terms of benefits and financing then its modelling also requires a dynamic MSM.

3. METHODOLOGY

> *Pension design affects the labour market, economic growth, the distribution of risk, and the distribution of income, including by generation and gender. Analysis of distributional effects should consider the progressivity of the system as a whole, rather than that of each element.*
>
> Nicholas Barr and Peter Diamond

Since this work can be regarded as a policy assessment, it will also use the policy evaluation method, i.e. the evaluation of a model with real policy rules as far as possible. The work can be considered an *ex post* analysis of the adoption of laws, but an *ex ante* analysis from the application point of view. The scenarios have different timelines. While some regulations have been in force for 20 years, other reforms have been adopted recently to be applied to the future, i.e. hence the analysis of these scenarios will be an *ex ante* analysis. Since the work analyses the impact of the laws adopted and the model includes real individual-level data, it is not a theoretical model but a real model.

The typical agent model and the microsimulation model have been developed to assess the impact of pension reforms on inequalities. Intergenerational effects can be estimated on the basis of individual-level data (real data), or the examples of typical agents. The use of microsimulation means involving people with different backgrounds, which in turn affects the aggregated outcome of the pension reform. In addition, the people's future actions should be simulated in the microsimulation which adds the dispersion to the results of the pension reform effects. Therefore, the typical agent pension simulation model ESTPEN is used to assess intergenerational effects and the microsimulation model ESTPEN-MICRO is used to simulate intragenerational effects and intergenerational effects. It is then possible to compare the typical agent model and microsimulation model results and differences. The previous version of the microsimulation model ESTPEN-MICRO has been already used to calculate public pension benefits (Piirits 2021).

The disadvantage of the typical agent model ESTPEN (ABM approach) is the lack of possibilities to analyse distribution effects, which in turn is the greatest advantage of the microsimulation model ESTPEN-MICRO. The distributional effects of pension reform are influenced not only by policy changes, but also by variations in behavioural responses of individuals to such policy changes, i.e. how individuals react to the implemented reforms by altering their decisions concerning (e.g. pension savings, fund choice or timing of retirement). The question is whether and how the behavioural responses of people can be taken into account in modelling. The ABM method can be used to calculate individual behavioural effects, but only in the predefined cases (Richiardi 2014). The behavioural responses can also be built into the microsimulation model, but it would make the model even more complex (black-box criticism) and would add an additional dimension to the validation. O'Donoghue and Dekkers (2018) point out that enhanced complexity of models makes them more time-consuming and the results harder to interpret, running in counter to the aims of modelling, which is to simplify reality with the purpose of gaining insights. The work by Patxot *et al*. (2018), who introduced behavioural responses into a dynamic microsimulation model to estimate the impact of retirement decisions on pension sustainability, shows that when behaviour is considered, people tend to act for a short-term benefit (e.g. retire when the entry pensions are higher and delay retirement in the years of a crisis). Despite some potential benefits of consideration of behavioural responses, the thesis opts for a non-behavioural approach to balance the trade-off between complexity and explanatory power of the analysis. Adding behavioural responses to the eight policy scenarios would considerably add complexity while diminishing the manageability of the model.

It should also be noted that the microsimulation model ESTPEN-MICRO does not use multiple inputs for the same issue, e.g. population forecast or macroeconomic forecast (subchapter 4.2.3 presents the results of the sensitivity analysis of the input data). Single inputs have also been used because forecasts are not available for Estonia on the same basis. Since the macro model is not part of the pension model, datasets described in subchapter 3.1.1 have been selected, while the initial macroeconomic and population forecasts are using similar assumptions. In turn, the model does not test the effect of the results on the input because, in addition to the micro model, there is no built-in macro model (with consideration to the black box criticism), and 7 out of 8 scenarios have been legislated, the results of which should be taken into account in the projections.

Since the early days of creation of microsimulation models, there has been a discussion about the issue of uncertainty of model estimates. McClelland *et al*. found that the point estimates of their microsimulation model were very accurate (McClelland *et al*. 2020). One way to get the confidence intervals in the ESTPEN-MICRO model is to run it several hundred times (assuming the independence of the error terms of the equations), which however would take the same number of days to run.

The first subchapter describes the data sources used, the scenarios of real pension reforms and assumptions. The second subchapter describes the operating mechanism of the typical agent model and indicators for assessing intergenerational inequalities. The last subchapter explains step-by-step the design of the microsimulation model and compares the results with historical information.

3.1. Data and scenarios

3.1.1. Data

The models used are structurally different and require a different amount of information. The microsimulation model requires significantly more data. The same data sources are used if the data requirements of the two models overlap. The typical agent model uses long-term macroeconomic forecasts and Eurostat population forecasts as input data (see Table 7). The Ministry of Finance's (MoF) long-term macroeconomic forecast is until 2070 and has been extended using the same assumptions as have been made in the forecast because pensions have been simulated until 2100. Macroeconomic forecast and long-term population projections are used as input data, which are not simulated in the models. Eurostat population projections are used as this is consistent with the macroeconomic forecast.

Table 7. Data used in the typical agent model

Data description	Data period	Source
Macroeconomic assumptions: average wage, CPI, GDP, employed people, pension index	Historic data: 2000–2019 Projection: 2020–2070	Ministry of Finance long-term macroeconomic projection
Demographic assumptions: life expectancy	2018–2100	Eurostat long-term population projection

Source: compiled by the author.

The macroeconomic data consist of five parts: 1) historic data (2000–2019); 2) MoF short-term forecast (2020–2024); 3) transition from MoF short-term forecast to ageing report projection (2025–2040); 4) the ageing report projection (2041–2070); 5) the author's extension (2071–2100).

At the beginning of this century, the growth of the Estonian economy was one of the fastest among European countries, but during the global financial crisis the economic downturn was also one of the greatest (see Figure 10). The consumer price index (CPI) growth is projected to be at 2% level in the long run (from 2020 to 2070). The growth of GDP (real) is projected to be around 1.5% in the long run, and the growth of average nominal wage is projected to be around 4%. As the population is decreasing, especially among the working-age population, the number of persons employed decreases and the annual rate of decline is estimated at 0.5% on average.

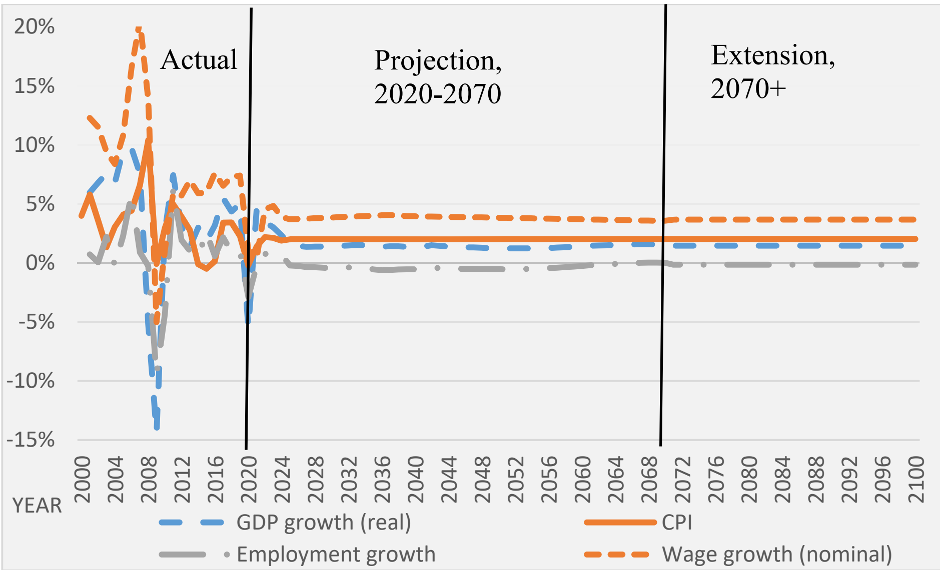

Figure 10. Long-term macroeconomic projection
Source: Ministry of Finance 2019; author's calculations.

The statutory pension age in the scenarios is set by law or calculated based on the law. Figure 11 depicts the projected evolution of the SPA and life expectancy at age 65. By 2026, the SPA will be gradually raised to 65. From 2027 onwards, the SPA will be linked to life expectancy.

The literature has shown that differences in life expectancy are one of the greatest factors in the redistribution (Bonenkamp 2009). In Estonia, the difference in life expectancy between men and women at age 65 was 5.0 years in 2016, but the difference is decreasing and by 2100 the difference is estimated to be 3.4 years according to the Eurostat long-term population projection.

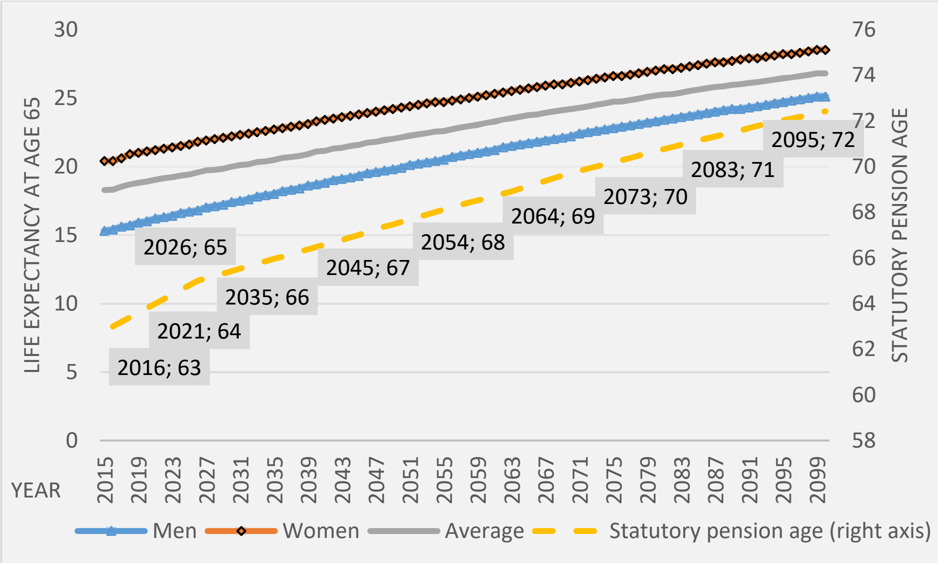

Figure 11. Projected life expectancy at age 65 and statutory pension age
Source: Eurostat 2021b; 2021j; author's calculations.

The microsimulation model uses significantly more input data. The datasets used in addition to the above information are described below (see Table 8). The entire simulation is based on data from the Social Insurance Board (SIB). This dataset includes people who are already retired and also all people who have paid at least some social tax over the period 1999–2015. In addition to SIB data, new cohorts that follow Eurostat's population forecast (through birth rates, mortality rates and migration) have also been simulated. Second and third pillar information is also added.

Table 8. Additional data used in a microsimulation model

Data description	Data period	Type	Source
Pension rights data**: Individual-level data about earned entitlements, wages, pensions, type of pension**	1999–2015	Individual level	Social Insurance Board (SIB)
Demographic assumptions**: Fertility, mortality rates and migration**	2019–2100	By age, gender and year	Eurostat long-term population projection for Estonia
Education data **for around 300,000 people**	End of 2015	Individual level	Estonian Education Information System (EHIS)
Second pillar data: **value, strategy**	End of 2015	Individual level	Estonian Central Register of Securities (CSD)
Third pillar data: **value, contribution**	End of 2015	Individual level	Estonian Central Register of Securities (CSD)
Overall background statistics	As available	Aggregated	Statistics Estonia, Eurostat

Source: compiled by the author.

In the thesis, the education information is only known about those for whom an Estonian Education Information System (EHIS) record is available. The coverage of education information is high (reaching 93%) up to the age of 30. In older age groups, the coverage drops to below 20% (see Figure 12). Education data have been added to the population data and the missing values have been imputed according to gender.

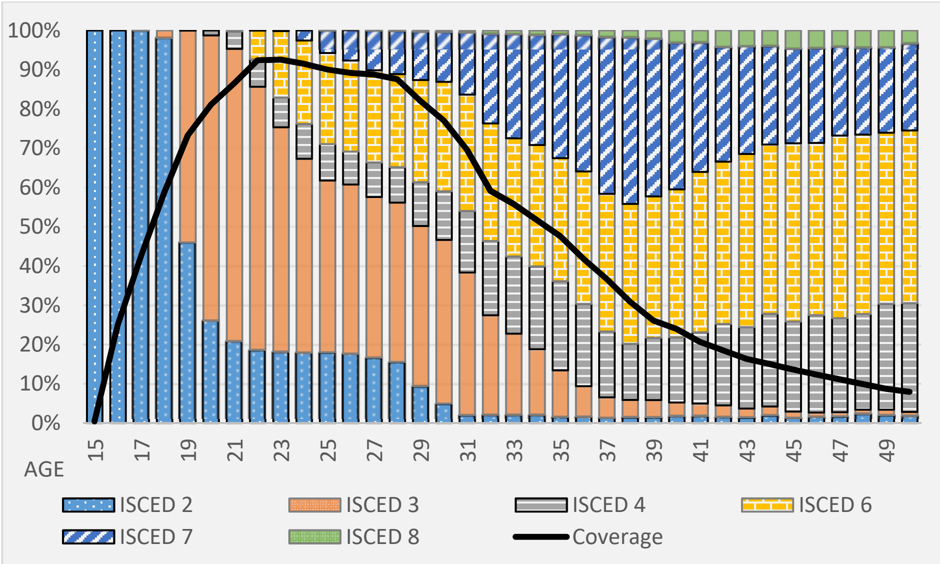

Figure 12. Distribution of education levels and coverage of educational information
Source: compiled by the author.

The following information is known about the first, second and third pillars.

First pillar:

- Retired people:
  - Birth year
  - Death year
  - Gender
  - Year of retirement
  - Type of pension
  - Size of the pension in 2015
  - Service years (earned before 1999)
  - Insurance years (total and years separately – earned from 1999)
- Not retired people:
  - Birth year
  - Death year
  - Gender
  - Insurance years (years separately – from 1999)

Second pillar:

- Year of joining
- The decision to continue contributions in 2009
- The decision to increase payments in 2014–2017
- The value of accumulated pension assets at the end of 2014
- Fund strategy (conservative, balanced, progressive, aggressive)
- Type of payment
- Year of payment

Third pillar:

- Funds:
  - Linkable[16] value at the end of 2014
  - Linkable joining year
  - Non-linkable contribution in 2015
  - Non-linkable income of that person
  - Non-linkable year of birth
  - Non-linkable gender
- Insurance
  - Non-linkable value at the end of 2015
  - Non-linkable joining year
  - Non-linkable contribution in 2015
  - Non-linkable year of birth
  - Non-linkable gender

More specifically, data and their distributions and simulation steps are described for the typical agent model in subchapter 3.2 and the microsimulation in subchapter 3.3. All previously described information is used in the microsimulation model ESTPEN-MICRO. Some information, like the decision to continue second pillar contributions in 2009 is used to calculate historical wages because wage data was not available in the first place. The first pillar insurance years and second pillar contribution information are used to calculate wages.

3.1.2. Scenarios

Eight scenarios have been established in order to meet the aim of the thesis. Four scenarios (scenarios 1 to 4) cover policies that have been in place for some time (see Table 9). Another three scenarios (scenarios 5 to 7) cover changes of the pension system that were legislated at the end of 2018. The last scenario (scenario 8) concerns an extreme scenario of making the second pillar voluntary (see Table 9).

The pension system which was in place before 1999 had only the first pillar. The size of the old-age pension depended on the service years (length of employment). This is scenario number one and is used as a base scenario. At first, the way first pillar entitlements are earned was reformed in 1999. Thereafter the entitlements are earned based on the wage (more specifically on the social tax paid on the wage), rather than length of employment status (scenario 2). At this stage, there was no automatic indexation and pension increases were decided *ad hoc* by the Parliament. However, in the scenarios the same indexation is used for the sake of comparison. In addition, the same SPA (gradually increase to 65) is used for scenarios that occurred before the 2018 legislation, i.e. the SPA will rise to 65 in 2026. The voluntary fully funded scheme was introduced in 1998 and is also included in the second scenario.

[16] As data sources are different not linkable information cannot be directly connected to the same person, but linkable information has the same anonymised identifier.

Table 9. Simulated reforms

Description (actual years)	Length of service	Insurance	Indexation*	II pillar	III pillar	SPA
1. PAYG + service component (…-1998)	Yes	No	50/50; 1/1	No	No	65 by 2026
2. PAYG + insurance component (1999-2002)	**No**	**Yes**	50/50; 1/1	No	**Yes**	65 by 2026
3. Introduction of the II pillar (2002-2008)	No	Yes	50/50; 1/1	**Yes**	Yes	65 by 2026
4. Indexation change in the PAYG (2008-2020)	No	Yes	**20/80; 1.1/0.9**	Yes	Yes	65 by 2026
5. PAYG + new service component (2021-…)	**2021-…: 50%**	**2021-…: 50%**	20/80; 1.1/0.9	Yes	Yes	65 by 2026
6. Linking pensionable age to life expectancy (2027-…)	**No**	**Yes**	20/80; 1.1/0.9	Yes	Yes	65 by 2026 and **linked to life expectancy afterwards**
7. New reforms together (2021-…)	**2021-…: 50%**	**2021-…: 50%**	20/80; 1.1/0.9	Yes	Yes	65 by 2026 and linked to life expectancy afterwards
8. Voluntary II pillar (2022-…)	2021-…: 50%	2021-…: 50%	20/80; 1.1/0.9	**No from 2022**	Yes	65 by 2026 and linked to life expectancy afterwards

Source: compiled by the author based on legislation.
* The first number shows the index components – 20/80 means that the index depends 20% on the CPI and 80% on the growth of social tax revenues. The second number shows how the index changes the base amount and value of points – 1.1/0.9 means that the base amount is increased by 1.1 times of the index and the value of the points is increased by 0.9 times of the index.

The mandatory fully funded scheme started in the middle of 2002 and this reform is used as scenario number three.

The fourth scenario covers the change of the indexation rules introduced in 2008. This reform made indexation more generous and more redistributive. The new index increased the weight of social tax revenues. The relative weight of CPI and the growth of social tax revenues in the index was changed from the earlier 50/50 proportion to a 20/80. The pace of indexation of the flat-rate base amount of the first pillar was also increased. The base part exists in all scenarios. The pension system consists of three pillars, where half of the first pillar depends on the size of wage and the second and third pillars are fully dependent on the size of wage.

Due to the financial sustainability and the solidarity aspects, the government proposed a number of amendments at the beginning of 2017 which should increase financial sustainability and solidarity (Piirits and Masso 2017) and the Parliament adopted those with some changes at the end of 2018. This work does not deal with financial sustainability and focuses only on how the pension reforms affect the distribution and solidarity of the pensions. However, sustainability is also important in terms of inequality because a surplus in the pension system will be divided between retirees, increasing the flat-rate base amount is an assumption used in the model. In real life, it needs to have a political decision.

A majority of the reforms have been simulated but flexible retirement is excluded as there is no data to simulate flexible retirement. This needs further investigation after receiving behavioural information. Analysing flexible retirement is also possible by making several scenarios based on health or employment, but this needs a separate study, and it is not the topic of this thesis.

Previous reforms (1 to 4) have been built on top of each other, but the new reforms (5 to 6) will be built on scenario 4. Scenarios 5 and 6 will be put together in scenario seven. Scenario 8 will be built on scenario 7.

Scenario five changes the logic of how the first pillar entitlements will be earned, i.e. 50% from service years and 50% from insurance years from 2021. Previously earned entitlements would remain as they were acquired. In addition, the second pillar contribution decreases the first pillar service years entitlements. The first pillar service component (ls_τ) is calculated as in the following equation:

$$ls_\tau = 0.5 * \min\left(\frac{AGW_{\tau,i}}{\min\_wage_\tau}, 1\right) * \frac{(0.2 - C_{\tau,i})}{0.2} \tag{11}$$

Where:

ls_τ – Length of service component from 2021 in year τ;

$AGW_{\tau,i}$ – Person i annual average gross wage in year τ;

$\min\_wage_\tau$ – Minimum wage in year τ;

$C_{\tau,i}$ – Contribution to the second pillar in year τ as a % (ordinary 4%).

According to the previous (Equation 12), a person earns 0.4 service years (ls_τ) every year if he/she earns more than the minimum wage and has joined the second pillar. If a person had not joined the second pillar, he/she would earn 0.5 service years.

From 2027 the SPA will be linked to life expectancy (a year after reaching the retirement age of 65). The life expectancy anchor point will be age 65. For example, if the life expectancy at 65 rises by one month, the SPA also increases by one month. The difference of life expectancy in five-year intervals is used, as in the following equation will be used (Riigi Teataja 2019f):

$$SPA_\tau = 65 + \frac{\sum_{\tau-8}^{\tau-4} LE_{65}}{5} - \frac{\sum_{2018}^{2022} LE_{65}}{5} \qquad (12)$$

Where:

SPA_τ – Statutory pension age in year τ;

LE_{65} – Life expectancy at 65.

The statutory pension age (SPA) will not be changed if the change of life expectancy is less than one month, i.e. the SPA is determined with the accuracy of one month. In addition, the maximum annual increase of the SPA can be 3 months and the SPA may be changed once a year (the Figure 13 shows the change in the SPA in scenarios).

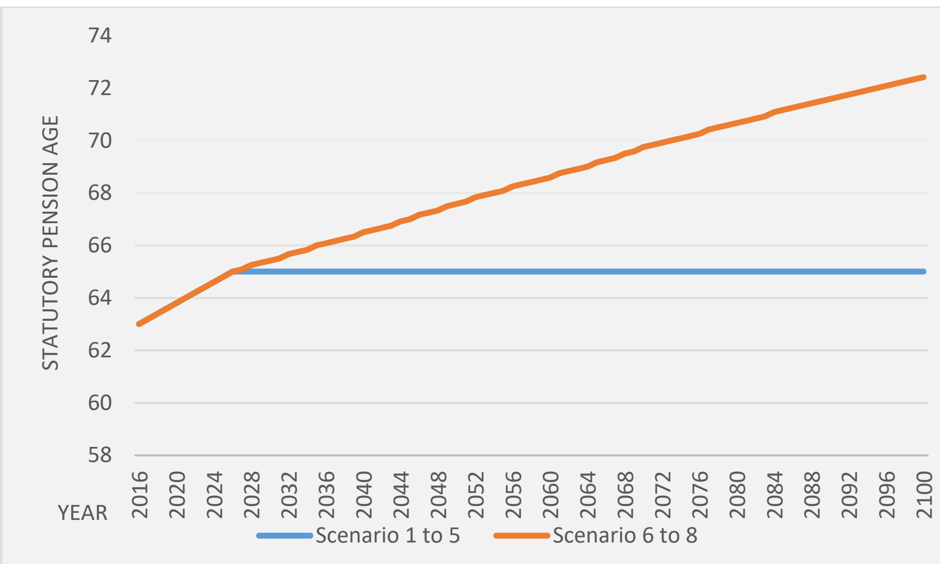

Figure 13. Statutory pension age in the scenarios
Source: author's calculations.

The seventh scenario is a combination of the fifth and sixth scenario – the SPA is linked to life expectancy and a new length of service component is added.

The eighth scenario is a hypothetical extreme scenario, where the mandatory funded scheme is made voluntary and all people would stop making contributions and take their assets out from 2022.

3.2. Typical agent model

The typical agent model allows pensions to be calculated for a typical person under various assumptions. In this thesis, different types of people who differ from each other by birth year (inter-generationally) and by wage (interpersonally) are used. Birth years start from 1953 and end in 2035. Wages vary from 30% of the average wage (a little lower than the minimum wage in 2019) to four times the average wage. Additional pension rights are not included because children are not considered in this model. Cohorts also differ with respect to the SPA (for the cohort born in 1953 it is 63 and it increases by 3 months with every cohort until the SPA is 65 from the birth year 1961).

The model of a typical agent is based on a model developed in the author's master's thesis (Piirits 2014), which has been updated and further developed. The model is called ESTPEN. Figure 14 describes the sequence of operation of the ESTPEN model (the sequence of operation of the model is numbered on the figure). First, it is necessary to know the statutory pension age to calculate future pensions. Second, it is important to know the potential values of pension components (Pension index box on figure 14), which depend on macroeconomic and pension system parameters (see Figure 14). The next input data is individual information – gender, salary and second pillar information. Based on the above information, a future pension can be calculated. An in-depth description is given in Appendix 1.

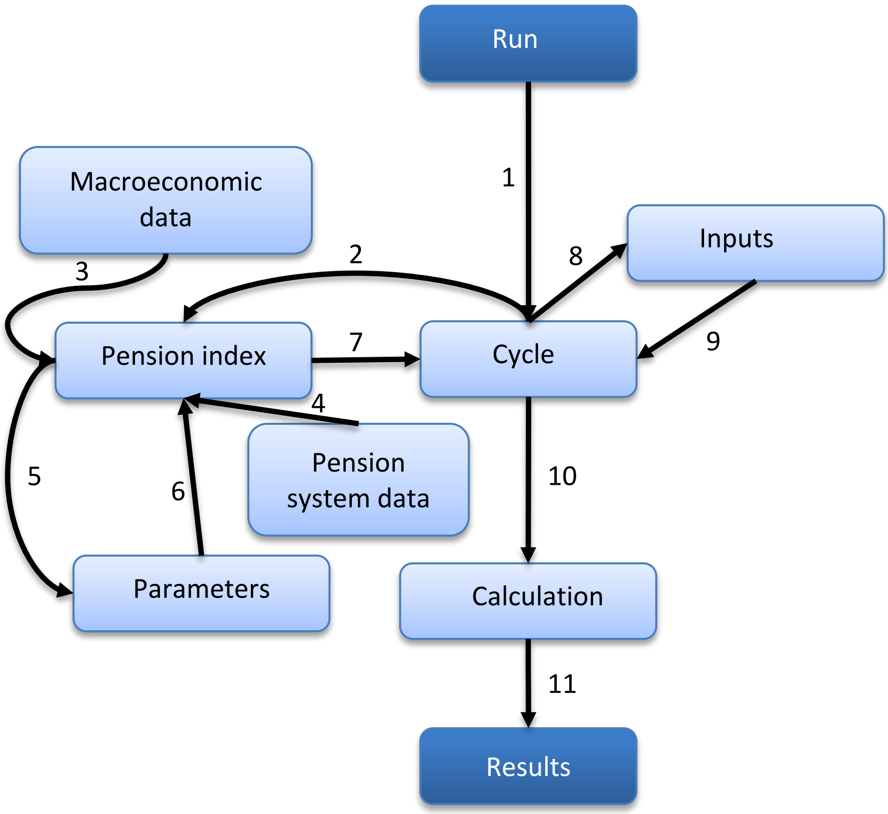

Figure 14. Schematic structure of the pension model ESTPEN by order
Source: Piirits 2014.

3.2.1. Typical agent model assumptions

It is assumed that every cohort starts working at the age of 20 and does not have unemployment periods in the general assumption's simulation. Different cohorts have also different life expectancies, varying from 20 to 22 years at the time of retirement. Macroeconomic background information is taken from the MoF long-term projection. This means that as the model does not have any feedback to macroeconomic assumptions, those are taken as given.

Although participation in the compulsory funded pension scheme was voluntary for some cohorts, it is still assumed that all people participate in the scheme for comparison reasons. In addition, 85% of working-age people (people aged 19–62 on 01.01.2015) were subscribed to the second pillar. Furthermore, 67% of those who were not obliged to join the second pillar and were not in retirement on 01.01.2015, also subscribed (share of subscribers in different cohorts vary between 29%–90%). Due to the global financial crisis, the contribution rate to the second pillar was different, but for a typical person the default option is assumed, as an average Estonian taxpayer decided to discontinue his/her contributions during that time (see Table 5). Furthermore, the contributions were not increased from 2014–2017. The actual rate of return of the pension funds is used for data up to 2018. Later we will assume 5% of the nominal rate of return. We also assume at the second pillar payment phase a nominal annuity interest rate of 3%.

Sensitivity. There are no unemployment periods in the general assumption's simulations, but in the sensitivity analysis 5 years and 15 years of unemployment are also used (see Figure 15). This means that the maximum time of working can be 40 or 30 years in those cases where the SPA is 65. The timing of unemployment is not important in the first pillar, but it is in the second pillar. The reason lies in the aspect that points are earned in the first pillar for which the value is given at SPA. It does not matter whether a person is earning an average wage in 2020 or 2030, he/she still earns the same amount of points from the first pillar. The unemployment periods are ordinary at the beginning or the end of the working career. Therefore, a person with 5 years of unemployment starts working at age 25 and a person with 15 years of unemployment starts working 10 years later (at age 30) and ends working 5 years before (at age 60).

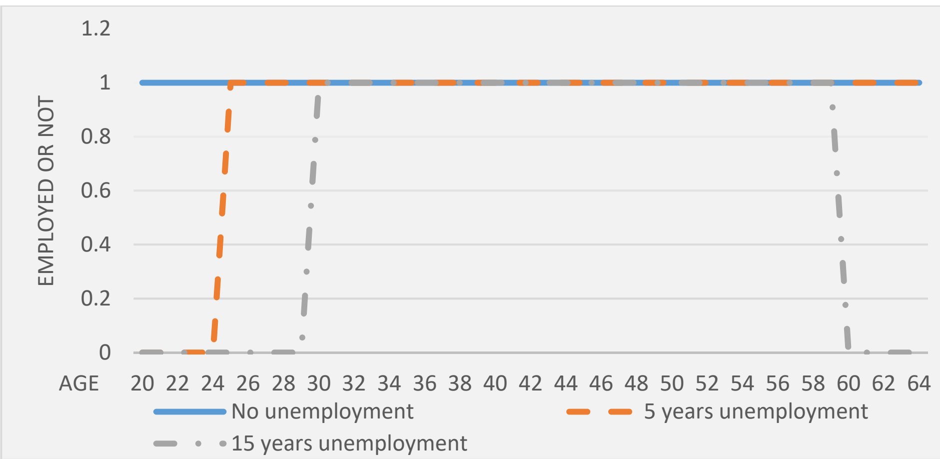

Figure 15. The typical agent model unemployment periods in the sensitivity analysis
Source: compiled by the author.

The important assumptions for the second pillar are the nominal rate of return and annuity interest rate. Lower and higher rates at the same time are used in the sensitivity analysis – a nominal rate of return of 3% and nominal annuity interest rate of 1% for the lower rates, and a nominal rate of return of 7% and nominal annuity interest rate of 5% for the higher rates.

3.2.2. Typical agent model indicators

Intergenerational effects of Estonian pension reforms are characterised using various indicators, such as gross and net theoretical replacement rate at the time of retirement and 10 years after retirement, both with respect to the economy-wide average wage and a person's last wage. In addition, gross and net pension wealth, IRR and NPV ratio are calculated. These methods measure different aspects of the pension reforms, such as adequacy and fairness.

The theoretical replacement rate is the simplest way to evaluate a future pension. That indicator can be found by either dividing the pension by the economy-wide average wage or by a person's last wage. Pensioners have an ordinary tax advantage, and it is therefore useful to evaluate gross and net theoretical replacement rates. The theoretical replacement rate for the economy-wide average wage at retirement time is called the gross relative pension level (GRPL). The replacement rate changes every year after retirement because the numerator and denominator are changing differently. Hence, the same replacement rate 10 years after retirement is GRPL+10. A change of quality of life is important and for this the gross replacement rate (GRR) is used in which the pension size is divided by a person's last wage (OECD 2011).

$$GRPL_{i,t} = \frac{GP_{i,t}}{AGW_t} \tag{13}$$

Where:

$GP_{i,t}$ – Person *i* monthly gross pension at period *t*;
AGW_t – State average gross wage at period *t*.

$$GRR_{i;t} = \frac{GP_{i,t}}{AGW_{i,t-1}} \tag{14}$$

Where:

$AGW_{i,t-1}$ – Person *i* average gross wage at period *t-1*.

The internal rate of return (IRR) is ordinarily used for investment projects. To calculate the IRR the investments and all benefits need to be known. In addition, the IRR shows the discount rate in which the investments and earnings would be zero. If the IRR is positive, the person will have more earnings than the investments. The pension system can be also seen as an investment project for retirement. At the same time, the state should also look at the pension system's IRR for different cohorts. The pension system would not be sustainable in the long run if the administration offers too high IRR through the pension system. The IRR is calculated by Mazzaferro *et al*. (2012) as:

$$\sum_{t=AoW_i}^{RA_i-1} C_{i,t} * (1 + IRR_i\ )^{RA_i-t} = \sum_{s=RA_i}^{LE_g} (\frac{GP_{i,t}}{(1 + IRR_i\ )^{s-RA_i}}) \quad (15)$$

Where:

IRR_i – Person i internal rate of return;
RA_i – Person i pension age;
$C_{i,t}$ – Person i monthly contributions (euros) in year t;
AoW_i – The age when person i started to work;
LE_g – Average life expectancy of g cohort (years);
$A_{i,t}$ – Person i age at period t.

The real and nominal values can be used to calculate the IRR. The prices and future cash flows are needed to know the NPVs, which allows the IRR to be assessed in real values. It is better to use nominal values for the IRR rather than the real values, as the real value carries a higher risk of errors. In this case, it is possible to compare the IRR with nominal market interest. Therefore, the gross pensions (before tax deductions, health care and care insurance contributions) need to be known to calculate the IRR (Schröder 2012).

An alternative way to consider all contributions and pension pay-outs is to use the net present value (NPV). Since the NPV is a monetary value and is needed to compare different cohorts, NPV must be converted into a comparable denomination. Mazzaferro *et al.* (2012) used the ratio of net present values (RNPV). They divided net present valued pension pay-outs with net present valued contributions. The RNPV is calculated at the year of SPA. If the RNPV is over one, the person will have more pay-outs than he/she made contributions and if vice versa then the RNPV is less than one. Therefore, RNPV is comparable for the intergenerational effects (Mazzaferro *et al.* 2012).

$$RNPV_i = \frac{PVP_i}{PVC_i} = \frac{\sum_{RA_i}^{RA_i+LE_g} \frac{GP_{i,t}}{(1 + d_t)^{A_{i,t}-RA_i}}}{\sum_{AoW_i}^{RA_i} C_{i,t} \times (1 + d_t)^{RA_i-A_{i;t}}} \quad (16)$$

Where:

$RNPV_i$ – Person i ratio of net present value;
PVP_i – Person i present value of pension payments (euros);
PVC_i – Person i present value of contributions (euros);
d_t – Real discount rate in year t (CPI is used in the model).

The replacement rates only indicate the size of a pension at any one moment. This indicator does not take into consideration personal contributions and all pay-outs. The IRR (nominal) and RNPV are used to take those aspects into account. The IRR can be used to compare pension system returns with the return of risk-free instruments. The IRR does not reflect if and how people are actually coping with the pension they receive. The RNPV shows clearly whether a person can have more or less back his/her contributions. The RNPV has the same problem as IRR, it does not have a link between pensioners real coping. However, the IRR and the RNPV allow the intergenerational effects to be evaluated.

3.3. Microsimulation model

In order to fulfil the aim, a population microsimulation model has been developed. The model is named ESTPEN-MICRO and is built in the data analysis and statistical software Stata. An overview of the model is given in the next figure (see Figure 16) and an in-depth description is given in Appendix 2.

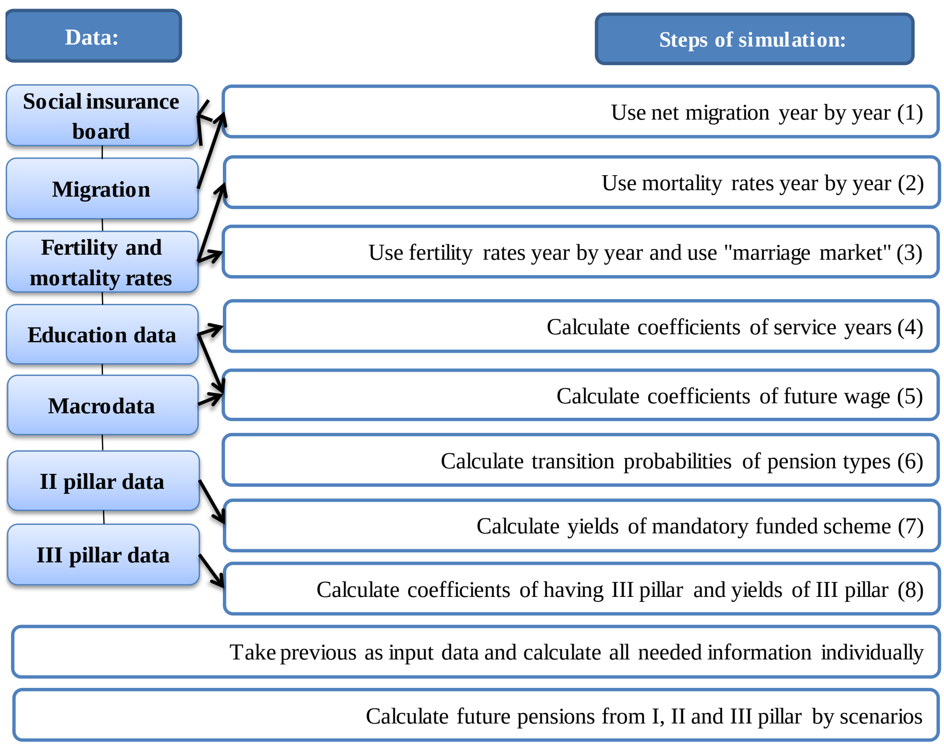

Figure 16. Logic scheme of the microsimulation model
Source: compiled by the author.

The model is explained step-by-step in the following subchapters and simulation results are compared with historical information. The following subchapters are using the same sub-numbering as the corresponding part is numbered in Figure 16. The model consists of 13 Stata do-files by scenario and all raw results are calculated within 24 hours with 32 GB RAM and 4 cores.

Stata can use all four cores. An extra 12 hours is used for the results to be calculated (average and median pension by cohort, year and scenario, inequality indicator Gini, sustainability).

3.3.1. Migration

Simulation of the migration occurs in a model module named "5_Mortality-Rates_Child" (see Appendix 2). In order to obtain a similar Estonian population as in the population statistics by gender and age, it is first necessary to achieve a similar starting point between population statistics and model population at the end of 2015. The number of people does not exactly coincide with the population statistics of Eurostat, as in 2016 there are more people aged 25–69 in SIB data than in official statistics (see Figure 17). The reason may be due to migration because people who have moved abroad are still inside SIB data because they have earned pension rights in Estonia from 1999 to 2015. Some people have worked in Estonia in the short term and then migrated abroad – they are in the SIB database because they have some pension entitlements but they are not in the population statistics. Therefore, it is necessary to find groups over-represented based on gender and age. To be in the line with the population data, around 70,000 people (around 5% of the population) are set to having migrated abroad.

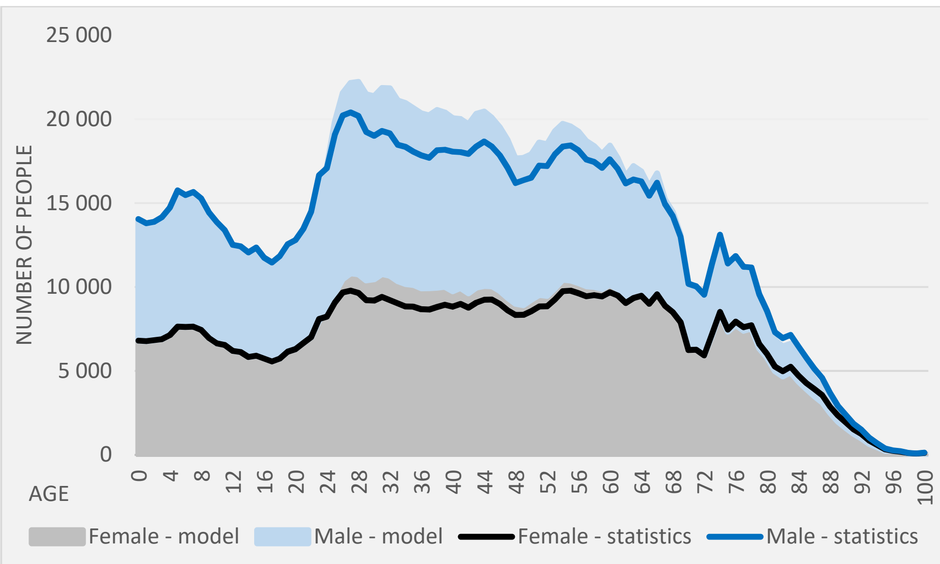

Figure 17. Model population comparison with population data in 2016 by gender
Source: Eurostat 2019b; author's calculations.

First, population statistics data is saved as of 1 January 2016, as SIB data is at the end of 2015. Second, the people who migrate must be chosen by the model. Statistics Estonia uses the residency index for those cases – 14 different administrative registers (Maasing *et al*. 2017) but in the ESTPEN-MICRO model only a person's last wages can be used. Therefore, people who have no wages for a longer period (starting from 2015) are removed from the model. As they still have some entitlements, they are kept in a different database to calculate the future cost of their entitlements. Afterwards, the population until the age of 70 is in line with the statistics (see Figure 18), but the population from age 70 onwards is underrepresented in the SIB database compared to official statistics. As they are not included in the SIB statistics, they also do not reflect the costs, but they may influence the overall size of the population.

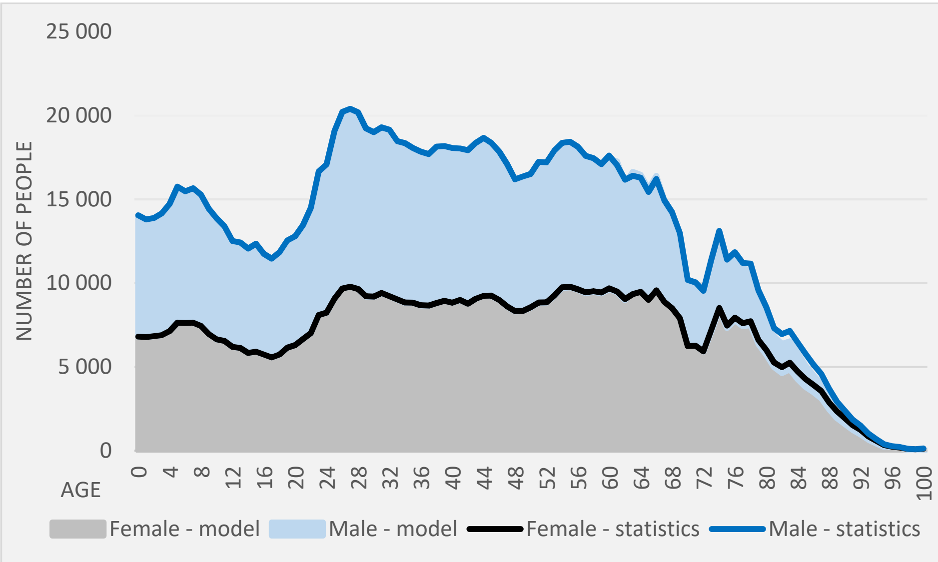

Figure 18. Model population comparison with population data in 2016 by gender after outmigration
Source: Eurostat 2019b; author's calculations.

The future (2016 to 2100) population is found using three components: immigration, deaths and children. Components are used in the same order as named every year. Migration is discussed in this subchapter but mortality and fertility are discussed in the next subchapters.

The Eurostat population forecast for migration is used for immigration. As total migration is positive for future years by gender, and to simplify the model, only positive migration (immigration) is used. Some age groups still have negative migration over the years, so to be in line with the total migration, those negative migrations are proportionally decreased to all positive migrations (see Figure 19 as an example).

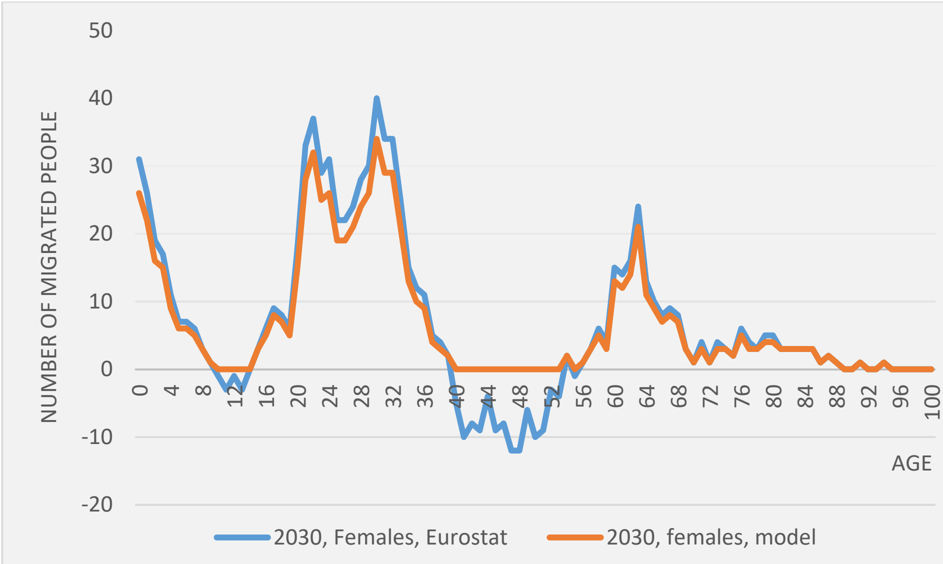

Figure 19. Eurostat migration projection compared to migration used in the model in 2030
Source: Eurostat 2021a; author's calculations.

A new data point is also needed for immigrated people because they can immigrate at any age, therefore it is important to know which year that happened.

3.3.2. Mortality

Simulation of the mortality occurs in a model module named "5_Mortality-Rates_Child" (see Appendix 2). The following step is to simulate the annual deaths and births. Age and gender-based mortality rates from the Eurostat long-term population forecast EuroPop2019 are used to simulate the mortality (see Figure 20).

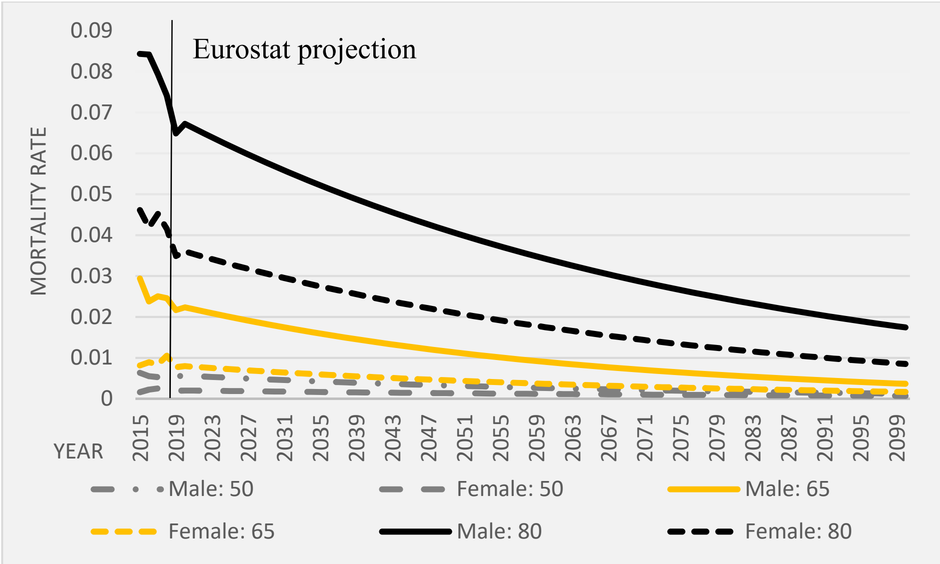

Figure 20. Mortality rates for females and males for selected ages from 2015 to 2100 in Estonia
Source: Eurostat 2021b; 2021c.

To find the year when a person dies a random number is used, from 0 to 1. Every year this random number is drawn again. A person is marked as dead if his/her random number is lower than the mortality rate for his/her cohort, gender and in a particular year.

$$Death_{\tau,i} = RN_{\tau,i} < MR_{\tau,g,a} \; if \; \tau > Y \tag{17}$$

Where:

$RN_{\tau,i}$	– Individual i random number for specific year τ;
$MR_{\tau,g,a}$	– Cohort mortality rate in specific year τ for male/female;
τ	– Year;
i	– Individual;
g	– Male/female;
a	– Age in given year;
Y	– Simulation year.

In year $t + 1$ only people who are still alive are used. This is done until the age 100, which is the last year when a person can live because the mortality rate is set to one at age 100.

3.3.3. Fertility – children, new cohorts and marriage market

Simulation of the fertility and marriage market occurs in a model module named "5_MortalityRates_Child" (see Appendix 2). The importance of children can be divided into two closely related groups: 1) gained pension entitlements raising the children and 2) new cohorts who are "born" in the future. The number of children and every new child is added to SIB individual-level data. It is important to know when children are born because the pension rights are received to the second pillar when a child is born in 2013 (scenarios 3-8) and afterwards. Before 2013 people received the pension rights to the first pillar.

Estonia's historic fertility rates (see Figure 21) are used to simulate the previous year's children who are not added to the individual-level data but are needed for pension entitlements. Actual fertility rates are used until 2018. Forecasted fertility rates (EuroPop2019) are used for simulating new children who are added to the individual-level data as new people, and they add pension entitlements to their parents. As more boys are born than girls, 51.3% of generated new observations (children, new cohorts) are male and 48.7% are female (average proportion during 1960–2019) (Eurostat 2021k).

Historical data show a sharp drop in fertility rates in the 1990s, especially in younger age groups. Eurostat's forecast expects a continued drop in birth rate in younger age groups, but a rise in other age groups. The overall birth rate will increase to 1.77 but not to the level of reproduction.

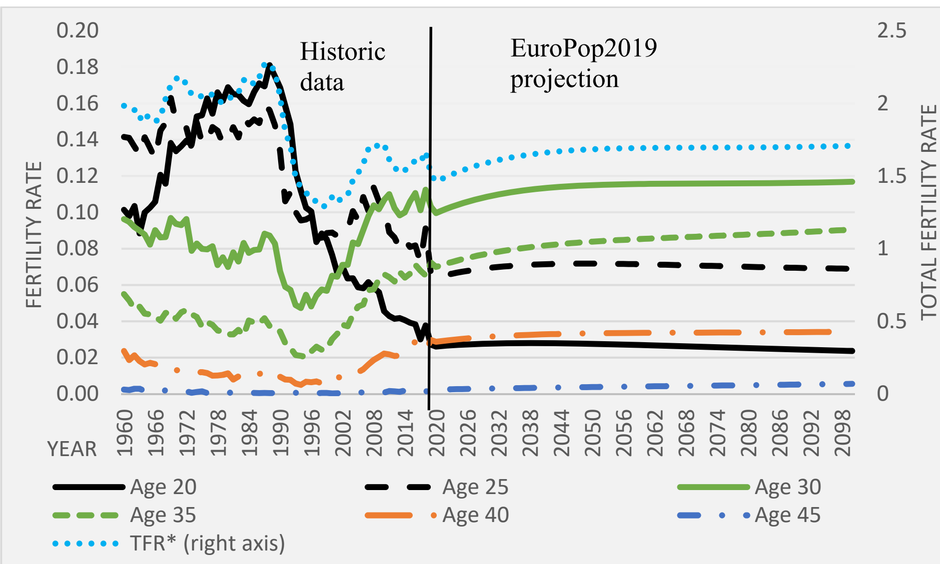

Figure 21. Historic and forecast fertility rates for selected ages and total fertility rate (* – TFR)
Source: Eurostat 2019b; 2019a.

The first step was to simulate new children based on fertility rates and the random number. This is done in a similar way as the deaths in the previous section.

$$Child_{\tau,i} = RN_{\tau,i} < FR_{\tau,a} \tag{18}$$

Where:

$Child_{\tau,i}$ – Individual i children birth year;

$FR_{\tau,a}$ – Cohort fertility rate in specific year τ.

The previous equation is simulated again for every year. As a simplification, it is assumed that only one child is born at a time. In addition, the order of birth or number of children has not been used in fertility rates, only women's age and year are used. The age of childbearing potential is 14–50 and theoretically it is possible to have a child every year (in total 38 children) but the model has simulated a maximum of 10 children for one woman. The children's simulation will be done as a second step after the simulation year deaths are simulated.

The number of simulated children is at first under-simulated compared to the statistics, but from the 2000s in line with them (see Figure 22). The reason is behind the model population – official statistics count every child born in some year, but the model counts only those children who are alive in 2015.

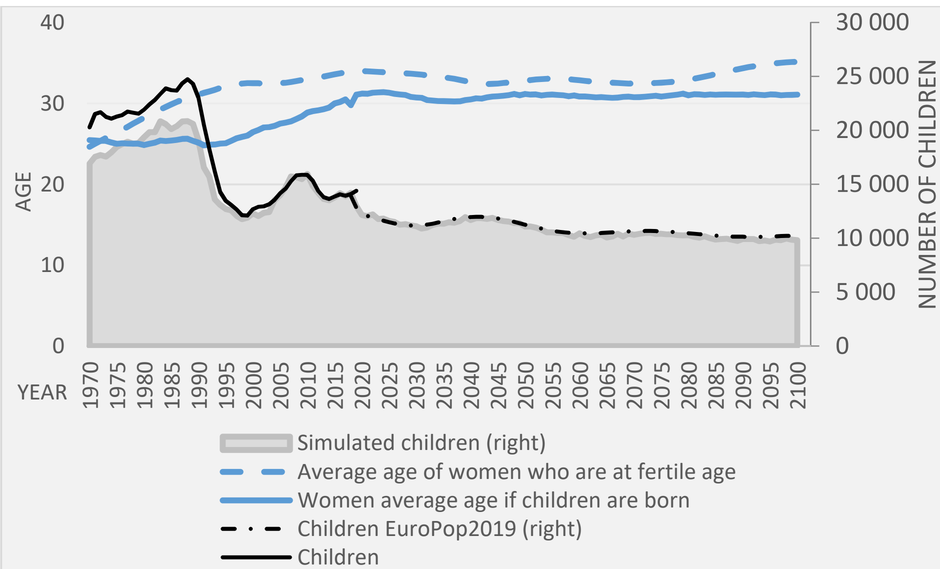

Figure 22. Simulated children compared to Eurostat forecast for Estonia
Source: Eurostat 2021e; 2021d; author's calculations.

All pension rights for children are assigned to women. This assumption is based on the knowledge that 95% of entitlements for children are used by women. At the same time, if the child(ren)'s mother would die before the father, the father would use the pension entitlements for the child(ren). Therefore, it is important to know the father of every child. A simulation is needed for all children, which is done by using the "marriage market" for the women for whom the children have been simulated. Thus, it is more about finding the other parent, rather than the marriage market because being married or not is not important in the Estonian pension system, at least for now.

The next step was to divide every individual (*i)* child into two groups: 1) children who are born before 2013 (*ChildBU12*), and 2) children who are born after 2013 (*ChildB13*). *ChildB13* is found for all but has to distinguish the people who have and who have not joined the second pillar.

$$ChildBU12_i = \sum_{\tau=b}^{2012} child_{i,\tau} \quad (19)$$

$$ChildB13_i = \sum_{\tau=2013}^{max} child_{i,\tau} \quad (20)$$

Where:

b – Individual birth year.

The "marriage market" is used to simulate the father for every simulated child. It finds by randomness a husband for a woman who has a child(ren). Women have been "married" to men who are three years older because according to the statistics men are on average three years older than women when they marry.

After these steps, the number of children and both parents of each child are known.

The overall population over the years is under-simulated by 9,000 in 2019 and by 32,000 in 2100 (see Figure 23). There may be two reasons for this: 1) on average, 225 children per year are under-simulated, and; 2) the maximum age is set to 100 but, for example, in 2100 more than 3,000 people are 100 years old or more.

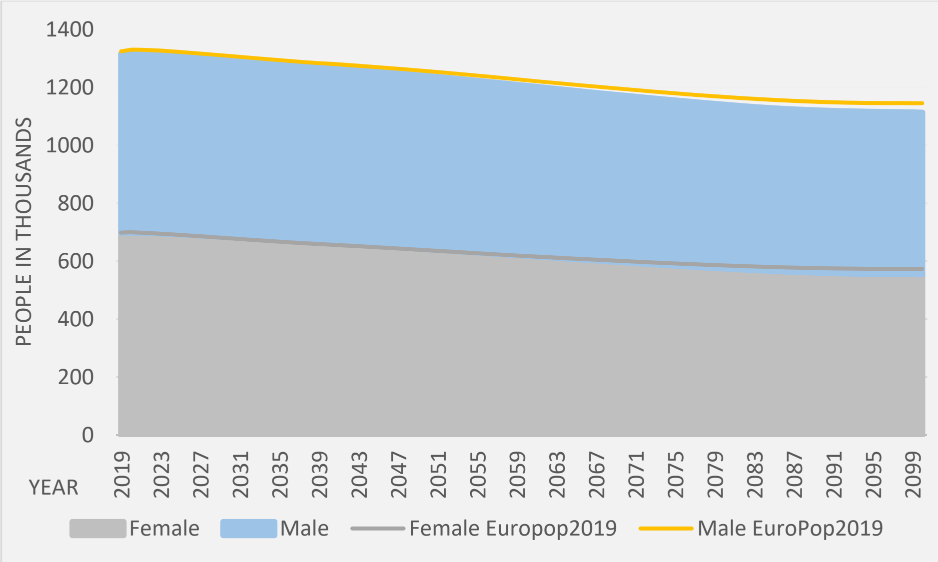

Figure 23. Simulated population compared to EuroPop2019 projection
Source: Eurostat 2021e; author's calculations.

3.3.4. Service years

Simulation of the service years occurs in a model module named "6_Service" (see Appendix 2). Service years are earned until 1998 (included) for working. Wages did not play a role in service years. All records about service years are proven by an employment record book or some other document, which are provided by people themselves when they will retire. Therefore, it is not known how many service years' people have who have not retired yet. The only indication about service years for every cohort is already retired people. Therefore, regression analysis is used to find service years for people who have not retired.

Service years contain entitlements for other things in addition to working records. As a result, the simulation can overestimate service years. For example, in older cohorts, some individuals have additional service years for compensation for being repressed at the Soviet Union, but the younger cohorts did not experience such repressions. Some individuals in the older cohorts (see Figure 26) have 80 service years which cannot be earned by only working. The distribution of the service years is gradually decreasing, from which it can be concluded that they have received fewer extra years for other activities. As a result, information on the length of service from people born between 1945 and 1952 have been used to simulate future retirees' length of service, because the length of service years is more stable and the length of service years is declining for those cohorts. Their length of service years is declining as no additional length of service years were earned after 1998.

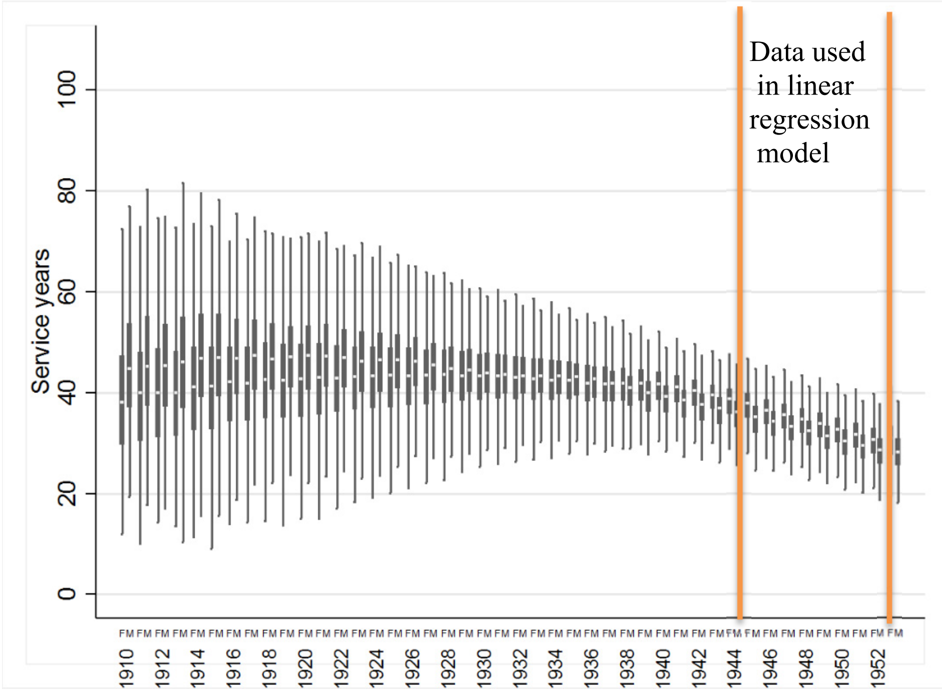

Figure 24. Actual service years of old-age retirees by birth year and gender (F-female, M-men)
Source: Social Insurance Board; author's calculations.

Linear regression where the endogenous variable is *service years* (s) and exogenous variables are *birth year, gender, dummy variables of education* are used in the model. Only people whose pension type is an old-age pension or old-age pension under favourable conditions are included in the regression. In addition, service years that are under the 90% decile are considered.

$$Y_i = \beta_0 + \beta_1 BirthYear_i + \beta_2 Gender_i + \beta_3 Edu\_1_i + \beta_4 Edu\_2_i + \beta_5 Edu\_3_i + \beta_6 Edu\_4_i + u_i \quad (21)$$

Where:

- Y_i – Service years;
- $BirthYear_i$ – Individual birth year;
- $Gender_i$ – Individual gender ($X_{2,i} = 0\ if\ female;\ X_{2,i} = 1\ if\ male$);
- Edu_1_i – Individual has primary education or lower ($0\ if\ not\ and\ 1\ if\ yes$);
- Edu_2_i – Individual has secondary education ($0\ if\ not\ and\ 1\ if\ yes$);
- Edu_3_i – Individual has vocational education ($0\ if\ not\ and\ 1\ if\ yes$);
- Edu_4_i – Individual has higher education ($0\ if\ not\ and\ 1\ if\ yes$);
- u_i – Error term.

Table 10. Regression model results for the service years based on 2014 data

Variable	Coefficient	Std. error	t	P>|t|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	1874.511	14.550	128.84	0.000	1845.994	1903.028
Birth year	-0.945	0.007	-126.53	0.000	-0.959	-0.930
Gender	-2.175	0.035	-62.43	0.000	-2.243	-2.106
Primary education	-0.023	0.064	-0.35	0.723	-0.148	0.102
Secondary education	-0.057	0.055	-1.03	0.302	-0.165	0.051
Vocational education	Omitted					
Higher education	-0.014	0.053	-0.27	0.789	-0.119	0.090

Observations = 84,822; R^2 = 0.1970
Source: author's calculations.

Since the service years could be earned until 1998, those are simulated up to the cohort who turned 15 in 1998 (born in 1983 or earlier). One of the exogenous variables is the year of birth, not age (as in other regressions), because earning a service years ended in 1998 and therefore earning a unit does not depend so much on age but on the year of birth. It should be noted that people could earn service years for studying or for working on a farm. Since the regression model variance is also used in the simulation, the maximum length of service is set in the simulation to the new pensioners' length of service. For this, the maximum possible working time is from age 15 to the year 1998. The results are the following:

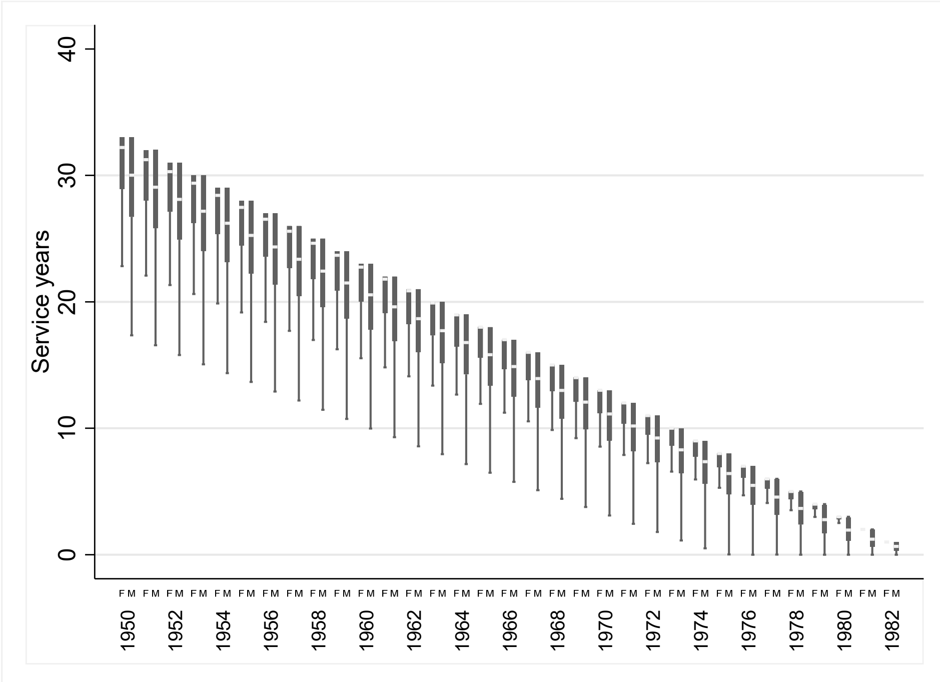

Figure 25. Simulated service years by birth year and gender (F – female, M – male)
Source: Social Insurance Board; author's calculations.

Real and simulated service years are compared to test the goodness of service years simulation, for which the cohort born in 1953 who should retire in 2016 (see Figure 26) is used. Only 60% of those born in 1953 can be compared because the rest of them retired later years and the information from those years is not in the dataset. Both females and males have similar median and 25% decile values, but the 75% deciles are narrower in the simulation, in contrast to the previous. The simulation has fewer outside values because it has an upper limit for the length of service – the maximum is 1998 minus 15 years and minus the birth year. Thus, the simulation of the service years can lead to under-estimation of the distribution of pensions because it reduces higher pensions.

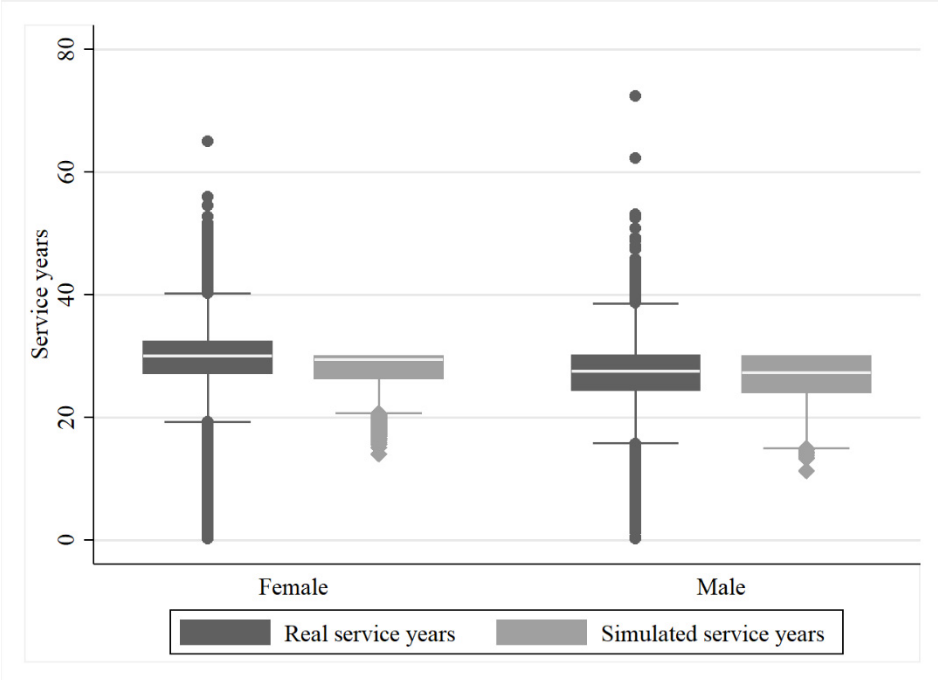

Figure 26. Real and simulated service years for the cohort born in 1953
Source: Social Insurance Board; author's calculations.

3.3.5. Future wages

Simulation of the wages occurs in a model module named "7_Wages" (see Appendix 2). Since the pension rights from the first, second and third pillars are linked to wages, it is important to know the individual's wage in the future. Secondly, a person needs to earn at least the minimum wage for at least 15 years (qualifying period) to be entitled to an old-age pension. This is calculated through the minimum wage (see Equation 25). If a person earns more than the annual minimum wage in a year, he/she earns one pension qualification year. If the wage is lower than the minimum wage, the person earns a proportion of it.

$$\text{Pension qualifying period}_{\tau,i} = \min\left(\frac{AGW_{i,\tau}}{\text{min\_}wage_{\tau}}, 1\right) \quad (22)$$

The minimum wage is set by the government, based on an agreement between social partners. To estimate the minimum wage in the future, the ratio of the minimum wage to the average wage is taken as a basis and a nine-year (2012 to 2020) average ratio is found, which is taken as a constant for the future.

$$\min\_wage\_ratio = \frac{1}{9}\sum_{\tau=2012}^{2020}\frac{\min\_wage_{\tau}}{average\_wage_{\tau}} \tag{23}$$

The ratio of the minimum wage to the average wage has grown in the last few years, but the nine-year average is 39.9%. If the government increases the minimum wage faster than the average wage growth, the model would overestimate the accumulated qualifying period. At the same time, a more rapid minimum wage growth would also increase the average wage (Ferraro *et al*. 2018). The increase in the minimum wage ratio, therefore, may not have an important effect on over or underestimation because most people still earn at least the minimum wage to earn one old-age pension qualifying year.

The simulation of future wages is made in two steps:

1. using a *probit* regression model for simulating employment, and;
2. if a person is employed linear regression is used to simulate the relative wage.

In the simulation of employment, a *probit* regression by gender is used where the endogenous variable is *working in 2015* (*y*) and exogenous variables are *dummy variable of last period working, dummy variables of education, years to retirement* and *squared years to retirement*. The first step is to simulate working, for which the following model is used:

$$\begin{aligned} P\left(Emp_{t,i}\middle|x_1,\dots,x_7\right) \\ &= \Phi(\beta_0 + \beta_1 Emp_{t-1,i} + \beta_2 Edu\_1_i + \beta_3 Edu\_2_i \\ &+ \beta_4 Edu\_3_i + \beta_5 Edu\_4_i + \beta_6 ToRet_i \\ &+ \beta_7 SqToRet_i) \end{aligned} \tag{24}$$

Where:

$Emp_{t,i}$ – Employed or not (1 = employed, 0 = not employed);
Edu_1_i – Individual has primary education or lower ($0\ if\ not\ and\ 1\ if\ yes$);
Edu_2_i – Individual has secondary education ($0\ if\ not\ and\ 1\ if\ yes$);
Edu_3_i – Individual has vocational education ($0\ if\ not\ and\ 1\ if\ yes$);
Edu_4_i – Individual has higher education ($0\ if\ not\ and\ 1\ if\ yes$);
$ToRet_i$ – Individual years to retirement;
$SqToRet_i$ – Individual squared years to retirement.

Table 11. *Probit* regression model results for the probability of working or not – females

Variable	Coef-ficient	Std. error	z	P>|z|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	-1.010	0.008	-131.54	0.000	-1.025	-0.995
Last period working	2.328	0.006	377.71	0.000	2.315	2.340
Primary education	0.030	0.009	3.27	0.001	0.012	0.048
Secondary education	0.010	0.007	1.56	0.119	-0.003	0.023
Vocational education	-0.035	0.009	-4.09	0.000	-0.052	-0.018
Higher education	Omitted					
Age to retirement	0.036	0.001	63.27	0.000	0.035	0.037
Squared age to retirement	-0.001	0.000	-73.54	0.000	-0.001	-0.001

Observations = 425,830; Pseudo R^2 = 0.4316; Log likelihood = -129,032.19
Source: author's calculations.

Table 12. *Probit* regression model results for the probability of working or not – males

Variable	Coef-ficient	Std. error	z	P>|z|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	-0.889	0.009	-95.15	0.000	-0.907	-0.871
Last period working	2.148	0.007	311.64	0.000	2.135	2.162
Primary education	-0.077	0.008	-9.08	0.000	-0.093	-0.060
Secondary education	-0.007	0.007	-1.01	0.312	-0.022	0.007
Vocational education	-0.024	0.010	-2.27	0.023	-0.044	-0.003
Higher education	Omitted					
Age to retirement	0.041	0.001	65.86	0.000	0.034	0.042
Squared age to retirement	-0.001	0.000	-71.72	0.000	-0.001	-0.001

Observations = 425,830; Pseudo R^2 = 0.4316; Log likelihood = -129,032.19
Source: author's calculations.

Based on the *probit* regression model results, employment for every person between the age 15 and 74 are simulated, and only for those who are alive and have already migrated to Estonia. The cumulative standard normal distribution (values from 0 to 1) stochastic component is also added to the *probit* regression model result.

As the probability found by using the *probit* model coefficients only shows the probability to be employed, the number of people must be defined annually. Since the macroeconomic assumptions have been taken from the MoF's long-term forecast, the number of employed people in the model should also coincide with the average wage, CPI and GDP. For this purpose, the employment rates of the age groups are multiplied by the size of the cohort, and this, in turn, is multiplied by a coefficient representing the share of the cohort from the whole employed people (see next equation).

$$Employed_{a,g,\tau} = EmpRate_{ag,g} * Pop_{a,g,\tau} * \left(\frac{Macro\_Employed_{\tau}}{\sum_{a=15}^{74}(EmpRate_{a,g} * Pop_{a,g,\tau})}\right) \tag{25}$$

Where:

$Employed_{a,g,\tau}$ – Number of employed people by gender g and age a in year τ;
$EmpRate_{ag,g}$ – Employment rate by age and gender;
$Pop_{a,g,\tau}$ – Size of population by gender and age in year τ;
$Macro\_Employed_{\tau}$ – Employed people by macroeconomic assumptions in year τ.

Employment rates are left unchanged until 2100 (see Figure 27). Since the employment rates of the working-age population in Estonia are among the highest in Europe, they are kept unchanged for the future. Likewise, changing the employment rates of older people (for example, due to increasing the SPA) implies a change in the whole macroeconomic environment and is not addressed in this work.

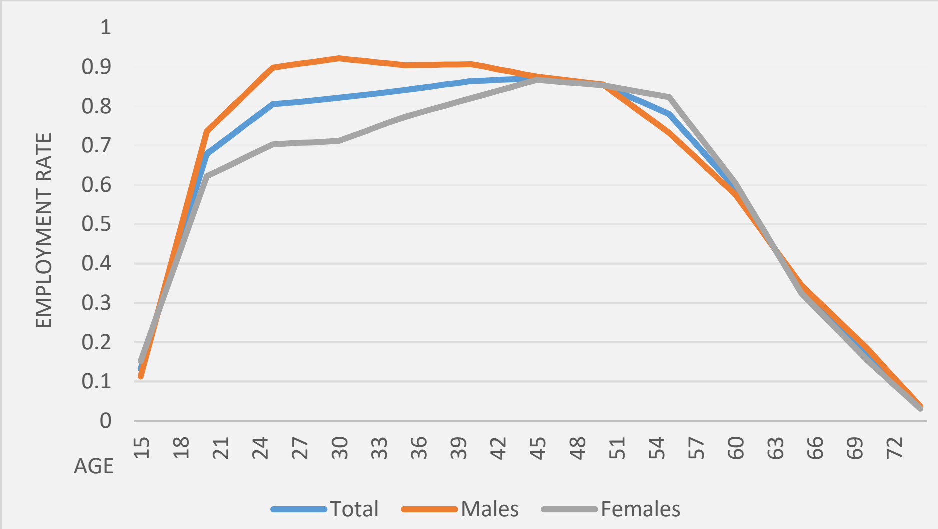

Figure 27. Employment rate by age and gender in 2017
Source: Eurostat 2019c.

The following step is to sort the working probabilities in descending order and set the number of people (found with the previous equation) into the employment. The overall number of employed people coincides with the macroeconomic assumption (forecast is until 2070) (see Figure 28). The macroeconomic projection estimates that by 2070 there will be around 16% fewer employed people than in 2019.

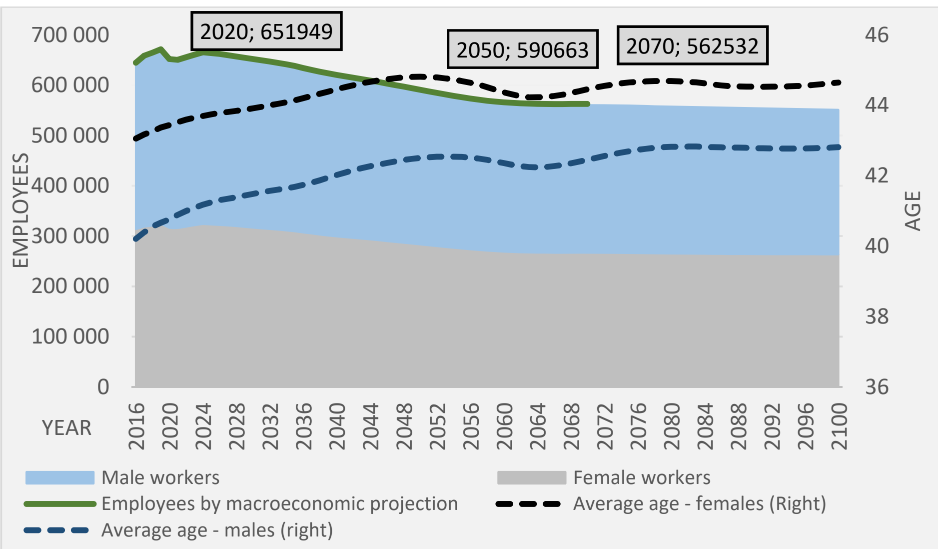

Figure 28. The number of employed and employed people age by gender from 2016 to 2100
Source: author's calculations.

Second, the wages of persons who have been set into employment need to be simulated. The wages of women and men are quite different. The distribution of women's wages is narrower and, at the same time, the average and median salaries are lower. In addition, the women's salaries peak is at a later age than men (see Figure 29 and Figure 30).

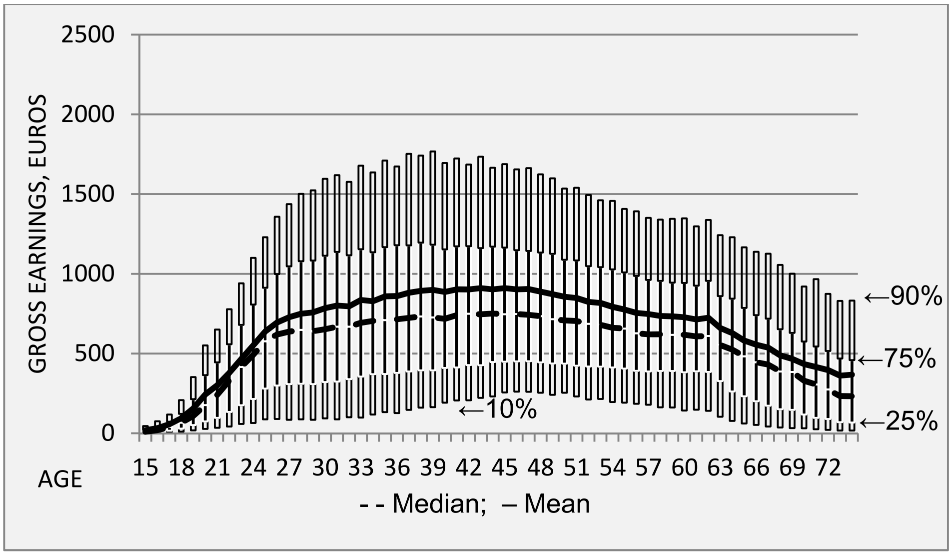

Figure 29. Actual average, median gross wages in age group 15–74 of females by age in 2015
Source: Social Insurance Board; author's calculations.

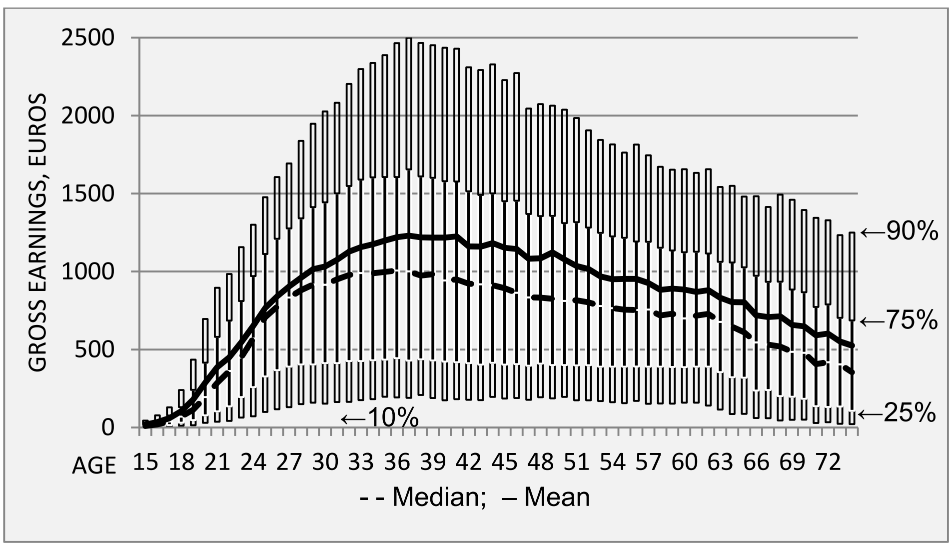

Figure 30. Actual average, median gross wages in age group 15–74 of men by age in 2015
Source: Social Insurance Board; author's calculations.

Linear regression has been used to simulate wages:

$$\ln(Wage_{t,i}) = \beta_0 + \beta_1 \sum_{s=t-1}^{t-3} IHS\_Wage_{s,i} + \beta_2 sq \sum_{s=t-1}^{t-3} IHS\_Wage + \beta_3 Edu\_1_i + \beta_4 Edu\_2_i + \beta_5 Edu\_3_i + \beta_6 Edu\_4_i + \beta_7 ToRet_i + \beta_8 SqToRet_i + u_i \quad (26)$$

Where:

IHS_Wage_i – Inverse hyperbolic sine relative wage (relative to the national average wage);

$\sum_{s=t-1}^{t-3} IHS\_Wage_{s,i}$ – Individual last three periods inverse hyperbolic sine relative wage;

$sq\sum_{s=t-1}^{t-3} IHS\_Wage_{s,i}$ – Individual squared last three periods inverse hyperbolic sine relative wage;

Edu_1_i – Individual has primary education or lower ($0\ if\ not\ and\ 1\ if\ yes$);

Edu_2_i – Individual has secondary education ($0\ if\ not\ and\ 1\ if\ yes$);

Edu_3_i – Individual has vocational education ($0\ if\ not\ and\ 1\ if\ yes$);

Edu_4_i – Individual has higher education ($0\ if\ not\ and\ 1\ if\ yes$);

$ToRet_i$ – Individual years to retirement;

$SqToRet_i$ – Individual squared years to retirement;

u_i – Error term.

Table 13. Linear regression model results for the inverse hyperbolic sine (IHS) relative wage for females

Variable	Coef-ficient	Std. error	t	P>|t|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	0.127	0.001	90.77	0.000	0.124	0.130
Last three period IHS relative wage	0.711	0.003	249.99	0.000	0.706	0.717
Squared last three period IHS relative wage	0.068	0.002	42.51	0.000	0.065	0.072
Primary education	-0.059	0.001	-39.87	0.000	-0.062	-0.057
Secondary education	-0.028	0.001	-27.46	0.000	-0.030	-0.026
Vocational education	-0.028	0.001	-21.55	0.000	-0.031	-0.026
Higher education	Omitted					
Age to retirement	0.006	0.000	68.38	0.000	0.006	0.007
Squared age to retirement	-0.0001	0.000	-30.27	0.000	-0.0001	-0.0001

Observations = 330,047; R^2 = 0.6775
Source: author's calculations.

Table 14. Linear regression model results for the inverse hyperbolic sine (IHS) relative wage for men

Variable	Coef-ficient	Std. error	t	P>|t|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	0.124	0.002	72.30	0.000	0.120	0.127
Last three period IHS relative wage	0.731	0.003	290.56	0.000	0.726	0.736
Squared last three period IHS relative wage	0.058	0.001	48.96	0.000	0.056	0.060
Primary education	-0.046	0.001	-31.77	0.000	-0.048	-0.043
Secondary education	-0.022	0.001	-17.96	0.000	-0.024	-0.019
Vocational education	-0.020	0.002	-11.63	0.000	-0.023	-0.016
Higher education	Omitted					
Age to retirement	0.005	0.000	39.65	0.000	0.004	0.005
Squared age to retirement	-0.000	0.000	-1.98	0.048	-0.0001	-0.0000

Observations = 305,273; R^2 = 0.7330
Source: author's calculations.

Based on the linear regression model, coefficients are simulated for every person's relative wage between the ages of 15 and 74 and only for those who are simulated as workers. The results of the relative wages through the years are the following:

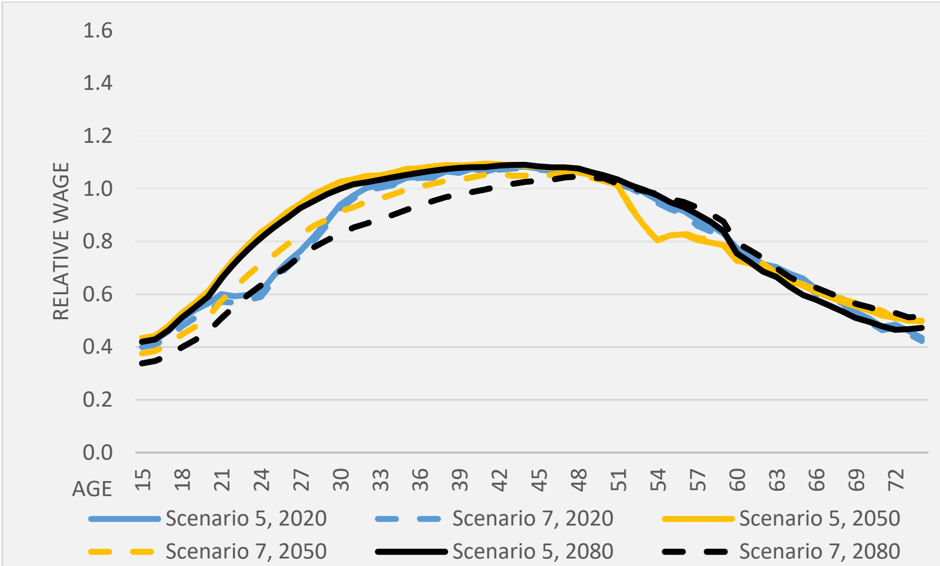

Figure 31. Simulated relative wage for females for selected years
Source: author's calculations.

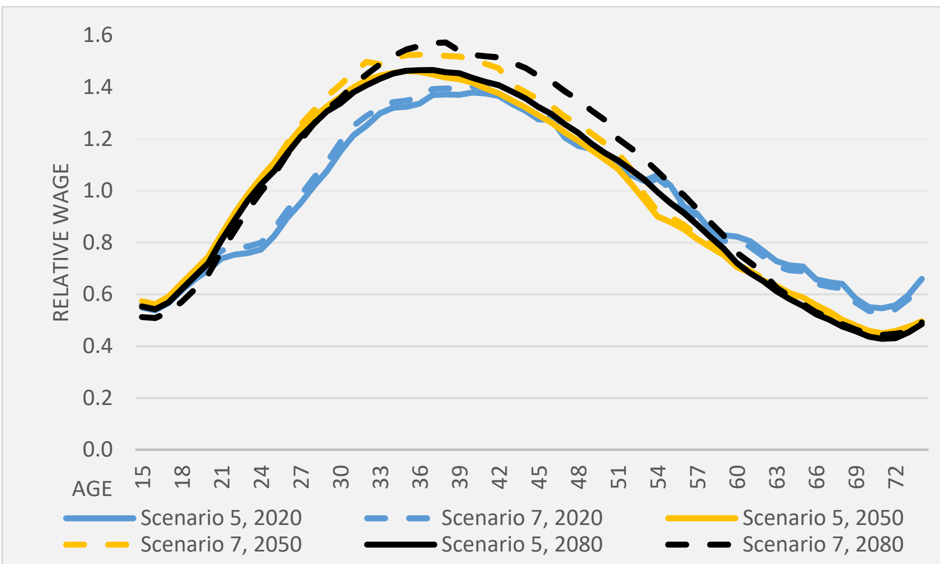

Figure 32. Simulated relative wage for men for selected years
Source: author's calculations.

The relative results are shown with scenario 5 and 7 because those scenarios have a different statutory pension age and the years to SPA is in the right-hand side of the linear regression model.

3.3.6. Type of pension

Simulation of the type of pension occurs in a model module named "8_Pension-Type" (see Appendix 2). All people are divided into four groups for each age ($Q_{k,a}$) for each year to simulate different types of old-age pensioners. One group is created for the non-retired people, while three groups are created for old-age pension types. A matrix of annual transition probabilities ($p_{jk,a}$) between these pension type groups for each age is then estimated. Results are averaged over the period 2010 until 2015 from the individual-level data of retired people. Consequently, each person (A_i) in a cohort is randomly assigned to pension type group ($Q_{k,a}$) for the period unknown year to *min(cohort+100, 2100)*. The assignment depends on its previous pension type group ($Q_{j,age-1}$) (starting from the pension type which is known) and estimated transition probabilities ($p_{jk,age-1}$).

$$\Pr\left(A_{i,a} \in Q_{k,a}\right) = p_{jk,a-1} \; if \; A_{i,a-1} \in Q_{j,a-1} \tag{27}$$

The three pension groups and one non-pensioner group are numbered in the following way:

1 Not retiree
2 Old-age retiree
3 Old-age retiree under Favourable Conditions Act – list 1
4 Old-age retiree under Favourable Conditions Act – list 2

Early retirement (one, two or three years) and other favourable conditions (like for children) are set by individual information. For example, if a person is unemployed at least one year before retirement, he/she will retire one year before the SPA. However, a person's future pension is not decreased for all 12 months but for the statistical average months for those who retire a maximum of one year before. The same is done for those who retire two and three years earlier. For example, 60-year-old women have a 92.3% probability to not retire (see Table 15) and a 7.2% probability to retire through the ordinary old-age pension type. There is a less than 1% probability to retire through favourable conditions (list 1 and list 2). The same probabilities are calculated for men and every age.

Table 15. Matrix of annual transition probabilities at age 60 for females

Pension type	Not retired	Old-age	List 1	List 2
Not retired	92.3	7.2	0.2	0.4
Old-age	0.0	100.0	0.0	0.0
List 1	9.4	3.4	87.2	0.0
List 2	7.9	7.1	0.0	84.9

Source: author's calculations.

Note that historical retiring transitions need to be extrapolated for age groups 61–65 for females and 63–65 for males, as the pension age increases from 61 to 65 for the women and 63 to 65 for the men. In addition, they are extrapolated three years before statutory pension age due to fact that people could retire three years earlier than the SPA. It is assumed that people's behaviour near the SPA in the future is like the behaviour that is observed in the past.

3.3.7. Mandatory funded scheme yields and strategies

Simulation of the mandatory funded scheme yields and strategies occurs in a model module named "9_Yield" (see Appendix 2). This subchapter covers the essential aspects of the compulsory scheme and some aspects of the voluntary funded scheme (subchapter 3.3.8), such as yield, the level of risk of the fund and the way payments are calculated.

The exact registry-based value of the second pillar at the end of 2014 is used in the model. Real wages are used in 2015 to calculate the contributions to the second and third pillars. Afterwards, simulated wages are used. The second pillar contribution rate is set by the law – 2% from the gross wage by the employee and 4% from the gross wage by the employer.

The following equation is used to find the value of the mandatory fully funded scheme each year:

$$V_{\tau,i} = V_{\tau-1,i} * \left(1 + Y_{\tau,\rho}\right) + CII_{\tau,i} * \left(1 + \frac{Y_{\tau,\rho}}{2}\right), \qquad (28)$$

Where:

$V_{\tau,i}$ – Value of second pillar in year τ

$Y_{\tau,\rho}$ – Yield of pension ρ-risk or pension fund in year τ

$CII_{\tau,i}$ – Individual annual contribution to the second pillar in year τ

Half of the yield is used for contributions yield for each year because contributions are paid each month, but the yield is taken for the whole year. The value of the funded pillar in the previous period is increased with the full yield.

The pension fund strategy information (ρ-risk fund) is also available in the second pillar registry data (see Figure 33). Therefore, in the first place, it is necessary to simulate changes in the pension fund strategy before the second pillar yield. The strategy is simulated until 2019 and from 2020 the exact pension fund is simulated. The pension registry does not divide pension funds between strategies from 2020, and therefore it is necessary to use fund information instead. In addition, people have used more funds with a higher proportion of equities and index funds than before.

The following step is to move from strategies to funds in 2020. People are divided between funds corresponding to their strategies – if the strategy is aggressive (maximum 100% to equities) then the aggressive fund is simulated to this person. If there are more people in funds with an aggressive strategy in

2020 but fewer people in aggressive strategies in 2019, more people are chosen from the progressive strategy (maximum 50% to equities). Real data is used to move from strategies to funds – real data of gender-age based proportions of all funds.

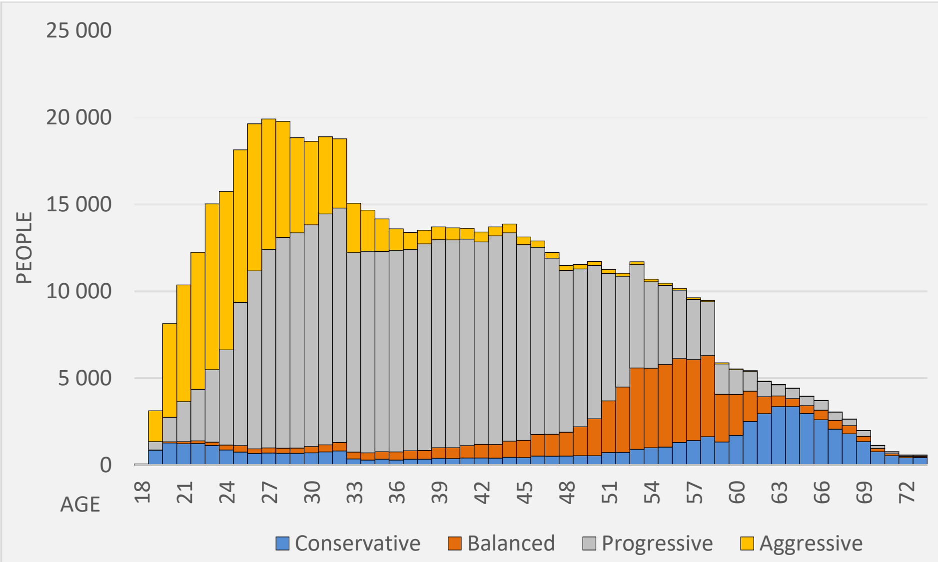

Figure 33. People who have joined the compulsory funded pension scheme by fund strategy and age at the end of 2014
Source: Estonian Central Register of Securities; author's calculations.

The proportions of the second pillar strategies will remain the same until 2019 as they were at the end of 2014 by gender and age (see Figure 34 and Figure 35) and the same as the funds were in 2020. For example, in 2040 30% of 29-year-old women are still joined to one of the aggressive funds. Movement between strategies and funds has been made with randomness and according to the previous strategy or fund. That means people who change their strategy are chosen randomly, for example from aggressive fund to progressive fund. This is because more people are in the aggressive funds at younger ages and then in the progressive funds until the middle-ages. Consequently, the model finds the number of people who should have a progressive fund in a particular year by age and gender. Then, people who have been in progressive funds during the previous period are also in the progressive fund in the new period. As the next step, the people in the aggressive funds will change the fund, as the proportion of aggressive funds will diminish by age increase.

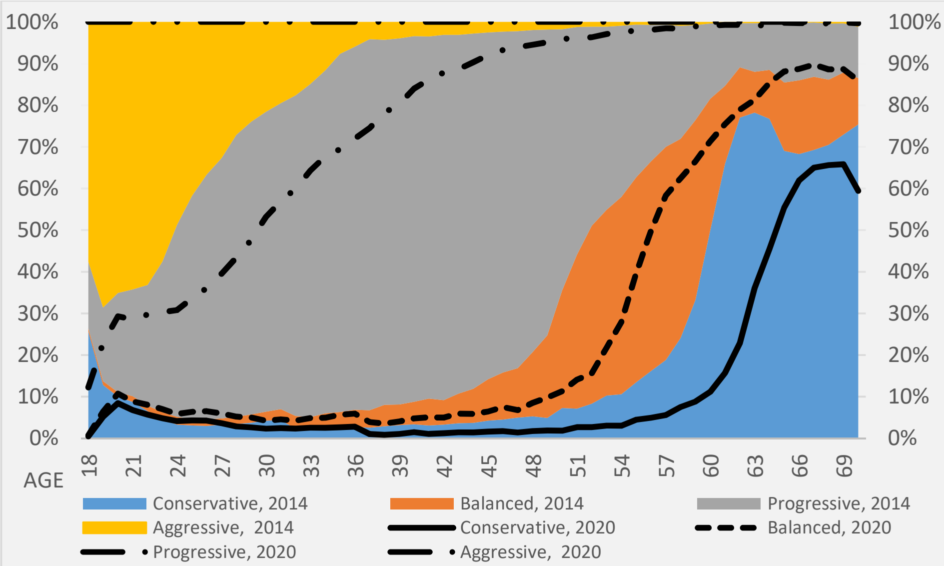

Figure 34. The proportions of the second pillar strategies by age for females in 2014 (left axis) and 2020 (right axis)
Source: Estonian Central Register of Securities; author's calculations.

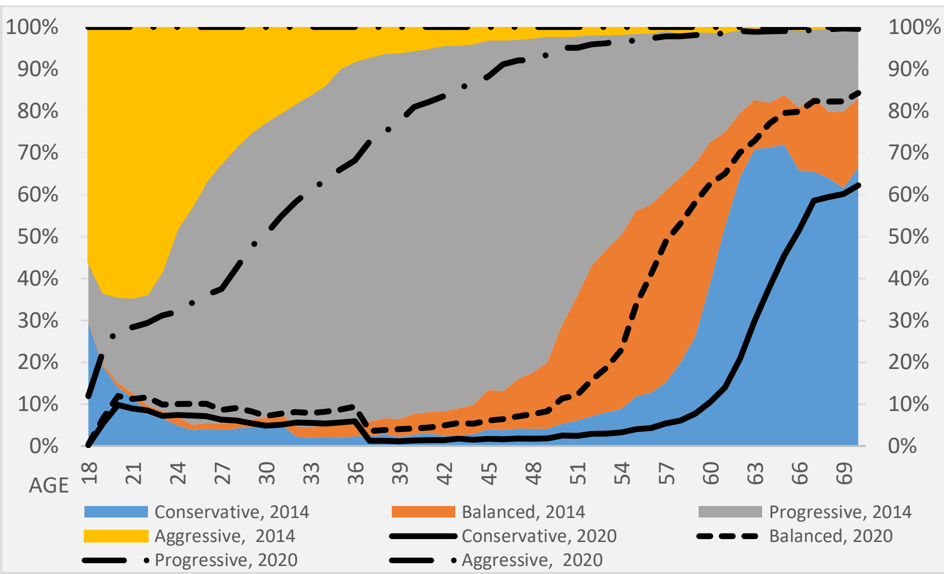

Figure 35. The proportions of the second pillar strategies by age for males in 2014 (left axis) and 2020 (right axis)
Source: Estonian Central Register of Securities; author's calculations.

The yield of the second pillar pension funds is an important factor for the future pension. Therefore, people are divided into 23 second pillar funds from 2020 which have different yields and volatility. Historical daily data of the Estonian second pillar pension index (see Figure 39) is used for simulating the future daily index.

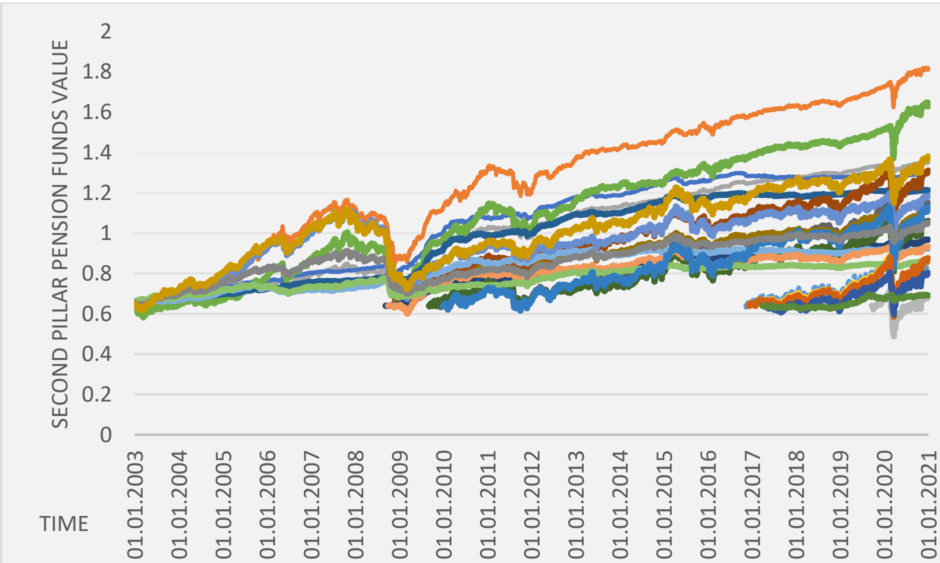

Figure 36. Historical daily Estonian second pillar pension funds value by pension funds until the end of 2020
Source: Pensionikeskus; author's adjustments.

The average daily log growth, variance and standard deviation of it are used to calculate the value of future pension funds.

Table 16. Historical Estonian pension index growth by strategies

	Average annual nominal yield until 2020	Average daily ln growth	Min	Max	Variance	Standard deviation
All funds	5.5%	0.0001	-0.036	0.027	0.00001	0.002
1	6.8%	0.0002	-0.099	0.079	0.00007	0.008
2	6.0%	0.0002	-0.034	0.040	0.00001	0.003
3	4.2%	0.0001	-0.020	0.025	0.00000	0.002
4	3.8%	0.0001	-0.013	0.019	0.00000	0.001
5	5.4%	0.0001	-0.036	0.040	0.00001	0.003
6	3.4%	0.0001	-0.012	0.022	0.00000	0.001
7	6.0%	0.0002	-0.045	0.023	0.00001	0.003
8	5.4%	0.0001	-0.063	0.038	0.00003	0.005
9	4.6%	0.0001	-0.028	0.016	0.00000	0.002
10	3.4%	0.0001	-0.026	0.016	0.00000	0.001
11	4.6%	0.0001	-0.058	0.036	0.00002	0.004
12	1.9%	0.0001	-0.022	0.014	0.00000	0.001
13	3.1%	0.0001	-0.021	0.010	0.00000	0.002
14	5.6%	0.0001	-0.075	0.045	0.00009	0.010
15	8.0%	0.0002	-0.098	0.080	0.00006	0.008
16	3.3%	0.0001	-0.038	0.023	0.00001	0.003
17	1.5%	0.0000	-0.016	0.012	0.00000	0.001
18	5.3%	0.0001	-0.083	0.059	0.00003	0.005
19	8.0%	0.0002	-0.096	0.078	0.00006	0.008
20	2.7%	0.0001	-0.023	0.010	0.00000	0.002
21	4.3%	0.0001	-0.041	0.030	0.00001	0.003
22	6.2%	0.0002	-0.056	0.047	0.00003	0.006
23	2.1%	0.0001	-0.012	0.011	0.00000	0.001

Source: Pensionikeskus, author’s calculations.

For the future daily pension fund value, the following equation is used (Black and Scholes 2019):

$$Y_{d,\rho} = Y_{d-1,\rho} * \exp\left(mean_\rho - \frac{Var_\rho}{2} + SD_\rho * RD\right), \qquad (29)$$

Where:

$Y_{d,\rho}$	– Daily fund value
$mean_\rho$	– Mean of log daily pension fund value change by funds
Var_ρ	– Variance of log daily pension fund value changes by funds
SD_ρ	– Standard deviation of log daily pension fund value changes by funds
RD	– Standard normal (Gaussian) random variates, that is, variates from a normal distribution with a mean of 0 and a standard deviation of 1.

This is done with every pension fund, in total 23 times because in 2020 Estonia had 24 different funds but one fund had a too short history (less than a year).

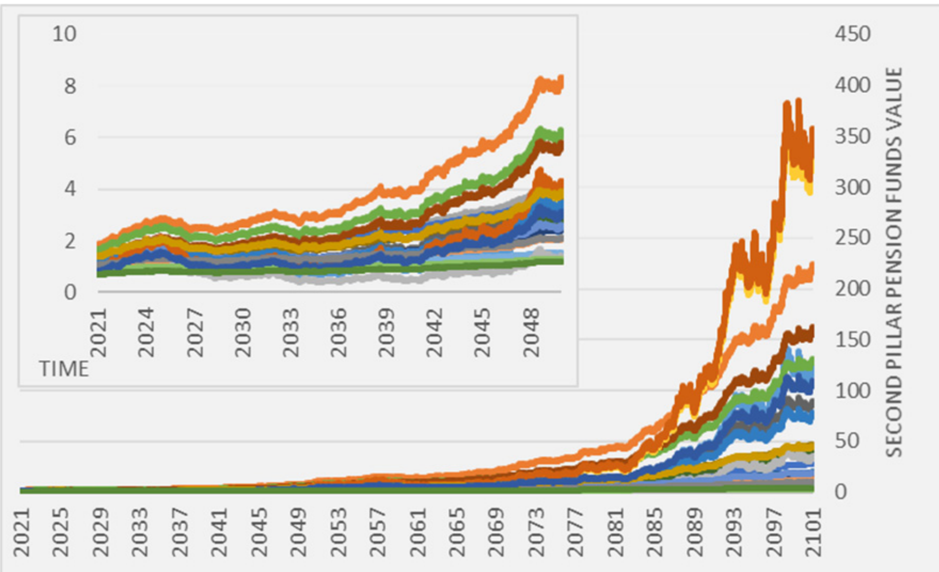

Figure 37. Simulated daily Estonian pension index by pension fund risk until 2100
Source: author's calculations.

The Black-Scholes model has many shortcomings. First, the return around the average is more frequent, while the extreme return, both negative and positive, is far from the average. (OECD 2020; Kou 2007) Second, the standard deviation of historical equity yields decreases faster over time than the usual normal distribution. (Rinaldi and Ceccarelli 2016) Therefore, the scope of the results of longer periods in the model is greater than the historical data show. Third, the normal distribution assumes that all revenues are independent of each other. However, the observations show that although the returns themself are not linked, the absolute returns tend to be positively correlated. There are also alternative models, but they need extra parameters, therefore it is practical to use Black-Scholes model. (OECD 2020)

The Black-Scholes model can be used in the microsimulation model since the aim of the pension model is not to assess the risk of the second pillar. To avoid these shortcomings, the average return of each fund will be found during the simulated period (2021–2100).

If the value of the assets of the second pillar is known, the last step is to annuitise with the following equation:

$$PII_{\tau,i} = \frac{V_{i,ry}}{\frac{1}{i/m} * [1 - \frac{1}{(1+\frac{i}{m})^{m*LE}}]}, \tag{30}$$

Where:

$PII_{\tau,i}$	– Annuity in year τ;
ry	– Retirement year;
i	– Yield of annuity (nominally 2% by assumption);
m	– Payments in a year (12);
LE	– Cohort unisex life expectancy at statutory pension age.

3.3.8. Voluntary funded scheme

Simulation of the voluntary funded scheme occurs in a model module named "10_IIIpillar" (see Appendix 2). As investments in the third pillar can be made into funds and insurance, their associated methods are also treated separately. It is assumed that people who already have the third pillar fund continue to have it. New entrants and annual contributions to a voluntary funded scheme must be simulated.

The *probit* model has been used by gender to find the probabilities of having the third pillar where the endogenous variable is *having a third pillar in 2015* (y) and exogenous variables are *last three period IHS relative wage, squared of last three period IHS relative wage, years to retirement, squared years to retirement, having second pillar* and *randomness*. The first step is to simulate having the third pillar fund, for which the following model is used:

$$P(IIIpillar_i | x_1, \dots, x_9) = \Phi(\beta_0 + \beta_1 \sum_{s=t-1}^{t-3} IHS\_Wage_{s,i} + \beta_2 sq \sum_{s=t-1}^{t-3} IHS\_Wage_{s,i} + \beta_3 ToRet_i + \beta_4 SqToRet_i + \beta_5 IIpillar_i) \quad (31)$$

Where:

$IIIpillar_i$ – Having a third pillar or not (1 = have, 0 = do not have);

$\sum_{s=t-1}^{t-3} IHS\_Wage_{s,i}$ – Individual last three periods IHS relative wage;

$sq \sum_{s=t-1}^{t-3} IHS\_Wage_{s,i}$ – Squared individual last three periods IHS relative wage;

$ToRet_i$– Individual years to retirement;

$SqToRet_i$– Individual squared years to retirement;

$IIpillar_i$ – Individual decision (or mandatory) of having the second pillar.

A higher salary, being a man and having a second pillar increase the probability of having a third pillar based on the *probit* model (see Table 17 and Table 18). Years to retirement and salary have an upside-down U-shaped probability, i.e. with increasing age the probability increases until age 27 for women and 39 for men, after which the age-related probability begins to decrease.

Table 17. *Probit* model results of having a third pillar fund for women

Variable	Coef-ficient	Std. error	z	P>|z|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	-3.822	0.049	-78.68	0.000	-3.917	-3.727
Last three years IHS relative wage	0.829	0.067	12.33	0.000	0.697	0.960
Squared last three years IHS relative wage	-0.154	0.033	-4.63	0.000	-0.220	-0.089
Age	0.032	0.004	9.02	0.000	0.025	0.039
Squared age	-0.001	0.000	-7.16	0.000	-0.001	-0.000
Having Second pillar	0.240	0.037	6.41	0.000	0.167	0.314

Observations = 488,131; Pseudo R^2 = 0.0899; Log likelihood = -5872.2461
Source: author's calculations.

Table 18. *Probit* model results of having a third pillar fund for men

Variable	Coef-ficient	Std. error	z	P>|z|	Lower 95% conf. interval	Upper 95% conf. interval
Constant	-3.765	0.044	-84.63	0.000	-3.851	-3.677
Last three years IHS relative wage	0.813	0.052	15.56	0.000	0.711	0.915
Squared last three years IHS relative wage	-0.141	0.021	-6.66	0.000	-0.183	-0.100
Age	0.019	0.003	5.55	0.000	0.012	0.025
Squared age	-0.000	0.000	-3.09	0.002	-0.000	-0.000
Having Second pillar	0.224	0.033	6.81	0.000	0.160	0.289

Observations = 446,294; Pseudo R^2 = 0.0911; Log likelihood = -6269.3861
Source: author's calculations.

Based on the *probit* regression model, the probabilities of having a third pillar fund are calculated. A normal distribution stochastic component is also added to the *probit* regression model. As the probability found by using the *probit* model coefficients shows only the probability to have a third pillar, the number of people who have a third pillar must be defined annually. The proportions of people who have a third pillar by year, gender and age are used to define the people who have the third pillar.

$$IIIpF_{a,\tau} = Pop_{\tau} * \frac{IIIpF_{G,2015}}{IIIpF_{2015}} * \frac{IIIpF_{a,2015}}{IIIpF_{2015}} * (\frac{IIIpF_{2015}}{Pop_{2015}} + const_{IIIp} * (\tau - 2015)) \tag{32}$$

Where:

$IIIpF_{a,\tau}$ – Number of people who have third pillar fund at age a and year τ;

Pop_{τ} – Total population in year τ;

$IIIpF_{g,2015}$ – Number of people by gender g who have third pillar fund in 2015;

$IIIpF_{2015}$ – Number of people who have third pillar fund in 2015;

$const_{IIIp}$ – Constant, which shows the growth the popularity of the third pillar.

The following figure shows the change of third pillar pension beneficiaries. At the same time, it should be taken into account that all receive the annuity to compare benefits during retirement time.

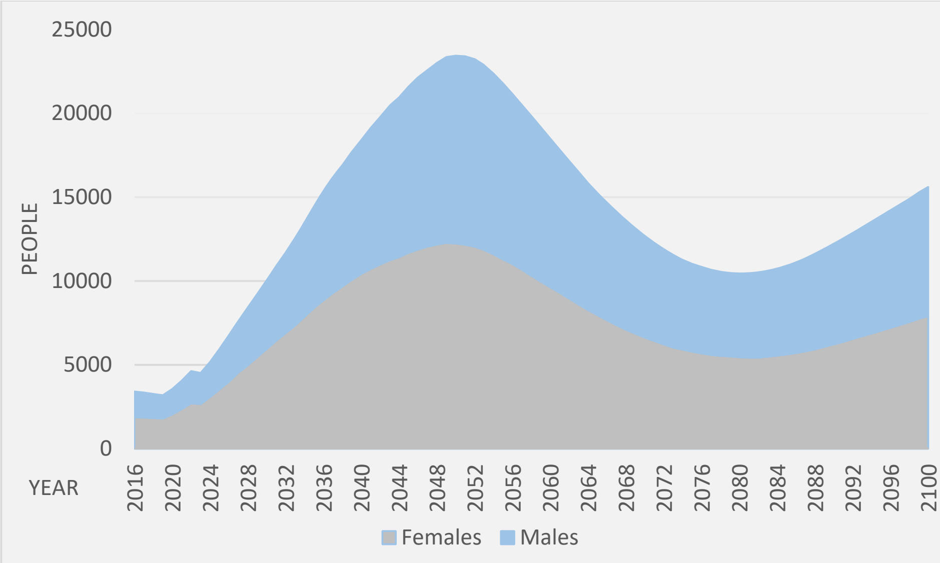

Figure 38. People who have a third pillar fund pension at retirement by gender in scenario 4
Source: author's calculations.

Simulating the amount of the contribution is the following step to the previous simulation of joining the third pillar. Contribution groups have been calculated using real data to achieve the size of contribution based on gender, age and ten income groups. Thus, there are over 1,000 contribution groups. When a person joins the third pillar fund, the proportion of contributions, which are based on a person's gender, age and income group, are used:

$$C\_IIIf_{\tau,i} = W_{\tau,i} * AGW_{\tau} * const_W * P\_IIIf_{g,a,\iota} * 12 \quad (33)$$

Where:

- $C\_IIIf_{\tau,i}$ – Individual contribution to the third pillar fund in year τ (euros);
- $W_{\tau,i}$ – Individual relative wage in year τ;
- AGW_{τ} – Macroeconomic forecast average wage in year τ;
- $const_W$ – Constant to go over from statistical average wage to the real average wage (around 0.9);
- $P\_IIIf_{g,a,\iota}$ – Individual contribution proportion for gender g at age a and for income group ι.

Although the third pillar is voluntary and has the possibility of withdrawing one's assets at any time, it is assumed that the benefits will only be received at the time of retirement. The value of the third pillar assets has been calculated in the same way as the second pillar (see Equation 33). The yield was also calculated in a similar manner, but the underlying data are the historical information of the third pillar funds (see Table 19).

Table 19. Historical Estonian voluntary pension funds yield by funds

Pension fund	Average annual nominal yield until 2017	Average daily ln growth	Min	Max	Variance	Standard deviation
1st	8.6%	0.0002	-0.102	0.073	0.00007	0.009
2nd	6.9%	0.0002	-0.041	0.046	0.00002	0.004
3rd	9.3%	0.0002	-0.074	0.039	0.00004	0.007
4th	3.5%	0.0001	-0.022	0.016	0.00000	0.002
5th	5.1%	0.0001	-0.072	0.048	0.00004	0.006
6th	3.2%	0.0001	-0.023	0.012	0.00001	0.002
7th	3.0%	0.0001	-0.028	0.018	0.00000	0.002
8th	3.7%	0.0001	-0.038	0.032	0.00001	0.004
9th	5.6%	0.0001	-0.084	0.058	0.00004	0.006

Source: Pensionikeskus; author's calculations.

The future values are simulated based on previous information. Afterwards, the average is taken from all simulated funds and it is used for the yield of third pillar funds (see Figure 39). The same annuity formula (see Equation 34) is used as in the second pillar in the payment phase.

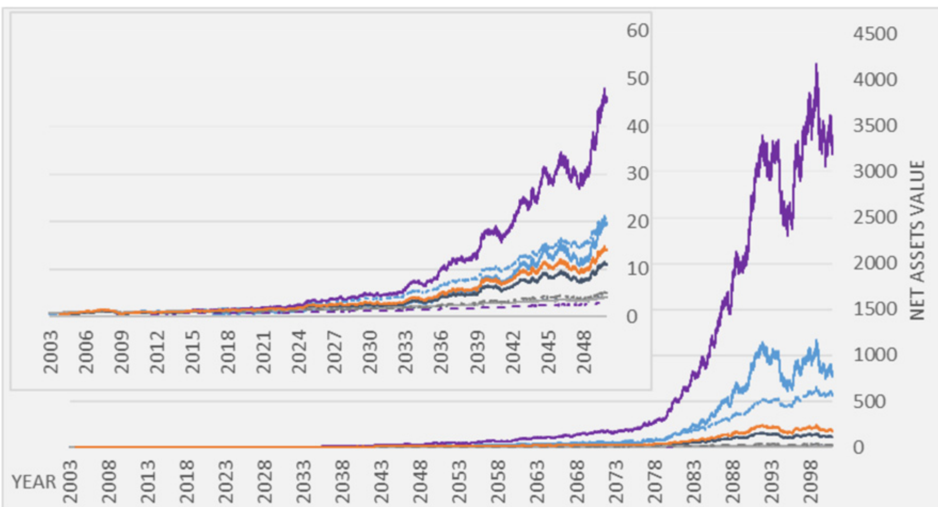

Figure 39. Simulated daily net assets value by funds until 2100
Source: Pensionikeskus; author's calculations.

The next phase is to simulate the third pillar insurance from the current situation to the payment phase. The individual-level insurance data are available, but this data cannot be linked to the model individual-level data. Therefore, the first step is to divide real insurance data between the people. This is done by cohort, gender and income group.

At first, every income group's (ten groups) lower income limit is saved by cohort and gender in real registry data. Then, ten income groups are created in the model data. The replacement of the insurance amounts is started on the highest income group.

1. First, the insurance amounts of the highest income group are saved;
2. A random number is created for all people who belong to the tenth income group;
3. Random numbers are sorted in descending order;
4. Real amounts are also saved in descending order;
5. The largest amount of insurance is assigned to the person with the largest random number;
6. Previous activities are repeated but now divided between the ninth income group insurance amounts. This is repeated until the lowest income group amounts are divided.

Finally, all amounts of insurance are divided inside specific cohorts and gender. In summary, the position of 2015 is set, and the future joiners and contributions are simulated in the following steps.

First, the number of people who have third pillar insurance in the future at an exact age and gender was found. The average of five years is taken as this is the number of people who have third pillar insurance:

$$\mathrm{IIIpI}_{a,g} = \frac{1}{5}\sum_{\tau=Y-5}^{Y-1} IIIpI_{a,g,\tau} \tag{34}$$

Where:

$\mathrm{IIIpI}_{a,g}$ – Number of people who have joined the third pillar insurance;

$IIIpI_{a,g,\tau}$ – Number of people who have joined the third pillar insurance in 2011–2015.

After finding the number of people who have third pillar insurance it is essential to simulate the exact individuals who have third pillar insurance. A random number is used for that. Random numbers are ordered in descending order and the first people are set to have third pillar insurance. From 2016 to the 2040s will see rapid growth in the number of people who receive a third pillar insurance pension, due to the maturation of the third pillar. Gradually, people start to receive the third pillar pension.

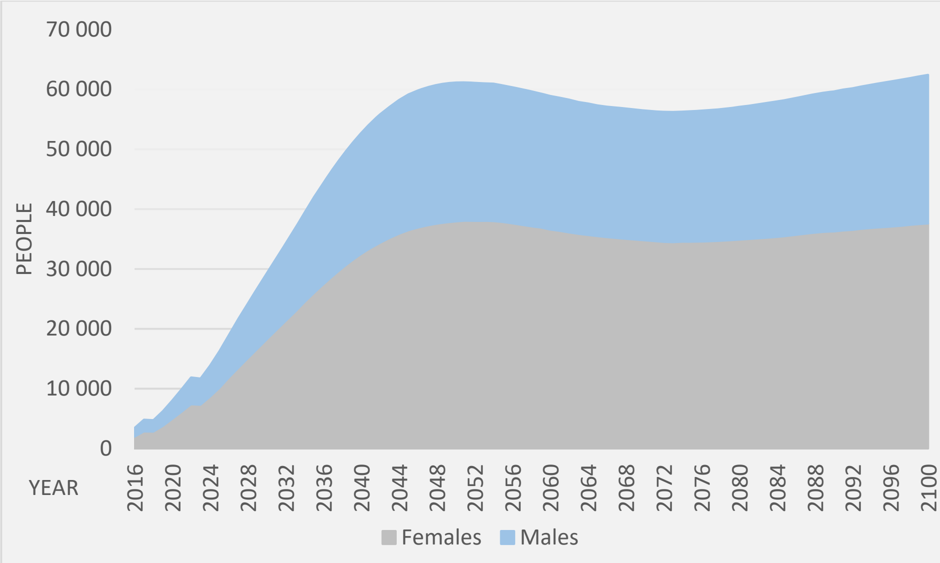

Figure 40. Number of people who have third pillar insurance pension at retirement by gender
Source: author's calculations.

The following step is to find contribution proportions from wages by age and gender. The same proportions are used in future contributions for people with the same gender and age. The same kind of equation is used as in the third pillar funds to find the contribution in euros in the future:

$$C\_IIIi_{\tau,i} = W_{\tau,i} * AW_{\tau} * const_{W} * P\_IIIi_{g,a} * 12 \quad (35)$$

Where:

$C\_IIIi_{\tau,i}$ – Individual contribution to the third pillar insurance in τ year (euros);

$P\_IIIi_{g,a}$ – Proportion of contribution to the third pillar insurance by gender and age.

The last step to find the value of the insurance is the simulation of the yield. Second pillar conservative funds are used as a proxy for the third pillar insurance yields. Only the conservative funds average is used as the yield of insurance.

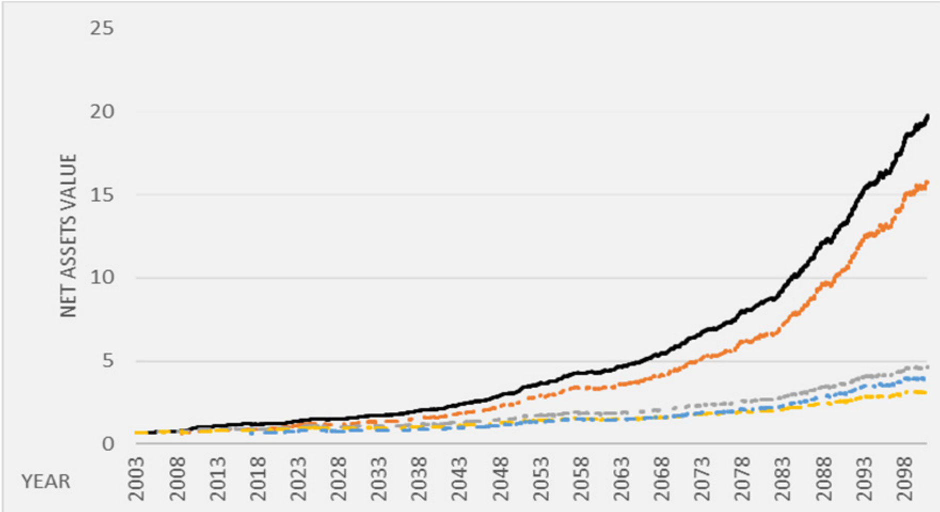

Figure 41. Simulated daily Estonian pension net assets value of conservative funds until 2100
Source: Pensionikeskus; author's calculations.

The same annuity equation is used in the payment phase as before (see Equation 33).

4. BENEFITS AND INEQUALITIES

4.1. Typical agent model results

Chapter three explained the models in detail and this subchapter, and the following subchapters take the results together. The analysis of the intergenerational effects of the typical agent model is illustrated with the figures which are shown by cohorts, indicators and income levels. See subchapter 3.1.2 for a detailed description of the scenarios – 1) base scenario (PAYG and service component); 2) insurance component added; 3) Introduction of the second pillar (mandatory funded scheme); 4) change of indexation; 5) New service component; 6) Linking SPA to life expectancy; 7) New service component and linking SPA to life expectancy together; 8) the second pillar is made voluntary.

General assumptions results. In general, pension reforms have increased the replacement rate for all, except for lower than average wage earners. Their replacement rate has decreased with the introduction of an insurance component, as they earn fewer insurance components compared to the base scenario (see Figure 42).

Younger cohorts who earn a minimum wage (40% of the average wage) get a lower GRPL (replacement rate at the time of retirement) than older cohorts with all scenarios. However, with the scenario of service component and where life expectancy is linked to SPA (scenarios 5, 6, and 7), the difference is already minimal. The worst position from the intergenerational point of view, are those born in the 1970s and 1980s because they have the lowest replacement rate when all the scenarios have taken place (scenario number 7). The youngest cohort (born 2028) would receive 13% of the average salary in the second scenario and 19% in the base scenario, but 33% in scenario 7. It can be said that the reforms that have been undertaken are likely to improve the quality of life of pensioners who earned the minimum wage. The replacement rate would decrease 10 percentage points (23%) in the last scenario (number 8) because of no funded scheme in this scenario.

A mandatory funded pension for those who earn average wages has contributed well to finding an intergenerational balance because it increases almost all cohorts to a similar GRPL level as it is in the oldest cohort. Changes in the wage-dependent part and the length of service do not change the future replacement rate for the person who earns an average wage because in both cases the person receives a similar number of units. As younger generations work longer due to the longer life expectancy, they also have a higher replacement rate than older cohorts (from 38% to 53% in scenario 7). Life-cycle average wage earners will have a 5-percentage point lower pension for the youngest cohort. This difference comes mainly from the time of contribution to the mandatory funded scheme.

As the first pension reforms have increased the share of wages in future pensions, therefore, reforms have been beneficial for people with higher wages. The GRPL has been raised by mandatory funded pensions the most. From the intergenerational point of view, the older cohorts are in a worse position, i.e. their GRPL is lower with most reforms (except base scenario, insurance component scenario and scenario with no funded scheme). The re-emergence of a service component and linking the SPA with the life expectancy will not change the expectations of a high-wage future pension, because these two changes have similar size counter-effects for them. But this would be more beneficial for younger cohorts because they work longer and therefore could also benefit more from the mandatory funded scheme.

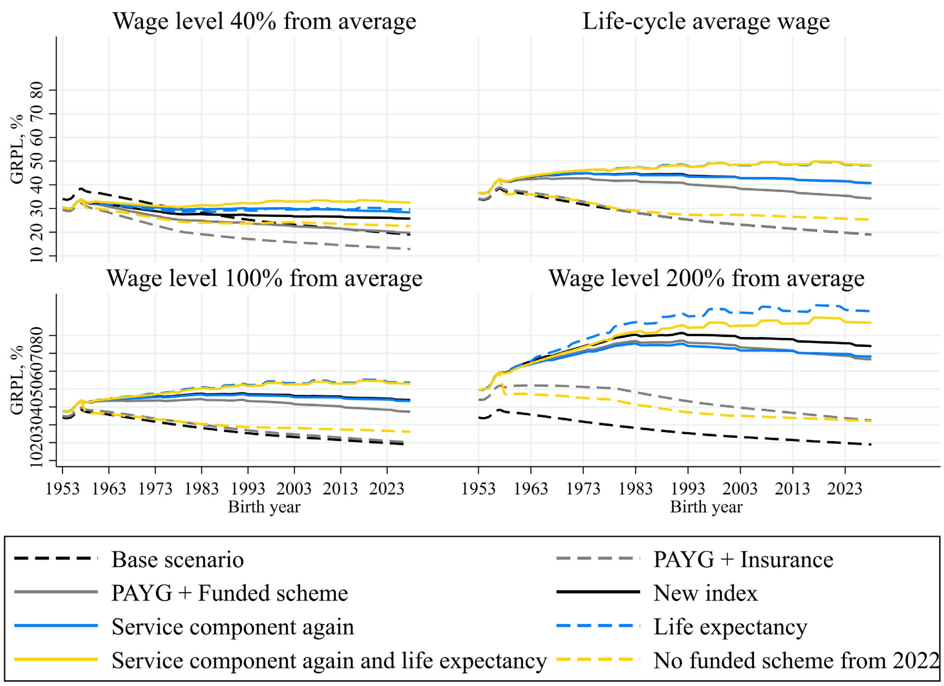

Figure 42. Gross theoretical replacement rate to the economy-wide average wage (GRPL) of persons from different cohorts who earn 40%, 100% and 200% of the average wage or the life-cycle average wage of the whole life
Source: author's calculations.

As the Estonian pension system is structured in such a way that the state old-age pension is indexed but the annuity of the mandatory funded scheme has not been indexed, then the replacement rate of the pension decreases in time. As a person earning a minimum wage receives most of the pension from the first pillar, his/her pension replacement rate will decrease by 1–5 percentage points over a decade. The least in scenarios where there was no mandatory funded scheme (scenarios 1, 2 and 8) and most in scenario 7 (see Figure 43).

The person earning the average salary must be prepared for a reduction of up to 10 percentage points in the replacement rate in ten years. Younger generations would lose more because their pension would depend to a greater extent on the mandatory funded scheme. For those born in 1983 onwards, when the second pillar is mandatory, the reduction in the replacement rate is similar to the intergenerational view.

The higher the salary, the more the replacement rate falls in ten years, as most of the pension is linked to mandatory funded scheme annuity. For example, a double average salary earner loses about 18 percentage points in the replacement rate with the seventh scenario. Younger cohorts are losing more in the replacement rate over time as pensions are linked to the life expectancy in the future and therefore the mandatory funded scheme annuity is higher.

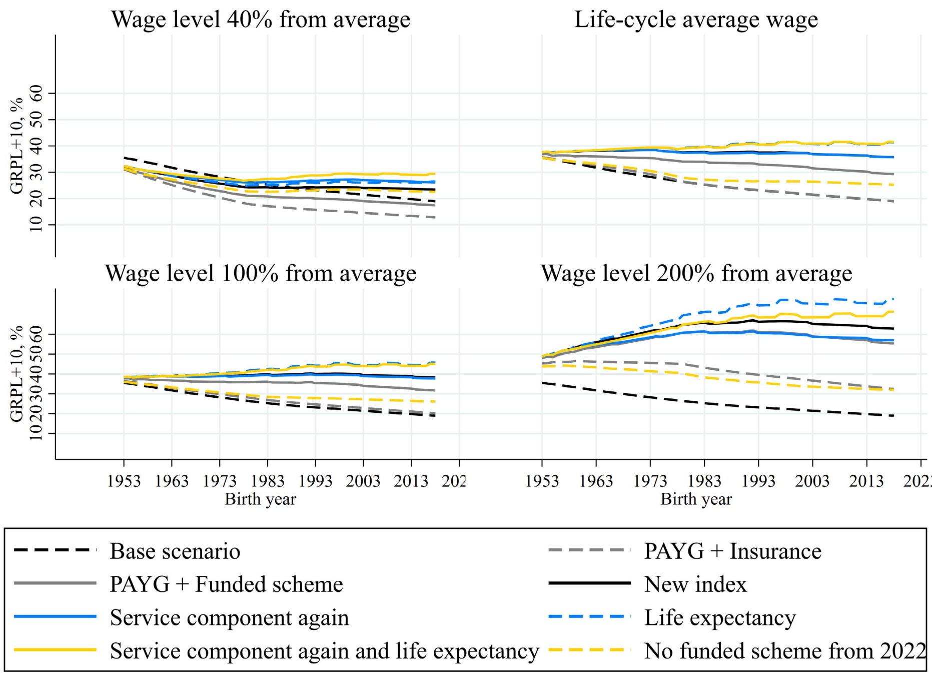

Figure 43. The difference of gross theoretical replacement rate to the economy-wide average wage at retirement and 10 years after retirement (GRPL+10) of persons from different cohorts who earn 40%, 100% and 200% of the average wage or the life-cycle average wage of the whole life
Source: author's calculations.

The theoretical replacement rate to a person's last wage (GRR) would be lower with every cohort and wage level in the base scenario (see Figure 44), except for cohorts born in 1956–1957 because they retired in 2020 and 2021 when there were extraordinary pension increases. The replacement rate would decline for most people earning the minimum wage because the replacement rate for older cohorts is roughly 80%, while the youngest would be 30–80%, depending on the scenario. However, this replacement rate would be higher compared to other incomes, i.e. the quality of life decreases the least with the minimum income.

The mandatory funded scheme increases the replacement rate of younger cohorts earning the minimum wage by 17 percentage points, then the more generous and redistributive first pillar (scenario 4) by 15 percentage points. The return of the service years increases by 7 percentage points and working longer increases by 10 percentage points, or both increase by 17 percentage points. The replacement rate for all cohorts born after 1980 is quite similar (around 80%) in scenario seven.

As a result of the reforms, the intragenerational distribution has approached the GRR, because in the base scenario the minimum wage earners would have a five times higher replacement rate than the double average wage earners, but with the seventh scenario the difference is two times. However, the difference would be the smallest (1.4 times) with the PAYG and funded scheme scenario (third).

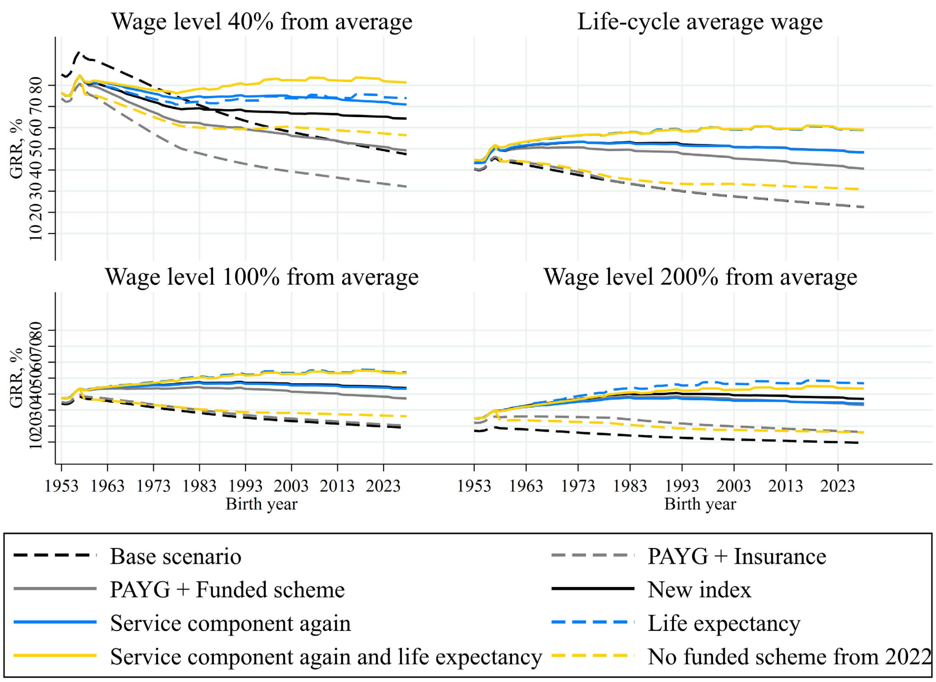

Figure 44. Gross theoretical replacement rate to the person last wage (GRR) of persons from different cohorts who earn 40%, 100% and 200% of the average wage or the life-cycle average wage of the whole life.
Source: author's calculations.

Yet, their IRR from the pension system is still lower, because younger cohorts have to contribute more than older cohorts (see Figure 45). Younger cohorts have a higher contribution due to the introduction of the compulsory funded scheme (the contribution increased from 20% to 22% of the gross wage). The higher the salary the person has had, the more evenly the IRR has been distributed. However, as a result of the reforms, the younger cohorts have a higher IRR than in the base scenario.

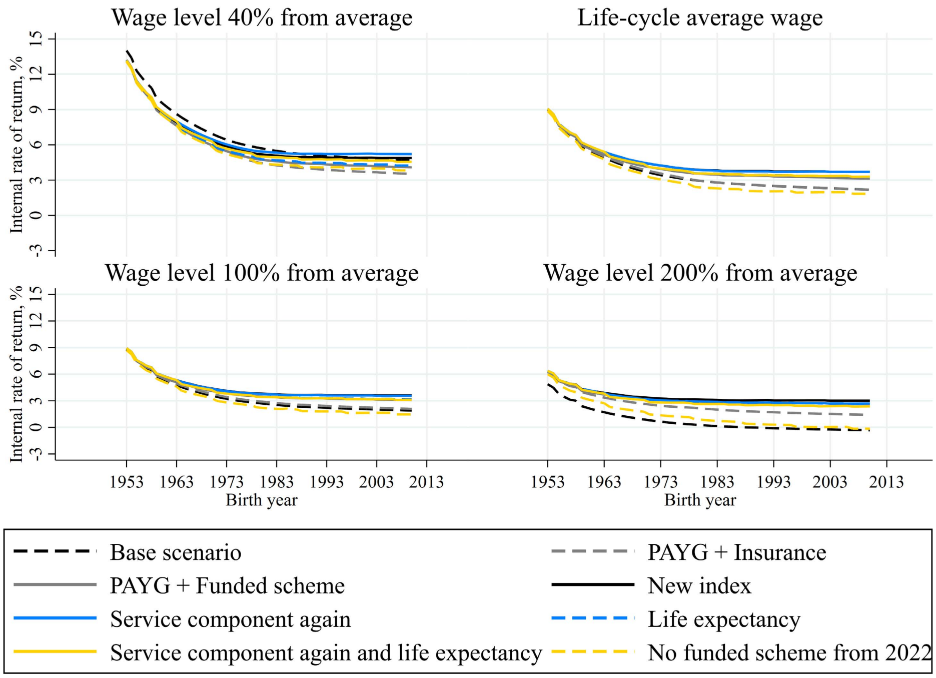

Figure 45. Internal rate of return (IRR) of persons from cohorts born 1953–2010 and who earn 40%, 100% and 200% of the average wage or the life-cycle average wage of the whole life
Source: author's calculations.

The ratio of net present value (RNPV) acts differently with wage levels (see Figure 46). At least every cohort has more discounted money from the pension system if they are contributing with PAYG to the insurance component and from the fourth scenario and until the average wage. The last reforms (5, 6 and 7) decrease two times the average wage earner RNPV compared to scenario 4 because they receive payments in fewer periods. The introduction of the compulsory funded scheme increased the younger cohorts' contribution, but it also changed the RNPV over the one (their benefits NPV is higher than contributions NPV and therefore it is beneficial for them). An extreme scenario (no funded scheme from 2022, scenario 8) decreases the RNPV with every cohort and with every wage level.

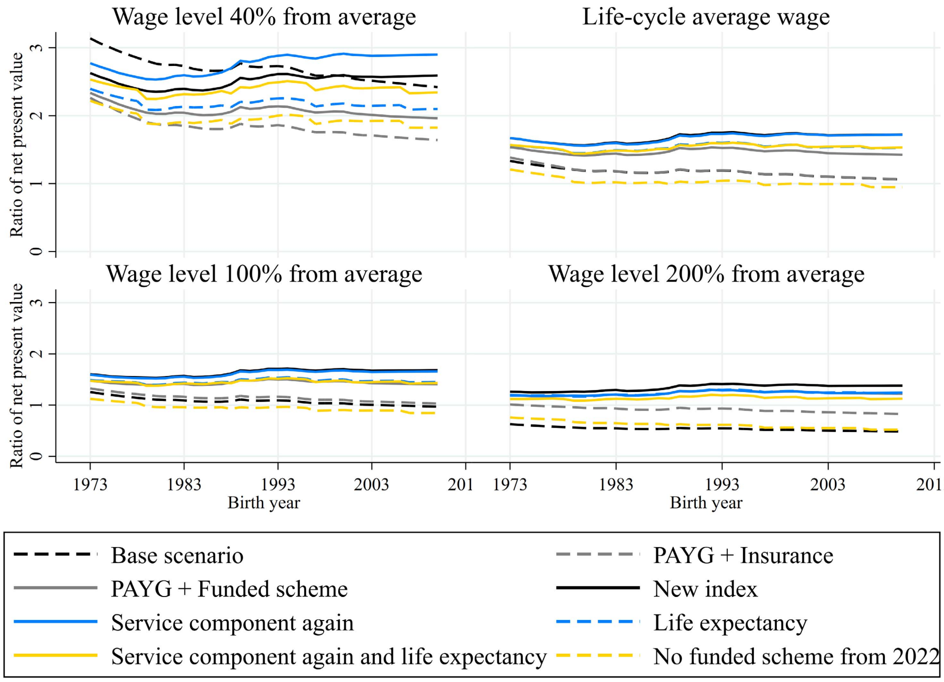

Figure 46. Ratio of net present values of persons from different cohorts and who earn 40%, 100% and 200% of the average wage or the life-cycle average wage of the whole life
Source: author's calculations.

Four variants have been tested in the sensitivity analysis: 1) 5 years of unemployment, 2) 15 years of unemployment, 3) lower second pillar yield and annuity interest (3% and 1%), and 4) higher second pillar yield and annuity interest (7% and 5%).

Five years of unemployment will be reduced by a maximum of 11.5% GRPL and a minimum of 2.5%, and these percentages are similar across the scenarios (except for the first scenario where everyone's GRPL will be reduced by 6.4%). The second variant of 15 years of unemployment reduces the GRPL (11–31%) in scenarios 2–7 by a similar amount. A smaller reduction of GRPL is in the last reform. GRPL will decrease by 13% for all incomes and cohorts in the first scenario (see Figure 47).

A lower rate of return will, at maximum, reduce GRPL by as much as 15 years of unemployment, but will depend largely on the combined effect of the two components: 1) the length of the collection period – the longer, the higher the loss, and 2) the higher the salary, the higher the loss. The same trend is with higher yields, but the biggest wins reach up to 75%. It can be said that a better return on investment is needed to reach a replacement rate of 70% for a person with an average wage.

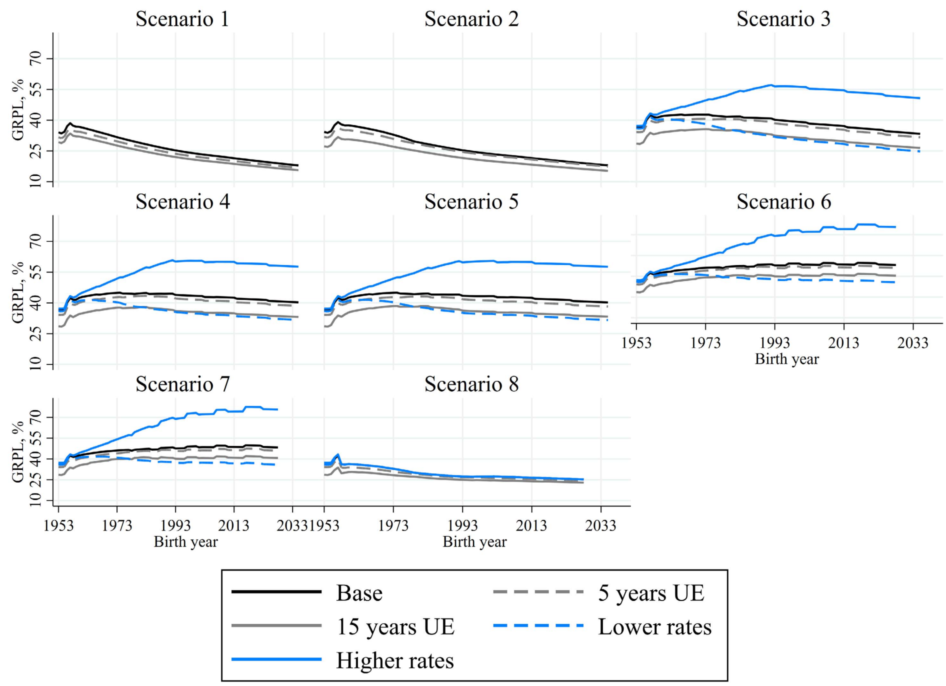

Figure 47. Sensitivity analysis using the gross theoretical replacement rate to the economy-wide average wage (GRPL) of persons who earn an average wage for the whole life
Source: author's calculations.

4.2. Benefits and inequalities in Estonian pension system based on the microsimulation model

The chapter of the results is divided into two parts: 1) an analysis of the seventh scenario results, and 2) the analysis of pension reform scenarios. In the first part, all three pillars are assessed separately and together and by different characteristics. Since the pension reforms are mostly related to the first pillar then the second part compares the first pillar and summary results. However, all indicators have been calculated only for those people who are entitled to a pension in the particular pillar. For example, the average of the third pillar annuity is €200 but there are only 50,000 people. At the same time, the first pillar pension is €1,000 and the pension from all pillars is €1,100.

4.2.1. Results of the pension system in force in 2020

The pension system (scenario number seven, which was valid in 2020) consists of three pillars: 1) mandatory PAYG point scheme; 2) mandatory fully funded defined contribution scheme; 3) voluntary fully funded defined contribution scheme. The SPA is linked to life expectancy in the seventh scenario (also in scenarios six and eight). The number of new retirees fluctuates (see Figure 48). This is due to the model setting – for example, the SPA can be 65 years and 5 months, but the model rounds it to 65 years because the model works with full years. The rights for 5 months are added based on the persons last full year data (working from age 64 to 65). The same happens with the SPA for 65 and 6 months, which rounds to 66 but pension rights for 6 months are taken away.

The number of total retirees starts from 306,000 and the highest point is 356,000 people in 2059 even with the retirement age linked to life expectancy. The total number of retirees starts to decline from 2059 and ends with a similar number as in the beginning. From the end of the 2050s, the number of new retirees will start to decrease, as the cohorts that were born in the 1990s, when Estonia had a very low birth rate, will retire.

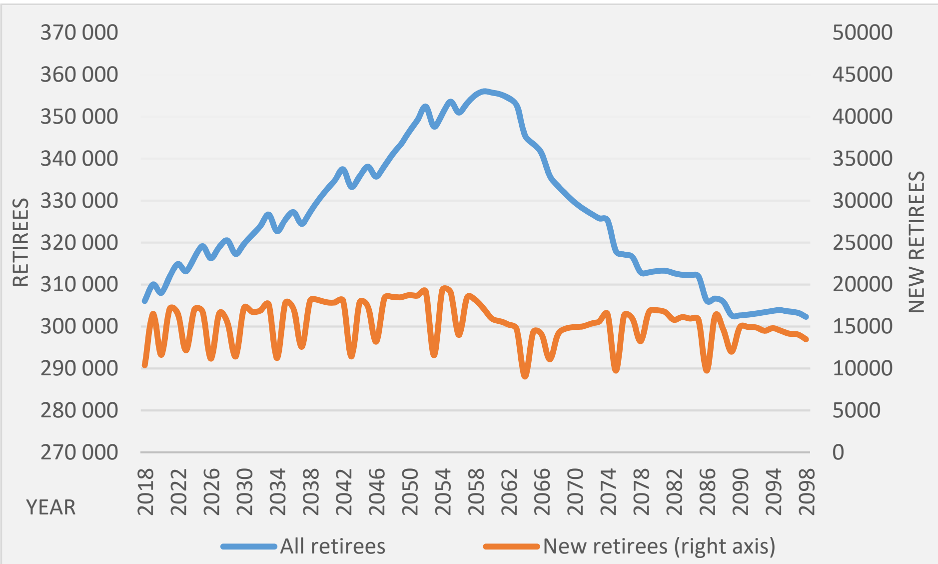

Figure 48. All retirees and new retirees in the seventh scenario
Source: author's calculations.

The accumulated value of the second pillar assets was 14% of GDP at the end of 2016 (see Figure 49). As there are more contributors to beneficiaries, then the percentage would rise to 60% of GDP at end of the 2040s[17]. Accumulated assets growth to GDP slows and would rise to 70% at the end of the 2060s. There are two reasons for this – more people start to get pay-outs from the second pillar and the total number of contributors decreases because of demography. New retirees take out around 0.3% of GDP in second pillar assets until 2030, which then rises by over 2% from the 2050s.

[17] As the mandatory funded pension was made voluntary in 2021, this has not been taken into account in these calculations.

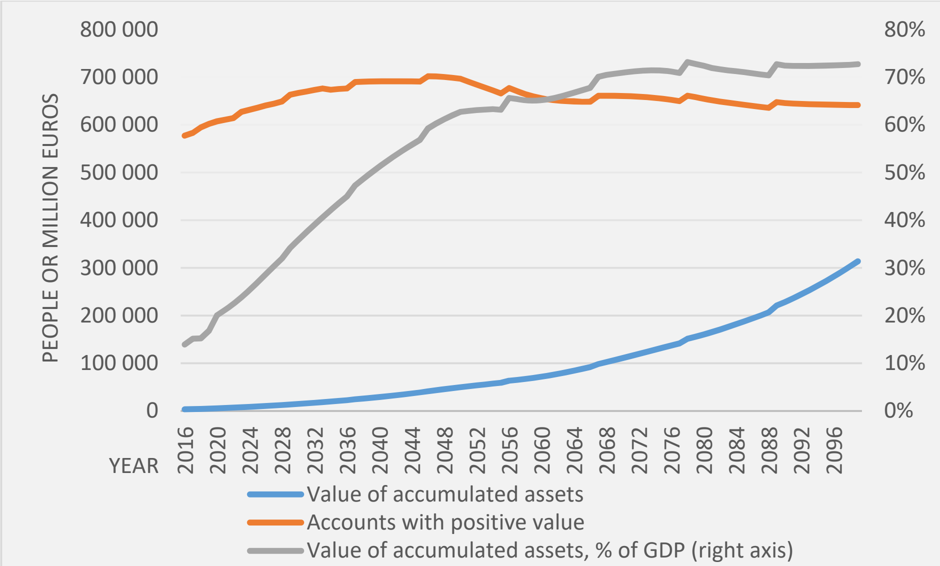

Figure 49. Value of the second pillar accumulated assets and number of accounts with a positive value in the seventh scenario
Source: author's calculations.

Although the role of the second and third pillars are increasing, the first pillar will still play a key role in the future (see Figure 50). Of course, when comparing these results, must consider that all retirees are compared together. For example, people who receive the second pillar annuity in 2050 are people whose birth year is 1951 to 1985. So, the maximum contribution period is 11 to 43 years for them. Payment of an annuity has its own effect because an annuity is nominally the same amount for all retirement, as it was at retirement it will be at age 80 as well. Of course, there are also contracts with investment risk and therefore an annuity can change during retirement and in the future there can also be other contracts.

In the results of the second and third pillars it must also be taken into account that they have not been cut off in the calculations (an annuity is also paid if the person has a couple of euros in the second pillar). However, the first pillar benefits have a cut-off value – the minimum amount of the public pension is the national pension and the minimum amount for the old-age pension is the base amount plus the amount for the minimum length of service. Although the second pillar has the minimum amount when the annuity is used in the law[18], then for comparison reasons the annuity is used for all.

Although the size of the pension initially depends entirely on the first pillar, the share of the second and third pillars will be higher in the future (see Figure

[18] The person had to take an annuity if the second pillar accumulated assets amount was over 50 times the national pension (€255.17 per month in 2021).

50). The proportion of the second pillar from total pension rises to 30% and the third pillar proportion to 5% in 2100.

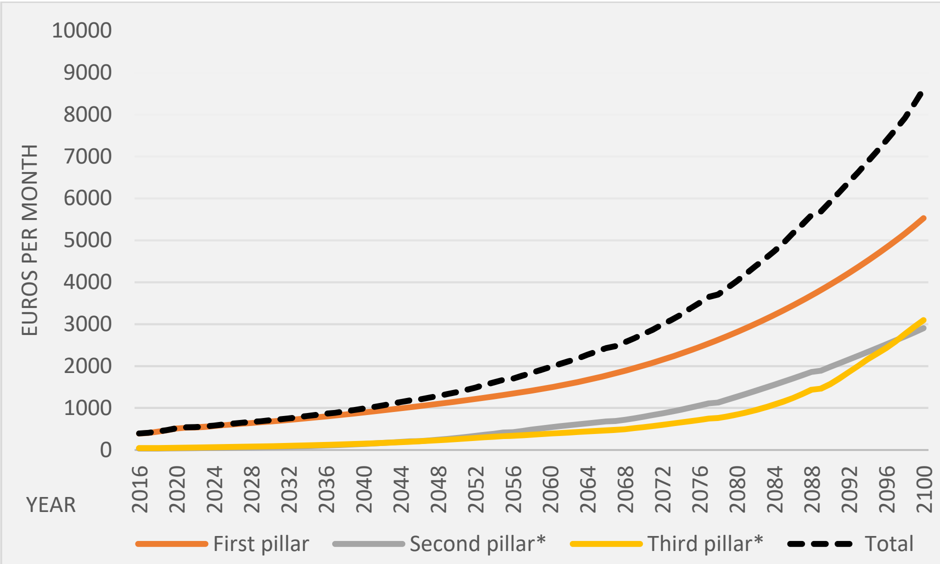

Figure 50. All retirees' nominal pension in the seventh scenario
Source: author's calculations.
* The second and third pillar average annuities are calculated for those who had a positive annuity.

As the first pillar pension grows slower than wages and the SPA is linked to life expectancy then according to the projections the first pillar costs will be lower than the social tax revenues from 2063 in the seventh scenario (see Figure 67). In the model, this surplus will be divided between all retirees by increasing the flat-rate base amount. In reality, this would not be automatic but would require a parliamentary decision to do so. At first, this increases the total average pension by 1% and growth increases every year to reach 21% in 2100 (see Figure 51).

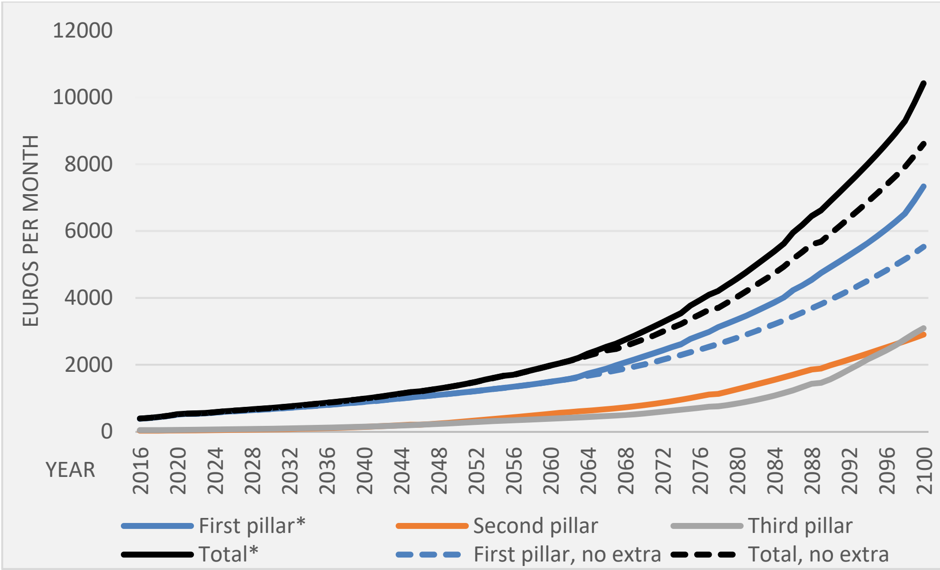

Figure 51. All retirees' nominal pension with and without distribution of surplus in the seventh scenario
Source: author's calculations.
* The first pillar pension and total pension have a distributed surplus which occurs from 2063.

The first pillar, i.e. PAYG scheme, is partly related to wages but over time the base amount importance and service part is growing. Since the historic wages (see Figure 29) and simulated wages (see Figure 31 and Figure 32) of women are lower than for men, then it is interesting that the first pillar pensions are on average almost the same until the 2060s (see Figure 52). Such a result could be twofold: 1) men's wages are higher but the probability to work is lower for men (see Table 11) and therefore men might likely have more unemployment periods; 2) since all entitlements for children are transferred to women and after the death of women to men, but ordinarily women are younger if men and women live longer on average. Therefore, entitlements for children ordinarily do not go over to men. Women's average pension from the first pillar slightly decreases compared to men, the reason for this might be a change in rights which are earned for raising a child. People who have a child in 2013 afterwards and have joined the second pillar have the second pillar contribution for three years instead of entitlements from the first pillar.

The wage gap effect is revealed in the second and third pillars payments and the difference between men and women payments increases, reaching 33% in the second pillar and 26% in the third pillar in 2100. As the differences will decrease in the first pillar and increase in the second and third pillars then until 2047, women have a higher total pension than men. Thereafter, men will have a higher pension – on average 1% and 14% more total gross pension in 2050 and 2100.

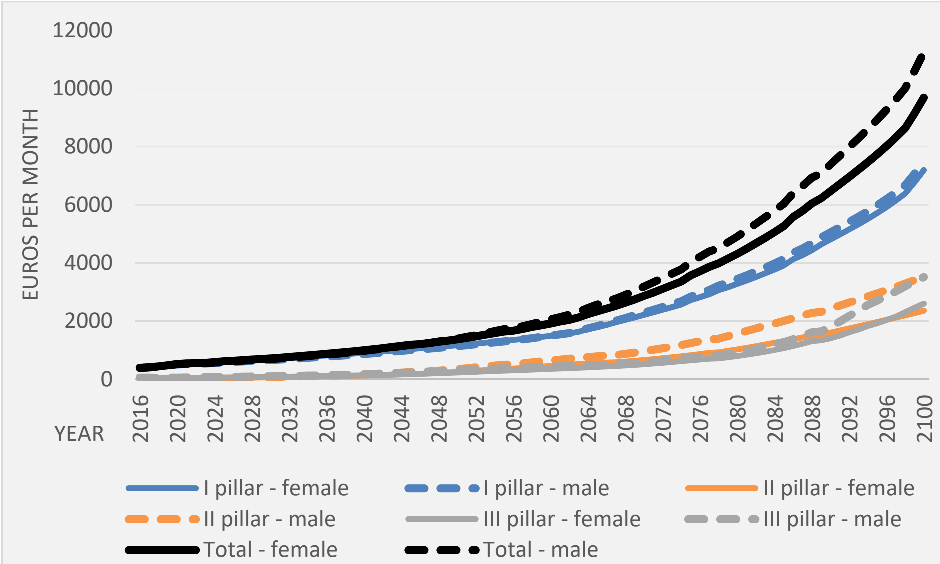

Figure 52. All retirees' average nominal pension in the seventh scenario by gender
Source: author's calculations.

The previous figures showed the situation of all retirees in a specific year which gives the general situation but not the situation of new retirees. For this purpose, the following figure (see Figure 53) expresses the situation of retirees at the SPA. To recap, paying the second and third pillar annuities starts at SPA in the model, but the first pillar pensions can start earlier due to other pension types than the old-age pension or early retirement.

The first pillar pensions are rather equal at the beginning comparing all retirees and retiring cohort. New retirees in later years have a slightly higher first pillar pension which could be due to a longer career (rising SPA). The difference in pensions is much higher in the second and the third pillar. The reasons are twofold – first, new cohorts have longer careers and their investment period is also longer because they were younger when the second pillar was made. Second, annuities are used, which are the same amount for the duration of the whole life. On average, the second and third pillar pensions are 80% higher for new retirees compared to all retirees.

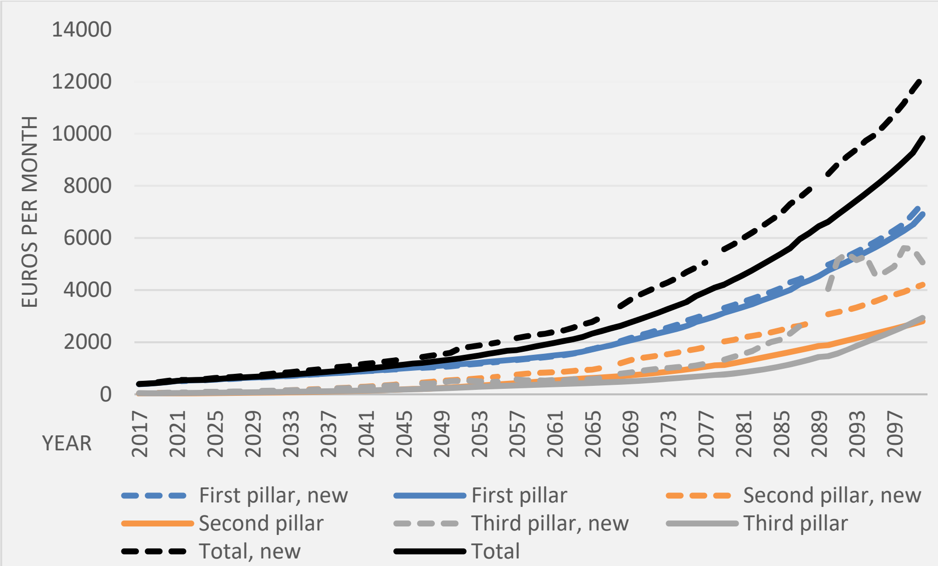

Figure 53. All retirees and retirees at the age of statutory pension age average nominal pension in the seventh scenario
Source: author's calculations.

The following part describes the seventh scenario replacement rates in certain years for all retirees. Here, two replacement ratios are used: 1) GRR (gross replacement rate, see chapter 3), the gross relative pension to a person's life average wage (from 1999 to pension age), and 2) GRPL (gross relative pension level, see chapter 3), the relative pension to the economy-wide average wage.

As the pension system is partly linked to the size of the wage and the fact that the realisation of changes to the pension system takes a long time, it can be that the GRR is expected to increase. The total pension GRR will decrease until the beginning of the 2060s (from 60.1% in 2016 to 37.6% in 2062) since the size of the overall pension is largely influenced by the first pillar (see Figure 54) and the first pillar pension does not rise as fast as wages due to the indexation rule[19]. The total pension GRR starts to slightly increase from the early 2060s (from 37.6% in 2062 to 42.8% in 2100). The slight increase occurs because the role of the second and third pillars in total pension increases and second pillar is fully linked to salary and the third pillar depends on the salary. In addition, the first pillar GRR stabilises – the first pillar surplus is divided between retirees and wage growth and the decrease in the number of employed people is slower than the previous period (2016 to 2060 vs 2061 to 2100).

[19] The pension indexation depends on the number of people who pay social tax, in addition to wages. According to the macroeconomic projection, the number of employed people decreases on average by 0.2% per year but the average wage will grow 4% per year during 2016 to 2060.

In addition, the decrease in GRR at the beginning of the simulation may be due to the data, as among the retirees are many people who had a working time before 1999 at the beginning of the simulation (2016), i.e. their salaries before 1999 are not known, and the average wage has been calculated by the last working years when people's wages are averagely lower (see Figure 29 or Figure 30). Therefore, the GRR is also higher at first. It is therefore necessary to examine the specific age of people in different years. In addition, the jump in the first pillar and total GRR in 2020 and 2021 comes from the extraordinary increase of the first pillar flat-rate base amount.

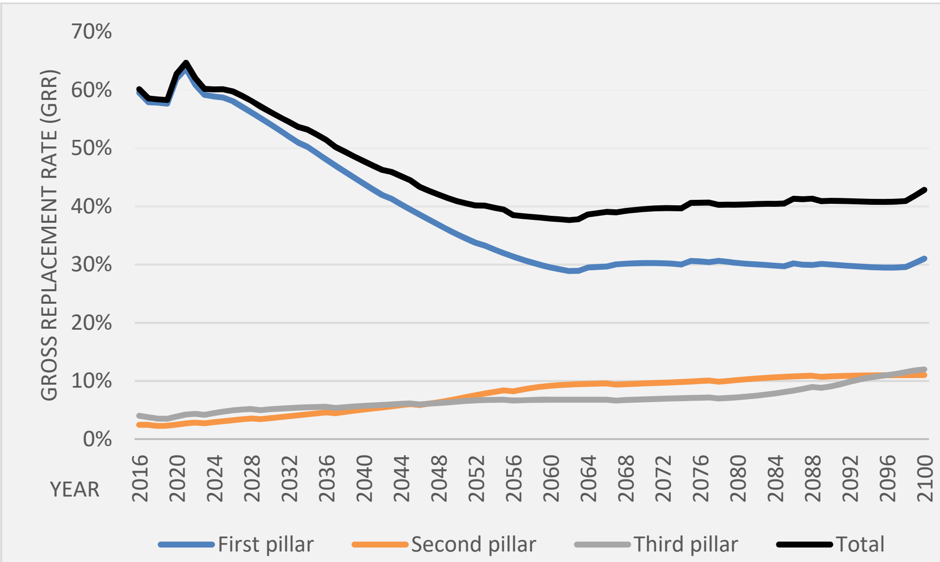

Figure 54. All retirees' gross replacement rate (GRR) by pension schemes in the seventh scenario
Source: author's calculation.

The first pillar result of GRPL depends heavily on the number of people who are employed because the second component (salary) in both cases is the same. Like most of the developed countries, Estonia also has an ageing population and low birth rate and therefore needs more employed people. Thus, it can be expected that the first pillar replacement rate will continuously decrease compared to the average national wage. The first pillar results show that the gross pension proportion of the economy-wide average wage was on average 33.8% in 2016, but by 2050 it has fallen to 26.2% and by 2062 to the lowest point 23.1% (see Figure 55). Afterwards, the GRPL starts to increase and reaches 27.8% in 2100.

The importance of the second and third pillars is also increasing in comparison with the developments of the average wage. First, this result reflects the longer contribution periods of fully funded schemes. Second, it may also reflect a higher return compared to the first pillar.

The total pension GRPL decreases from 33.8% in 2016 to 31.5% in 2048 and then stabilises to a similar level until 2063 due to the increase in the importance of the second pillar. Afterwards, the total pension GRPL increases by 8.6 percentage points to the level of 39.6% in 2100.

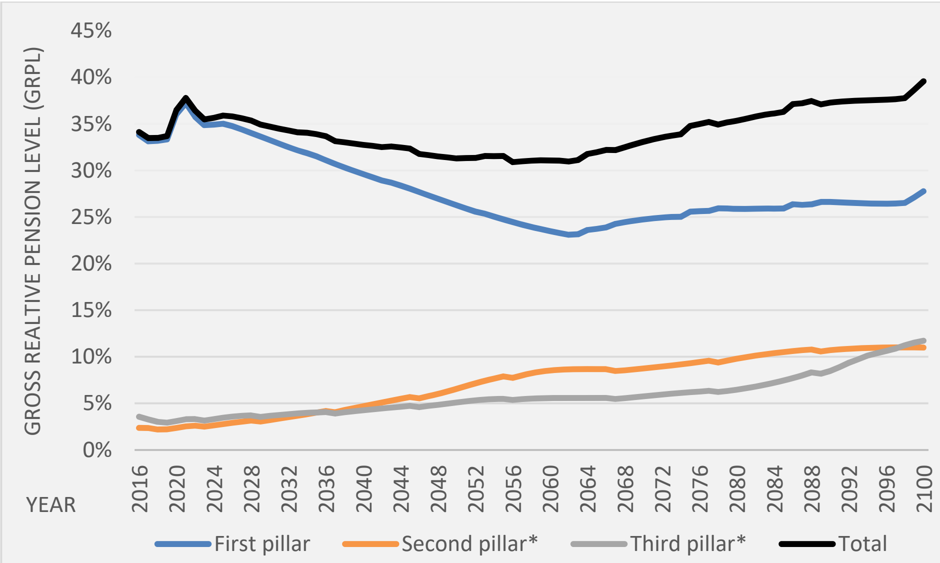

Figure 55. All retirees' gross relative pension level (GRPL) pension schemes in the seventh scenario
Source: author's calculation.
* The second and third pillar replacement rates are calculated based on people who had the second or third pillar pension, not based on all retirees.

As the topic of this thesis is inequality, before going to inequality of pensions we need to first analyse wages inequality and using the Gini coefficient for that purpose. Wages from registry data are from 1999 to 2015 and the Gini coefficient decreases over time, from 0.47 for women and 0.52 for men in 1999 to 0.44 for women and 0.47 for men in 2015 (see Figure 56). The Gini coefficient of simulated wages decreases remarkably – women's Gini decreases by 0.1 to 0.34 and for men to 0.4 in 2016. This is due to the simulation – simulated wages have a normal distribution, but real data wages have a bimodal distribution (first peak near zero and second peak around the minimum wage). Afterwards, the Gini of wages stabilises around 0.24 to 0.26, and the Gini coefficient is still higher, around 8% for men compared to women, which is similar to the period 1999 to 2015.

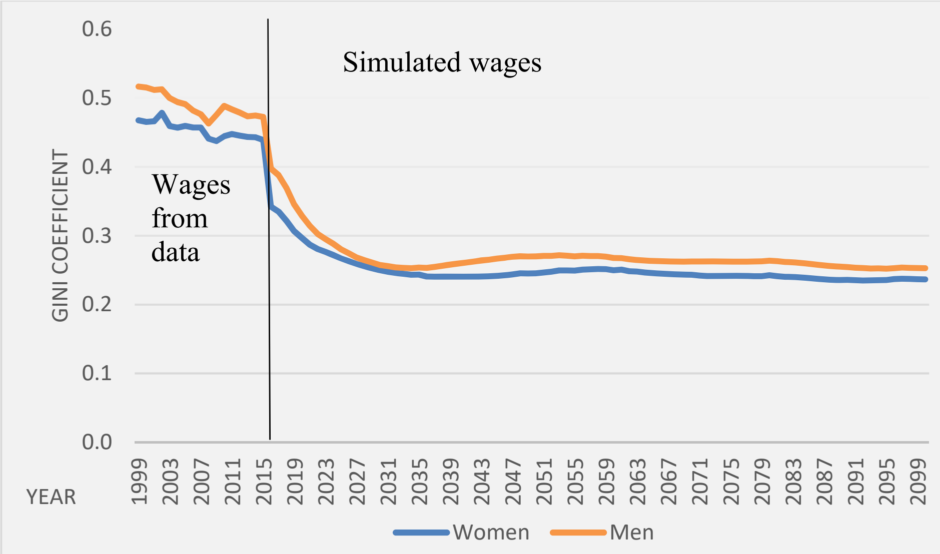

Figure 56. Gini coefficient for the historic (1999–2015) and simulated wages by gender
Source: SIB; author's calculations.

Before analysing the results of the Gini coefficient, it is reasonable to look at the Lorenz curve. The total pension curve is much closer to the straight line, and 50% of retirees would receive 39.3% of pensions in the seventh scenario in 2100 (see Figure 57). At the same time, 50% of those employed receive 30.7% of the sum of wages.

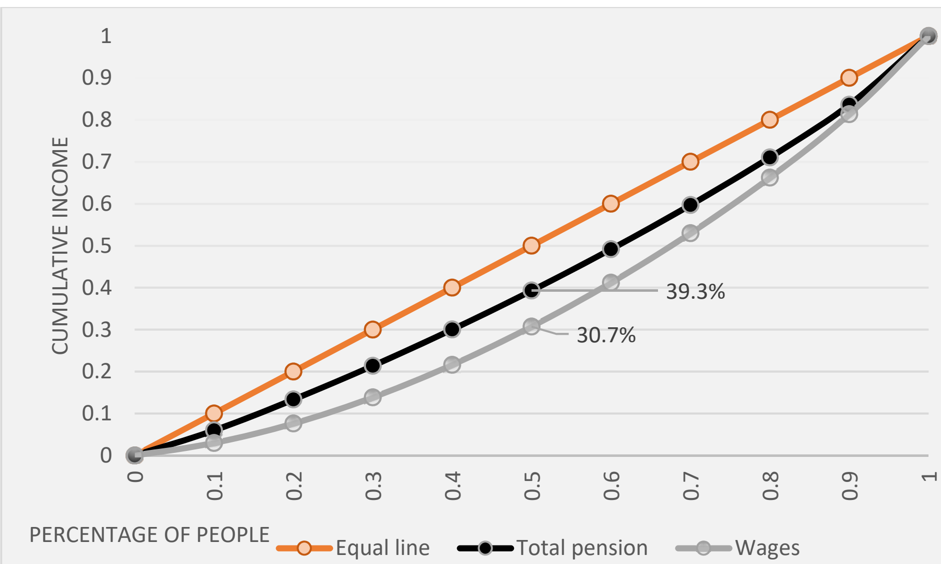

Figure 57. Lorenz curve of the wages and retirement income in 2100
Source: author's calculations.

A previous study (Piirits and Võrk 2019) examined the men born in 1980 who will retire in 2045 according to the time law, for whom the Gini coefficient increased to 0.2 in the first pillar, 0.39 in the second pillar and averagely 0.27 together in the first and second pillar. The first pillar Gini for all retirees increases gradually to 0.136 in this model. Thus, the inequality of the first pillar increases during the first simulated years by 34% (starts at the level of 0.10 in 2016 and reaches 0.136 in 2046) (see Figure 58) due to the insurance component. The first pillar inequality starts to decrease at the end of the 2040s because of the service years and the increase in the base amount[20]. Inequality will fall to 0.066 in 2100 which is 35% lower compared to the 2016 level.

The Gini of the wages and the second and third pillars are similar at the beginning of the simulation, being between 0.5 and 0.6. During the simulation, the funded pillars Gini decreases which may be due to more uniform contributions. The Gini coefficient of prefunded schemes is higher compared to wages – the second pillar Gini decreases by 36% from 0.514 in 2016 to 0.329 in 2100. The Gini of total pension for all retirees reaches the highest point at the beginning of the 2050s (0.19) and then decreases around 0.16 during the next 20 years and then stabilises.

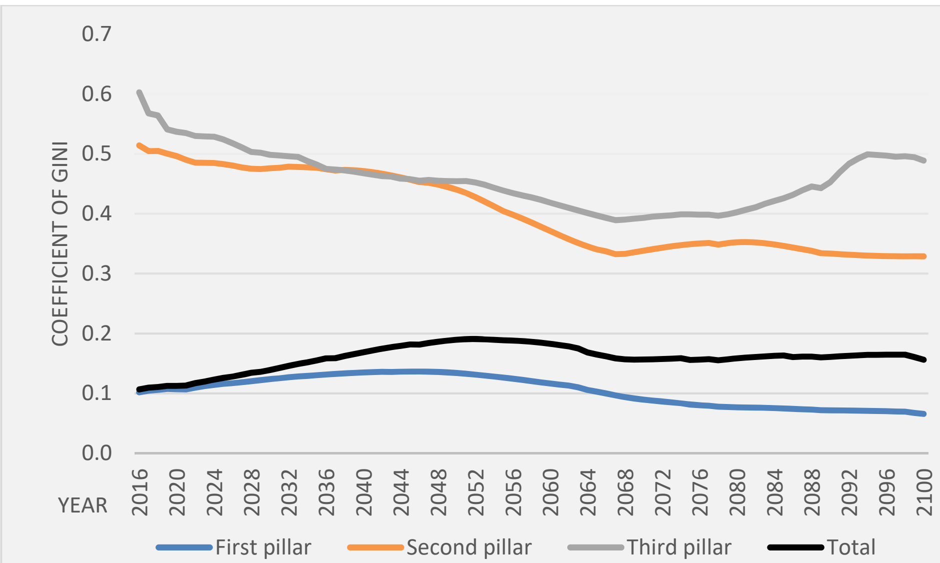

Figure 58. All retirees' Gini coefficient in the seventh scenario
Source: author's calculations.

[20] At first because of the indexation rule and later increasing the flat rate base amount by distributing the surplus.

Generally, men have a greater degree of inequality of pensions which is not the case in the first pillar in the future (see Figure 59). This could also be the result of inequality in wages which are quite similar between men and women in the simulated years. Inequality of pensions is quite similar by gender, but the total pension Gini coefficient is still higher for men. Men's inequality in the total pension might cause a lower proportion of people who have the third pillar and therefore, increases overall inequality more compared to women.

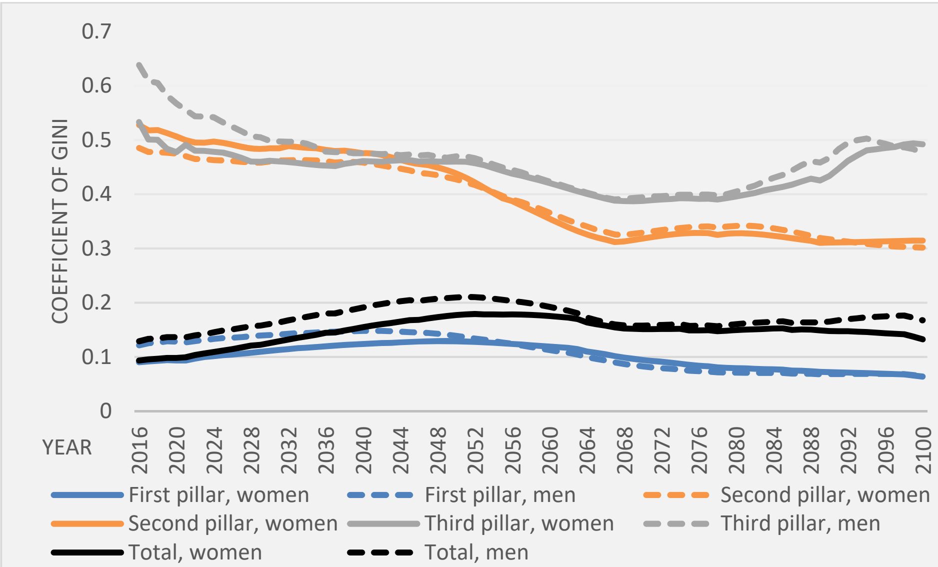

Figure 59. All retirees' Gini coefficient in the seventh scenario by gender
Source: author's calculations.

The impact of pension reforms takes time and the possibility to see changes faster is an opportunity to examine new retirees. The inequality of the first pillar is at first greater for the new retirees, but at the beginning of the 2040s they will converge and then decrease (see Figure 60). The convergence and then decline can be a result of joining the second pillar, as in the 2040s cohorts will retire who have earned fewer rights of the first pillar due to joining the second pillar (four out of 20 will be transferred to the second pillar). In later years, the inequalities between new and all retirees will be harmonised, because the new cohorts will not differ significantly from all retirees and the base amount of the first pillar will have an increasing impact on the size of the first pillar pension.

The inequality of the second and third pillars is lower for the new retirees since new retirees have collected for a similar period but all retirees collection period depends on the starting time (the second pillar was made in 2002 and a person could be 30 years old then) and ending time (the SPA is different for different cohorts). Moreover, when retired, the real value of talent is the highest. In addition, each subsequent cohort has a higher nominal value in the second pillar when they retire.

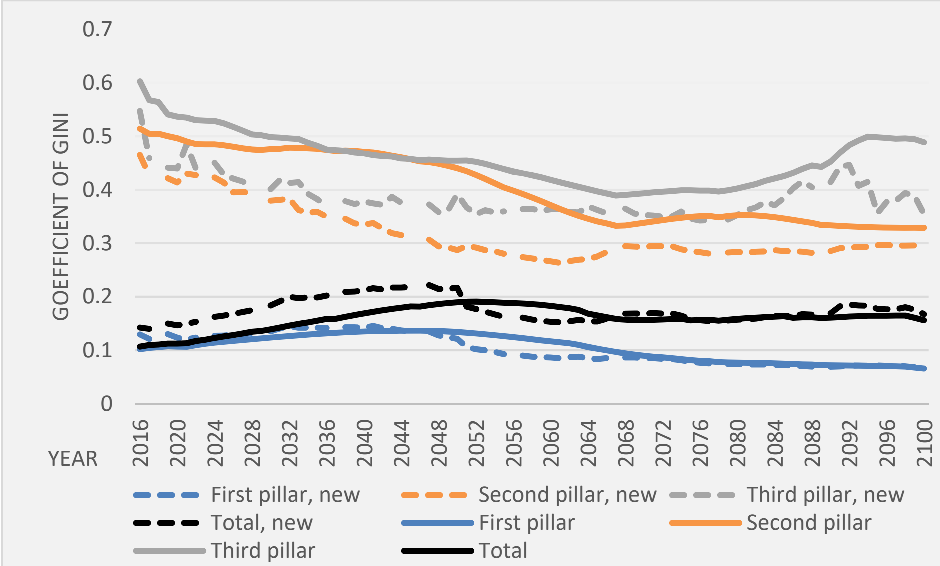

Figure 60. Retirees at the statutory pension age and all retirees' Gini coefficient in the seventh scenario
Source: author's calculations.

While the Gini coefficient has previously been assessed on the nominal pension, in the following paragraph the Gini has been assessed on the GRR. The inequality of GRR in the first pillar is larger than the inequality of nominal pension or GRPL (those are the same). Since the first pillar is redistributable, it will redistribute more and will be detrimental to a person with a higher income.

The second pillar is mandatory in the seventh scenario, and the future pension depends on a certain size of people's wages. Due to these reasons, the inequality of GRR is much lower than the nominal pension Gini, and the future inequality of GRR will stabilise at the same level as wage inequality.

Although the inequalities in the third pillar in the GRR are lower than the inequalities in nominal pensions, the difference is smaller than in the second pillar. This is due to volunteering – people with high and quite low incomes may have joined the third pillar.

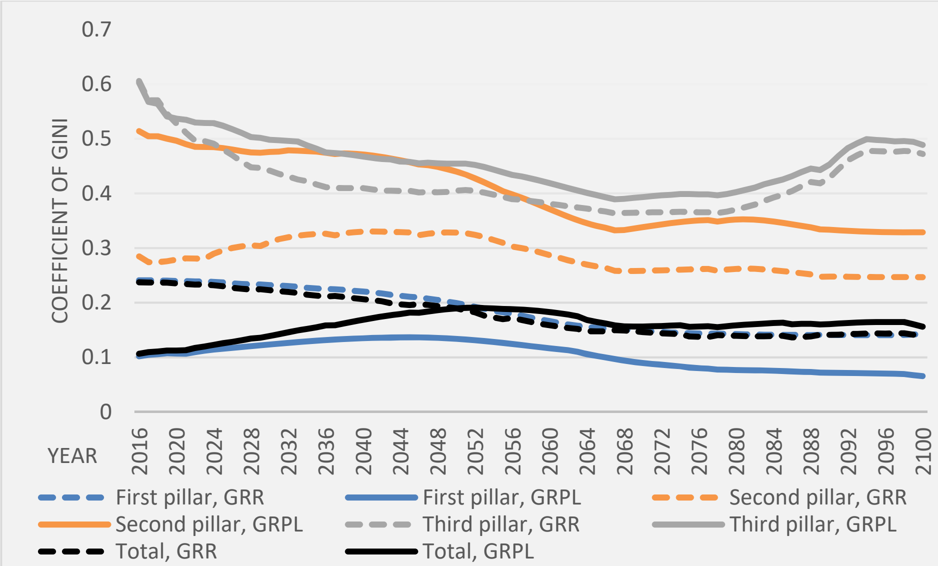

Figure 61. All retirees' GRR and GRPL Gini coefficient in the seventh scenario
Source: author's calculations.

Taking together the inequality of pensions, the Gini coefficient will increase in the first pillar for men and women but will start to decline in the 2050s (see Figure 59). The inequality increases until 2050 are caused by the growth of the wage component in the first pillar, i.e. the younger generations will work most of their life in the insurance component. Since the previous process stops and the wage component starts to decline due to the service component and by a flat-rate base amount (which ratio to the value of the insurance component is growing), then inequality will reduce in the first pillar. The value of the insurance component to the base amount was 3.6% in 2016 but falls to 2.6% in 2050 and 1.3% in 2100. A similar trend will continue in the future.

The Gini coefficient of the second pillar pension decreases in males and females and both converge. Interestingly, the Gini coefficient of the second pillar will decrease to between 0.31 and 0.35, although the value of Gini in wages is about 0.25. Such a difference may arise in conjunction with the combined effect of two aspects: 1) since the model has calculated the annuities with all values of the second pillar – the younger cohorts have longer collection periods and therefore the disparity decreases due to this; 2) The Gini of the wages are one year's value for all cohorts, but the Gini of the second pillar payments is one cohort value, who has had a similar payroll and therefore they are not so different from each other.

The Gini coefficient of the third pillar payments also declines but is stabilised at a level of 0.45. Since a smaller share of people has joined the third pillar, the inequality between the third pillar joiners can therefore be higher. The size of the contribution is also an important aspect. The second pillar contribution rate is always the same by law, but it is a voluntary amount in the third pillar. Therefore, different contribution rates are simulated according to income group, age and gender in the third pillar in the model.

The Gini coefficient increases rather slowly in the case of total pensions and will stabilise in 2050. The Gini increases by 0.06 by 2050 to 0.16 for men and by 0.05 to 0.15 for women.

The following paragraphs also focus on the distribution of pensions, but from the point of view of the deciles. Deciles have been created according to the total pension (the first, second and third pillar pension in total). The results are shown with the gross relative pension level (GRPL) indicator.

Analysing the total pension by deciles (see Figure 62), deciles 1 and 10 differ from the other deciles and deciles 2 and 9 to some extent in 2016. The average replacement rate for other deciles was similar – between 30.5% and 36.9%. By 2060, the disparities between deciles 3 and 8 have also increased. The replacement rate for the top decile has increased considerably. While some of the deciles were quite similar by the average replacement rate in 2016, the deciles will have clearly different average replacement rates in 2100.

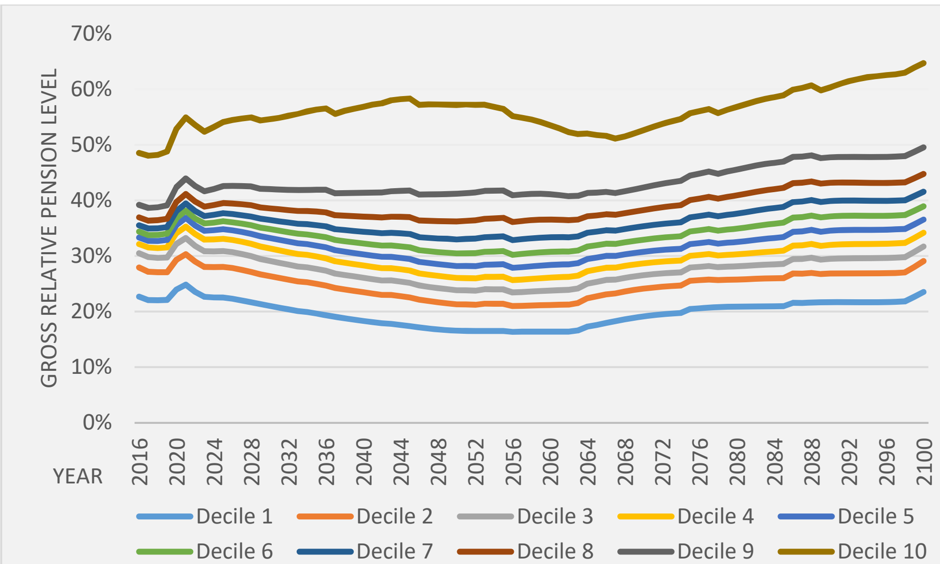

Figure 62. All retirees' GRPL for all pillars by deciles in the seventh scenario
Source: author's calculations.

As the Gini coefficient has shown before, the average replacement rates for deciles also show that the first pillar pension is converging (see Figure 63). This is because harmonisation aspects have been added to the first pillar over time (faster growth of the base amount and the creation of a solidarity unit in 2021), and the model assumes that the surplus will be distributed equally among existing retirees. The future average first pillar replacement rate from decile 2 to 10 will be between 26% and 31%.

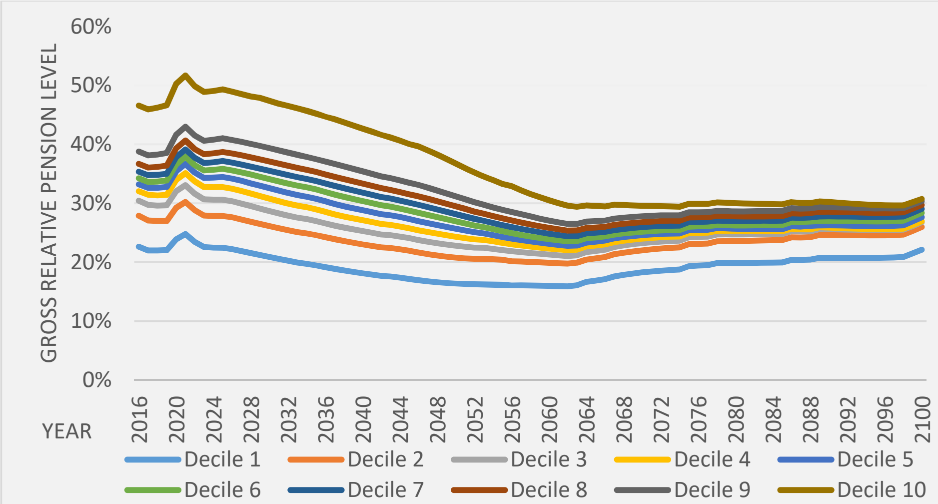

Figure 63. All retirees' first pillar average GRPL by deciles in the seventh scenario
Source: author's calculations.

The differences in total pension replacement rates by deciles in later years come from the second pillar because the differences in total pension increase, while the average replacement rates in the first pillar by deciles decrease – the difference in the replacement rates in the first pillar is 8.6 percentage points and 21.1 percentage points in the second pillar in 2100 (see Figure 64). In 2016, only decile 10 differs, but it must be taken into account that deciles have been created from the total pension income. This means that many did not have a second pillar pension in 2016.

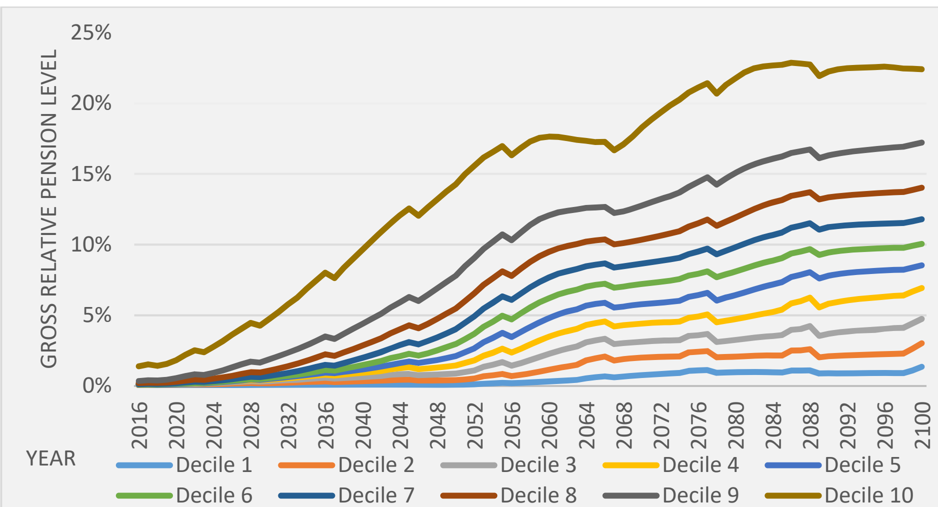

Figure 64. All retirees' second pillar average GRPL by deciles in the seventh scenario
Source: author's calculations.

The total pension GRPL figure by deciles (see Figure 62) clearly differs in decile 10 from the other deciles. The reason behind this is having the third pillar, which on the 10th decile differs considerably from the other deciles (see Figure 65). Decile 9 also differs to a small extent from the other deciles. The rest of the deciles average replacement rates are similar. Of course, it must be borne in mind that many people have not joined the third pillar, but it also shows that contributing to the third pillar will increase the possibility of better pensions in the future.

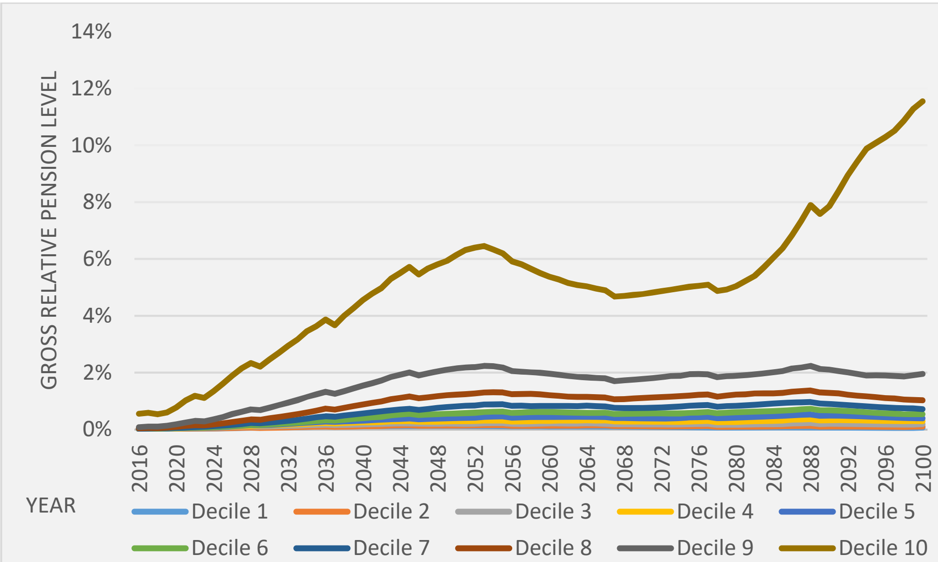

Figure 65. All retirees' third pillar average GRPL by deciles in the seventh scenario
Source: author's calculations.

To shed some light on poverty, absolute poverty and at-risk-of-poverty indicators are used. Both indicators have 2019 data taken as the starting point. Absolute poverty has increased until the year 2100 with CPI and at-risk-of-poverty with average wage growth. Thus, the indicator of at-risk-of-poverty does not take into account future changes in household composition. In addition, to assess at-risk-of-poverty, it is also necessary to know what the assessed household composition is, a simple presumption is made – whether it is a one-member or a two-member household. Only pensions are taken into account in incomes. Due to all these assumptions, we should not look specifically at the relative size of at-risk-of-poverty, but at changes over time. In 2019, 45.3% of people aged 65 and over were in at-risk-of-poverty (incomes include pensions and wages and other social transfers). Excluding pensions, 80.5% of people were in relative poverty.

The model's simple assumptions estimate that 69% of people receiving pensions were in at-risk-of-poverty in 2019 (see Figure 66). An extraordinary increase of the flat-rate base amount in the first pillar and slower wage growth in 2020 will reduce the at-risk-of-poverty to 54.1% by 2021. The number of people living in at-risk-of-poverty will start to increase and reach a peak in 2050. Thereafter the number of people in at-risk-of-poverty will start to fall and stabilise at 52% in the 2090s. According to the model, no pensioner lived in absolute poverty from 2020, and before that, less than 1% lived in absolute poverty.

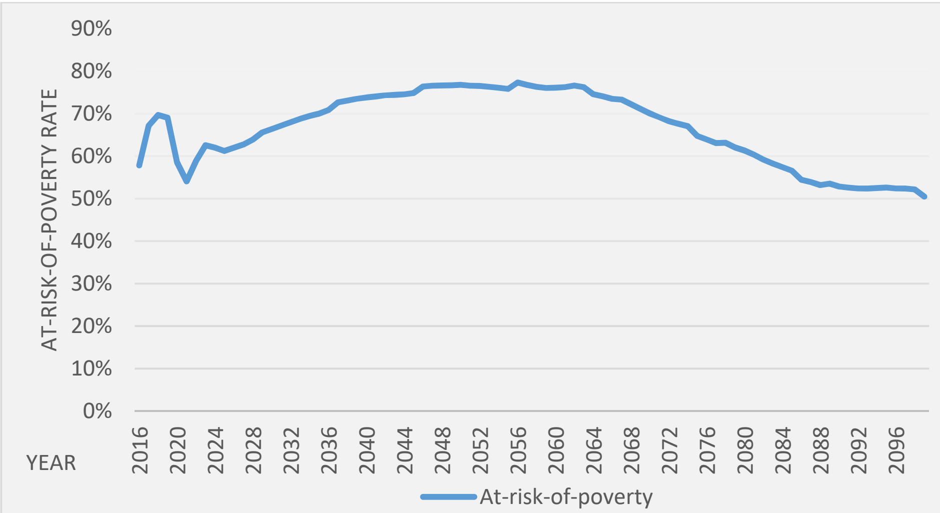

Figure 66. Percentage of all retirees at-risk-of-poverty in the seventh scenario
Source: author's calculations.

To summarise the previous subchapter, it can be said that future pensions are not as high as the result of the typical agent model and the second and third pillar proportions do not grow so high as hoped. On the positive side, it can be said that men and women's future total pension is not so different until 2050, but the difference will increase by 2100. The inequality from life-cycle wages is transferred to the retirement but the first pillar diminishes a great part of this.

4.2.2. Scenarios

Until the fourth scenario, the scenarios are built on top of each other or it can be said that these are cumulative. Pension reforms, legislated in 2018, are built upon scenario four and scenario seven takes both new reform ideas together and is also built on scenario four. Scenario eight (no funded scheme from 2022) is built on scenario seven.

Hereinafter, the baseline scenario, i.e. the system in force before 1999, has been marked by a continuous black line, insurance component scenario dashed grey line, introduction of the second pillar continuous grey line and more generous index continuous black line. The reforms which were legislated at the end of 2018 are indicated – a return of length of service years continuous blue line, linking SPA to life expectancy dashed blue line and all new reforms continuous orange line. The scenario where from 2022 there would not be a mandatory funded scheme with a dashed orange line.

The positive effect of the scenarios is the sustainability of the first pillar scheme. It should be considered that, in the case of the following figure, only the share of the first pillar contributions are taken into account, which is generally 16% of the salary and only those types of pension which have been used in the model are calculated as expenses. Since there have been no major changes in the population since 2060, the first pillar is also moving towards a surplus.

The base scenario would already be in the surplus in 2016 which would increase to near 3% of GDP in 2100 (see Figure 67). The funded scheme changed from a surplus to a deficit as 4 percentage points of 20% was directed to the second pillar from the first pillar. The new index scenario increased the deficit even more. The first pillar deficit would be around 1.1% of GDP in 2050 and near 0% in 2100 if the SPA would not be linked to life expectancy. The scenarios where the SPA is linked to life expectancy will move the first pillar from deficit to surplus at the end of the 2060s. The surplus would be 1.4% of GDP in scenario seven (service component again and life expectancy) in 2100. The first pillar will be in surplus if everybody would leave the second pillar in 2022 (scenario 8: no funded scheme from 2022). The surplus would be 1.1 to 1.2 percentage points of GDP higher compared to the seventh scenario.

The model divides the surplus between all retirees by increasing the flat-rate base amount. This also means that in scenario 5 (service component again) there will be no extra increase of base amount because this scenario does not achieve a surplus before 2100.

Taking all the changes together in 2100, the second pillar decreases the first pillar incomes around 1 percentage point of GDP, the new index decreases it by 1.6 percentage points of GDP, and the SPA linked to life expectancy increases it by 1.2 percentage points of GDP.

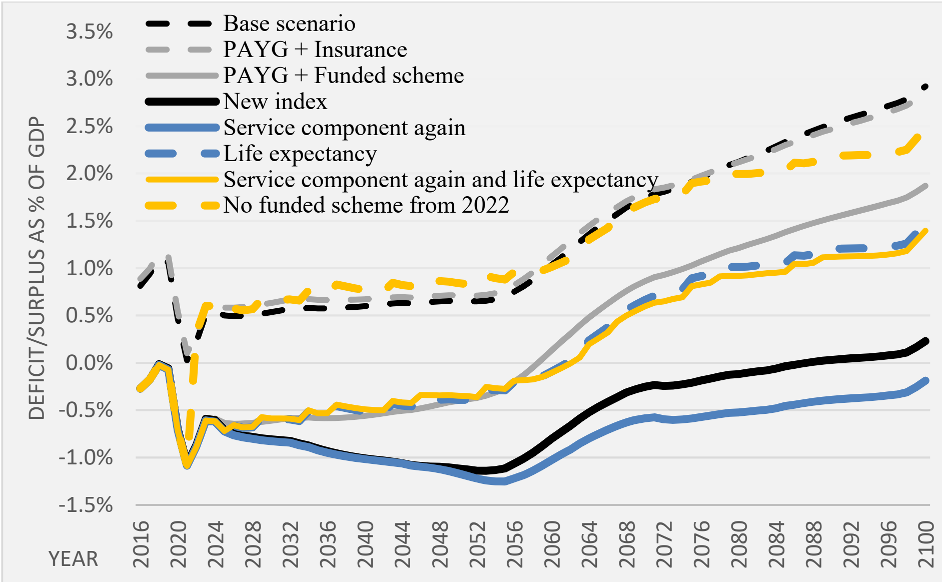

Figure 67. Contributions and expenditures by scenarios without redistributing the surplus, % from GDP
Source: author's calculations.

In the base scenario (pension system before 1999) and the PAYG + insurance system scenario, the total pension would have been higher than with the other scenarios until 2020. This comes from sharing the surplus. By 2021, the replacement rate in all scenarios will be around 38% of the average wage (see Figure 68). The average replacement rate in the base scenario and the PAYG + insurance scenario will then start to decrease, dropping to 26% in the 2060s. Furthermore, the replacement rate will increase by 2 percentage points by 2100. The creation of the second pillar will reduce the total pension until 2050 below the two previous scenarios, but by 2100 it will have a 3 percentage point higher replacement rate compared to the previous scenarios. The new index scenario will help to mitigate the fall in the GRPL created by the second pillar from 2020 to 2080 and the average replacement rate will be the same as in the preceding scenario in 2100.

The following three scenarios (service component again, life expectancy and both together) will not significantly change the replacement rate until 2050 and will stay between 31% and 32%. The return of the service component will increase the replacement rate by 1 percentage point in the future, but linking the SPA to life expectancy will increase the total pension significantly from the 2060s – by 2100 the replacement rate will be 8 percentage points higher compared to the new index scenario. To summarise both amendments, the impact of the SPA linked to life expectancy will remain dominant. The disappearance of the second pillar in 2022 will have different effects on the replacement rate in different time periods. In 2023, the total pension replacement rate without the second pillar would be 3 percentage points higher, but the impact would decrease and in 2052 the total pension would be higher together with the second pillar. For 2100, the average replacement rate with the second pillar system is more than 3 percentage points higher than without the second pillar.

From the perspective of intergenerational inequality, no similar replacement rate is guaranteed in any scenario. In all scenarios, the replacement rate will fall until the beginning of the 2060s and then continue to increase gradually. Therefore, cohorts who are retired in the 2050s are in the worst position.

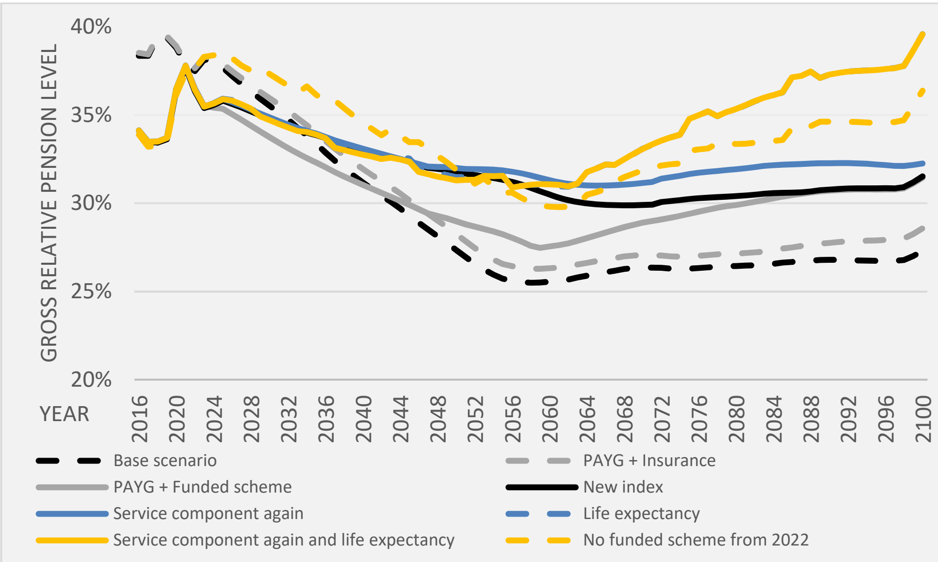

Figure 68. All retirees' GRPL for all pillars by scenarios
Source: author's calculations.

Looking only at first pillar replacement rates, the early 2060s have the lowest replacement rates in all scenarios (see Figure 69). The lowest pension from the first pillar would be in the scenario in which the second pillar was created – the replacement rate falling to around 20% by 2059. Then there will be a surplus that can be allocated to the first pillar increase. By the end of the 2080s, the new index and the SPA linked to life expectancy scenario will be able to compensate for the decrease of the replacement rate of the first pillar by the creation of the second pillar compared to the base scenario. The abolition of the second pillar (the eighth scenario) will increase the pension of the first pillar in 2023 by 3 percentage points and by 2100 it has increased to 7 percentage points compared to scenario 7.

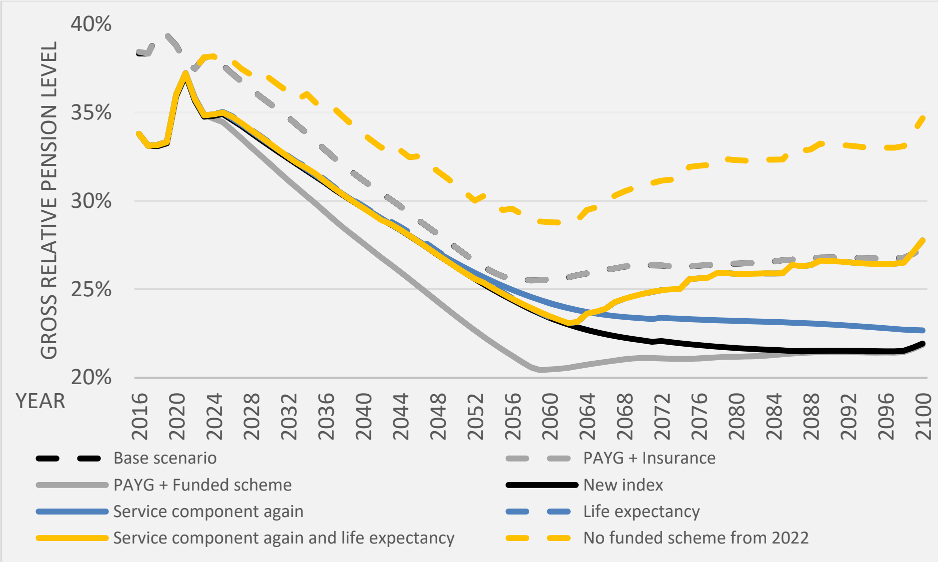

Figure 69. All retirees' first pillar pension GRPL by scenarios
Source: author's calculations.

The results of the second and third pillars are not analysed in all scenarios, such as the total pension and the first pillar pension, since the funded pension is directly affected by the reforms of SPA through the collection and the length of the benefit period. Thus, a comparison has been carried out between the situation where the SPA increases to 65 and remains there and the situation where the SPA is linked to life expectancy. In interpreting the results, it must be considered that in the same year retired cohorts are not the same, because in a scenario where SPA is linked to life expectancy, people will also retire later.

As a result, the second pillar pension will be similar until the mid-2050s, although the SPA will start to differ from 2027 onwards (see Figure 70). By 2100, the replacement rate will be more than 2 percentage points higher in the life expectancy scenario. As fewer people have joined the third pillar and the variance is higher in pensions, the effects of the life expectancy scenario will be revealed earlier (the early 2040s). The difference in the substitution rate between the two scenarios for the third pillar is 5.5 percentage points for the year 2100.

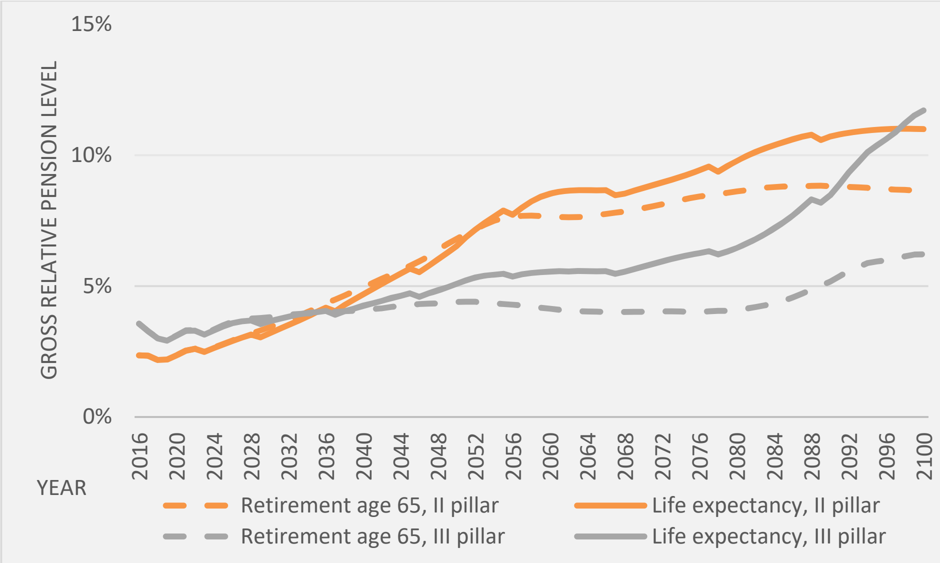

Figure 70. All retirees' second and third pillar pension GRPL by scenarios
Source: author's calculations.

The following is an analysis of the total replacement rate for a person's last salary (here the analysis uses the average salary of a person's entire working life instead of the last salary), using the gross replacement rate (GRR) indicator.

In all scenarios, substitution rates will fall until the beginning of the 2060s (see Figure 71). While the replacement rate is around 68% in 2016 in the base scenario and the insurance scenario, by 2060 it will fall to 33%. It must be borne in mind that the decline in the early years is not just due to the effect of the scenarios, but also to a lack of data, because given all lifetime wages, wages have been known since 1999 and previous wages have not been known. Since in the early years there are cohorts whose career tops remain much earlier than in 1999, the GRR is overvalued. Therefore, the differences between the scenarios need to be considered.

In general, the GRR indicator levels are higher than the GRPL indicator levels, and when the GRPL started to increase the replacement rate in all scenarios at the beginning of the 2060s, then this no longer applies to the GRR. Until the fifth scenario (from base scenario to service component again scenario), the value of the GRR indicator falls or stabilises. The change will result in linking the SPA to life expectancy, which will increase the GRR. By 2062, the lowest point of the GRR will be reached, with similar replacement rates for the last three scenarios (from life expectancy to no funded scheme from the 2022 scenario). The replacement rate will be higher by 2.4 percentage points with the second pillar scenarios by 2100 compared to the scenario with no funded scheme.

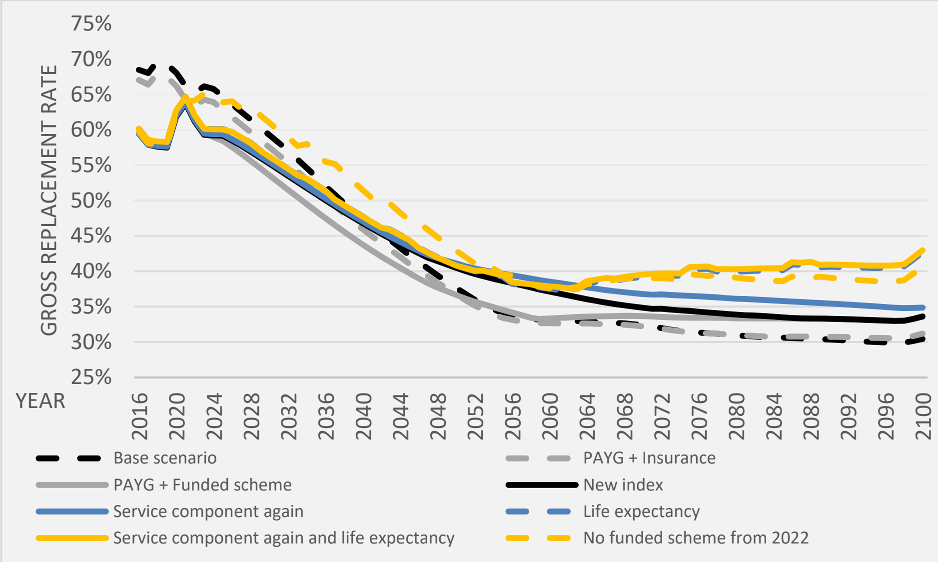

Figure 71. All retirees' GRR for all pillars by scenarios
Source: author's calculations.

The inequalities in total pensions vary quite differently in the scenarios (see Figure 72). In the baseline scenario, the difference in pensions is the smallest, because there is only the first pillar, which is not related to wages but only to employment. As the situation in the labour market has changed and continues to be diverse, the inequality of pensions in the base scenario also increases slightly. Then it starts to fall because the distribution of surpluses reduces the difference in pensions.

Linking the rights of the first pillar with wages would double the inequalities by 2100 (Gini coefficient 0.054 versus 0.103). Of course, it must be taken into account that the value of the Gini coefficient at 0.054 is very low. Introducing the second pillar increases the Gini coefficient to the highest level in comparison to scenarios in the early 2050s (0.198). In a scenario with a new index, inequality decreases compared to the previous scenario until the 2070s, because the pension of the first pillar will increase faster due to the change in the pension index. In a scenario with a new index, the inequality coefficient is higher than in the previous scenario in 2100, as in this scenario the surplus will only occur in the late 2080s, but in the scenario of introducing the second pillar, it occurs 30 years earlier.

The partial return of the service component will gradually reduce the Gini coefficient. For the year 2100, the Gini coefficient is reduced by 10% to 0.15. Linking the SPA to life expectancy increases the inequality in the period 2040–2060 and afterwards reduces it, and by 2100 it is similar to the new index scenario. Assembling the two components (service component and linking SPA to life expectancy) will lead to a slight increase in inequalities over the period 2040–2060 and will reduce it further thereafter. Abolishing the second pillar will significantly reduce inequality, already from 2022. Inequality decreases for two reasons: 1) the funded pension which is linked to the wages disappears, and 2) the surplus of the first pillar is distributed equally among all retirees.

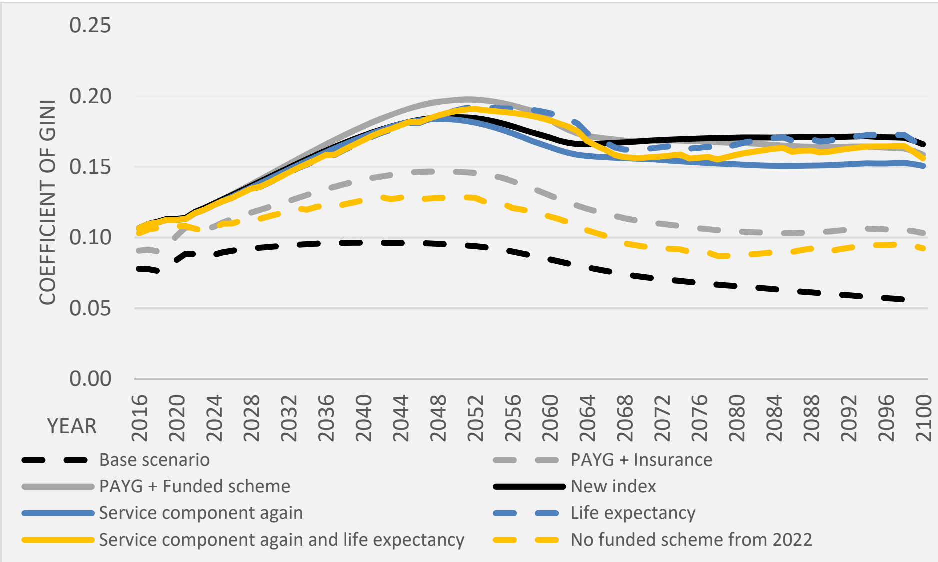

Figure 72. All retirees' Gini coefficient by scenarios for all pillars
Source: author's calculations.

The base scenario has understandably the lowest Gini coefficient because the amount of pension is not dependent on wages in this scenario (see Figure 73). Inequality still increases because the employment still varies. The inequality is lower from 2066 than 50 years earlier and will be 31% lower in 2100 compared to 2016 (from 0.078 to 0.054). The introduction of the insurance component will greatly increase the inequality in the first pillar. The introduction of the second pillar should not increase inequality in the first pillar, rather it should decrease it a little bit because people do not earn so many entitlements from the first pillar. In fact, the introduction of the second pillar increases inequalities, because part of the money is directed to the funded scheme and therefore there will be a surplus in the later years of the first pillar. The Gini coefficient increases by 45% by 2050 since the baseline value of the coefficient is low (0.1) in the funded scheme scenario. Surprisingly, the Gini coefficient will fall similar level in 2100 as would have been in 2016 with the base scenario.

In the new index scenario, inequality will be lower until 2065 compared to the introduction of the funded scheme scenario. From 2066 onwards, the inequality of the first pillar of the new index scenario will be the largest in the scenario comparison. At the same time, by 2100, the Gini coefficient will be lower than in 2016 (a decrease of 7.4%).

The bringing partially back service component will gradually reduce the inequality of the first pillar, and by 2066 the level of inequality will be lower than in 2016. By 2100, the level of inequality in the first pillar will be the same as it would have been in the base scenario in 2016. The same appears with the life expectancy scenario but first the inequality would be similar as in the new index scenario but starts to decrease from the middle of the 2060s. Combining the two previous scenarios, inequality will be 39% lower by 2100 (Gini coefficient 0.066) than in 2016 (0.102).

The abolition of the second pillar will reduce the inequality of the first pillar pension, as there will be a surplus in the first pillar, which will be shared among all retirees equally. However, the inequality of the first pillar is higher than in the base scenario and quite similar to that in the previous scenario by 2100 (0.062 with no funded scheme).

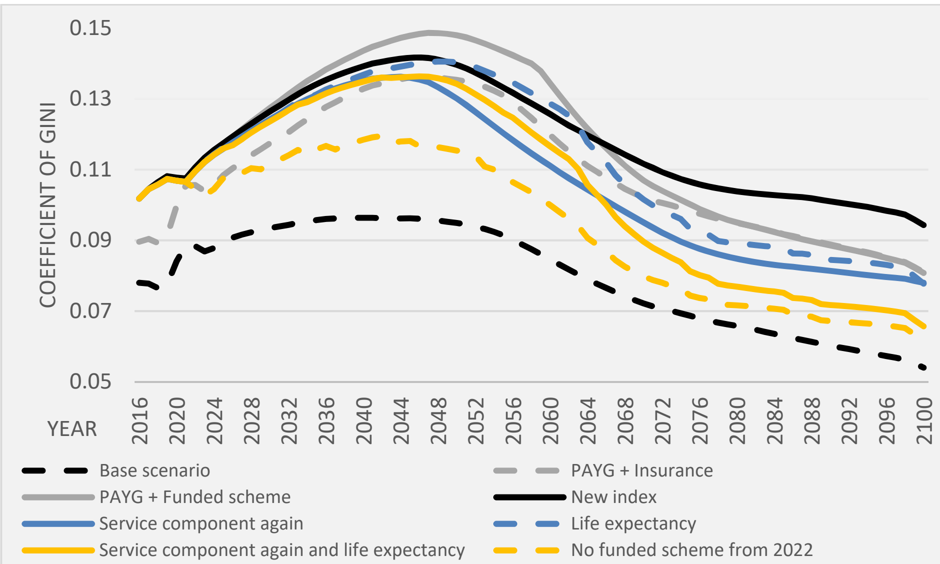

Figure 73. All retirees' Gini coefficient by scenarios in the first pillar
Source: author's calculations.

The inequality in the second and third pillars in the scenario view is quite similar (see Figure 74). Rather, in both cases, the inequality with a higher SPA is smaller. While the Gini coefficient of the second pillar was 0.514 in 2016, it would fall to 0.32 by 2100 which is similar to the level of simulated wages.

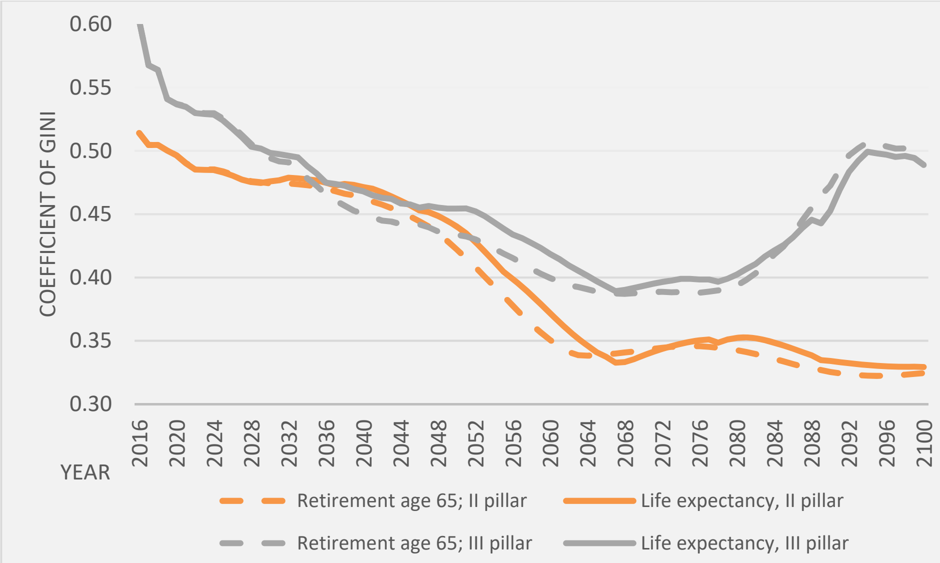

Figure 74. All retirees' Gini coefficient by scenarios in the second and third pillars
Source: author's calculations.

One factor is the inequality of nominal pensions or GRPL (replacement rate to national average wages), which does not take into account people's financial contributions. The Gini coefficient calculated on the GRR indicator can be used to express this. The scenarios are better compared based on inequality, then all scenarios are compared in two perspectives in 2100 (see Figure 75).

The base scenario is most left (lowest inequality of GRPL) and almost most up (greatest inequality of GRR). The insurance component increases the wage component and therefore the Gini coefficient of GRR decreases (from 0.146 to 0.121), but the inequality of GRPL increases (from 0.054 to 0.103). The introduction of a funded scheme would lower the inequality of GRR to 0.113 and increase the inequality of GRPL even more to 0.159. There are no major movements in the new index scenario by 2100 compared to the funded scheme scenario (coordinates 0.166 and 0.113). The partial return of the service component and linking the SPA with the life expectancy increase GRR inequalities (from 0.113 to 0.139) but reduce the Gini coefficient of GRPL (from 0.166 to 0.156). Abolishing the funded scheme will greatly reduce GRPL inequalities (from 0.156 to 0.092) but will increase the Gini coefficient of GRR (from 0.139 to 0.160). The difference between the two indicators is the smallest in 2100 in the scenario where the service component is again introduced and SPA is linked to life expectancy (a difference of 0.017).

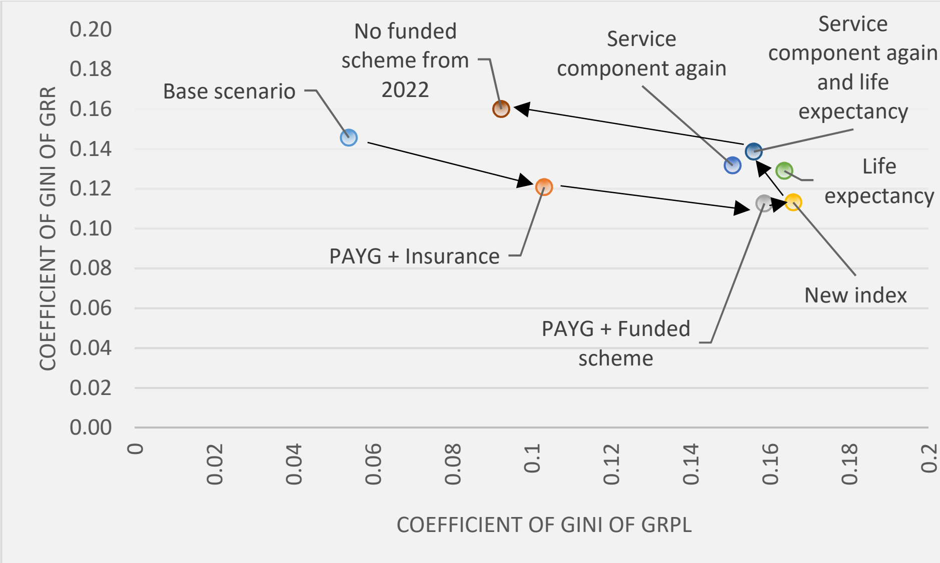

Figure 75. All retirees' Gini coefficient by scenarios of total pension in 2100
Source: author's calculations.

4.2.3. Sensitivity analysis

The sensitivity analysis looks at the validity of the results based on other assumptions as well. It must be borne in mind that this is a microsimulation model that does not itself simulate macroeconomic changes or changes in the macroeconomic situation due to population changes. Chosen changes for the sensitivity, may also lead to second or third-round effects, but they have not been taken into account. Three important factors have been changed in the sensitivity analysis:

1) Population – although migration has been taken into account in the base, migration is excluded in the sensitivity analysis. Thus, after such a long period, there are also second or third-generation effects, which means that the children and grandchildren of the immigrants will be out of the population. Migration in itself affects costs, but also revenues. To assess the impact of revenues, the number of people who migrated and their descendants by age has been found every year in the scenario bases. The number of people is then multiplied by the age-based employment rate. This leads to a decline in the revenue side. Certainly, population decline also has second and subsequent effects, but this would require a different model, which is not the aim of this dissertation. Only the first pillar pension is compared here because the second and third pillar pensions are individual and do not depend on the population.
2) Economic growth. Two extremes are expected here compared to the MoF's long-term macroeconomic forecast. The first extreme is zero real GDP growth. The second extreme is that real GDP is growing at double the speed compared to what is in the original prognosis. In both cases,

real GDP will change from 2022. Only the first pillar pension is compared here because the growth of the local economy largely affects the first pillar pension. The second pillar pension would also have a minor impact, but the link between the growth of the Estonian economy and the funded pensions cannot be assessed with this model.

3) Yield. While the base scenario simulates future returns based on historical returns, two extremes have been used in the sensitivity analysis. First, the yield of each simulated pension fund has been reduced by two percentage points and the second extreme has been increased by two percentage points. In addition, the annuity interest rate has been reduced and increased by two percentage points (one per cent and five per cent respectively). The second and third pillar pensions are compared here, as the first pillar pension does not depend on the yield.

Each sensitivity has been analysed separately. First, the results with migration (base) are compared with the non-migration population (abbreviation S1). The effect of zero real GDP growth (abbreviation S2) and then double of the base scenario real GDP growth (abbreviation S3) is then analysed. Finally, the comparison of two percentage points lower (abbreviation S4) and two percentage points higher (abbreviation S5) yields and interest of the second pillar and the third pillar is analysed.

The scenarios with no second pillar (base scenario, PAYG + insurance and no funded scheme from 2022) are the fastest to respond to migration deficiency, as these scenarios had the earliest surplus of the first pillar (see Figure 76). As there will be a smaller working population (including retirees) in the future, there will be less money left to be distributed in the first pillar. This also affects scenarios with the second pillar but to a lesser extent. In 2100, the biggest drop in the first pillar is in the eighth scenario (no funded scheme from 2022) – the first pillar pension is €2,000, or 22% lower. From the 2060s onwards, future pensions in the scenarios where SPA is linked to life expectancy will also be significantly lower than in the base scenario, as the majority of the population will be employed and the impact will be greater if people with a migrant background are “taken away”. By 2100, the nominal pension in these scenarios is €1,600, or 22% lower than in the base.

As the lack of migration has the greatest impact on the first pillar pension in the no funded scheme from 2022 scenario, the total pension will not become higher in any year than in the previous scenario (seven) – service component again and life expectancy.

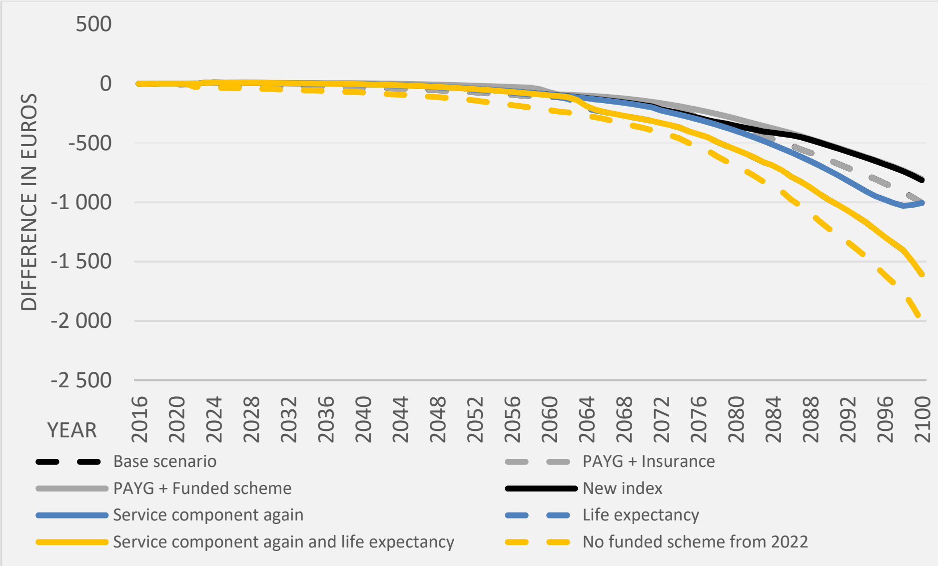

Figure 76. Sensitivity 1. All retirees' nominal pension difference in euros (S1 minus base results) by scenarios of the first pillar pension
Source: author's calculations.

The slower growth in the economy has the least impact on scenarios where there will be no surplus in the first pillar or a smaller one (see Figure 77). For example, PAYG + funded scheme, or new index, or service component again. However, even in these scenarios, by the 2100s, the first pillar pension will be 61–63% lower than in the base. In nominal euros, the biggest difference in the scenarios is in the scenario "no funded scheme from 2022" and over the whole simulated period. In 2050, the first pillar pension will be 36% lower (€660 per month) and 70% lower (€6,350 per month) by 2100. In addition, in scenarios related to life expectancy, the reduction in the first pillar pension for 2100 is 70% (€5,100) lower compared to the base.

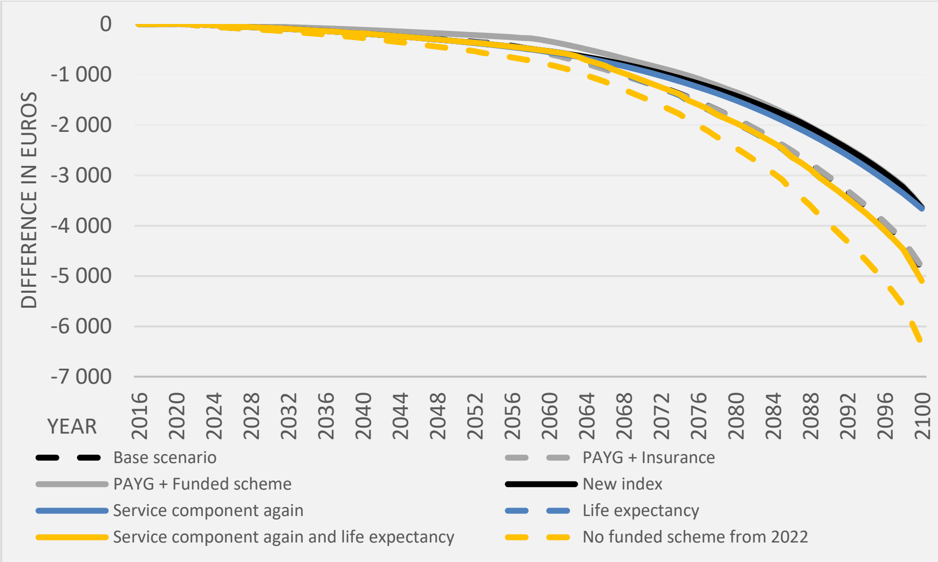

Figure 77. Sensitivity 2. All retirees' nominal pension difference in euros (S2 minus base results) by scenarios of the first pillar pension
Source: author's calculations.

Comparing sensitivity analysis number three to sensitivity two, the scenario where there is no second pillar since 2022 is most affected (see Figure 78). By 2050, the first pillar pension will be 57% higher compared to the base scenario. Similar results are found in scenarios one and two (there is no second pillar). By 2100, the first pillar pension in scenario eight will be 228% higher (€20,800 per month). In percentage terms, the difference is similar in all scenarios (growth by 2100 is between 217% and 228%). In terms of euros, changes in scenarios are divided into three groups: 1) life expectancy related to retirement age and no second pillar – an increase of €20,800; 2) the second pillar is, and the life expectancy is related to the retirement age, or there is no second pillar and the retirement age is 65 – an increase of €16,500 per month; 3) the second pillar and the retirement age of 65 – an increase of €13,000 per month.

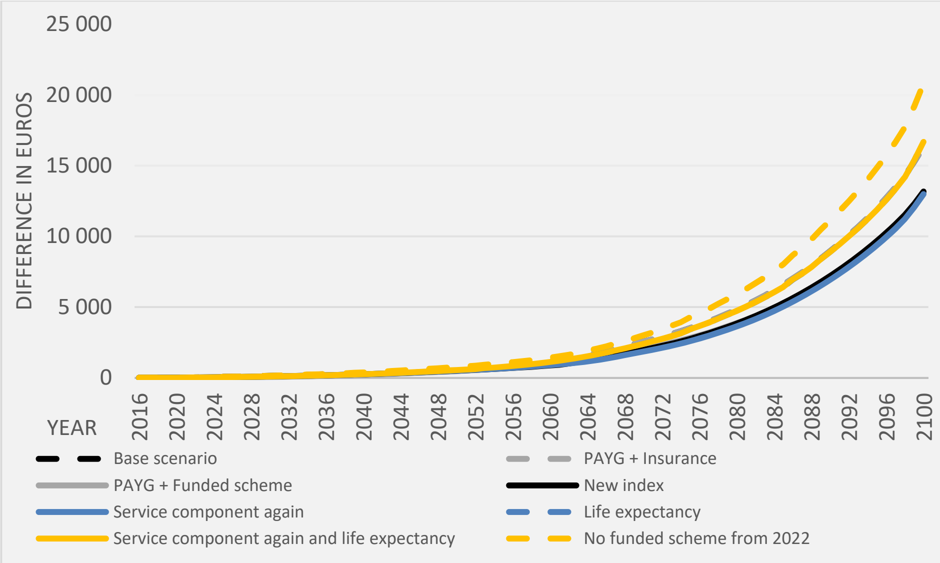

Figure 78. Sensitivity 3. All retirees' nominal pension difference in euros (S3 minus base results) by scenarios of the first pillar pension
Source: author's calculations.

The effects of declining and rising yields and interest rates on the second and third pillar pensions are analysed below. There are only two scenarios in the comparison – the retirement age of 65 and the retirement age related to life expectancy – because in other cases the pension is the same as in the comparative scenarios.

Although in the first twenty years the second pillar pension with a lower return and retirement age of 65 decreases more (both in euros and as a percentage) than in the life expectancy-related retirement age scenario, from the 2050s it will be the other way around (see Figure 79). By 2100, the second pillar pension is 53% lower (€1,530 per month) in the life expectancy scenario and 50% lower (€1,150 per month) with the retirement age of 65.

The two percentage points increase in yields and interest rates are in line with the same logic – until the 2050s, the difference is higher (in percentages and euros) with the retirement age of 65, but vice versa in the following years. By 2052 the difference between the two scenarios will be the same – the second pillar pension will be €237 higher, or 70% more than the base. By 2100, in the scenario with a retirement age of 65, the second pillar pension is 104% (€2,380 per month) higher than in the base. At the same time, in the life expectancy scenario, second pillar pensions are 118% (€3,430 per month) higher than in the base period.

The results of the third pillar are similar to the second pillar, and since the third pillar pension does not play a major role in the total pension, the differences of the third pillar are not compared.

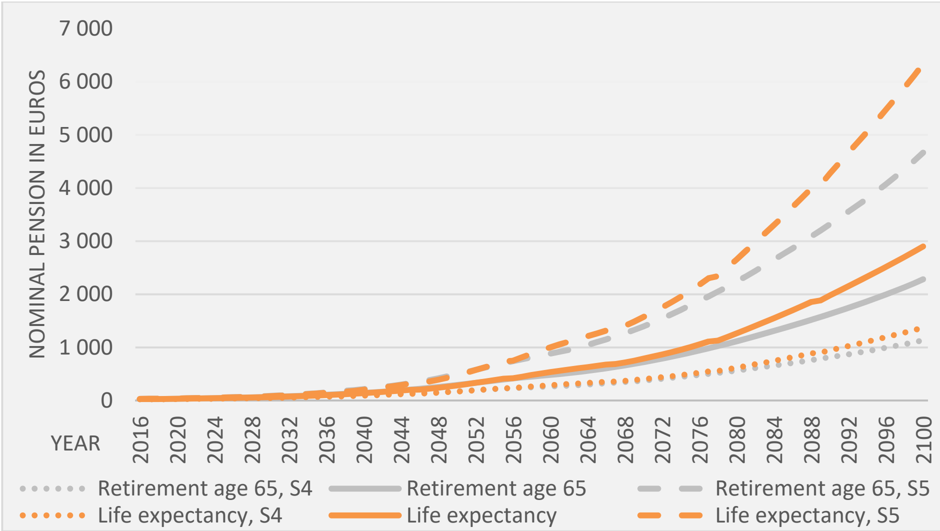

Figure 79. Sensitivity 4 and 5. All retirees' nominal pension in euros (S4 or S5 minus base results) by scenarios of the second pillar pension
Source: author's calculations.

In summary, the scenario where there is no second pillar since 2022 is significantly affected by the sensitivity analysis of the first pillar pension, as a large part of future pensions depends on the first pillar and the retirement age is related to life expectancy. In other words, the majority of the population is also linked to employment. To a lesser extent, the results are affected in scenarios where there is no second pillar or there is a second pillar, but the retirement age is related to life expectancy. Changes in migration and real GDP growth have the least impact in the scenarios with a second pillar and a retirement age of 65.

As the retirement age related to life expectancy "postpones" the pension, the effect of reducing or increasing yields in the period 2016–2050 with a retirement age of 65 will also be greater, but in the future the opposite.

The Gini coefficient of the total pension is examined below. For this purpose, the Gini coefficient value of the sensitivity analysis is subtracted from the result of the same scenario in the base.

The inequality of the total pension in all scenarios will be reduced almost every year without migration until the 2060s. The exception is the scenario no funded scheme from 2022, in which the Gini coefficient increases in the period 2022–2029 (see Figure 80). The increase is due to a lower increase in the first pillar pension than in the base. Scenarios with a second pillar will have a larger decline in Gini coefficient until the 2060s than scenarios without a second pillar. In the period 2060–2100, the decline in the Gini is lower in the second pillar scenarios, as the first pillar redistributed surplus will be reduced in these scenarios. Inequality will be higher in scenarios with SPA linked to life expectancy and with second pillar in 2100.

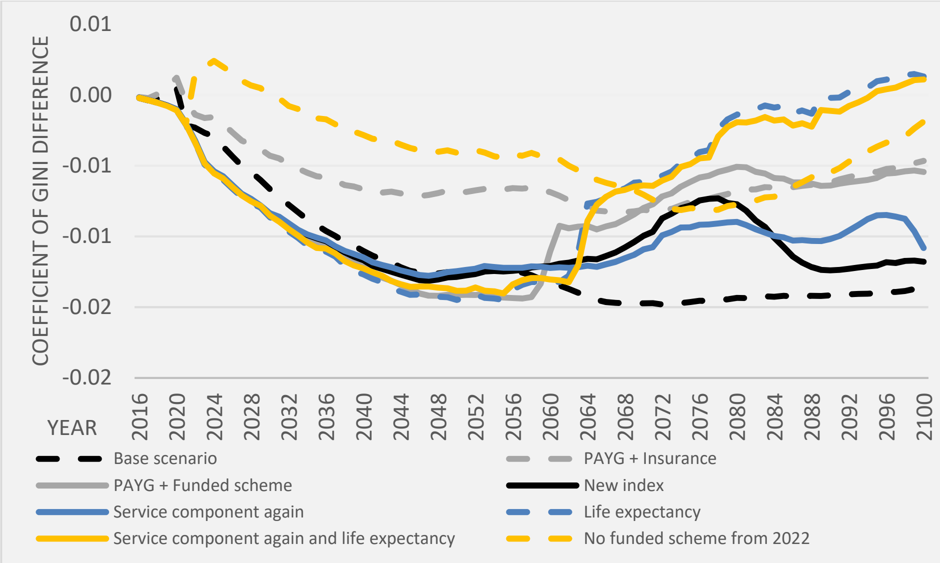

Figure 80. Sensitivity 1. All retirees' Gini coefficient difference (S1 minus base results) by scenarios of the total pension
Source: author's calculations.

Zero real GDP growth increases inequality in each scenario (see Figure 81). Initially, inequality increases the most in scenarios without a second pillar (base scenario, PAYG + insurance, no funded scheme from 2022). As the growth of the economy is slower, there will be no first pillar surplus in these scenarios, except in the no funded scheme from 2022 scenario, where a surplus will occur, but significantly lower than in the base period. In scenarios with a second pillar and a retirement age linked to life expectancy, inequality will increase the most in the 2070s and 2080s, as the first pillar will not yet have a surplus compared to the base period, but will start to do so from the 2090s.

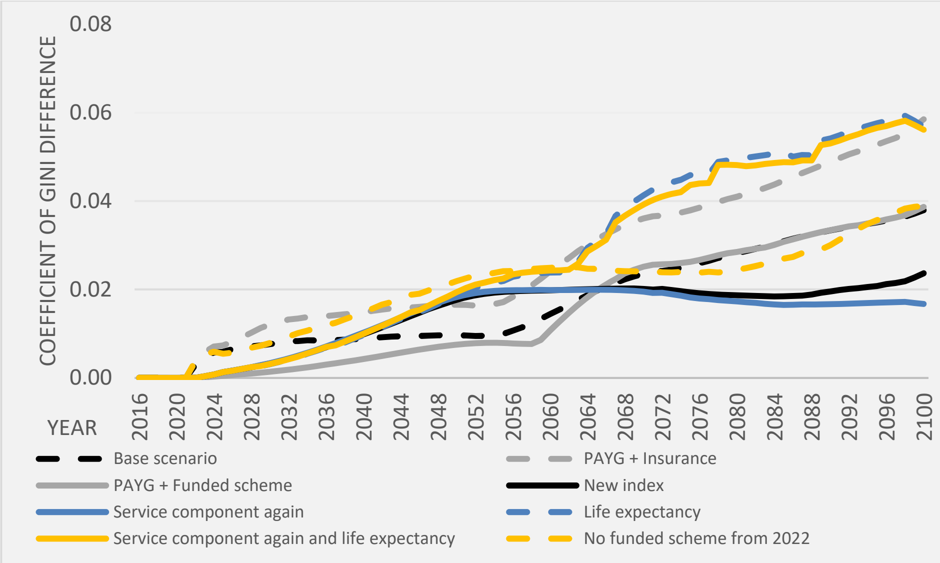

Figure 81. Sensitivity 2. All retirees' Gini coefficient difference (S2 minus base results) by scenarios of the total pension
Source: author's calculations.

Double growth in real GDP compared to the base, reduces inequality in every scenario (see Figure 82). In absolute values, the Gini coefficient decreases most in the PAYG + funded scheme scenario and the SPA related to life expectancy scenarios. In percentage terms, in these scenarios, the reduction is among the averages – 28–30% by 2100. The Gini coefficient decreases most in percentage terms (39–45%) but less in absolute terms in scenarios where there is no second pillar and SPA is 65, because the starting level is already quite low and most of the pension depends on the first pillar.

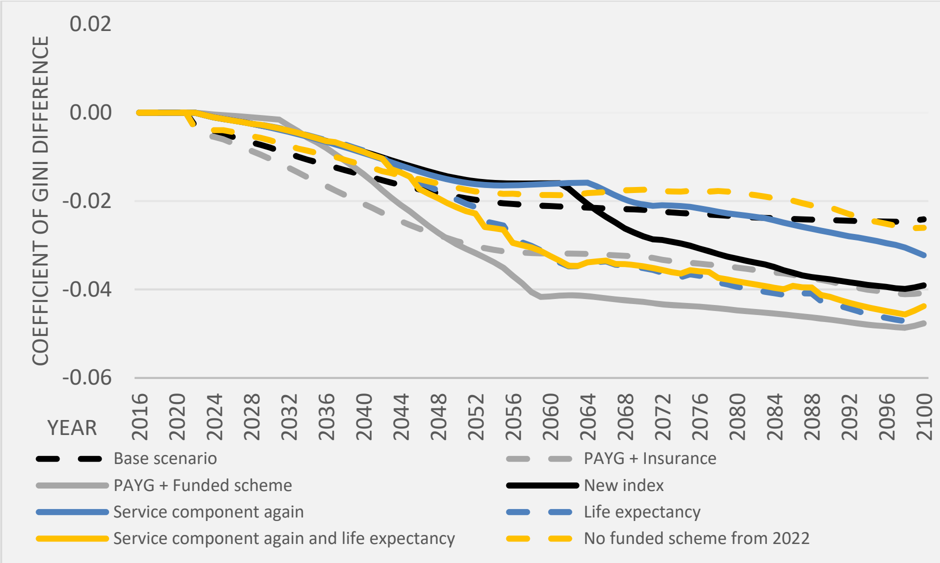

Figure 82. Sensitivity 3. All retirees' Gini coefficient difference (S3 minus base results) by scenarios of the total pension
Source: author's calculations.

Lower yields and annuity interest in the second and third pillars reduce inequality, except in the baseline scenario, where there is only the first pillar (see Figure 83). In scenarios where there is no second pillar, inequality is gradually reduced through the third pillar. In systems with the second pillar, the decrease in inequality is of a similar magnitude, but the difference occurs in the 2050s, when the inequality decreases more (26–30% by 2100) in the scenario SPA related to life expectancy. Lower yields have a similar effect on inequality as a double increase in real GDP compared to the base in the scenario with the service component again and life expectancy.

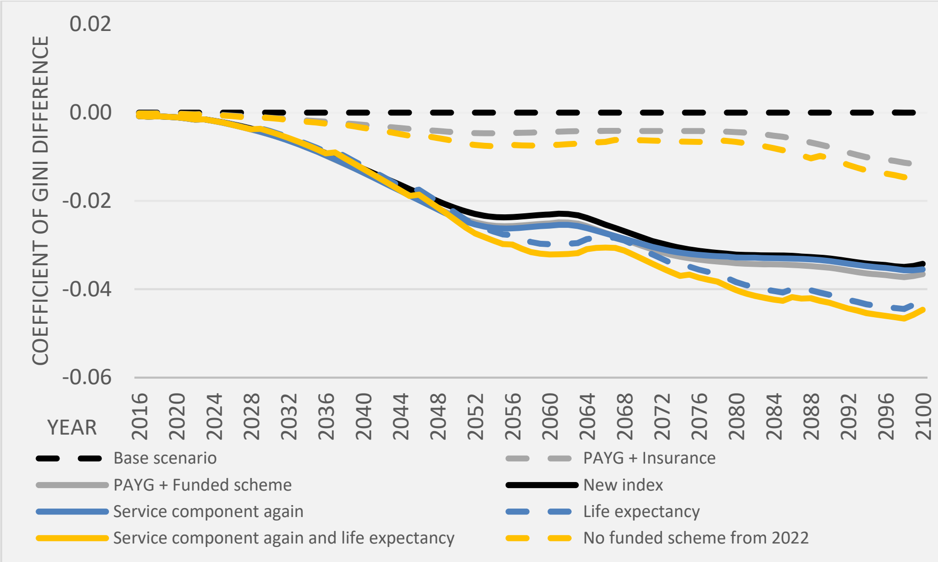

Figure 83. Sensitivity 4. All retirees' Gini coefficient difference (S4 minus base results) by scenarios of the total pension
Source: author's calculations.

A two percentage point increase in second and third pillar yields and interest increases inequality in each scenario (see Figure 84). In scenarios where there is no second pillar, there is a slight increase in inequalities through the third pillar. There will be more inequalities in scenarios with the second pillar and even more in scenarios with a higher SPA. As inequalities will increase more in higher SPA scenarios, the Gini coefficient for the total pension by 2100 will be the highest.

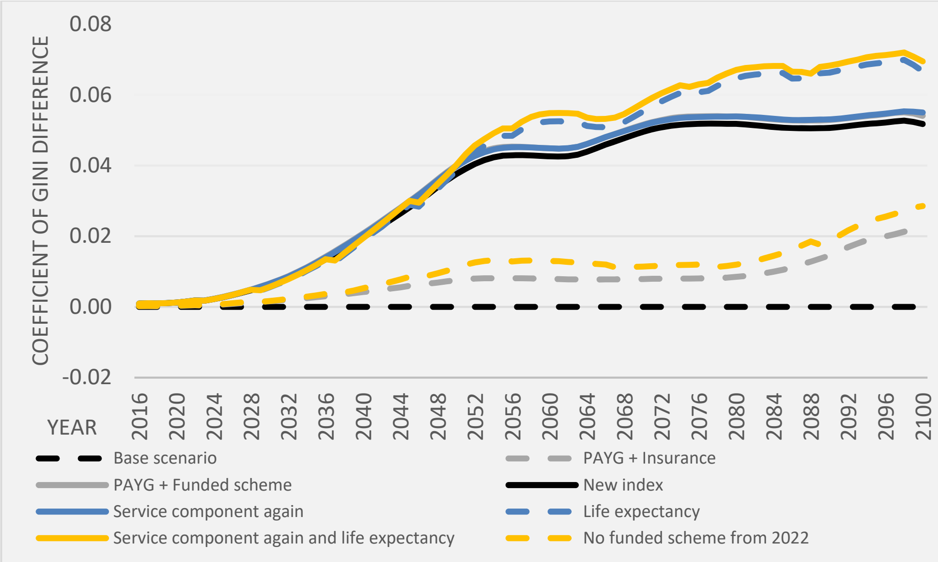

Figure 84. Sensitivity 5. All retirees' Gini coefficient difference (S5 minus base results) by scenarios of the total pension
Source: author's calculations.

While the decline in GDP growth has increased inequality, on the contrary, lower yields and interest rates in the second and third pillars reduce inequality. The reason lies in the fact that a lower GDP reduces the surplus of the first pillar and therefore the base share, which is equal for all, cannot be increased. At the same time, lower yields and especially interest rates do not allow differences to increase.

In summary, the sensitivity analysis suggests that scenarios with fewer pillars are more dependent on changes in one factor, such as the scenario where no funded scheme from 2022 is highly dependent on migration and growth. At the same time, the second pillar scenarios depend on both growth and yield, but the inequality between them is reversed (the faster growth reduces inequality through a larger first pillar surplus, while higher returns increase the second pillar share of the total pension as well as overall inequality), and thus the overall effect of the simultaneous change in the two factors can have similar repercussions in the direction of the response.

4.3. Discussion

This section discusses the chapter 4 results, reflecting upon the meaning and providing policy feedback on these results. In addition, at the end of this sub-chapter, there will be a discussion on possible shortcomings of the model and in which direction these could affect the results.

In 2016, compared to the rest of Europe the Estonian gross total disposable income inequality between people aged 65+ (based on the S80/S20 indicator) was one of the lowest (only the Czech Republic was lower) (Eurostat 2021h). In the scenario where the 2020 pension regulation is maintained, the aggregate inequality of pensions in the pillars by Gini coefficient would increase until the middle of the 21st century. Then the inequality decreases and stabilises. Although the increase in total pension inequality over the next 80 years seems large according to the Gini coefficient (50%), the level of inequality in 2016 according to the S80/S20 indicator is low compared to the rest of Europe (Estonia 0.78 and EU-27 3.74).

Like Estonia, pension reforms have generally increased people's own responsibility in Europe, but on the other hand, safety nets have been created (a minimum pension has been created or increased). These are mostly opposite factors in terms of inequality, although according to the best knowledge there is no long-term assessment of inequalities for all EU countries. However, estimations of the theoretical replacement rate for low-wage earners (66% of the average wage) and high-wage earners (200% of the average wage) by 2059, according to the pension adequacy report (European Commission 2021), see the gap increasing in half of the European Union countries and decreasing in the other. Unfortunately, the theoretical replacement rate does not show the size of groups of people of retirement age; this means the differences cannot be transferred to inequality, but it does provide an indication.

Across the pillars, inequalities change in the opposite direction in Estonia. The inequality of the PAYG scheme (first pillar) pension increases in the early years, but it will fall below the level at the beginning of the simulation (2016). In addition, by deciles, the PAYG scheme pension for 2100 is very similar (the difference in the replacement rate is five percentage points between the first and tenth decile). A significant contribution to reducing inequalities in the PAYG scheme pension will be the surplus of revenue in the PAYG scheme pension from the 2060s, which will help all retirees significantly increase their pensions. The surplus will be generated by the following factors: 1) smaller cohorts (born from the early 1990s) will begin to retire – fewer retirees; 2) small cohorts will move out from the workforce; 3) the SPA will be linked to the life expectancy.

In the literature (for example, Goudswaard and Caminada 2010; Bönke, *et al*. 2010), it has been argued that with a higher public pension share, inequality is lower – broadly, the same trend can be seen in Estonia, but with its own specificities. Although it is true in Estonia that the public scheme in the multi-pillar system has an important role, in the scenario where the 2020 pension regulation is maintained, the share of funded schemes is constantly growing, inequality should also grow but is still not growing. First, the inequality in the public scheme is decreasing to a very low level. Second, Estonia's mandatory (second pillar) and voluntary funded (third pillar) defined contribution schemes have several times the level of inequality than in the public scheme at the beginning. However, over the years the inequality would decrease in the mandatory and voluntary funded schemes. Thus, although the share of funded pensions is increasing from the total pension, in later years the total inequality will decrease.

Inequalities in the mandatory and voluntary funded schemes are several times higher than in the PAYG scheme pension, as there is no direct vertical redistribution mechanism in funded pensions. In the mandatory and voluntary funded schemes, inequality for newly retired recipients is much lower than for all funded pension recipients – first, the difference is due to the accumulation period (older cohorts had a shorter accumulation period), but the difference will continue to be greater, and it is due to the annuity – it is not indexed in contrast to the PAYG scheme pension. Therefore, those who have been retired for 10 years have a much lower funded pension than those who have just retired. Thus, the funded scheme payment system would need to be significantly improved to take account of rising prices, while ensuring a lifetime pension through the funded scheme or even in combination with the PAYG scheme pension.

Although the inequality of pensions among men continues to be greater than the inequality among women, the difference is beginning to decrease, especially in the PAYG scheme pension. This means that the level of inequality found with the value of the Gini coefficient among men or only among women will be similar in the future. This can be caused by a simulated wage inequality, even though, historically, the men's wage inequality has been greater. Compared to Europe, Estonia had the smallest pension gap for people aged 65-79 in 2019 (European Commission 2021). It is important to note that the PAYG scheme pension will be higher for women by 2059 than for men, according to the simulation. One of the reasons for this is the granting of children's pension rights to women, based on practice. The total pension for women will be higher until 2047, but then the difference will continue to grow (in favour of men). By 2100, women's total pension will be 16% lower than men's.

Scenarios show that intergenerational inequality changes over time because the replacement rates for all retirees to national average wage (GRPL) are moving in a U-shaped form (the lowest point, depending on the scenario, is between 7 to 12 percentage points lower than in 2021). At the same time, the PAYG scheme pension has stability in certain scenarios from the 2060s, but in these scenarios the evolution of the replacement rates is L-shaped (15 to 17 percentage points lower than in 2021). A similar trend is observed in the mandatory and voluntary funded schemes if the retirement age remains at 65. If the SPA is related to life expectancy, the replacement rate increases over time as each generation accumulates over a longer period of time.

If the replacement rate is taken from the average wage of a person's lifetime (GRR), the replacement rate for all retirees will remain relatively stable from the 2050s. To target intergenerational inequality, each generation should receive a similar degree of substitution rate. The latest reforms have turned the L-shaped line into a U-shape (3 to 5 percentage points higher replacement rate in 2100 if at the lowest point), as the pension system has been made more sustainable (SPA is linked to life expectancy) and in the model, the PAYG scheme pension surplus is divided equally among all retirees.

To reduce intergenerational inequalities, generations who retire between 2030 and 2080 and those who retire just in 2050 should be addressed, as they are at the lower point of the U-shaped replacement rate. This is similar to Spain (Catalán *et al*. 2010), where “middle” cohorts also suffered the most from the reforms. From 2051, cohorts that have joined the mandatory funded scheme from the beginning of their work career will retire, and this has helped to increase their replacement rate compared to previous cohorts. Compared to all retirees, by 2050 the mandatory funded scheme effect will not be strong enough to offset the slow growth of the PAYG scheme pension. The PAYG scheme pension is growing slowly compared to wage growth because wage growth is faster than the growth of the workforce and therefore the pension index. As the total number of retirees starts to decrease from the 2060s, there will be a surplus in the PAYG scheme pension scheme, which will help later cohorts to increase their PAYG scheme pensions. To reduce inequalities between cohorts, exceptional pension increases can be used, but this requires long-term consideration. It would also be possible to get the PAYG scheme and the funded scheme pension to work better together so that they would benefit people as much as possible during each year of retirement.

The evolution of the Gini coefficient of retired people is an upside-down U-shaped figure – some degree (0.02 to 0.09 points) of inequality will increase until the end of the 2040s in all scenarios, then in some scenarios inequality will fall until 2100 (from 0.01 to 0.03 compared to 2060s), and in others will fall until the 2060s and then stabilise. The inequality of the PAYG scheme pension has a similar line – it will grow until the end of the 2040s (0.02 to 0.05 points) and then start to fall. In all scenarios, the inequality of the PAYG scheme pension will fall below the level at the start of the simulation (2016) (0.01 to 0.04 points lower). Recent reforms have further reduced inequalities in the PAYG scheme pension and have an almost similar inequality as would have been in the pension system which was before 1999.

As described above, the inequality of the PAYG scheme pension will increase in the coming years, but in the long-term, inequality will decrease – this will be achieved by distributing the surplus of the PAYG scheme pension (linking the SPA to the life expectancy helps to achieve the surplus), by indexing the base part more rapidly and by creating a solidarity part. The Estonian pension system is heading towards the Beveridgian non-means-tested model because the flat-rate base part importance is increasing – so Estonia is heading towards vertical justice and moving away from horizontal justice, but the funding is still Bismarckian – social tax is earmarked and connected directly to the person. On the benefit side, the elements of the Bismarckian system are still the point system in the public pension and the funded schemes.

As described in the previous paragraph, the surplus of the PAYG scheme pension can be reached by linking the SPA to life expectancy. At the beginning of the 2000s, a mandatory funded scheme was created to change the paradigm – people's own responsibility for their future pension must increase. At the same time, one of the objectives was to improve the financial sustainability of the future pension system. This objective will be significantly enhanced by linking the SPA to life expectancy. The sharing of responsibility between the PAYG scheme and the individual depends to a large extent on the prevailing political sentiment. At the same time, it must be borne in mind that increasing people's responsibility requires much more time than vice versa. A good example of this is the mandatory funded pension, which takes decades from its creation to full functionality.

If the objective is to maintain a similarly low level of pension inequalities, one option would be to continue with the extraordinary increases of the base part in recent years (2020 and 2021). Those increases have reduced the inequalities in pensions.

As the doctoral thesis does not have an exact scenario corresponding to the pension system where the mandatory funded scheme is made voluntary from 2021 (it would require a separate analysis with several scenarios and more recent and more accurate data), the possible inequality from the PAYG scheme pension can be between the seventh and eighth scenario – it greatly depends on who withdraws their funded scheme pension.

Although there will be financial resources left in the pension system that can be distributed among retirees, in general, in a country with an ageing population, social protection costs are rising. Both health care and long-term care need additional costs, as more and more older people are consuming these services. Even though there will be monetary resources left in the PAYG scheme pension, this does not mean that the well-being of retirees will be guaranteed. It is also important to note that as pension replacement rates are rather low, PAYG scheme pension inequality is low and other sectors also need extra resources, it is difficult to differentiate PAYG scheme pension pensions in such a situation. Rather, the direction is to distribute lower costs evenly so that everyone has a minimum income. If pension costs were higher, the pension of the PAYG scheme pension would also be more differentiated, with the result that there would also be a higher inequality.

The dissertation has assessed the common indicator of distribution and poverty – at-risk-of-poverty. According to this, the number of retirees in at-risk-of-poverty will increase, i.e. the relative incomes of retirees will remain lower and lower until the 2050s compared to the working-age population. Thus, the bigger question is where to find extra financial resources so that retirees would not be at-risk-of-poverty. Although absolute poverty depends on an estimated minimum subsistence level, which reflects the cost of meeting minimum needs, according to the model retirees will be in absolute poverty from 2020.

With the PAYG scheme pension, there may be several further solutions in terms of inequality – either to change nothing to move gradually towards lower inequality or gradually turn the PAYG scheme pension into an equal basic pension for all. However, if there is a desire in society to move towards greater wage differentiation in the PAYG scheme pension, as the mandatory funded scheme no longer has such a role as before, one possibility is to split the PAYG scheme pension into two: first tier (according to the OECD), which is the current equal part, and public part of the second tier related to wages and/or other important factors (children, unemployment, etc.). As the PAYG scheme pension is not financially undermined in the long-term then it possible to unbundle the PAYG scheme pension rights from contributions of the mandatory funded pension scheme. Thus, the PAYG scheme pension and the collection pension would not compete for the same contributions. Such a solution still requires additional financial resources from the government budget to supplement the contributions to the mandatory funded scheme.

Reducing the importance of wages in the PAYG scheme pension and making the compulsory funded scheme voluntary has significantly reduced the link between wages and future pensions, and this, in turn, could create the problem of free-riding, because the PAYG scheme is sending out a message that everyone at retirement age is protected in the same way, and it does not matter how anyone has contributed during their working life. Both extremes (in the second extreme, the entire pension is closely linked to the contribution of working life) are likely not to be functioning in society – it is necessary for society to find an appropriate solution, which changes in time.

In Estonia, it has previously been argued that a mandatory funded pension adds unnecessary risks (for example, investment risk), but the sensitivity analysis showed that in scenarios where only one pillar played a single or very important role, the total future pension was highly dependent on one factor. However, scenarios where future pensions depend on several pillars also depend on more factors, but the impact of these factors may be counterbalanced to inequality. The faster economic growth reduces inequality through a large PAYG scheme pension surplus, while higher yields increase the mandatory funded scheme share of the total pension as well as average inequality. It is therefore worth diversifying the dependence of future pensions on different pillars because they behave differently with different shocks and can balance the effects. Since not all changes have been assessed in the doctoral thesis, there is a chance that there will also be a cumulation of risks and that the effects will be different in terms of replacement rate and inequality. For example, unemployment is increasing in Estonia and, at the same time, funded pension yields are low – they would reduce pensions, but inequality may not change.

As the possible future surplus of the PAYG scheme pension will play an important role in the further development of inequality, the different generations of society will have opposite motivations – the older generation would benefit from the abolition of the mandatory funded scheme and divide social tax (20%) revenues into their pensions in the future, but for the younger and future generation have beneficial to accumulate in the mandatory funded scheme to increase their future pension. The policy dilemma is how to meet the expectations of different generations so that in the end all generations receive a similar amount of replacement rate.

As each model has its own assumptions and shortcomings, so do the models used in the doctoral thesis. The typical agent model is based on fixed life courses of fictitious individuals, addressing the longitudinal evolution of benefit rates. However, the model does not account for possible transitions from one agent status to another. For these reasons, the typical agent model remains an idealistic approach, while the real life is more diverse. The microsimulation model tries to correct this shortcoming.

There are several aspects of the microsimulation model that can affect the results – they can be divided into three groups: 1) Assumptions. First, the maximum age is limited to 100 to ensure optimal calculation capacity and model clarity. This assumption may prove more problematic as time progresses, as more and more people live to be over 100 years old. Due to this assumption, the model slightly underestimates pension costs. Secondly, the model does not assume that the assets of the mandatory funded scheme will be transferred to the spouse or children in cases where a person dies before the retirement age or there is still time until the end of the guaranteed payment period. This assumption underestimates the future mandatory funded scheme pension, especially for women, because women live longer and are younger than their husbands (the model assumption).

2) Data. The macroeconomic forecast is based on the MoF's long-term forecast, which uses its own assumptions as an input. No macroeconomic model has been developed in this thesis and thus not all changes affecting the macroeconomy are reflected in the macroeconomics. For example, the SPA – the macroeconomic forecast takes into account that the SPA is linked to the life expectancy, whereas in scenarios one to five the SPA is 65 and thus these scenarios overestimate the pension of the PAYG scheme pension and thus the future pension if there is a surplus in the PAYG scheme pension.

3) Simulation. As the model does not take into account the country's minimum wage in predicting future wages, which leads to a two-tier distribution of wages, but instead uses a normal distribution of wages, the overall wage inequality is lower than it has been in the past. This is likely to reduce the inequality of pensions in all pillars. On the other hand, the inequality of the retirement pension is reduced by the simulation of yields, since each fund has used the average yield for the period 2021–2100, which reduces the dispersion of the yield of people who retire at different times, but which is due to the shortcomings of the method used.

Data from three PAYG scheme registers have been used in this doctoral thesis, but to improve the simulation, it would be good to use more background information of people, on the basis of which to differentiate work, wages and making different choices. For example, data on the education of the entire population would allow the relationship between education to be more accurately taken into account when simulating working and wages. If we want to have a broader picture of the well-being of older people, it would be necessary to assess their wealth, which in turn requires survey or register data. Although the pension is not dependent on the household composition, it would be essential to know the household income and assets to assess coping in old age.

A very important part of the pension model is the population forecast, which, in the current model, comes as a multiplier in terms of input from external forecasts. It would be good to create a population forecast for the pension model, which in turn would estimate healthy life years and through that would help to simulate to every person his/her healthy life years to better simulate working and wages. This, in turn, also needs a macro model because all three models are very closely related and depend on each other. Adding all the parts makes the whole model more complex and more difficult to maintain.

In conclusion, the microsimulation model is a tool for analysing the distribution of pensions, but if we want to validate the results with, for example, migration or changes in economic growth, then a more comprehensive picture would be given by linking the microsimulation model to the macrosimulation model. In this case, the disadvantage may be that the black box is inside the black box. Since there has not been a model in the past to assess possible inequalities in future pensions because of the need for a large number of data, it is labour-intensive and has needed a clear goal (until now, the assessment of inequalities in Estonia has not been a higher goal, because the level of pension inequality has been rather low), it has now been done and it will help to solve further issues.

CONCLUSIONS

The focus of this thesis has been on the effects of pension system reforms on the inequality of pension income. The thesis evaluates pension reforms undertaken in Estonia by using the analytical tools of microsimulation and typical agent models. The microsimulation model developed for Estonia for the current thesis is novel in the field of economic analysis of pensions in that it covers the entire population of the country and includes a multi-pillar pension system.

Reforms of pension systems are an interesting topic from many points of view. Demographic change has pushed for pension reforms. To cope with this, countries have raised the SPA and moved some of the risks previously covered by the state back to individuals. Such reforms will have different effects, including on income distribution, either increasing or decreasing inequalities in pension income.

Theoretically, pension systems may be categorised in several ways: based on financing; actuarial principle; benefit determination principle (is the contribution or benefit defined) or other. Pension systems are often divided into so-called pillars. In real pension systems, pension pillars may vary significantly between countries, but in the bigger picture, different goals are covered. All national systems differ in some respects and there is hardly a single best pension system for all countries due to demographic, socio-economic and cultural differences across countries.

The goal of the Beveridgian pension system is to prevent people from falling into poverty by using universal or means-tested pensions. For the Bismarckian pension system, the goal is to smooth consumption and to ensure benefit adequacy to replace the working-age earnings. For this purpose, earnings-related pension benefits are used. From the perspective of public financing, the system shall be sustainable, entailing a balance of long-term costs and revenues. In addition, the pension system should also consider other aspects such as the impact on the labour market and the tax burden, etc.

Pension reforms are carried out for various reasons. They may be caused by internal and external factors or a combination of them. Recently, one of the main external factors driving pension reforms has been the ageing of the population. It may be expected that future reforms are driven also by a change in the forms of work. An internal factor leading to reforms may be the excessive fragmentation of the pension system.

Although countries have moved more towards the defined contribution-based schemes, there are still many countries in the world with a DB scheme, but the issue of ageing and declining population is not so acute in these countries either. Since savings have also been suggested to cope with the population issue, in some way more than 50 countries will use a funded scheme in their pension system. Although mandatory funded pensions were created in the past, more recently, behavioural or nudging funded schemes have also been used. In these schemes, people are automatically joined to the scheme, but they have the option to opt out. In Poland, for example, the mandatory funded pension was abolished during the economic crisis, but at the end of 2018, an employer's funded pension was created, which has behavioural and nudging aspects in place. However, the creation of funded pensions is not the only way to cope with ageing – many countries have increased the SPA (including Estonia), the minimum pension or have increased the non-contributory part (including Estonia).

At the end of the 1990s, the Estonian pension system consisted of a PAYG scheme where pensions were linked to the length of service. Although the discussions on reforming the pension system started in the early 1990s, the first major step was taken in 1999, when the length of service was replaced with an insurance component, i.e. a wage-related share. At the same time, a voluntary funded scheme was also created. The compulsory funded scheme (the second pillar) was introduced in 2002 and therefore, future pension has a stronger link between earnings and future benefits. The following two major reforms are linked to the first pillar – first, the pension index was changed to be more dependent on the growth of social tax receipts and the flat-rate base part of the PAYG scheme was made to grow faster. The latest change with the PAYG scheme was made at the end of 2018, when it was decided to bring back the length of service component in 50% proportion from 2021 and link the future SPA to life expectancy at age 65 from 2027. The latter changes do not reflect in pension incomes so quickly as those who have earned the service component live long and new generations will retire later because of the increase of the SPA. From 2021 onwards, the mandatory funded scheme was transformed into a voluntary one. In the thesis, the transformation of the funded scheme was simulated as an extreme scenario where everyone who had joined quit the accumulation.

As noted, pension systems are generally designed to reduce inequalities. However, there are different ways how to conceptualise and measure inequality. In this work, inequality was operationalised in terms of monetary values of income. This is a conventional approach, but on the other hand, disregards inequalities in terms of unequal treatment. Equality was assessed based on a generational view, an assessment of inequality between cohorts and within cohorts. The assessment of intragenerational inequalities can be based on needs (vertical equality) and contribution (horizontal equality).

There are simpler and more complex indicators for assessing inequalities – each indicator has its own pros and cons. In this study, the Gini coefficient was used as one of the indicators for assessing inequality.

Previous studies on the Estonian pension system are mainly based either on the assessment of the situation of a typical person (e.g. average wage earner) or the aggregate national level. In Estonia inter- and intragenerational impact have been less studied. Piirits and Võrk (2019) published the first article on the intergenerational effects of the reforms of the Estonian pension system. Studies based on an intergenerational perspective have been conducted abroad, but similar studies on Estonia have been missing.

Although countries have different economic backgrounds and pension systems, it is generally observed that younger cohorts or cohorts who have just started to retire would have an advantage if the SPA is increased. However, future cohorts need to contribute more to maintain the same replacement rate. Making pension systems more actuarially fair would increase sustainability, but on the other hand, the risk of poverty may increase. While most of the pension system reforms do have intergenerational effects and although countries are aware of it, they do not always find a way to distribute the effects equally.

Depending on the aim, whether to consider the economy as a whole or from individuals' perspective and on the data availability, different models are used to deal with a matter of interest. Models can be categorised by various dimensions like theoretical or statistical model, general equilibrium or semi-equilibrium, static or dynamic model, deterministic or stochastic, typical or heterogeneous agents' model.

The typical agent model and the microsimulation model have been developed and are commonly used to assess the impact of pension reforms on inequalities. Intergenerational effects can be estimated based on individual-level data (real data), or the examples of typical agents. The use of microsimulation means involving people with different backgrounds, which in turn affects the aggregated outcomes of the pension reform. In addition, the future actions of people should be simulated in the microsimulation which also adds dispersion to the results of the pension reform effects. In this thesis, the typical agent pension simulation model ESTPEN is used to assess intergenerational effects and the microsimulation model is used to simulate intragenerational effects and intergenerational effects. It is then possible to compare the results and their differences of typical agent and microsimulation models.

The microsimulation model uses the Estonian population data (1.3 million people in 2016 and 1.1 million in 2100) based on three registries. The future cohorts are simulated based on Eurostat long-term projection of fertility rates, migration and mortality rate. The annual individual-level population, parents of children, length of service before 1999, future working and wages, pension types, mandatory and voluntary funded pension yields are simulated as dynamically as possible and voluntary scheme total pension enrollers and contribution sizes need to be simulated to learn about possible future pensions. The use of microsimulation of the entire population to assess inequality gives more stable results for several reasons: 1) the involvement of different cohorts who bear the effects of pension reforms in various scales; 2) life cycle simulation is not based on the typical person, i.e. one person can obtain higher wages in the first period and vice versa in the second period.

Estonia is an example of a country with a three-pillar pension system but with its own characteristics and peculiar history. Until 2000, Estonia had a PAYG scheme pension system where the pension entitlements were earned based on the length of activity (working, studying, military service and childcare). Therefore, the inequality of pensions has been relatively low. Although the compulsory funded pension was established in 2002, it takes many years until full maturation. The same also applies to the insurance component of the first pillar pensions, as the pensions of existing pensioners are largely influenced by the length of the service component. These are the reasons for the currently low inequality of pensions, while in the future inequalities will increase.

By using the typical agent model, this thesis demonstrates that low-paid workers from younger cohorts will have mostly lower pension replacement rates than older cohorts. But reforms have mostly increased the replacement rate (except the introduction of the insurance component). PAYG with insurance component lowered every cohort's pensions. Contrary to the introduction of insurance component reform, the introduction of the compulsory funded scheme and faster indexation have raised the size of expected future pensions. At the same time, the PAYG with service component would give a higher replacement rate for low-paid workers. In the intergenerational view, younger cohorts will have around the same level of pensions as older cohorts at the same wage level. In particular, the scenarios of the SPA related to life expectancy is balanced with average wages. The abolition of the mandatory funded pension will reduce the future pension of each cohort and with each income level in a typical agent model. The IRR and the RNPV also decrease for younger cohorts but at least IRR is positive and greater than the return of the risk-free instrument. This result is carried by a sufficiently redistributive first pillar and assumptions of the second pillar yield.

As a result of reforms, the pension system is also more actuarially fair because younger cohorts' IRR is more equal (horizontal equality) between different salary levels, meaning that one's pension will be more dependent on his or her actual contributions. From the state's point of view, the IRR and yield of the risk-free instrument are therefore diminishing; the yield of the pension system is more closely tied to the overall level of yield.

The inequalities of the first pillar after the 2018 pension reform (new service component and the SPA linked to life expectancy) Gini coefficient will increase from 0.102 in 2016 to 0.134 by 2050. Although at first the inequality increases by 2.2 percentage points compared to the initial level (from 2016 to 2050), inequalities in the following years are stabilising and decreasing. The 2018 reforms aimed to improve financial sustainability and raise the future pensions of low-wage earners. Accordingly, future inequality should decrease. As the impact of these reforms is long-term, the impact of the reforms will emerge in the second half of the 21st century. Therefore, inequality will decrease to a 0.066 level by 2100. The three-pillar system total inequality increases by over 50% by 2050, (from 0.107 to 0.190 in 2050) – half of the increase in inequality comes from the first pillar and half from funded schemes. As the inequality of the first and the second pillar begins to decrease after 2050, the income inequality of the entire pension system declines to 0.156 by 2100. The pension system attains a higher sustainability with the 2018 legislated pension reforms. To take together and answer to research question one (to what extent would the inequality of old-age pensions change until the end of the projection of the model?) – the total inequality has a non-monotonic (inverted U-shape) trend of Gini coefficient. The total inequality in 2100 would be higher than in 2016 but lower than in 2050, while the inequality of first pillar old-age pensions will be lower than 2016 by 35%.

While the wage simulation shows inequality is higher than in recent years real data (0.46 versus 0.38), all pillars are able to reduce inequality in wages as the Gini coefficient is about 3 times lower. Total pension inequality would be 0.156 compared to 0.46 of wages inequality. The second pillar inequality will be 70% of it (0.329). The reasons are different. The first pillar substantially redistributes pensions and even more after the last reforms. In addition, the first pillar surplus is divided equally between all retirees. The inequalities of the second and third pillars are affected by two aspects: 1) wage inequality is based on the one-year data while the pension is the cumulative result of a longer period; 2) the choice of funds affects future pensions. Overall, to answer the second research question (what is the role of different pension pillars – separately and jointly – in reducing labour market income inequalities?) – as the first pillar pension also accounts for a large proportion of pensions in the future (70–80%), the future inequality of all pensions will also be largely affected by the inequalities of the first pillar in which inequality will decrease over time.

The life cycle's average salary used in the typical agent model should be the best approach to compare to the average results of the microsimulation model. The replacement rate was around 49% in the typical agent model, and 49% for just retired people in the microsimulation model for 2100 and 40% for all retirees in 2100. There would be a difference if the surplus of the first pillar had not been shared in the microsimulation model (the replacement rate would be 42% without surplus distribution). Therefore, to answer the third research question (whether the results of the typical agent and microsimulation models differ and in what direction?), we may observe that compared to the micro-simulation model, the typical agent model gives higher estimates of pensions.

FUTURE RESEARCH

Although a major step has been taken towards a better understanding of the possible future, different approaches can be taken or tested with different aspects. The thesis assesses the impact of different pension reforms on pension inequalities, but there would also be a possibility to take one of the pension systems and assess the validity or sensitivity of different characteristics.

The base model takes the population projection as it was in the Eurostat population forecast – 1) fertility rate, 2) migration, and 3) mortality. It would be important to assess situations with lower or higher fertility rates, or increased immigration or instead increased emigration. As the SPA is linked to life expectancy, the change in mortality should not play a major role, but it could be tested.

The sensitivity of macroeconomic assumptions or employment rate might also be crucial for future pensions. As the first pillar pensions are linked to the local economy and the second and third pillar pensions are mostly linked to the world economy, the macroeconomic assumptions affect the proportions of the PAYG and funded pension schemes and therefore inequality. The model should therefore be assessed with slower or faster economic growth using a separate macroeconomic model.

If the life expectancy is increasing but the years of healthy life are not, then people will not be able to work longer, or if the years of healthy life are growing faster than life expectancy, then future pensions will also be affected. This would require a more detailed analysis of the years of healthy life and life expectancy and their linkage to the probability to work.

As previous paragraphs described a sensitivities analysis, then a further step would be to make the current semi-dynamic model more dynamic. Starting with macroeconomic decoupling from the long-term forecast by the MoF and building a macroeconomic simulation into the model, which in turn would depend on, for example, productivity, employment rates, fertility, mortality, health, wages or economic convergence. Currently, this model is used for Estonia, but it could also be applicable for other countries if this model would be more dynamic.

Further development can go ahead with scenarios, i.e. testing possible reform ideas and evaluating their *ex ante*. Such an approach would allow the good qualities of pension systems from other countries to be taken and test them on an example of Estonia. As there is an increasing trend towards individual responsibility and thus towards increasing savings, one hypothetical scenario could be expanding the third pillar through the employer with an opt-out option.

Since in a sense, this work deals with the financial well-being of older people, but in a narrowed option, the next direction would be to expand the view and add potential other incomes at retirement and add potential costs (for example, long-term care). It is also possible to move from the assessment of inequality to the assessment of poverty or deprivation, which are also very important topics for the pension system.

The transformation of the mandatory funded pension into a voluntary scheme in Estonia from 2021 needs a separate analysis. This analysis should take into account a wide range of behavioural aspects. It needs more accurate data on people's decisions or very different scenarios to assess the long-term impact on people's retirement age income (adequacy), inequality and the financial sustainability of the system.

The expenditure of the Estonian pension system as a percentage of GDP is among the lowest compared to the other European countries and the percentage will rather decrease in the future. A separate line of research could be to find ways to share the future surplus (the model increased the flat-rate base amount) or to alter possible savings rates or tax increases to increase costs that would ensure a more adequate future pension. Another possibility could be to analyse different combinations of PAYG scheme pension and funded pension to identify the pros and cons of each option.

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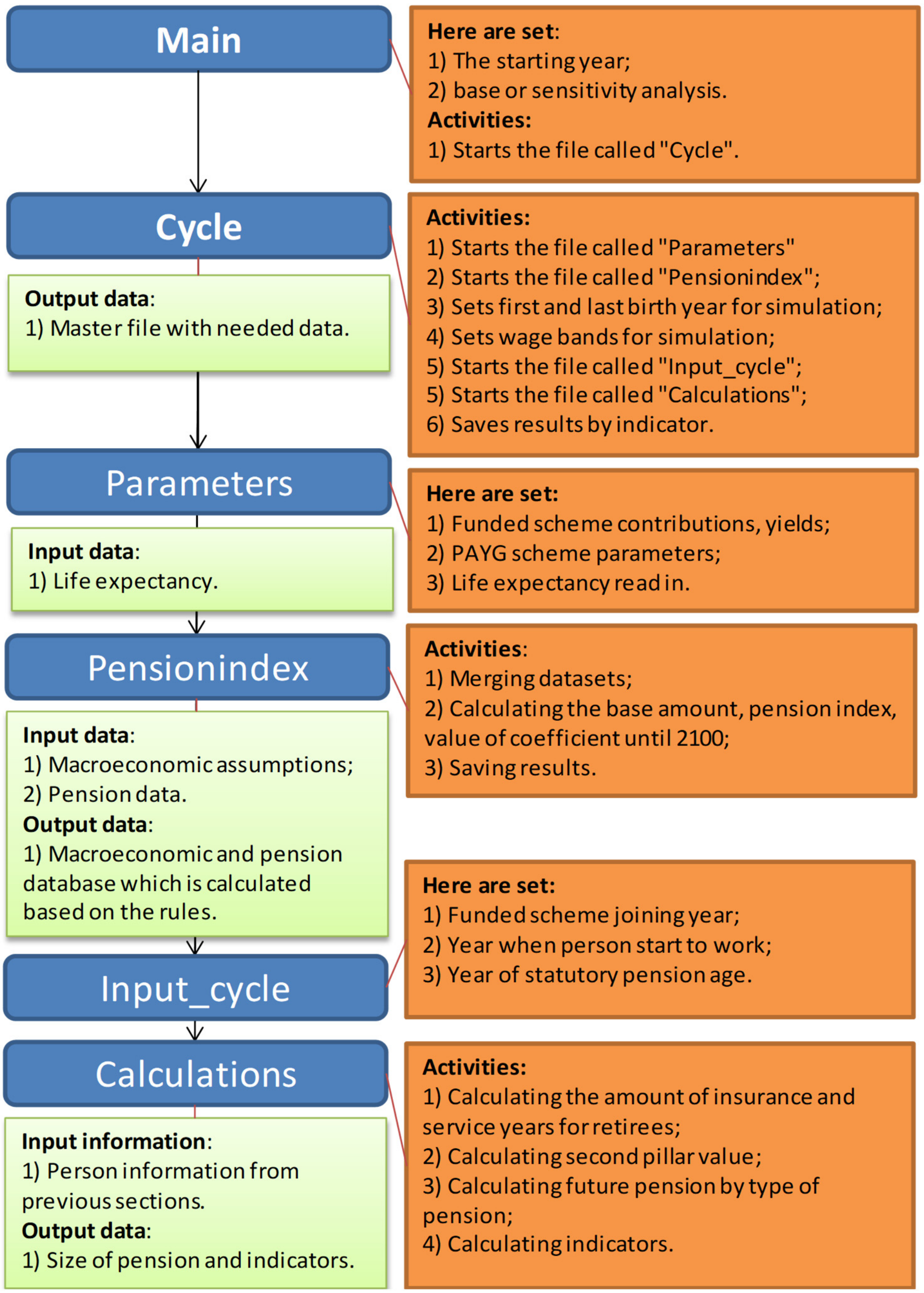
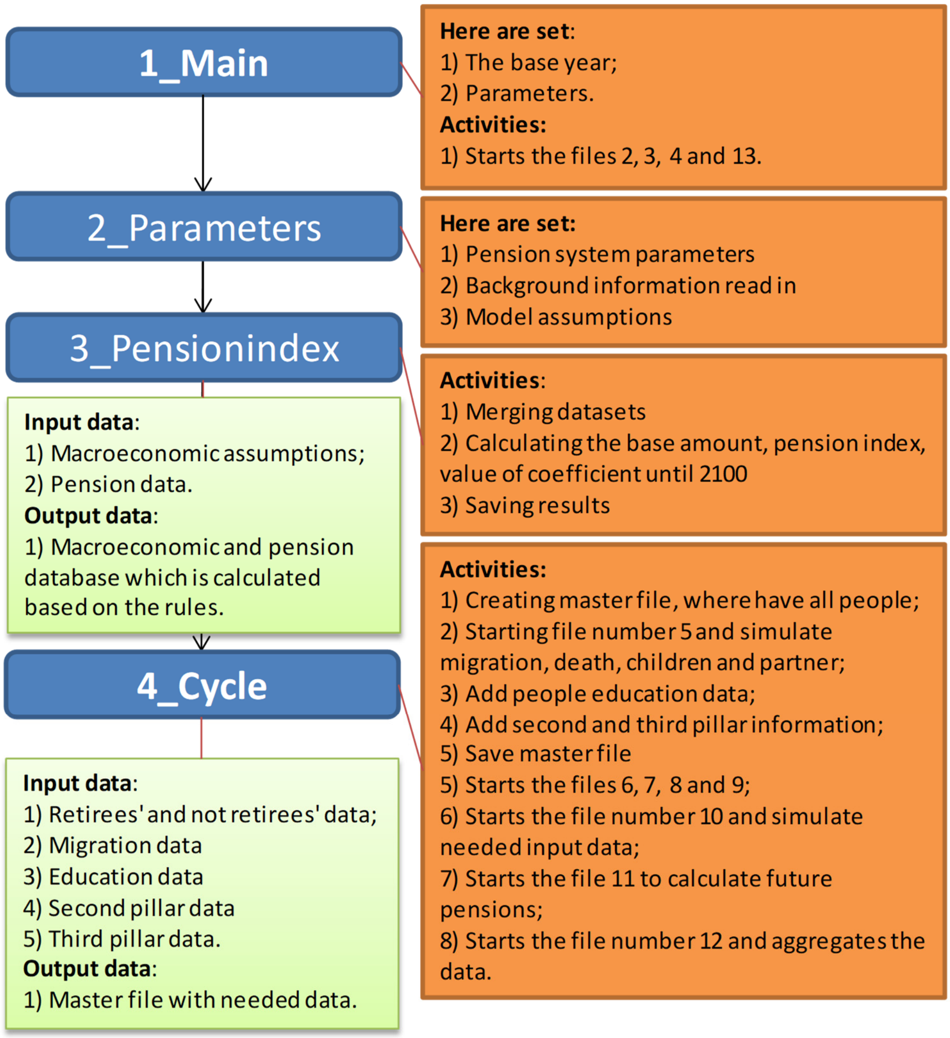
APPENDICES

Appendix 1. Technical description of the typical agent model ESTPEN



Appendix 2. Technical description of the pension microsimulation model ESTPEN-MICRO



Appendix 2 continues

5_MortalityRates_Child

Input data:
1) Mortality rates by age, gender and year of birth from EuroPop2019;
2) Historic population data;
3) Net positive migration by age, gender and year from EuroPop2019;
4) Fertility rates data from EuroPop2019;
5) Master file.

Output data:
1) Master file where is added simulated year of death.

Activities:
1) Drop people who have "left" Estonia and who are not in the Statistics Estonia population statistics by using longest unemployment period;
2) Simulating children information who are born before simulation starting year;
3) Add people to dataset if have less than 99% people in dataset compared to population data by age and gender;
4) Add positive migration by age, gender and year;

Mortality activities:
5) Generating random number between 0 and 1 for every year;
6) If random number is smaller than mortality rate (based on age, gender and year) then the year of death is generated for that person.
7) The maximum age is set to 100 and no one can live longer;
8) Saves the year of death data as separate file and also to the master file;

Children activities:
9) Simulating future children to the women who are in fertile age (14 to 50) by year of birth and age, using random number;
10) Simulating a father for mother's last child and set this man as a partner.

6_Service

Input data:
1) Retirees data;
2) Education data.

Output:
1) Regression model results for service years.

Activities:
1) Opens retirerees' data;
2) Drop people with zero or missing service years;
3) Merging education data;
4) Setting upper limit for regression (until 90th percentile service years);
5) Doing regression people born 1945 to 1952 with service years as dependent variable and with independent variables: year of birth, gender and education dummy variables;
6) Saving the results.

Appendix 2 continues

7_Wages

Input data:
1) Master file which was created in Cycle section.

Output data:
1) Working or not working and wage models results.

Activities:
1) Opens master file;
2) Probit regression by gender is used to forecast the working or not working. Independent variables are last year dummy working variable, education, age to retirement, age to retirement in square;
3) Generating last three years inverse hypobolic sinus (IHS) wages;
4) Linear regression by gender is used to forecast wage for working people. Independent variables are last three years IHS wage and square of it, education, age to retirement, age to retirement in square.
5) Saving the results.

8_PensionType

Input data:
1) Master file which was created in Cycle section.

Output data:
1) Transition probabilities for type of pension by age and gender.

Activities:
1) Finding the people who only works (do not get any pension);
2) Opens retirees file and divide pension types into 3 groups;
3) People who do not get any pension are set as not pensioner;
4) Calculating the transition probabilities by gender and age between not being retiree and 3 types of pension;
5) Transition probabilities for 62 men are taken to 64-years old men to take account retirement age increase and for women also (from 60 to 64). Transition probabilities between those ages are smoothed;
6) Transition probabilities are saved.

9_Yield

Input data:
1) Historic second and third pillar yields data;
2) Second pillar funds proportion data.

Output data:
1) Second and third pillar yields;
2) Second pillar funds proportion.

Second and third pillar yield activities:
1) Calculating every second and third pillar fund mean of log daily value change, variance of it, standard deviation of it;
2) Calculating every second and third pillar fund every day future value using Black and Scholes equation;
3) Calculating every second pillar fund long-term average yearly yield;
4) Calculating third pillar funds average yield by year;
5) Second and third pillar yields are saved;
6) Second pillar conservative funds average yield is setted for third pillar insurance yield.

Other activites:
7) Second pillar funds last know proportion is saved by age and gender.

Appendix 2 continues

10_IIIpillar

Input data:
1) Master file which was created in Cycle section;
2) Third pillar contribution data;
3) Third pillar insurance data.

Output data:
1) Probit model results for having third pillar;
2) Third pillar proportion and contributions.

Activities:
1) Generating 10 income groups;
2) Probit regression by gender is used to forecast the having the third pillar or not. Independent variables are last three years IHS wage, square of it, age to retirement, squared age to retirement, having second pillar or not;
3) Calculating third pillar proportions by gender and age;
4) Calculating third pillar funds contribution proportion by gender, age and income group;
5) Calculating third pillar insurance contribution proportion by gender, age and income group.

11_Input

Input data:
1) Master file;
2) Transition probabilities for type of pension;
3) Regression and probit models results.

Output data:
1) Type of pension, service years, wage over the years, second and third pillar information by individual level.

Activities:
1) Finding the retirement age by year of birth, gender and round it if need to and take into account difference;
2) Simulating the type of pension or not being at pension;
3) Simulating service years before the year 1999 for all whose birth year is before 1983 by regression model results and person characteristics;
4) Simulating working or not working based on person characteristics and probit model results;
5) Simulating the relative wage to those who were working by person characteristics and linear regression model results;
6) Simulating second pillar strategy and exact fund by gender and age and randomness;
7) Simulating third pillar by person characteristics and probit model results;

12_Calculations

Input data:
1) Output data in previous section.

Output data:
1) Size of pension on individual level.

Activities:
1) Taking also into consideration future wages to assess is person qualifying for the old-age pension or not;
2) Taking into account children for calculating the future pensions and taking into account children to find right year when person can retire;
3) Calculating the amount of insurance and service years for retirees;
4) Calculating second pillar value;
5) Calculating third pillar value;
6) Calculating future pension by type of pension.

Appendix 3. Results of microsimulation model –
The first pillar nominal average pension in euros without redistribution of the surplus

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	391	387	387	387	387	387	387	387
2017	407	404	403	403	403	403	403	403
2018	437	432	432	431	432	432	432	432
2019	470	466	465	464	465	465	465	465
2020	514	509	508	507	508	508	508	508
2021	534	529	528	526	528	528	528	528
2022	539	533	532	530	531	531	531	532
2023	551	545	544	542	543	544	543	544
2024	570	563	562	564	566	566	566	567
2025	589	582	580	587	589	589	589	590
2026	604	595	593	603	605	607	606	609
2027	619	610	607	620	621	623	623	625
2028	634	625	621	636	638	640	639	642
2029	649	640	636	653	655	657	656	660
2030	665	655	650	671	673	675	674	678
2031	682	671	666	689	691	693	692	697
2032	699	688	681	708	710	712	711	717
2033	716	706	698	728	730	732	730	737
2034	734	724	715	749	751	754	753	761
2035	753	743	733	771	773	776	775	783
2036	773	762	751	793	795	797	796	806
2037	792	782	769	815	817	819	817	828
2038	812	802	788	838	840	842	840	852
2039	833	823	807	862	864	865	863	877
2040	854	845	826	887	888	890	886	902
2041	876	867	846	911	912	914	911	928
2042	898	889	866	936	937	940	935	955
2043	921	912	887	963	964	969	964	986
2044	944	935	907	990	990	997	991	1015
2045	968	959	928	1016	1017	1024	1017	1044
2046	991	982	948	1043	1044	1051	1044	1073
2047	1015	1005	968	1069	1072	1078	1070	1102
2048	1039	1029	988	1096	1100	1104	1096	1132
2049	1064	1054	1008	1123	1130	1132	1123	1162
2050	1089	1078	1029	1151	1161	1159	1151	1193
2051	1114	1104	1049	1179	1192	1187	1180	1224
2052	1140	1130	1071	1209	1224	1215	1209	1256
2053	1168	1156	1093	1239	1258	1249	1244	1294
2054	1196	1184	1116	1270	1293	1279	1275	1329
2055	1225	1212	1139	1303	1330	1311	1307	1364
2056	1255	1240	1163	1336	1368	1343	1340	1401
2057	1286	1270	1188	1370	1407	1376	1375	1439
2058	1317	1300	1213	1406	1448	1411	1412	1480

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2059	1350	1331	1239	1443	1490	1448	1450	1522
2060	1384	1363	1266	1482	1534	1485	1489	1565
2061	1419	1396	1295	1523	1581	1525	1531	1611
2062	1456	1432	1325	1567	1630	1566	1574	1659
2063	1493	1469	1356	1613	1682	1609	1619	1708
2064	1532	1509	1390	1661	1735	1657	1670	1763
2065	1573	1550	1424	1712	1792	1704	1720	1818
2066	1615	1593	1461	1765	1851	1755	1772	1875
2067	1659	1638	1498	1820	1913	1806	1826	1934
2068	1704	1684	1537	1878	1977	1861	1884	1997
2069	1751	1732	1578	1938	2044	1919	1943	2062
2070	1800	1781	1620	2000	2114	1979	2006	2130
2071	1850	1833	1664	2065	2186	2041	2070	2201
2072	1908	1893	1715	2145	2274	2117	2149	2287
2073	1962	1949	1763	2216	2352	2184	2220	2364
2074	2018	2007	1812	2290	2435	2255	2294	2445
2075	2076	2067	1864	2367	2520	2332	2373	2532
2076	2136	2129	1917	2447	2609	2409	2453	2620
2077	2198	2193	1972	2531	2701	2490	2537	2711
2078	2261	2259	2030	2617	2797	2571	2620	2802
2079	2326	2326	2089	2707	2896	2659	2710	2901
2080	2393	2397	2151	2801	2999	2750	2804	3004
2081	2462	2468	2214	2898	3105	2845	2902	3110
2082	2533	2542	2280	2999	3216	2943	3003	3220
2083	2607	2620	2349	3105	3331	3045	3106	3334
2084	2682	2698	2420	3213	3449	3151	3214	3450
2085	2759	2779	2492	3325	3571	3260	3325	3572
2086	2839	2862	2566	3441	3697	3378	3445	3702
2087	2921	2948	2644	3562	3828	3496	3565	3833
2088	3006	3036	2723	3686	3963	3619	3689	3966
2089	3092	3127	2804	3815	4102	3741	3812	4101
2090	3182	3220	2888	3948	4246	3871	3944	4243
2091	3273	3314	2974	4085	4394	4004	4079	4389
2092	3367	3412	3062	4227	4547	4143	4219	4541
2093	3464	3513	3153	4374	4705	4285	4363	4696
2094	3563	3615	3246	4525	4868	4431	4512	4857
2095	3666	3720	3341	4681	5036	4584	4667	5024
2096	3770	3828	3439	4842	5210	4740	4825	5194
2097	3877	3938	3538	5008	5389	4900	4987	5368
2098	3988	4051	3641	5179	5573	5064	5156	5549
2099	4106	4169	3748	5359	5770	5241	5337	5743
2100	4228	4292	3860	5547	5974	5426	5526	5946

Source: Author’s calculations
Note: The first pillar pension is without redistribution of surplus

Appendix 4. Results of microsimulation model –
The second pillar nominal average pension in euros

Scenario Year	(3)	(4)	(5)	(6)	(7)
2016	27	27	27	27	27
2017	29	29	29	29	29
2018	28	28	28	28	28
2019	31	31	31	31	31
2020	33	33	33	33	33
2021	36	36	36	36	36
2022	39	39	39	39	39
2023	39	39	39	39	39
2024	43	43	43	43	43
2025	47	47	47	47	47
2026	51	51	51	51	51
2027	55	55	55	55	55
2028	60	60	60	59	59
2029	65	65	65	59	59
2030	70	70	70	65	65
2031	75	75	75	71	71
2032	81	81	81	77	77
2033	88	88	88	84	84
2034	95	95	95	91	91
2035	103	103	103	99	99
2036	111	111	111	107	107
2037	120	120	120	108	108
2038	129	129	129	119	119
2039	139	139	139	129	129
2040	149	149	149	140	140
2041	159	160	159	152	152
2042	171	171	171	165	165
2043	183	183	183	178	178
2044	196	196	196	192	192
2045	210	210	210	206	206
2046	224	225	225	209	209
2047	240	240	240	226	226
2048	260	260	260	245	245
2049	279	279	279	265	265
2050	299	299	299	287	287
2051	319	319	319	313	313
2052	340	340	340	338	338
2053	361	361	361	364	364
2054	382	382	382	390	390
2055	402	402	402	417	417
2056	420	420	420	424	424
2057	437	437	437	455	455
2058	454	454	454	486	486
2059	470	470	470	515	515

Scenario Year	(3)	(4)	(5)	(6)	(7)
2060	487	487	487	541	541
2061	503	503	503	566	566
2062	521	521	521	590	589
2063	540	540	540	613	612
2064	562	562	562	635	635
2065	586	586	586	658	658
2066	610	611	611	682	682
2067	636	637	637	691	691
2068	663	663	663	721	721
2069	692	692	692	756	756
2070	723	723	723	794	793
2071	756	756	756	832	832
2072	791	791	791	872	872
2073	828	828	828	914	914
2074	866	866	866	959	959
2075	906	906	906	1007	1007
2076	946	946	946	1058	1058
2077	986	986	986	1113	1113
2078	1027	1027	1027	1130	1130
2079	1070	1070	1070	1198	1198
2080	1116	1116	1116	1266	1266
2081	1162	1162	1162	1337	1337
2082	1211	1211	1211	1408	1408
2083	1262	1262	1262	1479	1479
2084	1312	1312	1312	1550	1550
2085	1362	1362	1362	1624	1624
2086	1413	1413	1413	1701	1701
2087	1466	1466	1466	1778	1778
2088	1520	1520	1520	1856	1856
2089	1575	1575	1575	1887	1887
2090	1631	1631	1631	1980	1980
2091	1687	1687	1687	2067	2067
2092	1745	1745	1745	2155	2155
2093	1804	1804	1804	2242	2242
2094	1865	1865	1865	2331	2331
2095	1928	1928	1928	2421	2421
2096	1994	1994	1994	2515	2515
2097	2061	2061	2061	2609	2609
2098	2132	2132	2132	2703	2703
2099	2205	2205	2205	2800	2800
2100	2283	2283	2283	2901	2901

Source: Author’s calculations
Note: All are annuities even if the value of the second pillar is very low

Appendix 5. Results of microsimulation model –
The third pillar nominal average pension in euros

Scenario Year	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	41	41	41	41	41	41	41
2017	40	40	40	40	40	40	40
2018	39	39	39	39	39	39	39
2019	41	41	41	41	41	41	41
2020	44	44	44	44	44	44	44
2021	47	47	47	47	47	47	47
2022	50	50	50	50	49	49	49
2023	50	50	50	50	49	49	49
2024	54	54	54	54	54	54	54
2025	59	59	59	59	58	58	58
2026	64	64	64	64	63	63	63
2027	67	67	67	67	66	66	66
2028	71	71	71	71	69	69	69
2029	74	74	74	74	69	69	69
2030	77	77	77	77	74	74	74
2031	81	81	81	81	79	79	79
2032	86	86	86	86	84	84	84
2033	90	90	90	90	89	89	89
2034	94	94	94	94	94	94	94
2035	98	98	98	98	99	99	99
2036	102	102	102	102	104	104	104
2037	107	107	107	107	104	104	104
2038	112	112	112	112	112	112	112
2039	117	117	117	117	119	119	119
2040	123	123	123	123	128	128	128
2041	129	129	129	129	135	135	135
2042	135	135	135	135	144	144	144
2043	142	142	142	142	153	153	153
2044	148	148	148	148	162	162	162
2045	156	156	156	156	172	172	172
2046	163	163	163	163	173	173	173
2047	170	170	170	170	185	185	185
2048	177	177	177	177	197	197	197
2049	184	184	184	184	209	209	209
2050	193	193	193	193	223	223	223
2051	201	201	201	201	238	238	238
2052	208	208	208	208	252	252	252
2053	215	215	215	215	265	265	265
2054	222	221	221	221	277	277	277
2055	228	228	228	228	289	289	289
2056	235	235	235	235	295	295	295
2057	242	242	242	242	310	310	310
2058	249	249	249	249	325	325	325
2059	256	256	256	256	339	339	339

Scenario Year	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2060	263	262	262	262	352	352	352
2061	270	270	270	270	367	367	367
2062	277	277	277	277	379	379	379
2063	286	286	286	286	394	394	394
2064	296	295	295	295	408	408	408
2065	306	305	305	305	423	423	423
2066	316	316	316	316	438	438	438
2067	327	327	327	327	446	446	446
2068	339	339	339	339	469	469	469
2069	352	351	351	351	494	494	494
2070	365	364	364	364	521	521	521
2071	379	378	378	378	549	549	549
2072	393	393	393	393	579	579	579
2073	407	407	407	407	609	609	609
2074	422	421	421	421	640	640	640
2075	437	436	436	436	671	671	671
2076	453	452	452	452	703	703	703
2077	471	469	469	469	737	737	737
2078	489	488	488	488	749	749	749
2079	508	507	507	507	790	790	790
2080	531	529	529	529	836	836	836
2081	555	555	555	555	888	888	888
2082	583	583	583	583	943	943	943
2083	615	615	615	615	1007	1007	1007
2084	651	651	651	651	1077	1077	1077
2085	688	688	688	688	1150	1150	1150
2086	732	732	732	732	1233	1233	1233
2087	783	783	783	783	1329	1329	1329
2088	838	838	838	838	1431	1431	1431
2089	896	896	896	896	1460	1460	1460
2090	955	955	955	955	1565	1565	1565
2091	1029	1029	1029	1029	1703	1703	1703
2092	1107	1107	1107	1107	1854	1854	1854
2093	1179	1179	1179	1179	2001	2001	2001
2094	1253	1253	1253	1253	2157	2157	2157
2095	1312	1312	1312	1312	2292	2292	2292
2096	1372	1372	1372	1372	2431	2431	2431
2097	1436	1436	1436	1436	2582	2582	2582
2098	1508	1508	1508	1508	2757	2757	2757
2099	1580	1580	1580	1580	2934	2934	2934
2100	1642	1642	1642	1642	3093	3093	3093

Source: Author’s calculations
Note: All are annuities even if the value of the second pillar is very low

Appendix 6. Results of microsimulation model –
The first, second and third pillar nominal average pension
in euros without redistribution

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	391	388	391	391	391	391	391	388
2017	407	405	408	408	408	408	408	404
2018	437	433	436	436	436	436	436	433
2019	470	467	471	469	471	470	470	467
2020	514	510	514	513	514	514	514	510
2021	534	531	536	534	536	536	536	530
2022	539	536	542	540	541	541	541	534
2023	551	548	554	552	553	553	553	547
2024	570	566	574	576	578	578	578	570
2025	589	586	595	602	604	604	604	594
2026	604	600	611	621	623	625	625	613
2027	619	616	628	641	643	645	645	631
2028	634	631	646	661	663	665	664	649
2029	649	647	664	682	684	682	681	667
2030	665	664	683	704	706	704	703	686
2031	682	681	703	727	729	727	726	706
2032	699	699	724	751	753	751	750	727
2033	716	718	746	777	779	776	775	749
2034	734	738	769	804	806	806	805	774
2035	753	758	794	832	834	835	833	798
2036	773	779	819	862	863	864	862	822
2037	792	800	845	892	893	884	882	844
2038	812	822	872	923	924	917	914	871
2039	833	845	900	956	957	950	947	897
2040	854	868	929	989	990	984	981	925
2041	876	891	958	1024	1025	1019	1016	953
2042	898	915	989	1059	1060	1056	1051	982
2043	921	940	1020	1097	1097	1100	1095	1017
2044	944	965	1052	1135	1135	1140	1134	1048
2045	968	990	1084	1173	1174	1180	1174	1079
2046	991	1015	1118	1212	1214	1205	1198	1108
2047	1015	1040	1151	1253	1255	1247	1239	1140
2048	1039	1066	1190	1298	1303	1290	1281	1172
2049	1064	1092	1230	1346	1353	1335	1326	1205
2050	1089	1118	1270	1393	1402	1380	1372	1238
2051	1114	1144	1311	1441	1454	1433	1426	1273
2052	1140	1171	1354	1492	1508	1487	1481	1308
2053	1168	1199	1399	1545	1565	1553	1547	1349
2054	1196	1227	1445	1600	1623	1610	1605	1385
2055	1225	1256	1491	1655	1682	1670	1666	1423
2056	1255	1286	1536	1709	1741	1696	1693	1458
2057	1286	1316	1581	1764	1801	1762	1761	1499
2058	1317	1347	1626	1819	1860	1830	1831	1541

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2059	1350	1378	1670	1875	1921	1899	1901	1585
2060	1384	1411	1716	1932	1984	1966	1970	1630
2061	1419	1446	1764	1992	2050	2035	2041	1677
2062	1456	1483	1814	2056	2119	2103	2111	1726
2063	1493	1521	1866	2123	2191	2172	2182	1778
2064	1532	1562	1923	2195	2269	2255	2268	1836
2065	1573	1605	1984	2271	2351	2329	2345	1893
2066	1615	1649	2046	2350	2436	2408	2425	1952
2067	1659	1696	2112	2434	2526	2451	2471	2010
2068	1704	1743	2179	2520	2619	2540	2562	2076
2069	1751	1793	2250	2611	2716	2634	2658	2145
2070	1800	1845	2325	2706	2819	2734	2761	2217
2071	1850	1898	2404	2806	2926	2836	2865	2292
2072	1908	1961	2493	2923	3051	2954	2986	2383
2073	1962	2018	2580	3034	3170	3065	3100	2465
2074	2018	2079	2671	3149	3294	3182	3220	2551
2075	2076	2141	2767	3271	3424	3328	3369	2645
2076	2136	2206	2864	3394	3556	3460	3504	2738
2077	2198	2273	2962	3521	3691	3600	3647	2835
2078	2261	2342	3064	3652	3831	3656	3705	2924
2079	2326	2413	3169	3788	3976	3813	3865	3029
2080	2393	2488	3279	3929	4127	3973	4028	3140
2081	2462	2564	3393	4076	4283	4144	4201	3255
2082	2533	2644	3512	4231	4448	4318	4378	3375
2083	2607	2727	3637	4393	4619	4494	4556	3499
2084	2682	2813	3762	4556	4792	4675	4738	3628
2085	2759	2901	3891	4724	4970	4865	4930	3763
2086	2839	2993	4022	4897	5153	5101	5169	3913
2087	2921	3090	4159	5078	5344	5307	5375	4061
2088	3006	3189	4301	5265	5541	5528	5598	4215
2089	3092	3292	4448	5459	5746	5610	5681	4345
2090	3182	3397	4597	5657	5954	5843	5916	4501
2091	3273	3507	4751	5862	6171	6073	6147	4664
2092	3367	3621	4910	6075	6395	6310	6385	4834
2093	3464	3737	5073	6293	6624	6547	6623	5008
2094	3563	3855	5239	6518	6860	6792	6868	5186
2095	3666	3973	5406	6747	7100	7041	7118	5367
2096	3770	4095	5579	6983	7348	7298	7376	5552
2097	3877	4220	5757	7227	7604	7559	7640	5743
2098	3988	4349	5947	7486	7873	7834	7912	5944
2099	4106	4487	6162	7774	8171	8180	8252	6166
2100	4228	4628	6389	8077	8482	8542	8606	6393

Source: Author’s calculations
Note: The first pillar pension is without redistribution of surplus

Appendix 7. Results of microsimulation model – The first pillar deficit or surplus in billion euros

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	0.18	0.19	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
2017	0.22	0.24	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
2018	0.28	0.30	-0.01	0.00	-0.01	-0.01	-0.01	-0.01
2019	0.30	0.31	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
2020	0.12	0.14	-0.19	-0.18	-0.19	-0.19	-0.19	-0.19
2021	0.01	0.03	-0.31	-0.30	-0.31	-0.31	-0.31	-0.31
2022	0.07	0.09	-0.27	-0.26	-0.26	-0.27	-0.27	0.09
2023	0.16	0.19	-0.19	-0.19	-0.19	-0.19	-0.19	0.19
2024	0.18	0.21	-0.19	-0.20	-0.21	-0.21	-0.20	0.20
2025	0.17	0.20	-0.22	-0.24	-0.25	-0.25	-0.25	0.17
2026	0.17	0.21	-0.23	-0.26	-0.27	-0.24	-0.23	0.20
2027	0.18	0.22	-0.23	-0.28	-0.29	-0.25	-0.25	0.20
2028	0.19	0.23	-0.24	-0.30	-0.30	-0.26	-0.26	0.21
2029	0.20	0.24	-0.24	-0.31	-0.32	-0.23	-0.23	0.26
2030	0.22	0.26	-0.25	-0.33	-0.34	-0.24	-0.24	0.27
2031	0.23	0.27	-0.25	-0.34	-0.35	-0.25	-0.25	0.28
2032	0.25	0.29	-0.25	-0.36	-0.37	-0.26	-0.26	0.29
2033	0.26	0.30	-0.26	-0.38	-0.39	-0.28	-0.27	0.30
2034	0.27	0.31	-0.27	-0.41	-0.41	-0.24	-0.23	0.36
2035	0.28	0.32	-0.28	-0.44	-0.44	-0.26	-0.26	0.35
2036	0.29	0.33	-0.29	-0.46	-0.47	-0.27	-0.26	0.37
2037	0.30	0.34	-0.30	-0.49	-0.50	-0.23	-0.23	0.43
2038	0.31	0.35	-0.31	-0.52	-0.53	-0.25	-0.25	0.43
2039	0.33	0.37	-0.31	-0.55	-0.55	-0.27	-0.26	0.43
2040	0.34	0.38	-0.32	-0.58	-0.58	-0.29	-0.28	0.44
2041	0.36	0.40	-0.32	-0.60	-0.61	-0.31	-0.29	0.45
2042	0.38	0.42	-0.32	-0.63	-0.63	-0.32	-0.31	0.46
2043	0.40	0.44	-0.33	-0.66	-0.66	-0.27	-0.25	0.53
2044	0.41	0.45	-0.33	-0.69	-0.69	-0.29	-0.27	0.54
2045	0.42	0.47	-0.34	-0.73	-0.73	-0.31	-0.29	0.55
2046	0.44	0.49	-0.33	-0.76	-0.76	-0.26	-0.24	0.62
2047	0.46	0.51	-0.33	-0.79	-0.80	-0.28	-0.24	0.63
2048	0.48	0.53	-0.33	-0.82	-0.84	-0.29	-0.26	0.64
2049	0.50	0.55	-0.32	-0.85	-0.88	-0.30	-0.26	0.66
2050	0.52	0.57	-0.32	-0.88	-0.93	-0.31	-0.28	0.67
2051	0.53	0.58	-0.32	-0.92	-0.98	-0.32	-0.29	0.68
2052	0.55	0.60	-0.31	-0.96	-1.04	-0.33	-0.31	0.69
2053	0.57	0.63	-0.30	-1.00	-1.09	-0.25	-0.22	0.80
2054	0.61	0.66	-0.28	-1.02	-1.13	-0.26	-0.24	0.81
2055	0.65	0.71	-0.25	-1.04	-1.17	-0.27	-0.26	0.82
2056	0.72	0.79	-0.19	-1.02	-1.17	-0.19	-0.18	0.93
2057	0.80	0.88	-0.13	-1.01	-1.18	-0.19	-0.18	0.95
2058	0.90	0.98	-0.05	-0.98	-1.17	-0.18	-0.18	0.98
2059	1.01	1.10	0.04	-0.93	-1.15	-0.15	-0.16	1.04

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2060	1.14	1.24	0.15	-0.88	-1.13	-0.10	-0.12	1.11
2061	1.26	1.37	0.25	-0.83	-1.10	-0.04	-0.07	1.20
2062	1.40	1.51	0.36	-0.78	-1.08	0.03	-0.01	1.30
2063	1.56	1.67	0.48	-0.72	-1.04	0.11	0.07	1.42
2064	1.71	1.83	0.60	-0.66	-1.01	0.30	0.25	1.64
2065	1.88	1.98	0.72	-0.61	-0.98	0.40	0.34	1.78
2066	2.04	2.14	0.85	-0.56	-0.96	0.51	0.44	1.93
2067	2.21	2.31	0.97	-0.51	-0.94	0.69	0.61	2.16
2068	2.39	2.48	1.11	-0.46	-0.91	0.81	0.73	2.33
2069	2.55	2.65	1.23	-0.42	-0.91	0.93	0.83	2.49
2070	2.72	2.81	1.35	-0.39	-0.91	1.04	0.93	2.65
2071	2.88	2.96	1.46	-0.38	-0.93	1.14	1.03	2.80
2072	3.03	3.10	1.55	-0.41	-1.00	1.21	1.09	2.91
2073	3.19	3.25	1.66	-0.42	-1.04	1.31	1.17	3.06
2074	3.36	3.42	1.78	-0.41	-1.07	1.39	1.25	3.19
2075	3.56	3.60	1.91	-0.39	-1.09	1.66	1.51	3.53
2076	3.77	3.81	2.06	-0.36	-1.10	1.77	1.60	3.69
2077	3.99	4.02	2.21	-0.33	-1.11	1.87	1.69	3.85
2078	4.23	4.24	2.37	-0.30	-1.12	2.07	1.89	4.12
2079	4.47	4.47	2.54	-0.27	-1.13	2.16	1.97	4.28
2080	4.71	4.69	2.69	-0.26	-1.16	2.24	2.04	4.42
2081	4.97	4.94	2.86	-0.24	-1.18	2.33	2.12	4.58
2082	5.24	5.20	3.04	-0.22	-1.20	2.44	2.22	4.77
2083	5.52	5.46	3.22	-0.20	-1.22	2.56	2.33	4.96
2084	5.83	5.75	3.42	-0.16	-1.22	2.66	2.43	5.15
2085	6.16	6.08	3.65	-0.10	-1.21	2.78	2.54	5.35
2086	6.49	6.39	3.86	-0.06	-1.21	3.11	2.87	5.79
2087	6.84	6.72	4.09	-0.01	-1.21	3.20	2.95	5.97
2088	7.20	7.06	4.33	0.03	-1.21	3.36	3.10	6.23
2089	7.57	7.42	4.58	0.07	-1.21	3.65	3.39	6.63
2090	7.95	7.78	4.82	0.10	-1.23	3.79	3.53	6.88
2091	8.34	8.15	5.08	0.13	-1.24	3.93	3.66	7.14
2092	8.74	8.54	5.35	0.16	-1.26	4.08	3.80	7.40
2093	9.16	8.94	5.62	0.18	-1.29	4.23	3.94	7.67
2094	9.59	9.36	5.91	0.21	-1.32	4.38	4.09	7.95
2095	10.05	9.81	6.22	0.25	-1.33	4.55	4.25	8.24
2096	10.54	10.29	6.55	0.31	-1.33	4.76	4.45	8.59
2097	11.05	10.78	6.89	0.36	-1.34	4.98	4.66	8.96
2098	11.60	11.32	7.28	0.46	-1.30	5.25	4.92	9.38
2099	12.29	12.01	7.79	0.71	-1.10	5.90	5.56	10.21
2100	13.05	12.77	8.36	1.03	-0.84	6.58	6.24	11.09

Source: Author's calculations

Appendix 8. Results of microsimulation model –
The potential raise of the first pillar pension using the surplus, euros in month per retiree

Scenario / Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	49	53	-16	-16	-16	-16	-16	-16
2017	60	64	-11	-11	-11	-11	-11	-11
2018	78	82	-2	-1	-2	-2	-2	-2
2019	80	85	-5	-4	-5	-6	-6	-5
2020	34	39	-51	-50	-51	-51	-51	-51
2021	2	8	-82	-81	-82	-82	-82	-82
2022	18	23	-71	-69	-70	-70	-70	25
2023	43	49	-52	-50	-51	-52	-51	51
2024	47	54	-51	-53	-54	-54	-54	52
2025	45	52	-57	-63	-65	-65	-64	45
2026	45	53	-59	-68	-70	-62	-62	53
2027	47	56	-60	-72	-74	-66	-65	53
2028	49	58	-61	-75	-77	-67	-66	56
2029	51	61	-62	-79	-81	-60	-59	69
2030	54	64	-62	-82	-84	-63	-62	70
2031	58	68	-62	-85	-87	-65	-64	73
2032	61	72	-62	-88	-90	-67	-66	75
2033	63	73	-64	-94	-96	-70	-69	75
2034	66	76	-65	-99	-101	-62	-60	92
2035	67	77	-68	-105	-107	-67	-66	90
2036	68	79	-69	-111	-113	-69	-67	93
2037	71	81	-71	-116	-118	-60	-58	109
2038	73	83	-72	-122	-123	-65	-62	109
2039	76	86	-73	-127	-129	-69	-66	109
2040	79	88	-74	-133	-134	-73	-70	110
2041	82	92	-74	-138	-139	-76	-73	111
2042	86	95	-74	-143	-144	-80	-75	113
2043	90	99	-74	-149	-150	-68	-63	133
2044	93	102	-74	-155	-155	-73	-68	133
2045	94	104	-75	-162	-163	-77	-70	135
2046	98	107	-74	-167	-169	-66	-59	154
2047	101	111	-73	-172	-175	-68	-60	156
2048	105	115	-71	-177	-182	-71	-62	157
2049	108	118	-69	-183	-189	-72	-64	160
2050	111	121	-68	-189	-198	-75	-66	161
2051	113	124	-67	-195	-207	-76	-68	163
2052	115	126	-66	-202	-217	-79	-72	162
2053	119	131	-63	-207	-226	-59	-53	192
2054	125	137	-58	-211	-234	-62	-57	192
2055	134	146	-52	-214	-240	-64	-60	193
2056	149	163	-40	-211	-242	-46	-43	220
2057	166	181	-27	-207	-243	-44	-43	224
2058	186	203	-10	-201	-242	-42	-42	231

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2059	209	228	9	-193	-239	-36	-37	242
2060	236	257	30	-184	-235	-24	-27	261
2061	264	286	52	-174	-231	-10	-15	281
2062	294	317	75	-164	-227	6	-2	305
2063	329	353	102	-152	-220	26	16	335
2064	364	387	128	-140	-214	72	60	397
2065	400	423	154	-130	-209	97	82	432
2066	436	458	181	-120	-205	124	106	471
2067	473	495	209	-109	-201	171	151	536
2068	514	535	238	-98	-196	203	181	582
2069	551	571	265	-91	-196	233	208	625
2070	588	606	291	-85	-197	262	236	669
2071	623	640	316	-81	-201	291	261	711
2072	653	669	335	-88	-216	310	277	743
2073	687	701	358	-90	-225	334	299	782
2074	726	738	384	-88	-232	357	319	818
2075	769	779	414	-84	-236	436	395	925
2076	817	824	447	-78	-239	464	420	969
2077	867	872	480	-72	-241	492	445	1013
2078	920	922	516	-65	-243	552	503	1098
2079	975	974	553	-59	-246	576	525	1139
2080	1026	1023	586	-57	-254	597	543	1176
2081	1084	1079	624	-52	-258	620	564	1218
2082	1146	1137	664	-47	-263	652	593	1270
2083	1209	1196	705	-43	-268	683	622	1323
2084	1279	1263	751	-34	-269	711	649	1373
2085	1358	1339	804	-21	-266	744	679	1430
2086	1433	1411	853	-13	-267	847	780	1575
2087	1513	1487	906	-3	-267	871	802	1622
2088	1596	1566	960	6	-268	916	846	1697
2089	1681	1647	1016	16	-269	1004	932	1826
2090	1766	1729	1072	22	-273	1044	971	1896
2091	1855	1814	1131	30	-277	1082	1007	1963
2092	1946	1901	1191	37	-281	1121	1045	2034
2093	2037	1989	1250	41	-288	1162	1083	2106
2094	2134	2083	1315	47	-293	1202	1122	2180
2095	2237	2183	1384	56	-297	1248	1165	2261
2096	2349	2291	1459	69	-297	1307	1223	2359
2097	2461	2401	1535	79	-299	1369	1281	2461
2098	2592	2530	1626	102	-291	1448	1358	2585
2099	2770	2707	1755	159	-249	1664	1570	2882
2100	2974	2911	1905	234	-191	1901	1803	3206

Source: Author's calculations

Appendix 9. Results of microsimulation model – The first, second and third pillar nominal average pension in euros with redistribution of the surplus

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	439	441	391	391	391	391	391	388
2017	468	469	409	409	409	409	409	405
2018	516	517	439	438	439	439	439	435
2019	554	555	474	473	474	474	474	470
2020	552	553	519	517	518	518	518	514
2021	540	542	540	538	540	540	540	534
2022	560	562	545	542	544	544	544	562
2023	597	599	556	554	555	555	555	599
2024	619	622	576	578	580	580	580	624
2025	635	639	596	604	606	606	605	641
2026	651	655	613	623	625	627	626	668
2027	667	673	630	643	645	647	646	686
2028	685	691	648	663	665	667	666	707
2029	702	710	666	684	686	684	683	738
2030	721	730	685	706	708	706	705	758
2031	741	751	705	729	731	729	728	780
2032	762	773	726	753	755	753	752	804
2033	781	793	748	779	781	778	777	826
2034	802	816	771	806	808	808	806	868
2035	822	837	796	834	836	836	835	891
2036	843	859	821	864	865	865	863	917
2037	865	883	847	894	895	886	884	956
2038	887	907	874	925	927	919	916	982
2039	911	932	902	958	959	952	949	1008
2040	935	958	931	992	993	986	982	1037
2041	960	985	961	1026	1027	1021	1018	1066
2042	986	1012	991	1062	1062	1058	1053	1097
2043	1013	1041	1023	1099	1100	1102	1097	1152
2044	1039	1069	1055	1137	1138	1142	1136	1183
2045	1064	1096	1087	1176	1176	1182	1176	1216
2046	1091	1125	1120	1215	1217	1207	1200	1263
2047	1118	1153	1154	1255	1258	1249	1241	1298
2048	1146	1182	1193	1301	1306	1292	1284	1331
2049	1174	1212	1233	1348	1355	1337	1328	1367
2050	1201	1241	1273	1396	1405	1382	1374	1401
2051	1229	1270	1314	1444	1457	1436	1428	1437
2052	1258	1300	1357	1495	1511	1489	1483	1472
2053	1289	1332	1402	1548	1568	1555	1550	1543
2054	1323	1367	1448	1603	1626	1612	1607	1579
2055	1361	1405	1494	1658	1685	1672	1668	1618
2056	1406	1451	1539	1712	1744	1698	1695	1679
2057	1454	1499	1584	1768	1804	1764	1763	1725
2058	1506	1552	1629	1823	1864	1833	1833	1773

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2059	1562	1610	1682	1879	1925	1902	1903	1829
2060	1623	1671	1750	1936	1988	1969	1972	1893
2061	1686	1735	1819	1996	2054	2038	2044	1961
2062	1753	1803	1892	2060	2123	2111	2113	2034
2063	1825	1877	1972	2127	2196	2201	2201	2115
2064	1899	1953	2055	2199	2273	2330	2330	2235
2065	1976	2031	2142	2276	2356	2429	2429	2327
2066	2054	2111	2231	2355	2441	2535	2535	2426
2067	2136	2194	2324	2439	2531	2625	2625	2548
2068	2221	2282	2422	2525	2624	2746	2746	2660
2069	2306	2367	2520	2616	2722	2870	2870	2773
2070	2391	2455	2621	2711	2824	3000	3000	2889
2071	2476	2542	2724	2811	2932	3130	3130	3006
2072	2565	2633	2833	2928	3057	3267	3267	3129
2073	2653	2723	2943	3039	3176	3403	3403	3250
2074	2748	2821	3061	3155	3300	3543	3543	3372
2075	2849	2924	3186	3277	3430	3768	3768	3573
2076	2957	3035	3316	3401	3562	3928	3928	3711
2077	3068	3149	3448	3528	3698	4096	4097	3852
2078	3185	3269	3586	3659	3838	4212	4213	4026
2079	3305	3392	3728	3795	3984	4394	4394	4172
2080	3424	3516	3872	3937	4135	4575	4576	4320
2081	3551	3647	4024	4084	4292	4769	4770	4477
2082	3683	3785	4183	4239	4456	4975	4975	4649
2083	3820	3928	4349	4401	4628	5183	5183	4826
2084	3966	4081	4520	4564	4801	5392	5393	5006
2085	4123	4245	4702	4733	4979	5614	5615	5197
2086	4278	4409	4883	4906	5162	5954	5955	5492
2087	4440	4582	5073	5087	5354	6184	6184	5688
2088	4607	4761	5270	5281	5552	6450	6450	5917
2089	4779	4945	5473	5485	5756	6620	6620	6176
2090	4954	5132	5678	5690	5966	6894	6894	6402
2091	5134	5327	5891	5903	6183	7162	7161	6633
2092	5320	5530	6110	6123	6407	7437	7436	6873
2093	5508	5733	6332	6346	6636	7716	7714	7119
2094	5704	5945	6563	6577	6872	8001	7997	7371
2095	5909	6163	6799	6814	7112	8296	8290	7634
2096	6125	6393	7048	7064	7361	8613	8607	7917
2097	6345	6628	7302	7319	7617	8935	8929	8210
2098	6586	6886	7583	7601	7886	9289	9277	8534
2099	6883	7201	7927	7946	8184	9851	9830	9053
2100	7209	7546	8303	8322	8494	10450	10417	9604

Source: Author’s calculations

Appendix 10. Results of microsimulation model –
The first pillar nominal average pension in euros with the redistribution of surplus in sensitivity 1 (no migration)

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	439	440	388	388	388	388	388	388
2017	468	468	405	405	405	405	405	405
2018	514	514	435	434	435	435	435	435
2019	548	548	470	469	470	470	470	470
2020	541	540	513	512	513	513	513	513
2021	539	534	533	532	533	533	533	533
2022	549	549	534	530	532	532	532	532
2023	588	588	552	552	553	554	553	569
2024	608	608	571	576	578	578	577	589
2025	623	623	587	596	598	598	598	602
2026	638	638	601	612	614	615	615	626
2027	654	654	614	628	630	631	631	641
2028	670	670	629	644	646	647	647	660
2029	688	688	643	661	664	664	664	688
2030	706	706	658	678	681	681	681	705
2031	725	725	673	696	699	699	698	724
2032	745	745	689	715	718	717	717	745
2033	763	763	705	734	737	737	736	763
2034	783	783	722	755	757	758	757	798
2035	802	802	739	775	778	779	778	818
2036	820	820	757	796	798	799	798	839
2037	841	841	774	817	820	819	818	875
2038	862	862	793	839	841	840	839	896
2039	883	883	811	861	864	862	861	917
2040	906	906	830	884	887	884	883	940
2041	928	928	849	907	909	907	905	965
2042	952	952	869	931	933	930	928	989
2043	975	975	889	955	958	957	955	1032
2044	999	999	908	979	982	982	979	1058
2045	1021	1021	927	1003	1006	1005	1002	1084
2046	1045	1045	945	1026	1030	1029	1025	1126
2047	1068	1068	964	1050	1054	1052	1048	1153
2048	1092	1092	982	1073	1080	1076	1071	1179
2049	1115	1115	1000	1096	1105	1099	1095	1204
2050	1138	1138	1018	1119	1131	1121	1118	1230
2051	1161	1161	1036	1143	1158	1144	1142	1256
2052	1185	1185	1055	1167	1186	1167	1166	1280
2053	1212	1212	1075	1192	1214	1194	1195	1336
2054	1240	1239	1095	1218	1244	1218	1220	1363
2055	1272	1272	1115	1245	1274	1243	1246	1392
2056	1312	1312	1136	1273	1306	1268	1273	1442
2057	1354	1354	1158	1301	1339	1295	1301	1477
2058	1402	1401	1181	1331	1373	1322	1330	1511

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2059	1454	1453	1204	1362	1409	1351	1361	1556
2060	1511	1511	1229	1395	1447	1382	1394	1607
2061	1572	1572	1258	1429	1487	1414	1428	1661
2062	1636	1636	1309	1466	1528	1447	1464	1723
2063	1703	1703	1363	1505	1572	1482	1502	1791
2064	1772	1772	1419	1545	1617	1521	1543	1889
2065	1844	1844	1476	1588	1665	1577	1584	1970
2066	1916	1916	1534	1632	1714	1642	1642	2050
2067	1989	1990	1593	1678	1766	1725	1725	2154
2068	2066	2067	1654	1726	1819	1798	1798	2246
2069	2141	2141	1714	1776	1875	1870	1870	2336
2070	2215	2216	1773	1826	1932	1946	1947	2431
2071	2288	2289	1832	1878	1991	2021	2021	2524
2072	2361	2361	1890	1932	2051	2097	2097	2619
2073	2435	2436	1950	1988	2114	2173	2173	2714
2074	2512	2513	2011	2045	2178	2246	2246	2805
2075	2592	2593	2075	2105	2245	2369	2370	2959
2076	2680	2680	2145	2165	2313	2451	2451	3061
2077	2772	2772	2219	2229	2383	2534	2535	3166
2078	2865	2866	2294	2298	2457	2637	2637	3294
2079	2963	2964	2372	2377	2532	2715	2715	3391
2080	3057	3058	2447	2452	2609	2798	2798	3495
2081	3158	3159	2528	2533	2688	2883	2883	3601
2082	3265	3266	2614	2619	2771	2977	2978	3719
2083	3375	3375	2702	2707	2855	3070	3070	3834
2084	3499	3500	2801	2807	2943	3176	3177	3968
2085	3626	3627	2903	2909	3032	3279	3279	4095
2086	3757	3757	3007	3013	3125	3445	3445	4303
2087	3888	3888	3112	3118	3220	3545	3546	4428
2088	4026	4026	3222	3229	3318	3666	3666	4579
2089	4168	4169	3337	3343	3420	3821	3822	4773
2090	4312	4312	3451	3458	3524	3941	3942	4923
2091	4459	4459	3569	3576	3630	4069	4069	5083
2092	4612	4612	3692	3699	3740	4202	4202	5248
2093	4769	4769	3817	3825	3853	4334	4335	5414
2094	4932	4933	3948	3957	3970	4470	4470	5583
2095	5106	5107	4087	4096	4098	4607	4608	5755
2096	5286	5286	4231	4240	4242	4762	4762	5948
2097	5471	5472	4380	4389	4391	4926	4927	6153
2098	5674	5674	4541	4551	4554	5113	5114	6387
2099	5926	5927	4744	4754	4757	5409	5410	6757
2100	6203	6204	4965	4976	4979	5723	5724	7149

Source: Author's calculations

Appendix 11. Results of microsimulation model –
The first pillar nominal average pension in euros with the redistribution of surplus in sensitivity 2 (lower GDP growth)

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	439	441	387	387	387	387	387	387
2017	468	468	404	404	404	404	404	404
2018	516	516	434	434	434	434	434	434
2019	554	554	469	468	469	469	469	469
2020	552	552	512	511	512	512	512	512
2021	540	540	532	530	532	532	532	532
2022	542	541	535	533	534	534	534	541
2023	558	558	539	533	534	534	534	557
2024	566	566	549	543	545	545	545	567
2025	573	573	558	553	554	554	554	573
2026	579	579	567	561	563	565	564	590
2027	587	585	576	570	571	573	573	596
2028	598	593	586	579	581	582	582	605
2029	608	600	595	588	590	591	591	624
2030	619	609	605	597	599	601	600	631
2031	630	620	615	607	609	610	609	640
2032	641	631	625	617	619	620	619	649
2033	652	642	635	627	629	630	629	656
2034	663	654	646	637	639	641	640	678
2035	675	666	657	648	649	652	651	685
2036	688	678	668	658	660	662	660	695
2037	700	691	680	670	671	673	671	715
2038	713	704	691	681	682	684	682	723
2039	726	718	703	692	694	695	693	731
2040	740	731	715	704	705	707	704	740
2041	753	745	727	716	717	718	715	750
2042	767	759	739	728	728	730	726	759
2043	781	773	752	740	740	744	740	784
2044	795	787	763	751	751	756	752	793
2045	808	801	775	763	763	768	763	804
2046	822	815	786	774	775	780	774	825
2047	837	829	798	785	787	791	785	836
2048	851	843	809	796	799	802	796	845
2049	865	857	820	807	812	814	807	856
2050	880	872	831	818	826	825	819	865
2051	895	887	843	830	839	836	830	876
2052	911	902	855	842	854	847	843	885
2053	927	918	867	855	869	862	858	916
2054	943	934	880	867	884	874	871	926
2055	960	950	893	881	900	886	884	936
2056	977	966	906	894	916	899	897	962
2057	995	983	919	907	933	912	911	975
2058	1013	1000	933	921	949	925	925	989

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2059	1031	1017	947	935	967	938	939	1006
2060	1050	1034	961	950	985	952	954	1027
2061	1069	1052	976	965	1003	966	970	1049
2062	1089	1071	991	981	1022	980	985	1073
2063	1109	1091	1007	997	1042	994	1001	1100
2064	1129	1112	1024	1014	1062	1012	1020	1145
2065	1151	1134	1042	1032	1083	1027	1037	1175
2066	1172	1156	1060	1051	1105	1044	1056	1206
2067	1195	1179	1079	1070	1127	1062	1074	1250
2068	1218	1203	1098	1089	1150	1080	1093	1284
2069	1241	1228	1118	1110	1174	1099	1114	1318
2070	1266	1253	1139	1131	1199	1118	1135	1352
2071	1291	1279	1161	1153	1224	1139	1156	1385
2072	1317	1307	1184	1176	1251	1160	1179	1418
2073	1344	1335	1207	1200	1279	1182	1203	1451
2074	1372	1364	1232	1224	1307	1206	1228	1483
2075	1401	1395	1257	1250	1336	1238	1254	1547
2076	1430	1425	1283	1276	1366	1266	1280	1582
2077	1460	1457	1310	1303	1397	1294	1307	1616
2078	1490	1489	1338	1331	1429	1335	1335	1667
2079	1522	1522	1367	1359	1462	1362	1363	1701
2080	1554	1556	1396	1389	1495	1388	1393	1733
2081	1586	1590	1426	1419	1529	1415	1423	1767
2082	1619	1625	1458	1450	1564	1445	1454	1806
2083	1654	1662	1491	1483	1600	1476	1486	1844
2084	1689	1699	1523	1515	1637	1506	1518	1881
2085	1724	1736	1557	1549	1674	1538	1551	1921
2086	1760	1775	1591	1583	1711	1598	1598	1996
2087	1797	1814	1626	1618	1750	1627	1627	2032
2088	1835	1854	1663	1654	1789	1663	1663	2078
2089	1874	1894	1699	1690	1830	1714	1714	2141
2090	1913	1936	1737	1728	1870	1749	1749	2185
2091	1953	1978	1774	1765	1912	1782	1782	2226
2092	1994	2020	1813	1804	1954	1817	1817	2269
2093	2035	2064	1852	1843	1997	1851	1851	2312
2094	2077	2108	1892	1883	2040	1886	1886	2355
2095	2121	2152	1933	1923	2085	1923	1923	2402
2096	2165	2198	1974	1965	2130	1963	1963	2452
2097	2209	2243	2016	2007	2176	2004	2004	2503
2098	2255	2290	2058	2049	2223	2050	2050	2561
2099	2303	2339	2103	2094	2272	2141	2141	2675
2100	2353	2389	2148	2140	2323	2237	2238	2795

Source: Author's calculations

Appendix 12. Results of microsimulation model –
The first pillar nominal average pension in euros with the redistribution of surplus in sensitivity 3 (higher GDP growth)

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	439	441	387	387	387	387	387	387
2017	468	468	404	404	404	404	404	404
2018	516	516	434	434	434	434	434	434
2019	554	554	469	468	469	469	469	469
2020	552	552	512	511	512	512	512	512
2021	540	540	532	530	532	532	532	532
2022	579	579	535	533	534	534	534	579
2023	639	639	558	562	564	564	564	640
2024	678	678	586	601	603	603	603	681
2025	704	704	610	634	636	637	636	707
2026	731	731	628	659	661	663	662	746
2027	760	760	647	684	686	689	688	775
2028	790	790	667	711	713	715	714	809
2029	822	822	687	738	740	742	741	856
2030	856	856	708	766	769	770	769	891
2031	892	892	730	796	798	799	798	929
2032	931	931	759	827	830	831	830	970
2033	968	969	789	861	863	865	863	1011
2034	1009	1009	821	896	899	902	900	1077
2035	1049	1049	852	934	936	939	937	1119
2036	1090	1090	884	970	973	975	973	1166
2037	1134	1134	918	1009	1011	1013	1010	1234
2038	1181	1181	955	1049	1051	1053	1050	1283
2039	1229	1229	992	1091	1093	1095	1091	1334
2040	1279	1279	1032	1135	1136	1138	1134	1388
2041	1331	1331	1073	1179	1181	1183	1178	1446
2042	1387	1387	1118	1226	1227	1229	1223	1507
2043	1446	1446	1163	1276	1277	1291	1291	1603
2044	1504	1504	1209	1327	1327	1341	1341	1667
2045	1561	1561	1254	1377	1378	1394	1394	1734
2046	1622	1622	1302	1429	1431	1469	1469	1828
2047	1684	1684	1351	1481	1484	1526	1526	1900
2048	1747	1747	1401	1535	1541	1582	1582	1971
2049	1813	1813	1453	1590	1599	1642	1642	2047
2050	1878	1878	1505	1646	1659	1702	1702	2122
2051	1946	1945	1558	1704	1721	1764	1765	2201
2052	2015	2015	1613	1764	1786	1826	1827	2279
2053	2091	2090	1674	1827	1854	1936	1936	2416
2054	2172	2172	1739	1892	1925	2005	2005	2503
2055	2262	2261	1810	1960	2000	2079	2079	2595
2056	2366	2366	1894	2032	2078	2190	2191	2735
2057	2478	2478	1983	2106	2160	2278	2279	2845
2058	2601	2601	2082	2185	2246	2373	2373	2963
2059	2735	2735	2189	2268	2338	2481	2482	3098
2060	2882	2882	2307	2356	2434	2605	2605	3252

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2061	3038	3037	2431	2450	2538	2738	2739	3419
2062	3204	3204	2565	2577	2649	2884	2884	3600
2063	3386	3386	2711	2723	2765	3044	3045	3801
2064	3578	3578	2864	2878	2888	3268	3269	4080
2065	3780	3780	3026	3041	3042	3457	3458	4316
2066	3991	3992	3195	3211	3213	3662	3662	4572
2067	4215	4216	3374	3391	3393	3915	3915	4887
2068	4454	4454	3565	3583	3586	4152	4153	5184
2069	4695	4695	3758	3778	3780	4395	4396	5487
2070	4944	4944	3957	3978	3980	4649	4649	5804
2071	5199	5200	4162	4183	4186	4910	4910	6130
2072	5465	5466	4375	4397	4400	5183	5183	6471
2073	5743	5744	4598	4621	4624	5469	5469	6828
2074	6040	6041	4835	4860	4863	5760	5760	7191
2075	6358	6359	5090	5116	5119	6194	6195	7734
2076	6700	6701	5363	5391	5395	6530	6530	8153
2077	7060	7060	5651	5680	5684	6880	6880	8590
2078	7441	7442	5956	5988	5992	7317	7317	9136
2079	7839	7840	6275	6308	6312	7696	7696	9609
2080	8247	8247	6601	6636	6641	8085	8085	10095
2081	8684	8685	6951	6988	6993	8499	8500	10612
2082	9147	9147	7322	7361	7365	8953	8954	11179
2083	9633	9633	7711	7752	7757	9427	9428	11771
2084	10155	10155	8128	8172	8177	9916	9917	12381
2085	10717	10717	8578	8624	8630	10439	10440	13035
2086	11291	11292	9038	9086	9092	11182	11184	13963
2087	11900	11900	9525	9576	9582	11738	11739	14657
2088	12538	12539	10036	10090	10096	12374	12375	15451
2089	13207	13208	10571	10628	10634	13148	13149	16418
2090	13900	13901	11126	11186	11193	13829	13830	17268
2091	14627	14628	11707	11771	11778	14529	14531	18143
2092	15390	15390	12318	12384	12392	15269	15270	19066
2093	16178	16179	12948	13019	13027	16041	16042	20031
2094	17011	17012	13615	13690	13698	16848	16849	21038
2095	17894	17895	14322	14400	14409	17709	17711	22114
2096	18835	18836	15075	15158	15166	18645	18646	23282
2097	19811	19812	15856	15944	15953	19624	19625	24505
2098	20881	20882	16712	16804	16813	20699	20701	25848
2099	22154	22154	17730	17828	17839	22282	22284	27824
2100	23560	23560	18855	18959	18971	24005	24007	29977

Source: Author’s calculations

Appendix 13. Results of microsimulation model –
The second pillar nominal average pension in euros
in sensitivity 4 (lower yield)

Scenario / Year	(3)	(4)	(5)	(6)	(7)
2016	23	23	23	23	23
2017	24	24	24	24	24
2018	24	24	24	24	24
2019	26	26	26	26	26
2020	28	28	28	28	28
2021	30	30	30	30	30
2022	32	32	32	32	32
2023	32	32	32	32	32
2024	35	35	35	35	35
2025	38	38	38	37	37
2026	40	40	40	40	40
2027	43	43	43	43	43
2028	46	46	46	46	46
2029	49	49	49	46	46
2030	52	52	52	49	49
2031	56	56	56	53	53
2032	59	59	59	57	57
2033	63	63	63	60	61
2034	67	67	67	65	65
2035	72	72	72	69	69
2036	77	77	77	74	74
2037	82	82	82	75	75
2038	87	87	87	81	81
2039	92	92	92	87	87
2040	98	98	98	93	93
2041	104	104	104	100	100
2042	110	110	110	106	106
2043	116	116	116	113	113
2044	123	123	123	121	121
2045	130	130	130	128	128
2046	138	138	138	130	130
2047	146	146	146	139	139
2048	156	156	156	148	148
2049	166	166	166	158	158
2050	175	175	175	169	169
2051	185	185	185	182	182
2052	195	195	195	194	194
2053	205	205	205	207	207
2054	216	216	216	219	219
2055	225	225	225	232	232
2056	234	234	234	235	235
2057	242	242	242	250	250
2058	250	250	250	264	264
2059	258	258	258	278	278
2060	265	265	265	290	290

Scenario Year	(3)	(4)	(5)	(6)	(7)
2061	273	273	273	301	301
2062	281	281	281	312	312
2063	291	290	291	322	322
2064	301	301	301	332	332
2065	312	312	312	343	343
2066	324	324	324	353	353
2067	336	336	336	358	358
2068	349	349	349	371	371
2069	363	363	362	387	387
2070	377	377	377	404	404
2071	393	393	393	421	421
2072	409	409	409	439	440
2073	427	427	427	458	459
2074	445	445	445	479	479
2075	464	464	464	500	501
2076	483	483	483	524	524
2077	502	502	502	548	549
2078	522	522	522	556	556
2079	543	543	543	587	587
2080	565	565	565	618	618
2081	587	587	587	650	650
2082	611	611	611	682	683
2083	636	635	635	715	715
2084	660	660	659	748	748
2085	684	684	684	782	782
2086	709	709	709	817	818
2087	735	735	734	853	853
2088	761	761	761	889	889
2089	788	788	788	903	904
2090	815	815	815	946	946
2091	843	843	842	986	987
2092	871	871	871	1027	1027
2093	900	900	900	1067	1067
2094	930	930	930	1108	1108
2095	961	961	961	1150	1150
2096	993	993	993	1193	1193
2097	1026	1027	1026	1237	1237
2098	1061	1061	1061	1280	1280
2099	1097	1097	1097	1325	1325
2100	1135	1135	1134	1372	1372

Source: Author’s calculations

Note: All are annuities even if the value of the second pillar is very low

Appendix 14. Results of microsimulation model –
all pillars nominal average pension in euros in sensitivity 4 (lower yield)

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	439	441	390	390	390	390	390	388
2017	468	469	408	408	408	408	408	405
2018	516	517	438	437	438	438	438	435
2019	554	555	473	472	473	473	473	470
2020	552	553	518	516	518	518	518	514
2021	540	542	539	537	539	539	539	534
2022	560	562	544	541	543	543	542	562
2023	597	599	554	552	554	554	554	599
2024	619	622	574	577	578	578	578	624
2025	635	639	594	602	603	604	603	641
2026	651	654	610	620	622	624	623	668
2027	667	672	626	639	641	643	642	686
2028	685	690	643	658	660	662	661	706
2029	702	708	661	678	680	679	678	737
2030	721	728	678	699	701	700	699	757
2031	741	749	697	721	723	721	720	779
2032	762	770	716	743	745	744	743	803
2033	781	790	737	767	769	768	766	825
2034	802	812	758	792	794	795	794	866
2035	822	833	780	819	820	822	820	889
2036	843	855	803	845	847	848	846	915
2037	865	878	826	873	874	869	867	953
2038	887	902	850	901	902	898	895	979
2039	911	926	875	930	932	927	925	1005
2040	935	952	900	960	962	958	955	1033
2041	960	978	926	991	992	989	986	1062
2042	986	1005	952	1022	1023	1021	1017	1092
2043	1013	1033	979	1056	1056	1060	1055	1146
2044	1039	1060	1006	1089	1089	1095	1089	1177
2045	1064	1087	1033	1122	1123	1130	1123	1209
2046	1091	1115	1061	1156	1157	1155	1148	1257
2047	1118	1143	1088	1190	1192	1190	1182	1290
2048	1146	1171	1118	1227	1231	1226	1218	1323
2049	1174	1200	1149	1265	1272	1263	1254	1358
2050	1201	1228	1180	1303	1312	1300	1292	1391
2051	1229	1257	1211	1342	1354	1341	1334	1426
2052	1258	1286	1244	1382	1398	1383	1377	1460
2053	1289	1318	1278	1424	1443	1434	1428	1529
2054	1323	1353	1312	1467	1490	1477	1473	1565
2055	1361	1390	1347	1511	1538	1523	1520	1603
2056	1406	1436	1382	1555	1587	1551	1549	1665
2057	1454	1484	1417	1600	1636	1601	1600	1709
2058	1506	1537	1451	1645	1687	1653	1653	1757
2059	1562	1594	1496	1692	1738	1705	1707	1812
2060	1623	1655	1553	1740	1792	1757	1761	1875

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2061	1686	1719	1613	1790	1848	1811	1817	1942
2062	1753	1786	1676	1844	1907	1871	1873	2014
2063	1825	1860	1745	1900	1969	1947	1947	2094
2064	1899	1935	1816	1960	2034	2058	2058	2213
2065	1976	2012	1889	2023	2103	2143	2143	2305
2066	2054	2092	1965	2089	2175	2234	2234	2403
2067	2136	2174	2044	2158	2250	2327	2327	2525
2068	2221	2261	2126	2229	2328	2431	2431	2636
2069	2306	2346	2208	2304	2410	2535	2536	2747
2070	2391	2433	2292	2383	2496	2644	2644	2862
2071	2476	2520	2378	2465	2585	2753	2754	2977
2072	2565	2610	2467	2562	2691	2868	2869	3098
2073	2653	2700	2557	2653	2790	2982	2982	3218
2074	2748	2796	2653	2748	2893	3097	3098	3338
2075	2849	2898	2756	2847	3000	3286	3287	3536
2076	2957	3008	2863	2948	3110	3418	3418	3672
2077	3068	3121	2974	3053	3224	3555	3555	3811
2078	3185	3240	3089	3162	3341	3683	3683	3985
2079	3305	3362	3208	3274	3463	3828	3828	4130
2080	3424	3484	3327	3392	3590	3973	3973	4275
2081	3551	3614	3454	3514	3722	4127	4127	4428
2082	3683	3750	3586	3642	3860	4293	4293	4596
2083	3820	3890	3724	3776	4003	4462	4463	4770
2084	3966	4041	3868	3912	4148	4633	4633	4945
2085	4123	4201	4021	4052	4299	4814	4814	5131
2086	4278	4362	4174	4197	4454	5093	5094	5418
2087	4440	4531	4335	4349	4615	5279	5279	5607
2088	4607	4705	4501	4512	4782	5495	5495	5828
2089	4779	4884	4671	4683	4955	5684	5685	6088
2090	4954	5066	4844	4856	5132	5903	5904	6308
2091	5134	5254	5023	5036	5315	6120	6120	6531
2092	5320	5449	5208	5221	5504	6343	6344	6762
2093	5508	5646	5395	5409	5699	6571	6571	7000
2094	5704	5851	5589	5603	5898	6805	6804	7243
2095	5909	6064	5790	5805	6103	7048	7047	7498
2096	6125	6288	6001	6017	6315	7312	7310	7774
2097	6345	6516	6217	6233	6533	7580	7578	8059
2098	6586	6767	6454	6471	6761	7876	7872	8373
2099	6883	7074	6745	6763	7008	8349	8341	8878
2100	7208	7410	7064	7083	7266	8855	8842	9418

Source: Author’s calculations

Appendix 15. Results of microsimulation model –
The second pillar nominal average pension in euros in sensitivity 5 (higher yield)

Scenario Year	(3)	(4)	(5)	(6)	(7)
2016	32	32	32	32	32
2017	34	34	34	34	34
2018	34	34	34	34	34
2019	36	36	36	36	36
2020	39	39	39	39	39
2021	42	42	42	42	42
2022	46	46	46	46	46
2023	46	46	46	46	46
2024	51	51	51	51	51
2025	56	56	56	56	56
2026	62	62	62	62	62
2027	68	68	68	68	68
2028	74	74	74	74	74
2029	81	81	81	74	74
2030	89	89	89	82	82
2031	97	97	97	91	91
2032	106	106	106	100	100
2033	116	116	116	110	110
2034	128	128	128	122	122
2035	140	140	140	134	134
2036	154	154	154	148	148
2037	168	168	168	149	149
2038	183	183	183	167	167
2039	199	199	199	185	185
2040	217	217	217	203	203
2041	236	236	236	224	224
2042	256	256	256	246	246
2043	277	277	277	269	269
2044	300	300	300	294	294
2045	326	326	326	320	320
2046	353	353	353	325	325
2047	383	383	383	357	357
2048	420	420	420	393	393
2049	458	458	458	431	431
2050	496	496	496	473	473
2051	535	535	535	524	524
2052	577	577	577	575	575
2053	620	620	620	627	627
2054	663	663	663	680	680
2055	704	704	704	736	736
2056	741	741	741	750	750
2057	778	778	778	816	816
2058	813	813	813	882	882
2059	848	848	848	945	945
2060	883	883	883	1002	1002

Scenario Year	(3)	(4)	(5)	(6)	(7)
2061	918	918	918	1057	1057
2062	957	957	957	1109	1109
2063	998	998	998	1159	1159
2064	1046	1046	1046	1210	1210
2065	1098	1098	1098	1261	1261
2066	1151	1151	1151	1316	1316
2067	1208	1208	1208	1336	1336
2068	1266	1266	1266	1406	1406
2069	1329	1329	1329	1485	1485
2070	1396	1396	1396	1571	1571
2071	1467	1467	1467	1659	1659
2072	1544	1544	1544	1752	1752
2073	1624	1624	1624	1848	1848
2074	1705	1705	1705	1951	1951
2075	1791	1791	1791	2061	2061
2076	1876	1876	1876	2178	2178
2077	1962	1962	1962	2303	2303
2078	2050	2050	2050	2343	2343
2079	2142	2142	2142	2498	2498
2080	2240	2240	2240	2654	2654
2081	2338	2338	2338	2817	2817
2082	2440	2440	2440	2978	2978
2083	2549	2549	2549	3140	3140
2084	2653	2653	2653	3302	3302
2085	2759	2759	2759	3469	3469
2086	2865	2865	2865	3644	3644
2087	2976	2976	2976	3818	3818
2088	3089	3089	3089	3992	3992
2089	3205	3205	3205	4061	4061
2090	3321	3321	3321	4273	4273
2091	3437	3437	3437	4470	4470
2092	3557	3557	3557	4667	4667
2093	3680	3680	3680	4861	4861
2094	3806	3806	3806	5062	5062
2095	3936	3936	3936	5264	5264
2096	4071	4071	4071	5474	5474
2097	4211	4211	4211	5682	5682
2098	4357	4357	4357	5892	5892
2099	4508	4508	4508	6107	6107
2100	4667	4667	4667	6334	6334

Source: Author's calculations

Note: All are annuities even if the value of the second pillar is very low

Appendix 16. Results of microsimulation model –
all pillars nominal average pension in euros in sensitivity 5
(higher yield)

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2016	439	442	392	392	392	392	392	388
2017	468	469	409	409	409	409	409	406
2018	516	517	439	439	439	439	439	436
2019	554	555	475	474	475	475	475	471
2020	552	553	520	519	520	520	520	514
2021	540	543	542	540	541	541	541	535
2022	560	563	547	545	546	546	546	563
2023	597	599	558	556	557	558	557	600
2024	619	623	579	581	583	583	583	625
2025	635	640	600	608	610	610	609	643
2026	651	656	618	628	630	632	631	671
2027	667	674	636	649	651	653	652	689
2028	685	693	655	671	672	675	674	710
2029	702	712	675	693	695	691	691	741
2030	721	732	696	717	719	715	714	762
2031	741	754	718	742	744	740	739	785
2032	762	776	741	768	770	767	766	809
2033	781	797	766	797	799	795	793	832
2034	802	820	793	827	829	828	827	875
2035	822	842	821	859	861	860	859	899
2036	843	865	851	893	895	893	892	926
2037	865	889	881	928	929	914	912	965
2038	887	914	913	964	965	952	950	992
2039	911	940	947	1002	1004	991	988	1021
2040	935	967	982	1042	1043	1032	1028	1050
2041	960	994	1018	1083	1084	1074	1071	1082
2042	986	1023	1055	1126	1127	1119	1114	1114
2043	1013	1052	1095	1172	1172	1173	1168	1171
2044	1039	1081	1136	1218	1219	1222	1217	1205
2045	1064	1109	1178	1266	1267	1273	1267	1240
2046	1091	1139	1221	1316	1318	1297	1290	1287
2047	1118	1169	1266	1368	1371	1351	1343	1323
2048	1146	1199	1321	1429	1434	1407	1399	1359
2049	1174	1229	1378	1493	1500	1467	1458	1397
2050	1201	1259	1435	1557	1567	1529	1521	1434
2051	1229	1289	1493	1624	1636	1604	1597	1473
2052	1258	1319	1556	1694	1710	1681	1675	1509
2053	1289	1352	1622	1768	1787	1775	1770	1583
2054	1323	1388	1689	1844	1868	1857	1852	1620
2055	1361	1426	1757	1921	1948	1945	1941	1660
2056	1406	1473	1822	1995	2027	1967	1964	1721
2057	1454	1522	1887	2071	2107	2066	2065	1767
2058	1506	1576	1951	2145	2186	2168	2169	1816
2059	1562	1633	2023	2219	2266	2270	2272	1873
2060	1623	1696	2110	2296	2348	2368	2372	1937

Scenario Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2061	1686	1760	2199	2376	2434	2468	2474	2006
2062	1753	1829	2293	2461	2524	2570	2572	2079
2063	1825	1904	2395	2550	2619	2688	2689	2161
2064	1899	1980	2503	2647	2722	2853	2853	2282
2065	1976	2059	2619	2752	2833	2983	2983	2375
2066	2054	2140	2736	2860	2946	3120	3121	2475
2067	2136	2225	2859	2974	3066	3205	3205	2595
2068	2221	2313	2988	3091	3191	3364	3365	2709
2069	2306	2400	3120	3216	3322	3531	3532	2823
2070	2391	2489	3257	3347	3460	3708	3709	2941
2071	2476	2577	3399	3486	3606	3886	3887	3060
2072	2565	2669	3549	3644	3773	4073	4073	3186
2073	2653	2761	3704	3799	3936	4260	4260	3309
2074	2748	2859	3867	3960	4105	4455	4455	3433
2075	2849	2964	4041	4131	4284	4758	4759	3637
2076	2957	3076	4217	4301	4463	4983	4984	3777
2077	3068	3193	4396	4475	4645	5223	5223	3921
2078	3185	3315	4582	4655	4833	5316	5317	4093
2079	3305	3440	4774	4841	5028	5581	5582	4243
2080	3424	3566	4969	5034	5231	5846	5847	4395
2081	3551	3700	5175	5235	5441	6130	6131	4556
2082	3683	3842	5390	5446	5663	6425	6425	4735
2083	3820	3989	5615	5667	5893	6721	6720	4920
2084	3966	4147	5844	5888	6124	7019	7017	5107
2085	4123	4316	6083	6115	6360	7334	7331	5307
2086	4278	4486	6323	6346	6602	7807	7805	5615
2087	4440	4667	6574	6589	6854	8136	8132	5823
2088	4607	4854	6835	6847	7116	8513	8509	6066
2089	4779	5046	7104	7116	7387	8642	8638	6323
2090	4954	5243	7375	7388	7663	9041	9038	6561
2091	5134	5450	7658	7670	7949	9424	9421	6809
2092	5320	5665	7948	7962	8244	9815	9812	7068
2093	5508	5880	8243	8257	8546	10207	10202	7331
2094	5704	6104	8547	8562	8854	10609	10602	7601
2095	5909	6333	8857	8873	9167	11017	11009	7877
2096	6125	6574	9183	9199	9492	11457	11447	8176
2097	6345	6820	9516	9533	9827	11902	11888	8486
2098	6586	7093	9886	9904	10181	12386	12360	8830
2099	6883	7423	10339	10357	10581	13146	13101	9376
2100	7209	7782	10831	10851	11000	13953	13882	9951

Source: Author’s calculations

SUMMARY IN ESTONIAN

Eesti pensionisüsteemi reformide mõju pensionide ebavõrdsusele – mikrosimulatsiooni ja tüüpilise agendi mudelite põhine analüüs

Doktoritöö keskmes on pensionisüsteemi reformide mõju pensionide ebavõrdsusele tulevikus. Töös hinnatakse Eestis läbiviidud pensionireforme, kasutades mikrosimulatsioonimudelit ja tüüpilise agendi mudelit. Väitekirja jaoks välja töötatud mikrosimulatsioonimudel on pensionide valdkonnas uudne, sest see hõlmab kogu riigi elanikkonda ja kolmesambalist pensionisüsteemi.

Pensionisüsteemi reformide analüüsimine on mitmetahuline teema ja vajab pika ajahorisondi vaadet. Paljud riigid on demograafiliste muutuste tõttu tõstnud kohustuslikku pensioniiga ja viinud osa riigi kaetud riskidest tagasi üksikisikutele. Selliste reformide mõjud on küllaltki erinevad, sealhulgas sissetulekute jaotusele – kas suurendavad või vähendavad pensionide ebavõrdsust.

Teoreetiliselt võib pensionisüsteeme liigitada mitmeti: näiteks rahastamise, kindlustusmatemaatilise põhimõtte või hüvitiste määramise põhimõtte alusel (kas määratud on sissemakse või hüvitis). Üldiselt on pensionisüsteemide keerukus tingitud sellest, et on soovitud tagada võimalikult paljude erinevate sotsiaaldemograafiliste tunnustega inimeste pensionikindlustus. Praktilisemalt öeldes jaguneb pensionisüsteem sageli nii-öelda sammasteks, kus igal sambal on oma eesmärk ja toimimismehhanism, kuid reaalsetes pensionisüsteemides erinevad sambad riigiti oluliselt. Näiteks esimese samba pension võib olla tingitud varasemast palgast, riigis elamise pikkusest või pensioniea teistest sissetulekutest. Riikide pensionisüsteemid on erisugused ning riikide demograafiliste, sotsiaalmajanduslike ja kultuuriliste erinevuste tõttu ei ole tõenäoliselt ühtegi parimat pensionisüsteemi kõikidele riikidele.

Pensionisüsteeme saab jagada Beveridge'i ja Bismarcki pensionisüsteemideks. Beveridge'i pensionisüsteemi eesmärk on hoida ära inimeste vaesusesse langemine, kasutades universaalseid või kuni teatud sissetulekuni saadavaid pensione. Bismarcki pensionisüsteemi eesmärk on hajutada tarbimist üle elukaare ja tagada tööeas teenitava tulu asendamine pensionieas pensioniga – selleks kasutatakse töötasuga seotud pensionihüvitisi. Riikliku rahastamise seisukohast peab süsteem olema jätkusuutlik, et pikaajalistelt oleks suund kulude ja tulude tasakaalu poole. Lisaks peaks pensionisüsteem arvesse võtma väliseid mõjusid, nagu mõju tööturule ja maksukoormusele jne.

Pensionisüsteemi reformid võivad tuleneda sisemistest ja välistest teguritest või nende kombinatsioonist. Viimasel ajal on üheks peamiseks pensionireformide väliseks mõjutajaks olnud elanikkonna vananemine. Võib eeldada, et tulevasi reforme ajendab tegema ka töövormide muutumine. Reformide sisemiseks teguriks võib olla pensionisüsteemi liigne killustatus või lihtsakoelisus, mis ei taga piisavat kaetust ja adekvaatsust.

Riigid on liikunud rohkem kindlaksmääratud sissemaksetel põhinevate skeemide suunas, aga on veel palju riike, kus on kasutusel kindlaksmääratud hüvitistega skeem, kuid vananemise ja rahvastiku vähenemise küsimus ei ole nendes riikides nii aktuaalne. Kuna säästmine on üheks viisiks rahvastiku vähenemisest ja vananemisest tingitud pensionisüsteemis avalduvate probleemidega tegelemiseks, siis eelfinantseeritud skeemi kasutab ühel või teisel viisil rohkem kui 50 riiki. Kuigi varasemalt loodi kohustuslikke eelfinantseeritavaid pensioniskeeme, on hiljuti kasutatud ka käitumuslikult taiplikke või nügimisskeeme. Nendes liidetakse inimesed automaatselt kogumisskeemiga, kuid inimestel on võimalus sellest loobuda. Näiteks Poolas kaotati majanduskriisi ajal kohustuslik kogumispension, kuid 2018. aasta lõpus loodi tööandja pensioniskeem, millel on käitumuslikud ja nügimise tunnused. Kogumispensionide loomine ei ole siiski ainus viis vananemisest tekkinud probleemidega toime tulla – paljud riigid on tõstnud kohustuslikku pensioniiga (sealhulgas Eesti) ja suurendanud miinimumpensionit või palgaga mitteseotud osa (sealhulgas Eesti).

1990. aastate lõpus koosnes Eesti pensionisüsteem PAYG-süsteemist (*pay-as-you-go* ehk jooksvalt rahastatav süsteem), kus pensionid olid seotud staažiga. Kuigi arutelud pensionisüsteemi reformi üle algasid 1990ndate alguses, oli esimene suur samm staažiosaku asendamine kindlustusosakuga (palgaga seotud osa) alates 1999. aastast. Samal ajal loodi ka vabatahtlik kogumispension. Töötasude ja tulevase pensioni vahelist seost tugevdas teine sammas – kohustuslik kogumispension loodi 2002. aastal. Järgmised kaks suurt reformi on seotud esimese sambaga – esiteks muudeti pensioniindeksit, et see oleks rohkem sõltuv sotsiaalmaksu laekumiste kasvust ja baasosa muudeti kindlustusosaku väärtusest kiiremini kasvavaks. Viimane muudatus PAYG-süsteemis tehti 2018. aasta lõpus, kui otsustati alates 2021. aastast luua solidaarosak ja siduda tulevane vanaduspensioniiga 65-aastaste oodatava elueaga alates 2027. aastast. Alates 2021. aastast muudeti kohustuslik kogumispension vabatahtlikuks. Doktoritöös ei muudetud kogumispensionit vabatahtlikuks, vaid lisati juurde hüpoteetiline ja äärmuslik stsenaarium, kus kõik, kes olid sellega liitunud, loobusid kogumisest.

Pensionisüsteemidesse on üldiselt sisse ehitatud ebavõrdsuse vähendamine. Selle kujundamiseks ja ka mõõtmiseks on erinevaid viise. Tavapäraselt mõõdetakse sissetulekute rahalist ebavõrdsust, mida on ka selles töös tehtud. Ebavõrdsuse hindamine võib põhineda inimeste vajadustel (vertikaalne võrdsus) ja panusel (horisontaalne võrdsus). Selles töös hinnati võrdsust põlvkondade vaatenurgast, selleks analüüsiti kohortide sisest ja vahelist ebavõrdsust. Ebavõrdsuse hindamiseks kasutati selles töös Gini koefitsienti. See indikaator ei näita täpselt, kuidas sissetulekud pensionisüsteemis ümber jaotatakse, aga näitab, mis on sissetulekute üldine ebavõrdsus.

Varasemad uuringud Eesti pensionisüsteemi kohta põhinevad peamiselt tüüpilise inimese hindamisel (nt keskmine palgatöötaja) või kogu riigi tasandil. Eestis on vähem uuritud põlvkondadevahelisi ja -siseseid mõjusid. Esimese artikli Eesti pensionisüsteemi reformide põlvkondadesisesest mõjust avaldasid Piirits ja Võrk (2019). Teistes riikides on analüüsitud pensionisüsteemi põlvkondadevahelisest vaatenurgast, kuid sarnased uuringud Eesti kohta puuduvad.

Kuigi riikidel on erinev majanduslik taust ja erinevad pensionisüsteemid, on üldiselt täheldatud, et kui vanaduspensioniiga tõstetakse, siis on eelisseisuses nooremad kohordid või kohordid, kes peagi hakkavad pensionile jääma. Tulevased kohordid peavad siiski pikemalt panustama, et säilitada sama asendusmäär. Pensionisüsteemide kindlustusmatemaatiliselt õiglasemaks muutmine suurendaks pensionisüsteemi finantsilist jätkusuutlikkust, aga teisalt võib see suurendada vaesust. Enamike pensionisüsteemi reformidega kaasnevad põlvkondadevahelised mõjud. Kuigi riigid on sellest teadlikud, ei leita alati viisi, kuidas saavutada võrdsem tulemus.

Sõltuvalt eesmärgist, kas vaadelda majandust tervikuna või üksikisikute vaatenurgast ja lähtuda andmete kättesaadavusest, kasutatakse uuringu küsimustele vastuste saamiseks sobivaimat mudelit. Mudelid võib liigitada teoreetilisteks või statistilisteks mudeliteks, üldise tasakaalu või pooltasakaalu mudeliteks, staatilisteks või dünaamilisteks mudeliteks, deterministlikeks või stohhastilisteks mudeliteks, tüüpilise või heterogeense agendi mudeliteks. Selle töö jaoks on välja töötatud tüüpilise agendi mudel ja mikrosimulatsioonimudel, sest need on pensionireformide ebavõrdsuse hindamiseks sobivaimad. Põlvkondadevahelist mõju saab hinnata individuaalsete andmete (tegelike andmete) või tüüpiliste inimeste põhjal. Mikrosimulatsiooni kasutamine tähendab erineva taustaga inimeste kaasamist, mis omakorda mõjutab pensionireformi koondtulemusi. Lisaks tuleks mikrosimulatsioonis simuleerida inimeste tulevasi elu aspekte, mis suurendab ka pensionireformi mõjude hajutatust. Selles väitekirjas kasutatakse põlvkondadevahelise mõju hindamiseks tüüpilise agendi pensionisimulatsioonimudelit ESTPEN ja põlvkondadevahelise ja põlvkonnasisese mõju simuleerimiseks mikrosimulatsioonimudelit ESTPEN-MICRO. See annab võimaluse võrrelda tüüpilise agendi ja mikrosimulatsioonimudeli tulemusi.

Mikrosimulatsioonimudelis kasutatakse kolmel registril põhinevaid Eesti rahvastiku andmeid (1,3 miljonit inimest 2016. aastal ja prognoosi järgi 1,1 miljonit inimest 2100. aastal). Tulevasi kohorte simuleeritakse Eurostati pikaajalise sündimuse, rände ja suremuse prognooside alusel. Iga-aastane elanikkond, lapsed, tööaeg enne 1999. aastat, tulevane töötamine ja palk, pensioniliigid, kohustuslik ja vabatahtlik kogumispension simuleeritakse võimalikult dünaamiliselt, et saada teavet võimalike tulevaste pensionide kohta. Vabatahtlikus kogumispensionis on lisaks eelnevale vajalik simuleerida liitumist ja sissemaksete suurust. Kogu elanikkonna mikrosimulatsiooni kasutamine ebavõrdsuse hindamiseks annab stabiilsemaid tulemusi mitmel põhjusel: 1) paljude kohortide olemasolu, kes saavad olema pensionireformidest erinevalt mõjutatud; 2) elutsükli simulatsioon ei põhine tüüpilisel inimesel, see tähendab, et üks isik võib saada kõrgemat palka esimesel perioodil ja madalamat palka teisel perioodil.

Eesti on näide riigist, millel on kolmesambaline pensionisüsteem, kuid millel on omad eripärad ja ajalugu. Kuni 1999. aastani oli Eestis riiklik pensionisüsteem, kus pensioniõigused teeniti vastavalt staažile (k.a töötamine, õppimine, ajateenistus ja teatud vanuseni lapse kasvatamine). Seetõttu on pensionide ebavõrdsus olnud suhteliselt madal. Kuigi kohustuslik kogumispension kehtestati 2002. aastal, kulub selle täieliku mõju saavutamiseni terve põlvkond. Sama kehtib ka esimese samba kindlustusosaku kohta, kuna praeguste pensionäride pensione mõjutab suuresti staaž. Need on põhjused, miks pensionide ebavõrdsus on olnud madal, ehkki viimastel aastatel kasvav ning tulevikus ebavõrdsus suureneb veelgi.

Kasutades tüüpilise agendi mudelit, näitab see, et kuigi nooremate kohortide madalapalgalistel töötajatel on reformid enamasti asendusmäära suurendanud (välja arvatud kindlustusosaku kasutuselevõtt), on nende inimeste pensionide asendusmäär siiski enamasti madalam kui vanematel kohortidel. Vastupidiselt kindlustusosaku reformiga on kohustusliku kogumispensioni kasutuselevõtt ja kiirem PAYG-skeemi pensionide indekseerimine suurendanud tulevaste pensionide suurust. Samal ajal annaks staažiosakuga PAYG-skeem madala palgaga töötajatele kõrgema asendusmäära. Põlvkondadevahelises vaates on nooremate kohortide pensionid ligikaudu samal tasemel kui vanematel sama palgatasemega kohortidel. Eelkõige on nii keskmist palka teenivatel inimestel stsenaariumis, kus vanaduspensioniiga on seotud oodatava elueaga. Kui arvutada tüüpilise agendi mudeliga, siis nähtub, et kohustusliku kogumispensioni kaotamine vähendab iga kohordi ja iga sissetulekutaseme tulevast pensioni. IRR ja RNPV vähenevad ka noorematel kohortidel, kuid IRR on positiivne ja suurem kui riskivaba instrumendi tootlus. Sellise tulemuseni viib piisavalt ümberjaotav esimene sammas ja eeldused teise samba tootluse kohta. Reformide tulemusel on pensionisüsteem ka kindlustusmatemaatiliselt õiglasem, kuna nooremate kohortide IRR-i suhtarv on erinevate palgatasemete vahel võrdsem (horisontaalne võrdsus), mis tähendab, et pension sõltub rohkem tema tegelikest sissemaksetest. Riigi seisukohast on riskivaba instrumendi tootlus ja IRR-i erinevus vähenemas.

Tulemustest ilmneb, et esimese samba pensionide ebavõrdsus pärast 2018. aasta pensionireformi (solidaarosaku loomine ja vanaduspensioniea sidumine oodatava elueaga) kasvab, mida väljendab Gini koefitsiendi suurenemine 0,102-lt 2016. aastal 0,134-ni aastaks 2050. Kuigi ebavõrdsus kasvab 2,2 protsendipunkti esialgsest tasemest (2016–2050), siis järgnevatel aastatel ebavõrdsus stabiliseerub ja väheneb. 2018. aasta reformide eesmärk oli parandada finantsilist jätkusuutlikkust ja tõsta madalapalgaliste tulevasi pensione. Sellest tulenevalt peaks ebavõrdsus tulevikus vähenema. Tehtud reformide muudatused on pikaajalised, sest nende mõju ilmneb alles 21. sajandi teises pooles. Reformide tulemusena väheneb ebavõrdsus 2100. aastaks tasemele 0,066. Kolmesambalise süsteemi täielik ebavõrdsus suureneb 2050. aastaks üle 50% (2010. aastal 0,107-lt 2050. aastaks 0,190-le), pool kasvust pärineb esimesest sambast ja teine pool teisest sambast. Kuna esimese ja teise samba ebavõrdsus hakkab pärast 2050. aastat vähenema, väheneb kogu pensionisüsteemi sissetulekute ebavõrdsus 2100. aastaks 0,156-ni. Pensionisüsteem saavutab suurema finantsilise jätkusuutlikkuse 2018. aasta pensionireformide tulemusel. Kui eelneva info põhjal vastata esimesele uurimisküsimusele (mil määral muutub vanaduspensionide ebavõrdsus aastaks 2100), siis ebavõrdsuse näitaja Gini koefitsient on ümberpööratud U kujuline. Kogu ebavõrdsus aastal 2100 on simulatsiooni järgi suurem kui 2016. aastal, kuid väiksem kui 2050. aastal, samas esimese samba vanaduspensionide ebavõrdsus on 35% väiksem kui 2016. aastal.

Kogu pensioni ebavõrdsus on Gini koefitsiendi järgi 0,156 võrreldes 0,4-ga palkadel. Seega kõik pensionisambad suudavad vähendada palkade ebavõrdsust, kuna Gini koefitsient on umbes 3 korda väiksem kui palkadel. Samas peab arvestama, et simuleeritud palkade ebavõrdsus on väiksem kui viimaste aastate tegelikel palkadel (0,46 versus 0,38). Teise samba ebavõrdsus moodustab palkade ebavõrdsusest 70% (0,329). Esimesse sambasse on sisse ehitatud tugevad ümberjagamise mehhanismid ja pärast viimaseid reforme suureneb ümberjagamine veelgi enam. Mudelis on eeldatud, et esimese samba tulude ülejääk jagatakse võrdselt kõigi pensionäride vahel. Teise ja kolmanda samba ebavõrdsust mõjutavad kaks aspekti: 1) palkade ebavõrdsus põhineb ühe aasta andmetel, pension aga pikema perioodi kumulatiivsel tulemusel; 2) fondide valik mõjutab tulevasi pensione. Vastuseks teisele uurimisküsimusele (milline on erinevate pensionisammaste roll – eraldi ja koos – tööturu sissetulekute ebavõrdsuse vähendamisel) selgub, et kuna esimese samba pension moodustab tulevikus suure osa pensionidest (70–80%), mõjutab esimese samba ebavõrdsus kõigi pensionäride tulevast kogupensioni ebavõrdsust suurel määral. Lisaks esimese samba ebavõrdsus aja jooksul väheneb.

Tüüpilise agendi mudelis kasutatav elutsükli keskmine palk peaks olema parim viis mikrosimulatsioonimudeli keskmiste tulemustega võrdlemiseks. Tüüpilise agendi mudelis oli asendusmäär ligikaudu 49%, mikrosimulatsioonimudelis just pensionile jäänutel 2100. aastal samuti 49% ja kõigi pensionäride puhul 40%. Erinevus ilmneks siis, kui esimese samba ülejääki poleks mikrosimulatsioonimudelis tekkinud ja pensionäride vahel ära jagatud (asendusmäär oleks 42% ilma ülejäägi jaotamiseta). Seega vastus kolmandale uurimisküsimusele (kas tüüpilise agendi ja mikrosimulatsioonimudeli tulemused on erinevad ja millises suunas nad erinevad) – võrreldes mikrosimulatsioonimudeliga on tüüpilise agendi mudeli tulevased pensionid suuremad.

Sellel väitekirjal on kaks suuremat praktilist väljundit. Analüüs annab poliitikakujundajatele ja laiemale avalikkusele pika vaate, milliseks kujuneb Eesti pensionisüsteem, selle adekvaatsus ja ebavõrdsus 21. sajandil. Töö eesmärkideni jõudmiseks loodud mudelid võimaldavad ka edaspidi analüüsida pensionisüsteemi kolme sammast just pikas perspektiivis. Tehtud töö annab parema teadmise ja ülevaate ka selle kohta, mis mudelit on otstarbekas kasutada vastavalt poliitikakujundamise eesmärkidele.

Tulevikuperspektiivina on loodud mudelite abiga võimalik hinnata aspekte, millele selles töös ei olnud eesmärk keskenduda. Näiteks saab analüüsida süvitsi pensioniea vaesust, soolist ebavõrdsust, vabatahtlikku kogumispensionit ja selle võimalikke alternatiive ning lisada saab inimeste varaseisu, mis on pensionieas ka oluline toimetulekut mõjutav tegur. Samuti on võimalik arendada mudeleid mitmekülgsemaks, võimalik on lisada makromudel, mis töötaks koos mikrosimulatsioonimudeliga iteratiivselt. Seeläbi muutuks mudel mitmekesisemaks, suudaks arvesse võtta erinevaid aspekte (näiteks hõivemäärade muutust) ja nende mõju tuleviku pensionile.

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