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Collective buffers in a new Dutch pension system with individual pension pots

The impact of the non-negative constraint

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1 Introduction

The Dutch pension system is considered to be among the best pension systems in the world. For many years, the Netherlands has been second place in the ranking of the Melbourne Mercer global pension index (Mercer, 2007), just after Denmark. The Netherlands receives high scores on sustainability, adequacy and especially integrity compared to other countries. Despite praise words from Mercer, there is much room for improvement for the Dutch pensions industry. Due to the substantial losses on equity markets in the financial crisis of 2008, the low discount rates afterwards and an increasing life expectancy, most Dutch pension funds became underfunded. Few pension funds were able to index the pension rights of their participants and some even had to cut pensions. The financial crisis and its effects triggered both Dutch pension fund participants and policymakers to start a discussion about the future of the Dutch pension system.

In 2012, the previous government already increased the retirement age in the first pillar pension (AOW, the Dutch pension pillars are described in section 2.1) and, in 2015, it decided to speed up that increase. Afterwards, to also reform the second pillar, that same government asked the Social Economic Council (Sociaal Economische Raad, SER) to come up with possible new pension system and investigate its effect. The SER is the most important advisor of the government regarding social economic policy and consists of representatives of employers, employees and independent specialists. Partly based on reports written by the SER, the current government took a stand in the discussion. Specifically, in their coalition agreement of 10 October 2017, the government set guidelines for the new pension system (see section 2.3.1) and urged the SER to come up with an agreement to reform the system. Moreover, the current government proposed a system with individual pension pots together with a collective buffer, described in the SER (2016) report as option IV-C-R, see section 2.2.4. However, the coalition remarks that this collective buffer should never be negative. As such, the largest Dutch labour union (FNV) said, in their reaction to the coalition agreement, that this 'non-negative constraint' is their biggest concern regarding the pension paragraph in the coalition agreement. The FNV advocated that this constraint is an obstruction for 'Intergenerational Risk Sharing'(IGR), while the government is in favour of this constraint, to not forward deficits to future generations. This disagreement between the coalition and FNV is the primary motivation for this thesis.

In this thesis, the effect of the 'non-negative constraint' on the welfare of both the current and future generations is provided, assuming a new pension system described by the SER as IV-C-R. This thesis contains an analysis of the system proposed in the coalition agreement and the reports of the SER. Additionally, alternative buffer systems and the effects of these systems are provided.

In section 2 the background of the problem is defined. Specifically, a description of the current Dutch pension system is provided and the content is given of the new pension systems as proposed in the two SER reports. Additionally, the view on the pension discussion of both the current government and the FNV is further explained. The aim of the collective buffer is to share risks between generations, section 2.4 therefore contains a description of the positive effects of sharing risks between generations (IGR), based on previous research. Furthermore, in section 2.4.4 it is explained that accepting possible negative buffers, can lead to an unsustainable system if the inflow of new premium is lower than expected, known as the discontinuity risk.

In section 3, a Monte Carlo model, based on the IV-C-R option of the SER is described. In the simplified pension fund model we only consider stock market risk and abstract from all other forms of risks. In this section, the assumptions on the population, financial market, premium and livecycle are explained. Furthermore, a description is given of how the pension benefits are calculated. Using the model described in section 3, three core buffer strategies are compared with each other;

- a system without a buffer
- a system with only positive buffers
- and a system with a buffer that can become both positive and negative

In section 4, the outcomes of the simulation are provided. The expectation and confidence intervals of the pension benefits are provided for the three different buffer strategies. Using utility theory, the welfare of the different strategies are compared. Furthermore, the welfare effects of two alternative buffer systems are provided, and the robustness of the assumptions are tested.

Finally, in section 5 it is concluded that a buffer can be welfare improving for all generations (compared to a system without a buffer), but only if the buffer is allowed to be negative and a risk premium is provided for future generations. In addition to that, it is stated that there is a severe discontinuity risk when negative buffers are allowed.

2 Background and Literature

In this section, the background of the problem is outlined. First, in section 2.1, a description is provided of the current Dutch pension system including its strengths and weaknesses. In section 2.2 a description of the pension systems, proposed by the Social Economic Council (Sociaal Economische Raad, SER) is provided. Since the motivation for this thesis is the disagreement between the current government and the FNV about the pension reform, their points of view are provided in section 2.3. Afterwards, in section 2.4, previous literature on IGR is pointed out. Finally, in section 2.5, the new Dutch law (from 2016) about investing after retirement date is discussed.

2.1 Current Dutch pension system

The income of Dutch retirees is divided into three pillars. In this section, the characteristics of these pillars are described. Bovenberg and Nijman (2017) identified the most important strengths and drivers of change of the Dutch pension system, in sections 2.1.4 and 2.1.5 their arguments are provided.

2.1.1 First Pillar: AOW

The first pillar consists of a general, wage independent, pay-as-you-go scheme called AOW (Algemene Ouderdoms Wet). This pension benefit is provided to all Dutch citizens who are older than the AOW age and have lived in the Netherlands for more than 50 years . The benefit is relatively low and equal to 70 % of the net minimum wage for people who are living alone and 50% of minimum wage for people who are living together. In 2017, 3.4 million people received AOW (CBS, 2018). Due to an ageing population, the AOW has become increasingly expensive, and for that reason, the government decided in 2012 to gradually increase the AOW age from 65 to 67, and later, in 2015, decided to speed up that increase. The AOW age will be 67 in 2022, and afterwards, the government will increase it with the life expectancy. Although some political parties and labour unions want to stop the AOW age increase, the political and public debate is now focused on the second pillar, which is discussed in the next section.

2.1.2 Second Pillar: occupational pension

The second pillar of the Dutch pension system consists of a semi-obligated occupational funded pension scheme. Most second pillar pension contracts are part of a (collective) labour contract, and therefore most employees must participate in the collective pension plan of the employer. A second pillar scheme is typically executed by non-profit pension funds (often company- or sector-specific) but these can also be implemented by general pension funds (Algemeen Pensioen Fonds, APF), premium pension institutions (PPI's) or insurers. In general, there are two types of occupational pension scheme, Defined Benefit (DB) and Defined Contribution (DC). In DB schemes, a wage-dependent premium is paid, and the accrued rights are (in principle) guaranteed, whereas in a DC scheme, participants pay a wage dependent premium and the pension benefit is based on this contribution and its accumulated returns until retirement. In the Netherlands, 95% of the contracts in the second pillar are DB (CBS, 2015). In a DB contract employees build up nominal rights which are indexed for inflation if the funding ratio is above a certain threshold. On the other hand, if the funding ratio is below a certain threshold, the nominal value of the pension rights can be lowered as well. Since the pension rights are not guaranteed but indirectly dependent on the financial markets, therefore this is actually a mixture of DB and DC.

Since premiums in the second pillar are tax deductible and the pension benefits are generally taxed at a lower rate, there is a substantial subsidy through taxes for pension savings in the second pillar.

2.1.3 Third Pillar: private savings

The third pillar consists of all savings aside from the second pillar schemes. Savings in the third pillar can include life insurance, ordinary bank savings but also investments in a house or other real estate. In contrast to the second pillar, savings in the third pillar are not subsidised.

2.1.4 Strengths

For most employees, retirement savings are mandatory. Therefore, the coverage ratio of the Dutch pension plan is relatively high; 90% of Dutch employees have coverage in a second pillar pension plan (CBS, 2015). Furthermore, the focus of pension funds is on a lifelong stable income stream. In contrast with other countries, Dutch employees are obligated to use their second-pillar pension wealth for a lifelong income stream. This obligation results in few retirees with (too) low pension income. Other strengths are due to the joint decision-making process of the Dutch pension funds. Since representatives of all stakeholders take a seat in the boards of these funds, individuals are protected against behavioural biases and have relatively high bargaining power. The third main strength comes from the collective nature of the Dutch pension schemes. Due to this collective system, participants share both micro longevity and disability risk and generations share the inflation, interest rate, marco longevity and stock-market risk.

2.1.5 Drivers of change

Besides the above strength, Bovenberg and Nijman (2017) indicated a few so-called drivers of change. The core argument is that the current system is designed for a 20^{th}-century society when most employees were employed by the same employer for their entire career. The Dutch DB contracts are financed with the so-called 'doorsneesystematiek'. In the 'doorsneesystematiek', the premium for specific pension rights is independent of age. The premium of young participants can be invested over a longer period than the premium of old participants, the total expected return on the premium is therefore higher for younger participants than for older ones this fact results in an implicit wealth transfer from young to old. Thus transfer is not much of a problem when participants pay this subsidy early in their career and receive it later on, but in a society with more labour flexibility and self-employed people, there is an increasing part of the population that is negatively affected by this policy. Besides the actuarial unfairness, this system can also be an obstruction to changing jobs or becoming self-employed.

2.2 SER alternatives

Although the government subsidises the second pillar pension due to a tax exemption, this second pillar is an agreement between the employers and employees. For that reason, reforms in the second pillar are unlikely to happen without the approval of the SER. The SER consists of representatives of employers and employees together with independent specialists and is an essential advisor to the government regarding socio-economic policy issues. In that role, the former Secretary of State of Social Affairs, Jetta Klijnsma, asked for a recommendation as part of the social dialogue about the future of the pension system. As a result of this question, the SER published a report called 'Future pension system' ('toekomst pensioenstelsel') (SER, 2015) that identified four different core alternative pension systems, which are described below. In their second report (SER, 2016) they investigated the fourth option more deeply.

2.2.1 Option I: Benefit agreement with degressive accrual

Option I-A Option I-A is based on the current DB system of nominal agreed benefits with a high probability of realising those benefits. In contrast to the current system, the accrued benefits become age dependent to abolish the intergenerational wealth transfer as a result of the current 'doorsneesystematiek'. In option I-A, the participation remains mandatory. However, it creates room for more choice regarding the allocation of risks among participants and age groups.

Option I-B Option I-B is the same as option I-A, with the difference that pension rights are real instead of nominal, which means that indexation is standard and does not depend on the financial markets. A result of the shift from nominal to real pension rights is that the probability of pension cuts will be higher. Furthermore, in option I-B the rules for cutting and increasing pensions are simplified.

2.2.2 Option II: National pension plan

In option II, there is one big national pension fund with one standardised mandatory pension plan for all Dutch employees. Although the 'doorsneesystematiek' is not abolished, its negative effects on labour market mobility are removed since the pension plan is independent of the participants' employer. Furthermore, the discontinuity risk (described in section 2.4.4) is reduced since, due to the mandatory origin, the inflow of new participants is guaranteed. In this option, risks can be shared optimally between and within generations.

2.2.3 Option III: Personal pension wealth with voluntary risk sharing

Option III creates maximum individual freedom of choice regarding the executor, the amount of pension premium, the amount of risk, the withdrawal strategy (lump sum or annuity) and insurance (survivor's pension, incapacitated pension, etc.). Participants have their own 'pension pot' in which they pay their premiums and receive their returns. Risks are in principle assigned to the participants themselves. However, one can share longevity risk by buying an annuity at retirement age. In option III, participation is not mandatory anymore.

2.2.4 Option IV: Personal pension wealth with collective risk sharing

Option IV is comparable with III, with the differences that participation is mandatory and risks are shared among participants. In the first report of the SER (2015), this option is called 'interesting but still too unknown'. For that reason, the SER wrote a new report in 2016 called 'Personal pension wealth with collective risk sharing' ('Persoonlijk pensioenvermogen met collectieve risicodeling') (SER, 2016). In the report of 2015, the SER proposed three different sub-alternatives, and in 2016 they slit-up the third alternative (IV-C) into two variants (IV-C-R and IV-C-D. Furthermore, they investigated all the options more deeply. The three sub-options are:

Option IV-A In option IV-A only micro longevity risks are shared among participants, all other risks are carried by the participants. Participants can, depending on their risk appetite, choose a life cycle with a suitable risk profile. Furthermore, in the retirement phase, they can choose between a relatively certain annuity or a more variable pension which depends more on equity returns.

Option IV-B Option IV-B is the same as IV-A with the difference that participants share investment risks. Within this option, the SER proposes different alternatives, ranging from sharing risks only among current retirees to sharing risks among all current participants. Option IV-B does not include a buffer since risk are only shared between living participants.

Option IV-C In the IV-C alternatives, there is personal pension wealth combined with a collective buffer. In contrast with the IV-B, the risk sharing is mandatory. The SER proposes two options. The first is, the IV-C-D where the pension fund sets a benefit goal: when the expected pension benefit is higher than a certain threshold, some wealth goes from the personal pension pot, into the buffer. If, on the other hand, the expected pension benefit is below a certain threshold, the personal wealth receives some wealth from the buffer. The expected pension benefits depend on fluctuations on the financial market but also on the estimation of parameters such as expected return, inflation, interest rate and mortality tables.

The second alternative is IV-C-R, which is a DC contract where wealth is going into a buffer in years with a high return, and the other way around when the stock market return is low in a specific year. The main difference between these two alternatives is that in IV-C-D the buffer is only used when the long-term (expected) final benefits are too high or too low and in IV-C-R, the buffer is used when the actual return in a specific year deviates too much from the expectation. Since the IV-C-R will be the basis of the model used in this thesis, a more detailed description of this alternative can be found in section 3.

2.3 Disagreement between government and FNV

2.3.1 Coalition Agreement

As part of the public debate, the SER published two reports in respectively 2015 and 2016. In anticipation of the national elections of the House of Representatives (Tweede Kamer), most political parties wrote a paragraph about pensions in their election programme. As a result of that, the coalition agreement of 10 October 2017 also contains a section about the upcoming pension reform. In the coalition agreement (VVD, CDA, D66, & ChristenUnie, 2017) the four political parties state that they want to reform the pension system but only with a mandate of the SER. As a guideline, they state that they want to abolish the weaknesses in the current system but keep the strong parts. As for weaknesses, they identify unmet expectations, the tension between generations and a bad fit with the current labour market. The strong parts according to the coalition are mandatory savings, collective execution, risk sharing and fiscal subsidy. To accomplish this, they want to abolish the 'doorsneesystematiek' and introduce an age-independent premium with an actuarial fair accrual. Secondly, in the new system, the lifelong annuity is still mandatory to prevent participants outliving their assets. Furthermore, in line with the reports of the SER, a collective buffer is introduced to absorb shocks in investment returns and life expectancy, with the constraint that the buffer is maximised and cannot be negative. The government wants to keep mandatory participation and an adequate pension for survivors and incapacitated people. In addition to these demands, the coalition seeks to allow more freedom of choice in the new pension system and the option for self-employed to participate. The government expects the SER to agree on a recommendation on how to reform the pension system, considering the above guidelines.

2.3.2 Labour unions

Although the discussions within the SER are confidential, one of the most prominent and influential labour unions, FNV, gave a reaction to the coalition agreement in the Dutch financial times, 'Financieel Dagblad'(Wolzak, 2017), just after the release of the agreement. The FNV shares the SER's concern about risk sharing among generations. The FNV is afraid that some generations will be lucky and others unlucky, after the proposed reform. Its primary concern is the 'non-negative constraint' of the collective buffer. The FNV states that in the current system negative buffers (funding ratios below 100%) are allowed and that if this option is abolished, there is less room for the absorption of shocks. In fact the FNV states that the impact of IGR is smaller when buffer are strictly positive.

2.4 Intergenerational Risk Sharing (IGR)

Both in the current Dutch pension system as in most proposed alternatives to the SER, risks of the current population are shared with future generations. In the current system, funding ratios are allowed to become below 100%, which means that the pension fund is not able to meet all its liabilities. Dutch pension funds have to increase the funding ratio within a recovery period of maximal ten years, by either increasing premiums, cut pensions or making higher returns. In all cases, new participants are negatively affected by current financial shocks. The other way around, if funding ratios are relatively high, the probability of indexation is higher for both the current participants as for new generations. In the IV-C-R alternative of the SER (the focus of this thesis) a buffer is created to absorbs shocks on the stock market. This buffer mechanism also leads to risk sharing of the current generation with the new generations. When the returns on stocks are high, future generations will benefit from a large buffer while if returns are low, a smaller buffer is left for next generations. Sharing risks with future generations is called 'Intergenerational Risk Sharing' (IGR). In this section, the advantages and disadvantages of IGR are described based on previous research.

2.4.1 Introduction to IGR

Diamond (1977) already referred to the concept of IGR. In his paper 'A Framework for social security analysis' he described the benefits of "the public provision of pensions in the U.S. by means of the Social Security system". Besides arguments regarding redistribution of labour income and paternalism, Diamond mentioned that an obligated pension system could reduce market failure. According to Diamond, one of these market failures is the lack of an opportunity for reasonable yields and a safe real rate of return. Diamond proposes that with a longer time horizon, a public pension provider can realise a safer pension. In other words, Diamond suggest that without IGR yield are either not high or not safe enough. He states that when risks are shared between generations, one can achieve a safe return with a higher yield.

Gordon and Varian (1988) explained that "markets cannot allocate risk efficiently between two generations whenever the two generations are not both alive before the occurrence of a stochastic event". Ideally one would share the risk of a current generation with as many generations as possible so that all generations are exposed to a risks occurring in as much as different time periods. Since stock market returns of different periods have typically a low or no correlation with each other, risk is reduced. However in regular financial markets it is not possible to make a contract to share risks with unborn agents or generations.

In their paper 'Intergenerational Risk Sharing', Gordan and Varian came up with a two-period overlapping generation model to show that sharing risks with (unborn) generations, is welfare improving. In this simple model, they assume that each generation receives a fixed income(W) and an uncertain income with expectation zero(e_t) which are independent and identically distributed (i.i.d). They propose a system where each generation shifts half of e_t to the next generation so that the income of generation t ($t > 1$) is not $[W + e_t]$ but $\left[W + \frac{e_t+e_{t-1}}{2}\right]$. Since e_t and e_{t-1} are uncorrelated and both have expectation zero, the variance of $\left[W + \frac{e_t+e_{t-1}}{2}\right]$ is smaller than $[W + e_t]$. Both incomes have expectation W, and therefore the utility (see 3.13.1) of $\left[W + \frac{e_t+e_{t-1}}{2}\right]$ is higher than $[W + e_t]$. Furthermore, the first generation only has income $\left[W + \frac{e_1}{2}\right]$ which has a higher utility than $[W + e_1]$ because the risk is reduced. Gordan and Varian proved that this simple form of IGR leads to a higher expected utility for all generations, which they call 'Pareto improvement'.

2.4.2 IGR in PAYG

In this section recent research is used to provide the effects on IGR in pay-as-you-go(PAYG) systems. A pay-as-you-go system is a pension system where current workers pay for the pension benefits of the current retirees. Krueger (2005) showed that given incomplete markets and inperfectly correlated returns to capital and wages, an unfunded PAYG system is Pareto improving, which again means, welfare improving for all generations compared to a system without PAYG. Krueger and Kubler used a simple two-period overlapping generation model. Furthermore, van Hemert (2005) came up with a more sophisticated model which takes into account the financial risk of both the workers and the retirees to optimise the wealth transfers from workers to retirees in a PAYG system. Hemert used data on US GNP and US stock data to proxy labour income and capital returns and found that the welfare improvement in this optimal setting is even more significant than in more simpler settings with a constant wealth transfer. Besides Krueger and Hemert, Bohn (2009) among others proved similar results.

2.4.3 IGR in Funded systems

In contrary to the authors in the previous section, Cui, Jonge, and de Ponds (2011) used a multi-period overlapping generation model (OLG) to study the risk sharing between generations in a funded system. Using a 55-period model they found that a pension fund which allows adjustments in both contributions as benefits is most welfare efficient. Furthermore, they found that with IGR, a pension system can bear more risk while participant do not receive more uncertain pension benefits. When more risk is taken, the pension fund benefits more from the equity premium.

2.4.4 Discontinuity risk

Despite the welfare improving opportunities described before, there is also the other side of the coin called discontinuity risk. Discontinuity risk is the risk that, due to IGR, future participants are not willing to enter the collective pension system, due to a (too large) deficit in the system. If risks can be shifted unlimited to new generations, this can be welfare improving for all generations. However transferring risks to new generations always means that there is a probability that new, young generations will have to hand in wealth to the old and retired generation. If the transfers needed from new inflow is too high, the risk occurs that the new generation is not willing to participate in this contract. Westerhout (2011) described that even in a system with mandatory participation new generations can avoid participation by leaving a firm, industry or even their country. Furthermore, less radical, new generations can use political methods to try to not participate in a such a pension system. This means that pension schemes with mandatory participation are not by definition sustainable.

2.4.5 IGR and buffer in the Dutch pension system

In the current Dutch DB system, wealth and risk are transferred between generations. If funding ratios are above a certain level, pension rights are indexed, but only with a maximum of the price inflation. In fact, a system where funding ratios are not necessarily equal to 100%, can be seen as a system with a buffer which can be both positive and negative. If the funding ratio remains high, the probability of being above that threshold is higher and therefore the probability of indexation will go up for future generations. On the other hand, if the funding ratio of a pension fund becomes under 100%, pension rights are not cut immediately but gradually over a smoothing period of maximum ten years. Due to this smoothing period also the accrual of new generations is cut and in general their probability of indexation is lowered.

2.4.6 Summary of background on IGR

Research shows that Intergenerational Risk Sharing has the potential to increase welfare for all generations participating in a pension fund. Most papers discussed assume mandatory participation and a constant inflow of new premium. In practice however, new inflow is never guaranteed and therefore this assumption is not always met. In that case, a pension system can become unsustainable due to IGR.

2.5 Investing in stocks after the retirement date

In September 2016 a new law is approved which allows pension funds with a DC scheme, to invest the pension wealth of participants in stock markets after they reach the retirement date. The law is called 'wet verbeterde premieregeling' (law better Defined Contribution schemes). Before September 2016 it was mandatory to transfer the wealth of the participants at retirement into a lifelong, guaranteed annuity and therefore only invest in government bonds. This new law gives the opportunity for pension funds and insurers to come up with products that did not exist before, yet only few pension providers provide these products now. The guaranteed, fixed, lifelong annuity, which was (and is) the standard in the Dutch second pillar pension, is a standard product with no variations. The variable annuity, on the other hand, lets more room for variation. One can for example chose different life cycles after retirement. It is however still mandatory to buy a lifelong annuity.

3 Model

In this section, a description is given of the model used to determine the welfare effects of the different buffer strategies. As mentioned in the introduction, the model is based on the IV-C-R option of the SER (2016) which is further described in section 3.1. In section 3.2, simplifying assumptions are made where necessary. In section 3.3, the outline of the model is provided, and in sections 3.4 to 3.7, assumptions on respectively population, financial market, premium and life cycle are made. Sections 3.8 to 3.12 explain how the pension wealth, benefits en buffer heights (amount of wealth in the buffer) are calculated. Finally, in section 3.13.2 the 'Certain equivalent' is explained, which is used as a measure of welfare. All descriptions and assumption in this section relate to the standard model. At the end of this section,

3.1 Characteristics according to the SER

In the IV-C-R alternative, personal pension wealth is combined with a collective buffer, which is used based on the annual returns. The buffer is only used for stock market risk and is therefore only considering the parts of personal pension wealth which is invested in stocks. If the returns on these stock portfolios are below the 20^{th} percentile of the expected distribution of the stock returns, the returns on the personal pension pots (invested in stocks) are compensated by wealth from the buffer while if the returns are above the 80^{th} percentile, wealth goes into the buffer. Furthermore, the SER proposes to maximise the buffer at 10, 20 or 30 percent of total personal pension wealth. If the buffer is at its maximum, no part of the return will flow into the buffer. Besides that, the SER prescribes that the investment mix of the personal pension wealth should follow a life cycle, while the investment mix of the buffer should be uniform. For this model, we assume that the buffer is invested according to the weighted average investment mix of all personal pension pots as explained in section 3.12.

3.2 Assumptions about the new pension system

Both the coalition and the SER did not yet state strict rules on the proposed IV-C-R system. Furthermore, the goal of this thesis is not to provide exact outcomes of the proposed system but above all the directions of the welfare effects. Therefore, we make (simplifying) assumptions, which are stated below. In robustness checks of section 4.7, some of the assumptions are tested.

- Stock and bond prices follow the Black and Scholes market
- Wage and pension premiums are constant and age-independent
- Inflation is equal to zero
- Micro- and macro-longevity risk is not taken into account
- The life cycle is linear declining
- Pension benefits are calculated every year, based on current wealth and expected returns
- The employees carry all risks
- The buffer is maximised at 20% of total personal pension wealth
- The buffer is invested according to the weighted average investment mix of all personal pension pots

3.3 Model description

In this section, a description is given of how the proposed pension system is implemented in the model, which is based on the aspects and assumptions of the previous section. A fictional population is modelled in a simplified system, to identify the effects of the 'non-negative constraint' of the collective buffer. Three pension systems are identified which are all evaluated under the same scenarios, namely

- a pension fund with no buffer
- a pension fund with a strictly positive buffer
- a pension fund with a negative or positive buffer

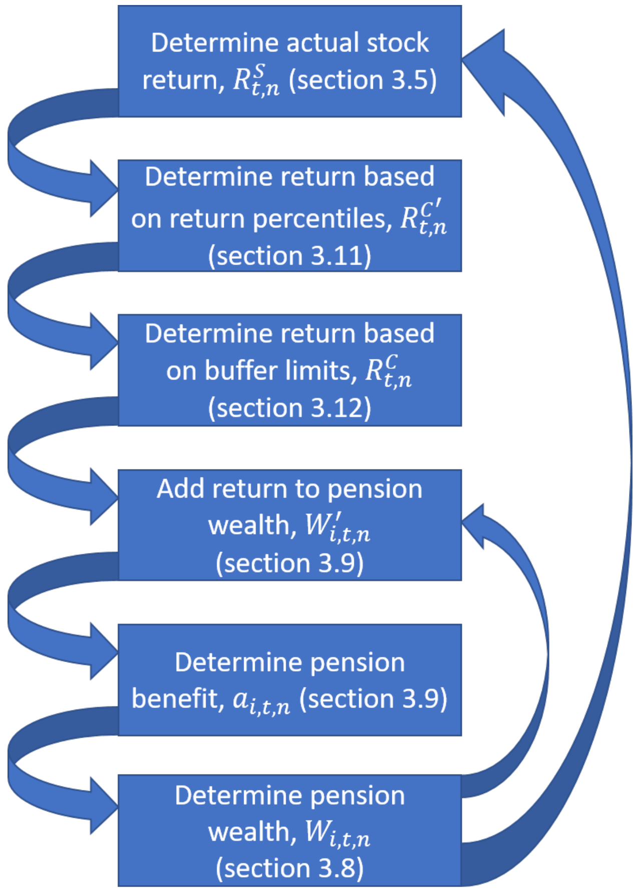

Figure 3.1: Overview of the simulation model

A pension fund is modelled and simulated over different scenarios of the stock market. This section describes all elements of the model. In section 3.4 a description of the proposed population is given, in section 3.5 the assumptions about the financial market are explained, and in sections 3.6 and 3.7 there are explanations about the assumptions regarding income, contribution and the life cycle respectively. In section 3.8 the methodology of calculating the evolution of wealth is shown, and in section 3.9 the calculations of the yearly pension benefits are illustrated. Then, in 3.10, the way of dealing with the proposed buffers is identified and in the final section, 3.13, a measure of comparing different types of buffers is introduced.

In the different sections, all variables and functions are introduced and explained. Some variables have subscripts. Subscript i indicates the year of birth of the specific generation (range from 1933 to 2093), subscript t indicates the particular year of the calculation (range from 2017 to 2117). It is clear that the age corresponding to i and t is equal to $t - i$. Furthermore, subscript n indicates a specific run in the Monte Carlo simulation (20,000 in total). In figure 3.1 an overview is provided in which steps are taken in the simulation model. The first three steps are generally taken in every time period t and the last three steps are simulated separately for all i.

3.4 The population

We assume a population of 60 equally large generations. In contrast to some of the described papers in section 2, we define a generation as an age cohort born in a specific year. Each generation is represented in the model as an agent with age ranging from 25 to 84. Agents are employed between their 25^{th} and 65^{th} birthdays and they pay a constant proportion of their wage into a personal pension pot. They are retired between their 65^{th} and 85^{th} birthdays, and during retirement, they receive a benefit based on the premium they have paid and the (expected) yearly investment returns. Every year, one generation leaves the system (aged 85) and one generation enters the system (aged 25). It is assumed that all participants live exactly 85 years. As mentioned in section 3.2, both macro and micro longevity risk is not taken into account.

3.5 Financial market

For the financial market, the standard Black-Scholes model in discrete time (Black & Scholes, 1972) is assumed. The portfolio of the pension pot consists of two assets, one riskless asset, a bond B, with a fixed return r^f, and one risky asset, a diversified collection of stocks S with an uncertain return. We define the following parameters:

- r^f, the constant risk-free rate
- Z_t, a standard Brownian motion
- σ, the volatility of the stock portfolio
- λ, the Sharpe ratio of the stock portfolio
- S_t, the price of a stock at time t
- B_t, the price of a bond at time t

The dynamics of the assets are as follows;

$$\Delta S_t = (r^f + \lambda\sigma)S_t\Delta t + S_t\sigma\Delta Z_t \tag{3.5.1a}$$

$$\Delta B_t = r^f B_t \Delta t \tag{3.5.1b}$$

We consider the returns over one year and therefore $\Delta t = t-(t-1) = 1$ and $\Delta Z = Z_t - Z_{t-1} = z \sim \mathcal{N}(0, 1)$. We define $z_{t,n}$ as the z corresponding to a given year and run of the simulation. From equation (3.5.1) follows the annual return of the stock portfolio in a given year(t) in a given run(n) of the simulation. We define $R^S_{t,n}$ as the return on stocks in a given year t in a given run n

$$\begin{aligned} R^S_{t,n} &= \frac{(r^f + \lambda\sigma)S_t\Delta t + S_t\sigma\Delta Z}{S_t} - 1 \\ &= r^f + \sigma\lambda + \sigma z_{t,n} \end{aligned} \tag{3.5.2}$$

and $R^B_{t,n}$ the return on bonds

$$R^B_{t,n} = r^f \tag{3.5.3}$$

3.6 Income

All agents have the same, deterministic income in every period. In this model, we define $s = 30$ (in €1.000). All working generations pay a constant contribution rate of their income into their pension pot. The fixed pr indicates the proportion and $p_{(t-i)}$ the absolute premium for a generation with a specific age.

3.7 Life cycle

The theory of life cycle investment tells us that it should be optimal to invest more in risky assets when an agent is young and less when an agent is old. The idea is that an agent owns both financial and human capital and during their life, the human capital is gradually transformed into financial wealth. Since human capital is assumed to be riskless, the proportion of financial wealth invested in risky assets should decrease with age to keep the risk exposure constant. Merton (1975) and, Merton and Samuelson (1974) drew up

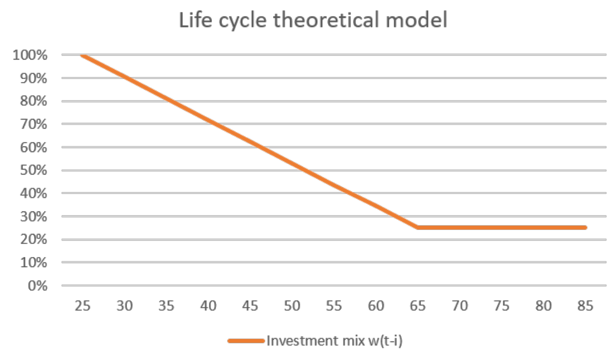

Figure 3.2: Life cycle theoretical model

the basic principles of this theory. Given the CRRA utility preferences, they came up with an optimal investment strategy (w) for total capital. In equation (3.7.1) λ is the Sharpe ratio or "the price of risk", γ is the risk aversion parameter, and σ is the volatility of the stock portfolio. Furthermore, H is the human capital and F the financial capital.

$$w = \frac{\lambda}{\gamma\sigma} * \left(\frac{H}{F} + 1\right) \tag{3.7.1}$$

Since, in the first year of an agent's life (i.e. at the age of 25), financial capital is relatively low compared to human capital, the amount of financial capital invested in stocks is likely to be over 100% according to this theory. In practice, however pension funds are not allowed to go short in cash and usually, invest much less than 100% in risky assets. In this model, we use a simplified version of the life cycle, namely a linear decreasing asset mix, which starts at 100% in stocks at age 25 and goes to 25 % in stocks at age 65. In the retirement phase (aged 65 to 85) the asset mix is assumed to be constant (25% in stocks). The proportion of wealth invested in stocks $w_{(t-i)}$ is given by equation (3.7.2) and displayed in figure 3.2.

$$w_{(t-i)} = 100\% - ((t-i) - 25) * (\frac{75\%}{40}), \qquad if(t-i) < 65 \tag{3.7.2a}$$

$$w_{(t-i)} = 25\%, \qquad if(t-i) \geq 65 \tag{3.7.2b}$$

Since the return of a specific agent in a specific year is dependent on $w_{(t-i)}$, we define $R^A_{i,t,n}$ as the return of a specific generation at time t in run n.

$$R^A_{i,t,n} = (1 - w_{(t-i)}) * R^B_{t,n} + w_{(t-i)} * R^S_{t,n} \tag{3.7.3}$$

In section 3.11 and 3.12 it is explained that, due to the buffer rules, the actual return on the individial stock portfolios is $R^C_{t,n}$ and therefore;

$$R^A_{i,t,n} = (1 - w_{(t-i)}) * R^B_{t,n} + w_{(t-i)} * R^C_{t,n} \tag{3.7.4}$$

3.8 Pension wealth

For the initial composition, we assume that all agents were in the system since their 25^{th} birthday and got the expected return every year. The simulation runs from 1958 (the year when the generation born in 1933 became 25) until 2017 (the year when the same generation became 84). This simulation is executed the same way after 2017, the only difference being that we assume that until 2017, the realised return is equal to the expected return, while after 2017, the return is stochastic. Both before and after 2017, the pension wealth ($W_{i,t,n}$) of every generation is calculated by adding the return to the wealth in the previous period. Furthermore, the pension premium $p_{(t-i)}$ is added (for a working generation) or the pension benefit $a_{i,t,n}$ is subtracted (for a retired generation) as shown in equation (3.9.3).

$$W_{i,t,n} = W_{i,t-1,n} * (1 + R^A_{i,t,n}) - a_{i,t,n} + p_{i,t} \tag{3.8.1}$$

3.9 Pension benefits

At retirement, every year the pension benefit is equal to the annuity which is calculated based on the current value of the pension pot, the expected return and the remaining time of the generation in the system. The yearly pension benefit is calculated based on the expected return. Every year the realised return will differ from the expected return. After a year, the remaining wealth differs from the expected value and the annuity has to be recalculated. To determine the annuity, the wealth at the end of a period is calculated. A pension benefit has to be determined so that, given a yearly return and a number of pension payments n, the present value of those payments is equal to the current wealth. In equation (10) the formula for the annuity is derived. For the sake of readability, the following variables are introduced.

$$\text{Wealth before paying pension benefits} = W'_{i,t,n} = W_{i,t-1,n} * R^A_{i,t,n} \tag{3.9.1a}$$

$$\text{Expected return after retirement} = \mu_{i,t,n} = E[R^A_{i,t+1,n}] = r^f + w_{i,t+1,n} * \sigma\lambda \tag{3.9.1b}$$

$$\text{Remaining number of years in the system} = m_{i,t} = 85 - (t - i) \tag{3.9.1c}$$

$$\begin{aligned}
W'_{i,t,n} &= \sum\nolimits_{g=0}^{m_{i,t}-1} (1 + \mu_{i,t,n})^{-g} * a_{i,t,n} \\
W'_{i,t,n} &= \sum\nolimits_{g=1}^{m_{i,t}} (1 + \mu_{i,t,n})^{-g+1} * a_{i,t,n} \\
W'_{i,t,n} &= \frac{(1 + \mu_{i,t,n})^{m_{i,t}} - 1}{\mu_{i,t,n} * (1 + \mu_{i,t,n})^{m_{i,t}-1}} * a_{i,t,n} \\
a_{i,t,n} &= \frac{\mu_{i,t,n} * (1 + \mu_{i,t,n})^{m_{i,t}-1}}{(1 + \mu_{i,t,n})^m_{i,t} - 1} * W'_{i,t,n}
\end{aligned} \tag{3.9.2}$$

If we substitute 3.9.1 into 3.9.2 we get;

$$a_{i,t,n} = \frac{E[R^A_{i+1,t,n}] * (1 + E[R^A_{i,t+1,n}])^{(84-(t-i))}}{(1 + E[R^A_{i,t+1,n}])^{(85-(t-i))} - 1} * W_{i,t-1,n} * R^A_{i,t,n} \tag{3.9.3}$$

3.10 Buffer rules

According to the report of the Social Economic Council of the Netherlands (SER, 2016), in IV-C-R, the buffer is increased by the part of the return which is above the 80^{th} percentile of the distribution of stock returns and decreased by the difference of the 80^{th} percentile. Furthermore, an upper limit of 20% of total personal pension wealth is assumed. According to the SER, the lower limit of the buffer should be 0%, and we assume that according to advocates of (possible) negative buffers, the lower limit is equal to minus 20%. These two rules are modelled as follows. First, the actual return on stocks is determined. If this return is between the 20^{th} and 80^{th} percentile, the actual return is given to the participant, and the buffer is only increased by the return on the buffer itself. In principle, if the return is lower than the 20^{th} percentile, the return given on the individual stock portfolio is equal to the 20^{th} percentile and, the difference with the actual return is compensated by the buffer. If the return is higher than the 80^{th} percentile then only the 80^{th} percentile is given as a return, and the difference with the actual realised return goes into the buffer. After this calculation on the height of the return provided to the individual pension pots, and before adding premiums and paying pension payments, it is checked whether or not the limits of the buffer are exceeded. If these limits are exceeded, the return given to the participants is adjusted (up or down) so that the buffer is exactly equal to the critical limits. In the following subsections, the described procedure is explained in more detail accompanied by a mathematical description.

3.11 Upper- and lower -limits

In equation (3.5.1) we can see that the volatility of the stock return is only due to the Brownian motion. For that reason, the 20^{th} and 80^{th} percentiles of the stock returns can be calculated by solving;

$$P(z_{i,t} < 20^{th} percentile) = 0.2 \tag{3.11.1a}$$
$$P(z_{i,t} < 80^{th} percentile) = 0.8 \tag{3.11.1b}$$
$$\tag{3.11.1c}$$

From equations (3.11.1a) and (3.11.1b) and the standard normal distribution of $z_{i,t}$ it follows that the 20^{th} percentile is equal to -0.85 and the 80^{th} percentile is equal to 0.85. If these values are substituted in equation (3.5.2) and we assume that $r^f = 0.02, \lambda = 0.2$ and $\sigma = 0.2$ then we get the distribution of the annual stock return in figure 3.3 with a 20^{th} percentile of the return at -10.8% and a 20^{th} percentile of the return at 22.8%. In general we get the lower- and upper- bound of the stock return, respectively R^{S-} and R^{S+}

$$R^{S-} = r^f + (\lambda - 0.85) * \sigma \tag{3.11.2a}$$
$$R^{S+} = r^f + (\lambda + 0.85) * \sigma \tag{3.11.2b}$$

In the model, if the stock return $R^S_{t,n}$ is lower than R^{S-}, then the stock portfolios are increased by R^{S-} and the buffer is decreased by $(R^{S-} - R^S_{t,n})$ times the total stock portfolio (defined as $W^{\sum S}_{t,n}$). Conversely, if $R^S_{t,n}$ is greater than R^{S+}, the stock portfolios are increased by R^{S+} instead of $R^S_{t,n}$ and the buffer is increased by $(R^S_{t,n} - R^{S+})$ times $W^{\sum S}_{t,n}$. The variable $R^C_{t,n}$ is introduced as the return used to increase the individual stock portfolios. ${R^{C}}'_{t,n}$, the dummy variant of $R^C_{t,n}$, is introduced in equation (3.11.3). Since $R^C_{t,n}$ can change due to the limits of the buffer, we introduce the dummy variable $R^{C'}_{t,n}$, which represents the return provided to the individual pension pots, when ignoring the buffer limits. In section 3.12 $R^C_{t,n}$ is formally defined.

$$R^{C'}_{t,n} = min(R^{S+}, max(R^{S-}, R^S_{t,n})) \tag{3.11.3}$$

3.12 Calculating buffer height

With ‘buffer height’ we refer to the amount of wealth in the buffer. If the limits of the buffer (buffer height is $Q_{t,n}$) are not exceeded, the difference between $R^S_{t,n}$ and $R^{C'}_{t,n}$ goes into or comes from the buffer. Furthermore, recall that the investment mix of the buffer is equal to the weighted average investment mix of all personal pension pots. We call $\bar{w}_{t,n}$ the investment mix of the buffer and $W^{\sum P}_{t,n}$ the total value of all personal pension pots. Furthermore $W^{\sum S}_{t,n}$ is the sum of total personal stock portfolios and $W^{\sum B}_{t,n}$ is the sum of total personal

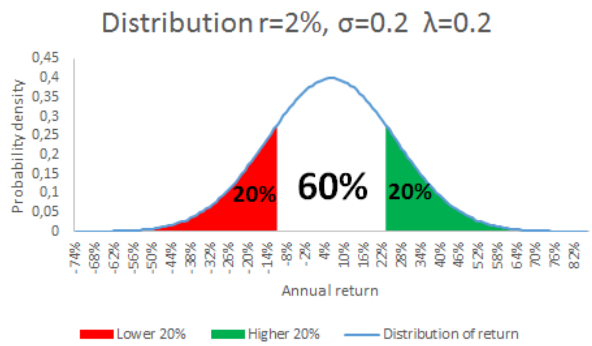

Figure 3.3: Distribution of annual stock return

bond portfolios

$$\bar{w}_{t,n} = \sum_i W_{i,t,n} * w_{i,t,n} \tag{3.12.1a}$$

$$W_{t,n}^{\sum P} = \sum_i [W_{i,t,n}] \tag{3.12.1b}$$

$$W_{t,n}^{\sum S} = \sum_i [W_{i,t,n} * w_{t-i}] \tag{3.12.1c}$$

$$W_{t,n}^{\sum B} = \sum_i [W_{i,t,n} * (1 - w_{t-i})] \tag{3.12.1d}$$

The conditional new value of the buffer $Q'_{t,n}$ (which is the new buffer height if the buffer limits are not exceeded) is;

$$Q'_{t,n} = Q_{t-1,n} * \left(1 + (1 - \bar{w}_{t,n})R^B_{t,n} + \bar{w}_{t,n}R^S_{t,n}\right) + (R^S_{t,n} - R^{C'}_{t,n})W^{\sum S}_{t,n} \tag{3.12.2}$$

As stated at the beginning of this section, there are upper- and lower-limits of the buffer. And whether or not these limits are restrictive is checked after the (temporary) returns on personal stock wealth are calculated. To check the limit of the buffer (upper-limit = F^{Q+} and lower-limit = F^{Q-}), the buffer is calculated by equation (3.12.2) and divided by the total personal pension wealth. If the buffer exceeds the upper-limit or is below the lower-limit, the $R^C_{t,n}$ is adjusted so that the buffer is exactly on the relevant limit. We introduce the variable $F^Q_{t,n}$ as the buffer represents a fraction of total personal pension wealth.

$$F^Q_{t,n} = \frac{Q'_{t,n}}{\sum_i \left[W_{i,t-1,n}\left(1 + (1 - w_{i,t})R^B_{t,n} + w_{i,t}R^{C}{'}_{t,n}\right)\right]} \tag{3.12.3}$$

The denominator in equation (3.12.3) is the total wealth of the personal pension pots at the end of period t, before adding the premiums and subtracting the pension benefits. The return on the personal stock wealth, $R^C_{t,n}$, is depending on this $F^Q_{t,n}$. We have 3 different options

I : $F^{Q-} < F^Q_{t,n} < F^{Q+}$

II : $F^Q_{t,n} < F^{Q-}$

III : $F^{Q+} < F^Q_{t,n}$

I: $F^{Q-} < F^{Q}_{t,n} < F^{Q+}$

$$R^{C}_{t,n} = R^{C'}_{t,n} \tag{3.12.4a}$$
$$Q_{t,n} = Q'_{t,n} \tag{3.12.4b}$$

II: $F^{Q}_{t,n} < F^{Q-}$

Define $R^{A}_{t,n}$ as overall return, $W^{\sum P}_{t,n}$ as total personal pension wealth and $W^{\sum}_{t,n}$ as total wealth ($W^{\sum P}_{t,n} + Q_{t,n}$) and

$$R^{A}_{t,n} = (1-\bar{w}) * R^{B}_{t,n} + \bar{w} * R^{S}_{t,n} \tag{3.12.5a}$$
$$W^{\sum}_{t,n} = \left(Q_{t-1,n} + W^{\sum P}_{t-1,n}\right)\left(1 + R^{A}_{t,n}\right) \tag{3.12.5b}$$
$$Q_{t,n} = \frac{F^{Q-}}{1+F^{Q-}} W^{\sum}_{t,n} \tag{3.12.5c}$$
$$W^{\sum P}_{t,n} = \frac{1}{1+F^{Q-}} W^{\sum}_{t,n} \tag{3.12.5d}$$

To calculate the $R^{C}_{t,n}$ corresponding to the $W^{\sum P}_{t,n}$ of equation (3.12.5), the $W^{\sum P}_{t,n}$ minus the total bond portfolio of last year plus the risk free return is equal to the correct new total stock portfolio. When that stock portfolio is divided by the total stock portfolio at the end of the previous period, the $R^{C}_{t,n}$ can be calculated.

$$\begin{aligned}
W^{\sum P}_{t,n} &= W^{\sum P}_{i,t-1,n}\left(1 + \bar{w}_{t,n} R^{C}_{t,n} + (1-\bar{w}_{t,n})(1+R^{B}_{t,n})\right) \\
R^{C}_{t,n} &= \frac{W^{\sum P}_{t,n} - W^{\sum P}_{i,t-1,n}(1-\bar{w}_{t,n})(1+R^{B}_{t,n})}{W^{\sum P}_{i,t-1,n}\bar{w}_{t,n}} - 1 \\
&= \frac{\frac{1}{1+F^{Q-}} W^{\sum}_{t,n} - W^{\sum P}_{i,t-1,n}(1-\bar{w}_{t,n})(1+R^{B}_{t,n})}{W^{\sum P}_{i,t-1,n}\bar{w}_{t,n}} - 1 \\
&= \frac{\frac{1}{1+F^{Q-}}\left(Q_{t-1,n} + W^{\sum P}_{t-1,n}\right)\left(1+R^{A}_{t,n}\right) - W^{\sum P}_{i,t-1,n}(1-\bar{w}_{t,n})(1+R^{B}_{t,n})}{W^{\sum P}_{i,t-1,n}\bar{w}_{t,n}} - 1 \\
&= \frac{\frac{1}{1+F^{Q-}}\left(Q_{t-1,n} + W^{\sum P}_{t-1,n}\right)\left(1+R^{A}_{t,n}\right)}{W^{\sum P}_{i,t-1,n}\bar{w}_{t,n}} - \frac{W^{\sum P}_{i,t-1,n}(1-\bar{w}_{t,n})(1+R^{B}_{t,n})}{W^{\sum P}_{i,t-1,n}\bar{w}_{t,n}} - 1 \\
&= \frac{\left(Q_{t-1,n}\big/W^{\sum P}_{i,t-1,n} + 1\right)\left(1+R^{A}_{t,n}\right)}{(1+F^{Q-})\bar{w}_{t,n}} - \frac{1-\bar{w}_{t,n}}{\bar{w}_{t,n}}(1+R^{B}_{t,n}) - 1
\end{aligned} \tag{3.12.6}$$

III: $F^{Q+} < F^{Q}_{t,n}$

According to the same reasoning as above, we get

$$Q_{t,n} = \frac{F^{Q+}}{1+F^{Q+}} W^{\sum}_{t,n} \tag{3.12.7a}$$
$$R^{C}_{t,n} = \frac{\left(Q_{t-1,n}\big/W^{\sum P}_{i,t-1,n} + 1\right)(1 + R^{B}_{t,n} + \bar{w}_{t,n}R^{S}_{t,n})}{(1+F^{Q+})\bar{w}_{t,n}} - \frac{1-\bar{w}_{t,n}}{\bar{w}_{t,n}}(1+R^{B}_{t,n}) - 1 \tag{3.12.7b}$$

3.13 Certain equivalent

To determine the effects of different buffer strategies, it is necessary to come up with an objective measure and compare the different outcomes. Since the goal of a collective buffer is (Intergenerational) Risk Sharing, not only are expected pension benefits important, but the variation in these benefits also has to be taken into account. In line with CRRA utility, a certain equivalent amount is calculated.

3.13.1 Expected CRRA utility

The foundations of CRRA utility were created by von Neumann and Morgenstern (1947). The underlying concept is that agents experience a decreasing marginal utility of one extra unit of consumption. It is stated that the utility function should be concave and the marginal utility should be decreasing. An example of such a utility function is the constant relative risk aversion (CRRA). When assuming CRRA, 1% of extra consumption has a fixed increase in utility independent of the current consumption level.

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma} \tag{3.13.1a}$$
$$u'(c) = c^{-\gamma} \tag{3.13.1b}$$
$$u''(c) = -\gamma c^{-\gamma-1} \tag{3.13.1c}$$

Define absolute risk aversion (ARA) and relative risk aversion (RRA) as

$$ARA(c) = -\frac{u''(c)}{u'(c)} = \frac{\gamma}{c} \tag{3.13.2a}$$
$$RRA(c) = -\frac{cu''(c)}{u'(c)} = \gamma \tag{3.13.2b}$$

So for CRRA the relative risk aversion is constant and equal to γ.

3.13.2 Expected utility and certain equivalent

In order to compare the different buffer strategies, not only is the utility of a pension payment in a single year in a single run interesting, but also all pension payments in all runs. For that reason we use expected discounted utility where $E[U_i]$ is defined as the expected, discounted utility over all runs for a specific generation i.

$$E[U_i] = E\left[\sum_{t=i+65}^{i+84} (1+r)^{-(t-i-65)} \frac{a_{i,t,n}^{1-\gamma}}{1-\gamma}\right] \tag{3.13.3}$$

These U_i's are usefull to compare with each other, but has in itself no meaning. Therefore a certain equivalent(CE_i) is calculated. The certain equivalent consumption can be seen as a hypothetical constant payment during the 20 years of retirement with the same utility as the uncertain pension resulting from the model. We set CE_i such that the expected, discounted utility for this constant pension benefits is equal to U_i i.e.

$$U_{CE_i} = E[U_i] \tag{3.13.4}$$

where

$$\begin{aligned} E[U_i] = U_{CE_i} &= \sum_{t=1}^{20} (1+r)^{-(t)} \frac{CE_i^{1-\gamma}}{1-\gamma} \\ \frac{E[U_i](1-\gamma)}{\sum_{t=1}^{20}(1+r)^{-(t)}} &= CE_i^{1-\gamma} \\ CE_i &= \left(\frac{E[U_i](1-\gamma)}{\sum_{t=1}^{20}(1+r)^{-(t)}}\right)^{\frac{1}{1-\gamma}} \end{aligned} \tag{3.13.5}$$

4 Results

In this section, the results of the simulation described in section 3 are displayed given the initial parameters. Furthermore, the buffer strategies described in section 3.3 are compared. The simulation includes 20,000 scenarios and runs over 100 years. The oldest generation included in the model is generation 1933, which had its last pension benefit payment in 2017. Recall that we define a generation as an age cohort born in a specific year. In the results, only the generations that are in the system during all of their 20 years of retirement are taken into account (generation 1953 until 2033). In section 4.1 the results of the initial model are presented. In section 4.2 a risk premium is added to the initial model and in section 4.3 the results are provided for a system where the inflow of new premium is adjusted. In section 4.4 to 4.6 two alternative models are explained and in section 4.7 the robustness of different parameters is checked.

4.1 IV-C-R model

In figure 4.4, the average pension benefit of the different generations and 3 different buffer strategies are presented. It is seen that the average pension payments for a system with no buffer and a positive/negative buffer, are approximately equal. In a system with only positive buffers however, the average pension payment, compared to a system without buffers, are lower for the early generation (until 1987) but higher for all generations afterwards. This makes sense since the early generation have to fill the buffer (in expectation), while later generations can benefit from the buffer and the return on the buffer. In figure B.13 in the appendix the average buffer-height over time is given and one can see that indeed the buffer is (on average) increasing in the early years for a 'positive buffer strategy' while being on average stable for a buffer which can be both positive and negative.

Although figure 4.4 gives an idea of the height of the pension payments for the different generations, it is not the full picture. In the appendices, in figures B.15 to B.19, the specific average pension benefits in every year of generation 1953, 1973, 1993, 2013 and 2033 respectively are given. Furthermore, in these figures, the 90% confidence intervals are added. In figure 4.5 the average pension benefits over the retirement period is given, including the same confidence interval. One can see that in the early years, the width of the 90% confidence interval is smaller for the buffer strategies than for the strategy without a buffer. For later generations however, the width of the 90% confidence interval is larger. This larger interval can be explained by the fact that, due to the buffer, part of the risk of the early generations is shifted to the new generations. To take both the expected pension benefit as the uncertainty into account, we introduced the 'certain equivalent consumption(CEC)' in section 3.13.2. In figure 4.6 the certain equivalent consumption of a pension in the three different buffer strategies is given for all generations. The decreasing CEC can be explained by the fact that for the first generations, there is less uncertainty since we assumed a deterministic return before 2017. In figure 4.7 the CEC of the two different buffer strategies is compared with the strategy without a buffer. From this figure, we can conclude that given the assumed parameters, a strategy both negative and positive buffers is welfare improving for generations born before 1987 and welfare declining for all generations born since 1988. A system with only positive buffers however, has the opposite effect. In section 4.7 the robustness of this conclusion is determined.

4.2 Initial model with a risk premium

In this section the welfare effects of the buffer are presented for the case that the upper percentile of the buffer rules is changed from 80 to 70 percent. As mentioned in section 4.1, in the IV-C-R system, the welfare of early generations is lower than a system without a buffer while welfare improving for later generations. This is due to the fact that the early generations have, in expectation, to fill the buffer while later generations benefit from the earlier created buffer. In that same section it is stated that if negative buffers are tolerated in the IV-C-R, the effect is the other way around, old generations gain welfare, while later generations lose. Since the buffer can be both positive and negative and the rules of transferring wealth to and from the buffer is also symmetric, the buffer height is approximately zero (as can be seen in figure B.13). The effect of this

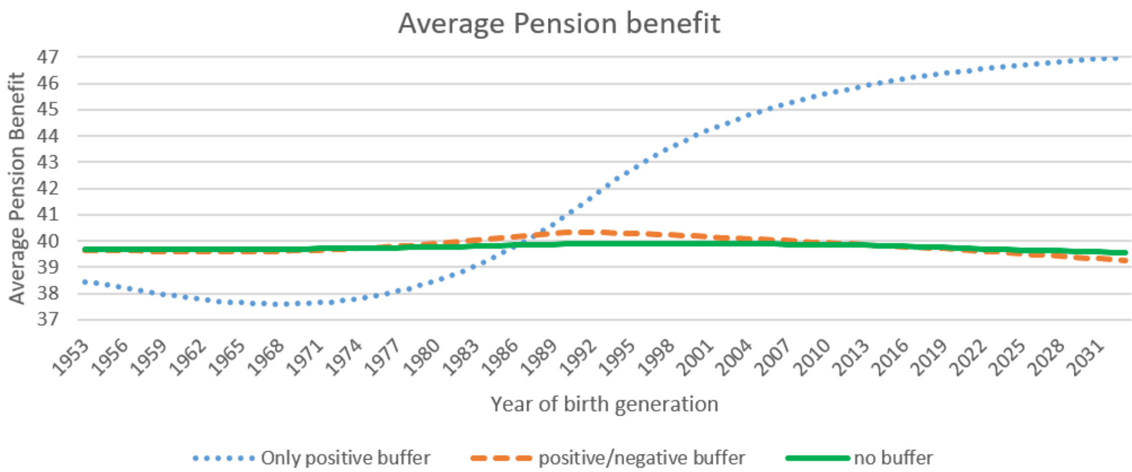

Figure 4.4: Average Pension benefit

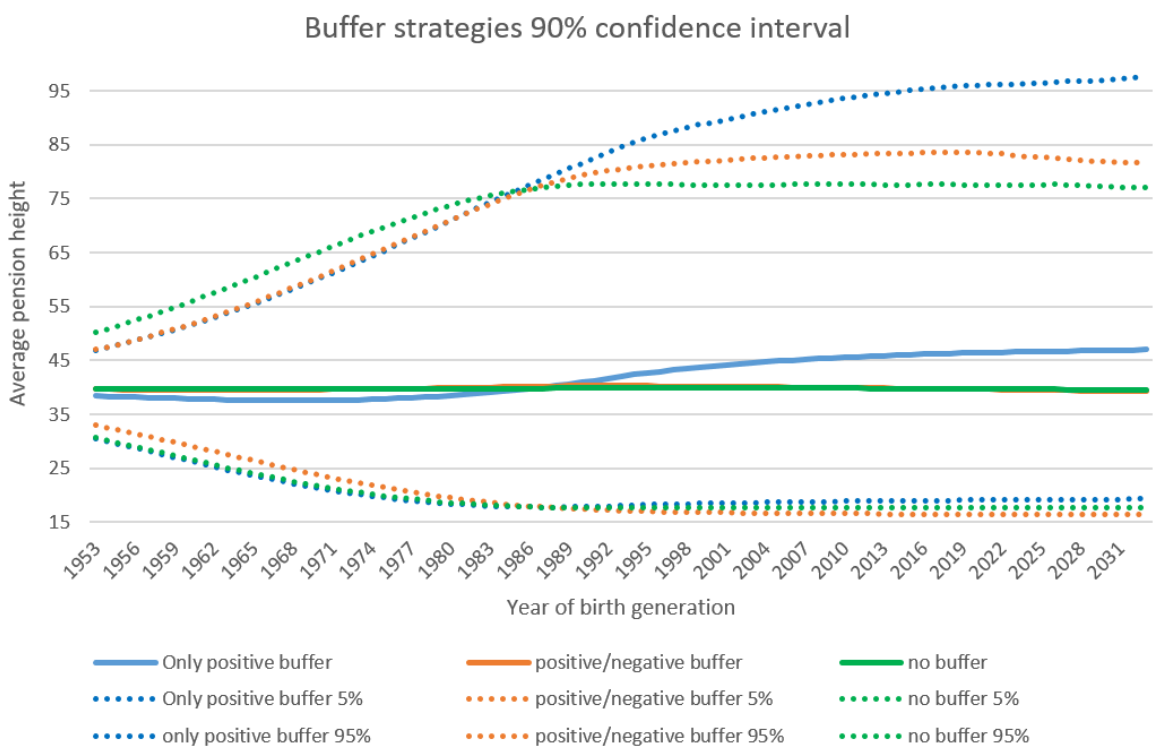

Figure 4.5: Average Pension benefit with 90% confidence interval

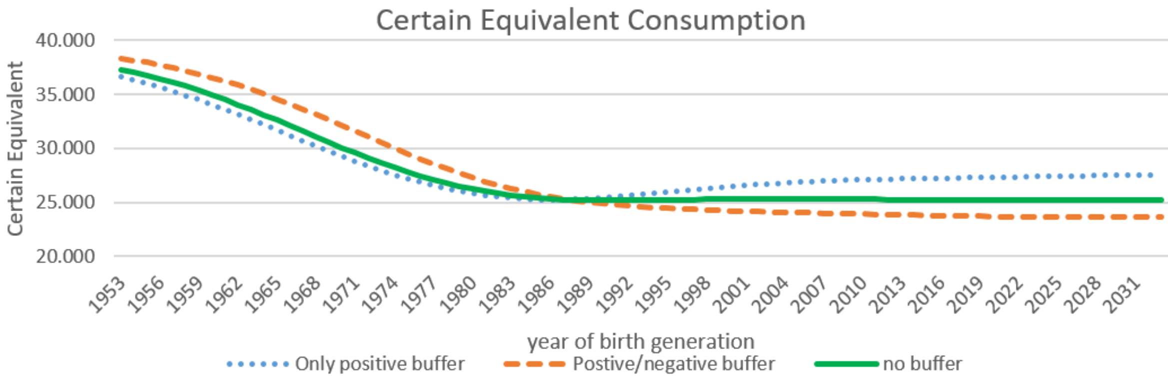

Figure 4.6: Certain equivalent consumption

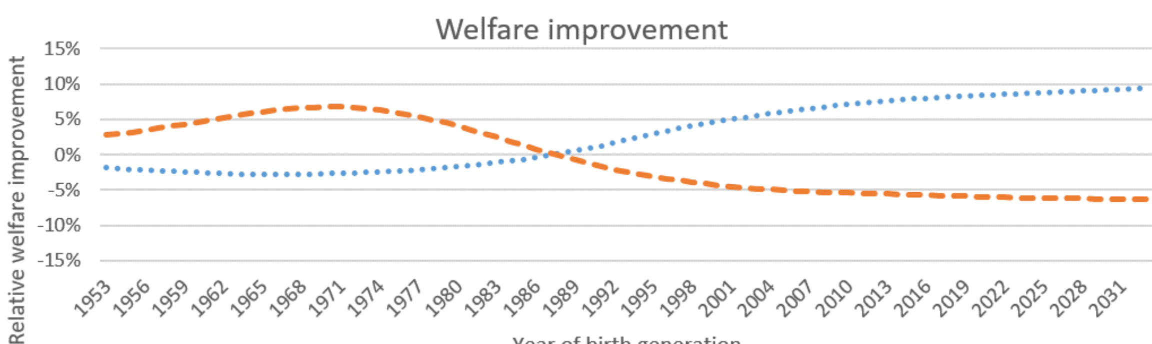

Figure 4.7: Welfare improvement

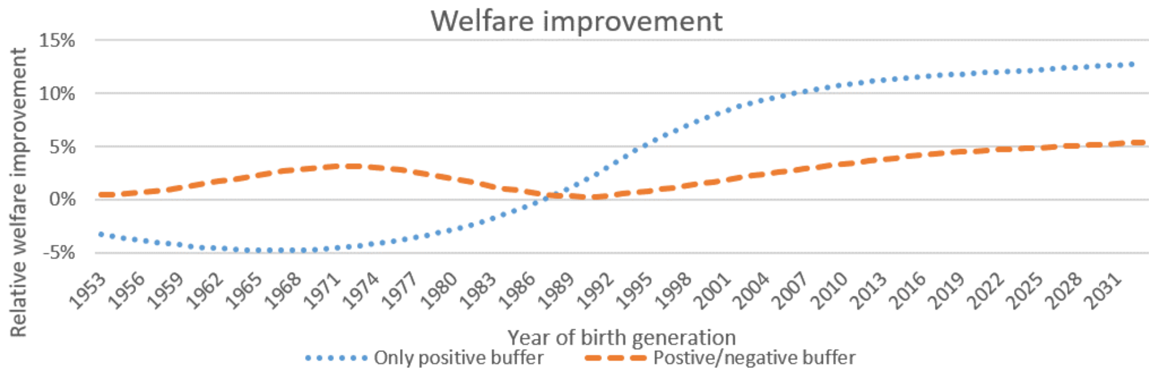

Figure 4.8: Welfare effects IV-C-R with risk premium

is, that the early generations do not have to fill the buffer (in expectation) but do benefit from buffer since it absorbs theirs shocks in the stock market. Later generations, however, are left with an uncertain amount of wealth in a buffer with expectation zero. In other words, the risk of the early generations is partly shifted to the later generations while not paying a risk premium. For that reason the welfare effect for later generations is negative. One option to provide a risk premium to new generations (who bear part of your risk) is to lower the percentile which is used to determine the amount of the return which is transferred to the buffer from 80% to 70% (see section 3.10). In figure 4.8 it is seen that in that case, the welfare effect is positive for all generations. See figure B.20 in the appendix for the expected pension benefits, certain equivalent and average buffer.

4.3 Discontinuity risk

As mentioned in section 2.4.4, discontinuity risk is the most important disadvantage of Intergenerational Risk Sharing. In this section, the welfare effects are provided when the new inflow differs from what was expected, namely a constant inflow. In order to determine the discontinuity risk, it is assumed that all generations born before 1993 still pay their annual premium while the premium of generations born since 1993 is changed. A situation with lower premium inflow can be seen as a 'gray' pensions fund, which is a pension fund with relatively many old participants. A situation with higher premium inflow on the other hand can be seen as a 'green' fund, which is a pension fund with relatively many young participants. In figure 4.9 the welfare effects are presented of these situations, with a changed premium inflow for generations born since 1993 and a buffer which can be both positive and negative. A different line in the graph represents different inflow changes, where the new premium inflow (for generations born since 1993) is represented as a fraction of previous pension inflow (for generations before 1993). In order to have a fair comparison, the pension benefits are normalized to the initial premium inflow before the certain equivalent is determined.

In section 4.1 it is already pointed out, that a system with negative buffers has a negative welfare effect on current young and future generations. This negative effect is due to the risk of the earlier generations that is shifted towards those later generations. If the new generations are smaller (either in size or in premium contribution), the same risk is shifted to a smaller group and has, therefore, a larger effect. On the other hand, if the new generation is larger, the relative effect of the risk of previous generations is smaller. In this case, they even benefit from shifting risk to new generations themself. For a system with strictly positive buffers, the effect is the other way around, (as can be seen in figure B.23 of the appendix). The positive effect of the buffer, created by the oldest generations, is relatively large if the future generations are small. In fact, the changing in new inflow, increases (in case of lower inflow) or decreases (in case of higher inflow) the

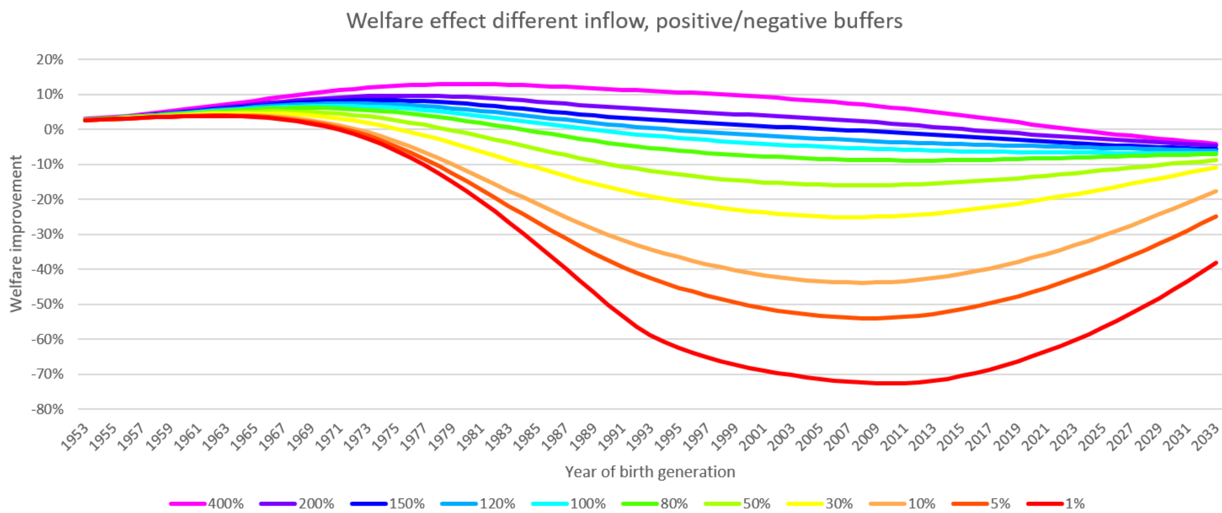

Figure 4.9: Welfare effects changing premium inflow on system with positive/negative buffers

welfare effect explained in section 4.1. In section 4.2 a system was proposed with positive welfare effects for all generations. If the new inflow is decreased in this system, these positive effects do not hold. Although the risk premium paid by the previous generations is relatively large compared to future premium, the negative effect of the increased risk outweighs the welfare effect of increased expected pension benefits. (See figure B.24 in the appendix)

4.4 Alternative models

As mentioned in section 2.1.5, one of the arguments in favour of the IV-C-R alternative is that we live in an Individualized society and that pension plan participants want to know the height of their own pension wealth. One of the arguments in favour of IV-C-R is that participants own their personal pension wealth and that it is clear what capital is theirs and what capital is used for the collective. However, one can argue that in IV-C-R participants still do not really own their personal pension wealth since they have to transfer part of their return (so part of their wealth) to the collective buffer in case of high returns. In the following two sections, two alternative buffer strategies are proposed in which the buffer is not filled by yearly returns but by part of the premium. Besides the buffer rules, the alternative models work exactly the same as the model described in section 3. In both models the buffer is filled by a fixed percentage of the annual premium of all participants. Furthermore, in the first model(A1), a fixed percentage of the buffer is added to the personal pension wealth while in the second model(A2), only the low annual stock market returns are compensated in the same way as in the basic model.

4.5 First alternative model (A1): Fixed premium and smooth payout

As mentioned above, in the first alternative model(A1), a constant fraction of the annual pension premium is going to the buffer. The fraction of the pension premium that is going to the buffer is assumed to be 20% and called Pf. The fraction that is going to the personal pension wealth is $(1 - Pf)$ and therefore equal to 80%. The wealth in the buffer is still invested on the stock market based on the weighted average life-cycle but in contrast to the standard model, in this alternative model, every year a constant fraction Bf of the total buffer is added to the personal pension wealth. The extra wealth that is received from the buffer is provided in the form of an extra return on the personal pension pots. In this way, the wealth received from the buffer is dependent on the current height of the personal pension pot, which makes sense, since participants who have more personal pension wealth also contributed more to the buffer. The last difference with the initial system is that in this alternative model (A1) it is assumed to start the buffer with Pf of total initial personal pension wealth. The initial personal wealth can be seen as 'past premiums' and therefore it makes sense to also add Pf of the initial capital to the buffer. Finally in this first alternative, the buffer is not capped at a minimum nor at a maximum. The minimum is not necessary since every year a fraction (lower than one) of the buffer is paid out. Therefore the buffer cannot become negative. A maximum on the other hand is also not needed since the higher the buffer; the more is paid out. This is a mean reverting process.

4.5.1 Determine payout fraction

To make this system a sustainable system, the buffer should be, in expectation, constant over time. For that reason, the inflow and outflow of the buffer in expectation should be equal. The calculations below do not give the exact answer since it assumes that $\bar{w}$ (see 3.12) and 'Buffer height' are independent, however this is not necessarily true. Furthermore we assume that $E[\bar{w}]$ is equal to $\bar{w}$ at the start of the simulation (which is also not necessarily true). However the answer seems to be a good approximation of a Bf for which the buffer is more or less stable.

$$\begin{aligned} E[\text{Inflow buffer}] &= E[\text{Outflow buffer}] \\ E[\text{Inflow from premium + return on buffer}] &= E[\text{Constant fraction of buffer}] \\ E[Pf * \text{total premium} + ((r^f + \lambda\sigma + \sigma z) * \bar{w} + r^f * (1-\bar{w})) * \text{buffer height}] &= E[Bf * \text{buffer height}] \\ E[Pf * \text{total premium} + (r^f + \lambda\sigma\bar{w}) * \text{buffer height}] &= E[Bf * \text{buffer height}] \\ Pf * \text{total premium} + (r^f + \lambda\sigma E[\bar{w}]) * E[\text{buffer height}] &= Bf * E[\text{buffer height}] \end{aligned} \tag{4.5.1}$$

For the total premium we assume $s * pr * 40$ (40 paying generations). Furthermore, if we assume $s = 30$ and $pr = .20$, we get a total premium of 240. As motioned before, for $E[\bar{w}]$ we take $\bar{w}$ at the start of the simulation which is 0.3887. λ and σ are still .20 and $r^f = 0.02$. As mentioned above the initial buffer should be $Pf*$ total initial wealth where the total initial wealth is equal to 15.783.

$$\begin{aligned} Pf * 240 + (0.02 + 0.2 * 0.2 * 0.3887) * Pf * 15.783 &= Bf * Pf * 15.783 \\ Pf * 240 + .035548 * Pf * 15.783 &= Bf * Pf * 15.783 \\ 240 + 561 &= Bf * 15.783 \\ Bf &= 0.0508 \end{aligned} \tag{4.5.2}$$

The above derivation of Bf not only shows that Bf is around 0.05 but it also shows that the Bf for which the buffer is more or less stable, is not dependent on Pf.

The welfare improvement graph for $Pf = 0.2$ is added to figure 4.7 in purple and shown in figure 4.10. The graph shows that for the early generations there is a negative welfare effect relative to a system without a buffer but for generations after 1963 there is a positive effect. The negative effect for early generations can be explained by the initial 'loss' of 20% which that generation has to put into the buffer at the start of the simulation period while in a system without a buffer that early generation can consume all of their wealth. The positive effect of the later generations can be partly explained by the positive buffer left by the older generations but also the positive welfare effects of IGR.

4.5.2 Impact of IGR

The benefits of IGR in the first alternative(A1) lies in the return on the buffer which is not directly given to the current living generation but gradually over time to future generations. When a return has occurred, Bf

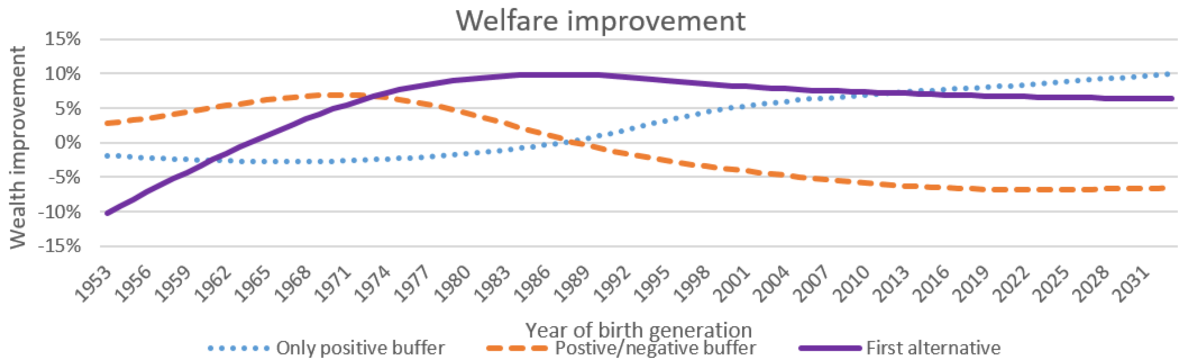

Figure 4.10: Welfare effect including the first alternative, A1

of the return is given to the current generation in the first year. The impact of a return declines gradually over time and is given by the following equation.

$$\text{Impact return after n year} = Bf * (1 - Bf)^{n-1} \tag{4.5.3}$$

In figure 4.11 the blue bars represent the effect of a return after n year, given $Bf = 0.0508$. For example 5.08% of a shock in the buffer wealth today has a direct impact on the current annual return on the personal pension pots. After 20 years however, only 2% of this shock impacts the return on the personal pension pots. The orange line is the cumulative of all blue bars, which mean the total fraction of today's shock which is already paid out after n years. One can see that for example after 30 year, 80% of the shock is allocated to personal pension pots.

Since, in expectation, only 20% of the total wealth is located in the buffer, also only 20% of the financial shocks are shared between generations and 80% is directly absorbed by the personal pension pots. A result of this is that of the total return on the stocks market of the pension fund, only a small part is shared with future generation.

4.6 Second alternative model (A2): Fixed premium and low returns compensated

The second alternative model can be seen as a hybrid between the initial model described in section 3 and model A1. Like in A1, the model is exactly the same as in the initial model, except for the buffer rules. Furthermore, like in A1, the buffer is filled by a fraction (Pf) of both initial personal pension wealth and pension premium. In contradiction with A1, the amount of wealth that is going from the buffer to the personal pension pots is not a fraction of the total buffers but, like in the initial model, related to the annual return. Since the aim of model A2 is to prevent wealth transfers from the personal pension pots to the buffer, the low returns are compensated (like in the initial model), but high returns do remain the property of the participant. This is possible since there is a constant inflow in the buffer from the annual pension premiums. We assume again that $Pf = 0.2$ and therefore the initial buffer is 20% of total wealth, which is 25% of the total personal wealth. Given the initial height of the buffer, the maximum buffer height is set at 40% instead of 20%. In figure 4.12 the welfare effects of the second alternative model are added in the same graph as the initial model, figure 4.7. Both for the initial model as model A2 the welfare effects are given for a system with only positive and positive/negative buffers. In figure B.22 of the appendix the average pension benefits, certain equivalents and average buffers are also provided. As we saw in model A1, the buffer has a negative effect for the early generations due to the fact that they have to give 20% of their wealth

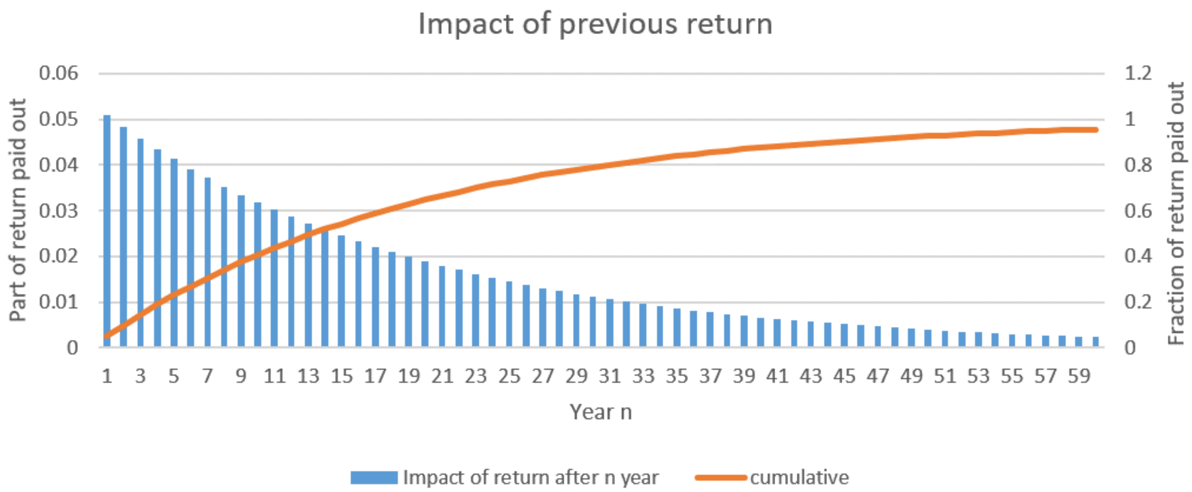

Figure 4.11: Impact of previous returns

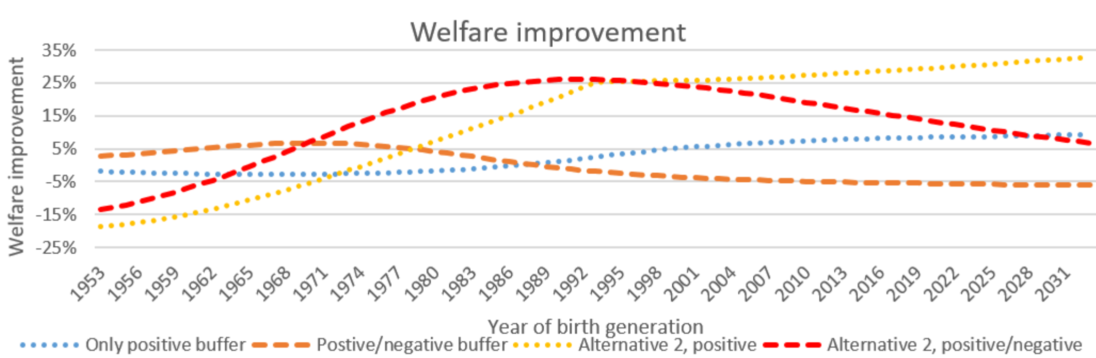

Figure 4.12: Welfare effects second alternative model, A2

(and premium) to the buffer. In a system without a buffer they can consume 100% of their wealth in the upcoming years and therefore the welfare in that system is higher for old generations. For later generations, however, this alternative buffer system has a positive impact on their welfare. These generations benefit from both the buffer created by previous generations and IGR. Furthermore, it is seen that when the buffer can be negative this is better for early generations but worse for future generations. This is because with negative buffers, early generations can shift more risk to future generations, but future generations on the other hand receive in expectation a lower buffer which is more uncertain and therefore has less welfare than with strictly positive buffers.

4.6.1 Impact of IGR

However IGR has, for some generations, a positive effect when using the A2 model, not all generations benefit from it. Furthermore, it is less beneficial than in the initial model. It is less beneficial because the cutoff of high returns is replaced by a constant premium which the participant has to pay each year. The welfare effects are calculated with the use of a utility function. Utility theory tells us that we do not experience much utility of extra consumption when we already have a high consumption. If we translate this to the buffer system, in fact participants do not really lose much utility when they have to transfer part of their high stock market returns to the buffer. Giving away a constant premium (even in years with low stock market returns) on the other hand, has a larger negative effect on the utility. Furthermore with this second alternative it was not possible to find parameters setting were all generations benefit from IGR.

4.7 Robustness checks

In this section the robustness of the results are tested. It is shown whether or not the results presented before do still hold when assumptions are changed, and by how much. Besides the robustness of the results, this section also provides the effect of certain choices that can be made. In the different subsections, the effects and the causes of the effect of changing the various parameters are pointed out. To improve readability, the effects of the change of a parameter are only described in one direction unless stated differently. For example, when the sentence “y goes up when x goes up” is reported, this implies that y goes down when x goes. The result in both the sections below as is the overview, are the effects of a change in parameters on the welfare effect of the buffer. The results are not the welfare effects of a change in the parameters itself. For example, if the risk free rate (r^f) goes up, the return on both stocks and bond goes up and therefore all pension benefits are higher without extra risk. As a result, the welfare of all generations goes up. However, the welfare effect of the buffer does not necessarily will be larger. At the end of this section an overview is given of the different robustness checks.

4.7.1 Risk free rate

The risk-free rate (r^f) is changed by 1% up and down. A first obvious effect is that pension benefits are increased when the risk-free rate goes up since both stock market and bond returns are linear dependent on r^f. Furthermore, since the return on the buffer is also increased when the risk free rate is higher, future generations benefit more from a positive buffer, for that reason both the expected pension benefit as the expected welfare is higher for more generations when r^f is increased. Besides that, in the system with negative buffers (where the buffer is zero in expectation), a higher r^f lead to more risk since the buffer increases faster when positive and decreases faster when negative. For that reason, the overall welfare is lower compared to a system without a buffer when r^f is increased. The welfare effects of the risk-free rate can be found in the appendix figure B.25.

4.7.2 Volatility

To check the impact of the assumed volatility (σ), the initial value ($\sigma = 0.2$) is changed by 0.1 up and down. In equation 3.5.1, it can be seen that σ has influence on both the volatility of the stock returns as well as the expectations of the returns, since both the Brownian motion, Z_t as the market price of risk, λ are multiplied by σ. A direct implication is that the expectation of the pension benefits is increased with a higher σ. Furthermore, the change in expected stock market return does have an impact on the effects of a positive buffer. With a higher σ, the return on a positive buffer is higher and therefore the positive effect of a positive buffer holds for more and earlier generations. The welfare effects of a change of σ can be found in the appendix figure B.26. Besides the effects of an adjustment of the expected stock market return, there are also effects of the changed volatility. To investigate these effects separately, in figure B.27 the welfare effects of a change in σ are provided but without changing the risk premium ($\lambda\sigma$). For early generations, these welfare effects are larger if the volatility is higher, both the positive effect of the positive/native buffer as the negative effect of the strictly positive buffer. If the volatility is smaller, the wealth transfers between the buffer and the personal pension accounts will also be smaller, so that its welfare effects will be smaller as well. For younger generations, on the other hand, the welfare effects of the buffers are smaller when the volatility increases. Since the buffer has a minimum and a maximum height, the effect of the buffer is also limited. If the volatility is increases, the probability of reaching those limits becomes larger. The welfare effects in comparison with a system without a buffer in relative terms are then smaller.

4.7.3 Market price of risk

In figure B.28 in the appendix, the welfare effects of a change in λ are shown. A shift in λ only implies a modification of the risk premium part of the stock market returns, and for that reason, this change is almost the same as a change in r^f with the only difference that there is no effect in the bond returns. The effects however are comparable with the effects described in section 4.7.1

4.7.4 Risk aversion parameter

To investigate the effect of the risk aversion parameter on the welfare, the initial risk aversion parameter ($\gamma = 5$ is changed to respectively 1.5 (very risk tolerant) and 10 (very risk averse)). These extreme values are chosen since for small changes in the risk aversion parameter the differences are negligible. In figure B.29 of the appendix, one can see that the welfare effect for early generation is larger when participants are more risk averse. This is because risk averse participants care more about a stable pension than less risk averse participants. Furthermore the positive welfare effect of the strictly positive buffer for later generations is larger for participant with low risk aversion than for participants with a relative high risk aversion. Participants with a low risk aversion parameter care more about the expected benefits than about the risk. Since in a system with strictly positive buffers, the expected pension benefit is higher, participants with a low risk aversion parameter appreciated that more than participants with a high risk aversion parameter.

4.7.5 Live cycle

In the initial model, w, the fraction of personal pension wealth invested in stocks, declines linearly from 1 at age 25 to 0.25 at age 65 (and constant afterwards), denoted by [0.25;1]. To investigate the effect of the life cycle on the results, the Livecycle is changed to respectively [0;0.75] and [0.5;1]. In figure B.30 one can see that in the [0;0.75] variant, the welfare effects is zero for the earliest generations. This generation retires at the start of the simulation and since $w = 0$ after retirement, their exposure to stock market risk is also zero. If there is no stock market risk, the effects of the buffers is also zero. For later generations the welfare effects are smaller than they are in the initial model, which is also caused by the lower exposure to stock market risk.

4.7.6 Upper and lower percentile

In figure B.31 the welfare effects are provided of changing the distance between the upper and lower percentile on which the buffer rules are based. In the initial model the 20^{th} and 80^{th} are used. For this robustness check, the model is simulated using the $10/90^{th}$ percentiles and $30/70^{th}$ percentiles respectively. When using $10/90^{th}$, the probability of using the buffer is smaller and therefore the welfare effects of the buffer are also smaller.

A second way to test the impact of the buffer rules is to choose asymmetric percentiles. In figure B.32 the welfare effects of two changes are given. First changing the upper percentile from 80 to 70 (while keeping lower percentile the same) and second, changing the lower percentile from 20 to 30 (while keeping the upper percentile the same). In a system with strictly positive buffers and where we start with an empty buffer, irrespective of the buffer rules, the buffer will in expectation always increase. This is true because the probability of adding something to the buffer is smaller than receiving something from the buffer. For that reason, the welfare effects of the buffer rules are relatively small for a system with only positive buffers. On the other hand, the welfare effects of the buffer rules for the system with positive/negative buffers are larger. In the 20/70 variant, (are already mentioned in section 4.2), there is (in expectation) a wealth transfer from the personal pension account to the buffer, and therefore the buffer is increasing (which has a positive welfare effect on later generations). On the other hand, in the 30/80 variant, in expectation wealth is going from the buffer to the personal pension account which implies that the buffer becomes negative (in expectation) which has a substantial negative effect on future generations.

4.7.7 Buffer limits

In figure B.33 the effect of the buffer limits are provided. In the initial model the buffer is maximal 20% of total personal pension wealth, and in the system with positive/negative buffers, the buffers are at least -20% of total personal pension wealth. If the maximum is increased, the minimum is decreased by the same percentage. If the buffer limits are decreased, the probability of reaching those limits becomes higher, and when reaching those limits the buffer has no welfare effect anymore. This results in smaller welfare effects of lower buffer limits and higher welfare effects for larger buffer limits.

4.7.8 Initial buffer

In all previous sections, it is assumed that the buffer is zero at the start of the new system. However, it is possible to not assign all current wealth to individual pension accounts but use part of the wealth to fill the buffer. In figure B.34 the welfare effects are provided when 10 or 20 percent of the initial (personal) pension wealth is not assigned to a specific participant or generation but to the collective buffer. As in all the other results and robustness checks, the welfare effects are compared with a system of personal pension account without a buffer. If there is no buffer in the system, it does not make sense to assign less than 100% of total wealth to the personal pension account, and therefore we see that for both an initial buffer of 10 and 20 percent, the welfare of the early generations is negative. These generations start with a lower initial capital and do not have enough time left to benefit from the buffer. Later generations on the other hand experience a substantial welfare increase compared to a system without a buffer, since they benefit from the buffers, partly paid by the previous generations. Despite of the initial buffer, the probability of a negative buffer will increase over time, which leads eventually to less welfare gains for every late generations or even a negative effect compared to a system without a buffer.

4.7.9 Overview robustness checks

In the table on the next page, a summary is provided of the welfare effects of a change in parameter values. Like in the sections above, if it is stated that the increase of a parameter has a certain effect, this implies that a decrease of that parameter has the opposite effect, unless stated differently.

Variable	Effects on the system with positive buffers	Effects on the system with positive/negative buffers
Risk free rate, r^f	If r^f goes up, more (and older) generations benefit from the buffer and the welfare effect is larger for young generations	If r^f goes up, more (and older) generations are negatively effected by the buffer and the negative welfare effect for young generations is larger
Volatility, σ	If σ goes up, more (and older) generations benefit from the buffer but the positive effect is smaller for young generations.	If σ goes up, the positive effect for old generations goes up a bit, but more (and older) generations are negatively effected and this effect is more negative.
Volatility, σ ($\lambda\sigma$ = constant)	If σ goes up, the welfare effect is positive for more (and older) generations but the positive effect for young generations is smaller.	If σ goes up, the positive welfare effect for old generations is larger and the negative effect for young generations is smaller.
Market price of risk, λ	If λ goes up, the positive effect for young generations is larger.	If λ goes up, the positive effect for old generations is smaller and the negative effect for young generations is larger.
Risk aversion parameter, γ	If γ goes up, the negative effects for old generations and the positive effects for young generations are smaller.	If γ goes up, the positive effects for old generations and the negative effects for young generations are larger.
Investment mix, w	If w is higher, their is a negative effect for more (and younger) generations	If w is higher, the positive for old generations is higher but their is a negative effect for more (and older) generations
Spread buffer rules	If the spread is higher, the negative effect for old generations is smaller but it is negative for more (and younger) generations.	If the spread is higher, their is a positive effect for less generations and the negative effect for young generations is larger.
Asymmetric buffer rules	If the rules are 20/70%, the negative effects for old generations and the positive effects for young generations are larger. If the rules are 30/80%, the negative effects for old generations and the positive effects for young generations are smaller.	If the rules are 20/70%, the positive effects for old generations are smaller but the effects for young generations are positive instead of negative. If the rules are 30/80%, the positive effects for old generations and the negative effects for young generations are larger.
Buffer limits	If the buffer limits are larger both the negative effects for old generations and the positive effects for young generations are larger.	If the buffer limits are larger both the positive effects for old generations and the negative effects for young generations are larger.
Initial buffer	If the initial buffer is larger, the welfare effect for the first generations is more negative but for more (and older) generations the effects are (more) positive.	If the initial buffer is larger, the welfare effects for the first generations are negative (instead of positive), but for more (and older) generations the welfare effects is positive.

5 Conclusion

The goal of this thesis was to determine the welfare effects of a buffer in a new Dutch pension system with individual pension pots. The FNV advocated that 'Intergenerational Risk Sharing' (IGR) is only beneficial when buffers can be both positive and negative, while the government do not want to leave deficits to future generations and therefore they are in favour of a system with strictly positive buffers.

To determine the effects of these buffers, a simplified model was constructed based on the coalition agreement and reports of the SER. In this fictional pension fund, three buffer systems are compared with each other; a system without a buffer (as a reference), a system with only positive buffers (proposed by the government) and a system with both positive and negative buffers (proposed by the FNV). The welfare effects of these buffers systems are defined by using utility theory.

It is concluded that, if the buffer is strictly positive, it has a negative effect on the welfare of old generations since the old generations have to fill the buffer (on average). On the other hand, for young generations, a strictly positive buffer is welfare improving. When the buffer can be both positive and negative, the effects are the other way around. Without the 'non-negative constraint', the old generations benefit from a reduced risk since this risk is shifted to younger generations. The welfare of younger generations is therefore reduced by the positive/negative buffer system. Only when a risk premium is paid, and negative buffers are allowed, the welfare effect can be positive for all generations.

The described effects are all concluded under the assumption that the inflow of new participants (and premium) is constant over time. In this thesis, it is explained that a pension system with negative buffers is not sustainable when the inflow of new participants is significantly smaller than expected. This effect is known as the discontinuity risk.

One should be careful by generalising the result of this simplified model to all current Dutch pension funds. In this thesis, only stock market risk is taken into account. All other risks, such as inflation, interest rate and longevity risk are ignored. Furthermore, simplifying assumptions are made such as; constant wages, homogeneous generations, a simplified, uniform life cycle and a Black-Sholes financial market with a constant r^f , σ and λ. A result of these simplifications is that the conclusions of this thesis should not be considered as exact results. However, the directions of the results give useful insights into the welfare effects of the different buffer strategies as described above. Future research should make clear whether or not the conclusions of this report are robust in a more advanced setting. Another remark that should be made is that the buffer rules are only one aspect of a new pension system. This thesis shows that the buffer rules (IV-C-R, as proposed by the current government and the SER reports) result in a negative welfare effect for old generations. In a new pension system, this negative effect might be well compensated as well by other aspects of the reform.

To sum up, a collective buffer in a system with personal pension pots can have positive welfare effects. To make the effect positive for all generations, one should allow the buffer to be negative and provide a risk premium for future generations. However, when buffers are allowed to be negative, there is a significant discontinuity risk. It is the role of both the government and the SER to decide whether the increased welfare is worth the increased discontinuity risk.

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A List of symbols

List of symbols		
Symbol / Variable	Description	Value assumption
i	Year of birth of a generation	-
t	Year of calculation	-
n	Index number of run in simulation	-
s	Annual wage	€30,000
pr	premium percentage	20 %
H	Human Capital	-
F	Financial Capital	-
w_{t-i}	Fraction of pension capital invested in stock	-
$\bar{w}_{t,n}$	Weighted average invested in stocks	-
age	Age of a generation	t - i
r^f	Risk free rate	0.02
Z_t	Brownian motion process	-
σ	Volatility of stock portfolio	0.2
λ	Sharpe ratio of stock portfolio	0.2
S_t	Price of stock portfolio	-
B_t	Price of bond	-
$z_{t,n}$	Random factor	$\sim \mathcal{N}(0,\, 1)$
$R^S_{t,n}$	Stockreturn	-
$p_{(t-i)}$	Premium	-
$W_{i,t,n}$	Personal pension wealth	-
$W^{\sum P}_{t,n}$	Total personal pension wealth	-
$W^{\sum S}_{t,n}$	Total personal wealth in stocks	-
$W^{\sum}_{t,n}$	Total wealth	-
$a_{i,t,n}$	Annual pension benefit	-
W'	Dummy variable for wealth	-
μ	Dummy variable for expected return	-
R^{S-}	Lower bound of stock return	-10.8%
R^{S+}	Lower bound of stock return	22.8%
$R^A_{i,t,n}$	Return on portfolio specific agent	-
$R^A_{t,n}$	Overall return on total wealth	-
$R^C_{t,n}$	Return to increase personal stocks	-
$R^{C'}_{t,n}$	Dummy for $R^C_{t,n}$	-
$Q_{t,n}$	Height of the collective buffer	-
$Q'_{t,n}$	Dummy for $Q_{t,n}$	-
$F^Q_{t,n}$	Buffer as fraction of total pension wealth	-
F^{Q-}	Lower-limit of the buffer	-
F^{Q+}	Upper-limit of the buffer	-
CE_i	Certain equivalent consumption	-

B Figures

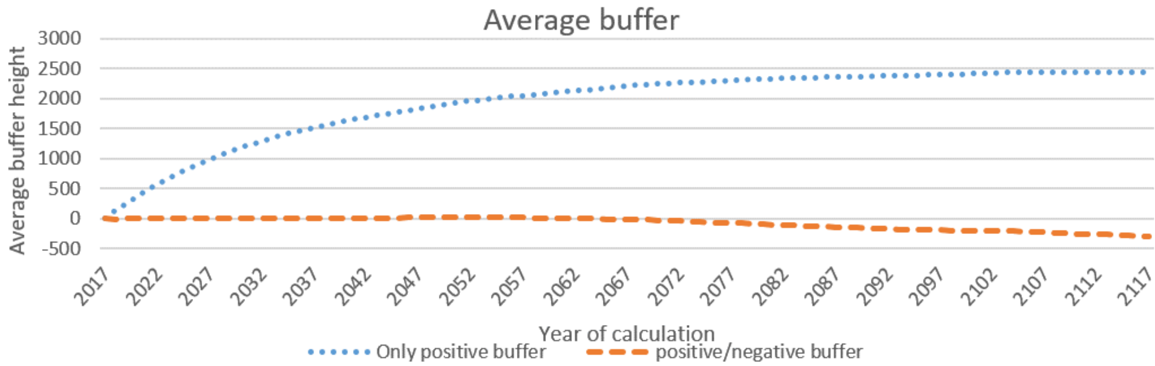

Figure B.13: Average buffer over time

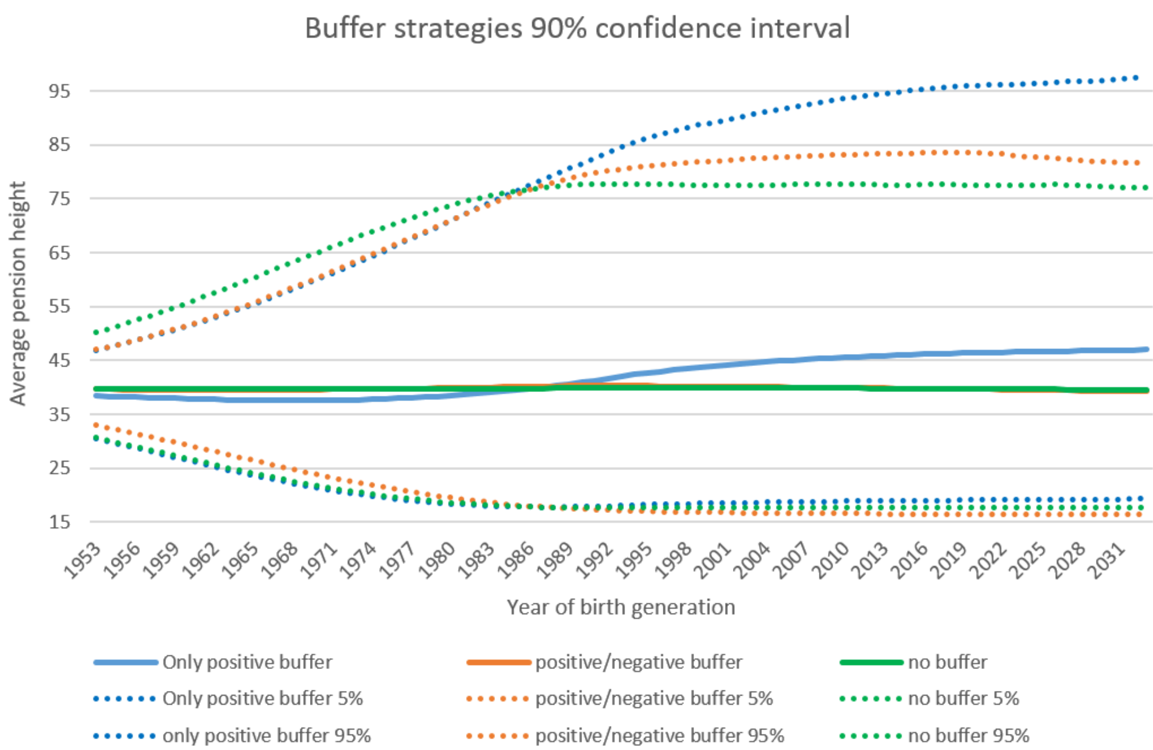

Figure B.14: Average Pension benefit with 90% confidence interval

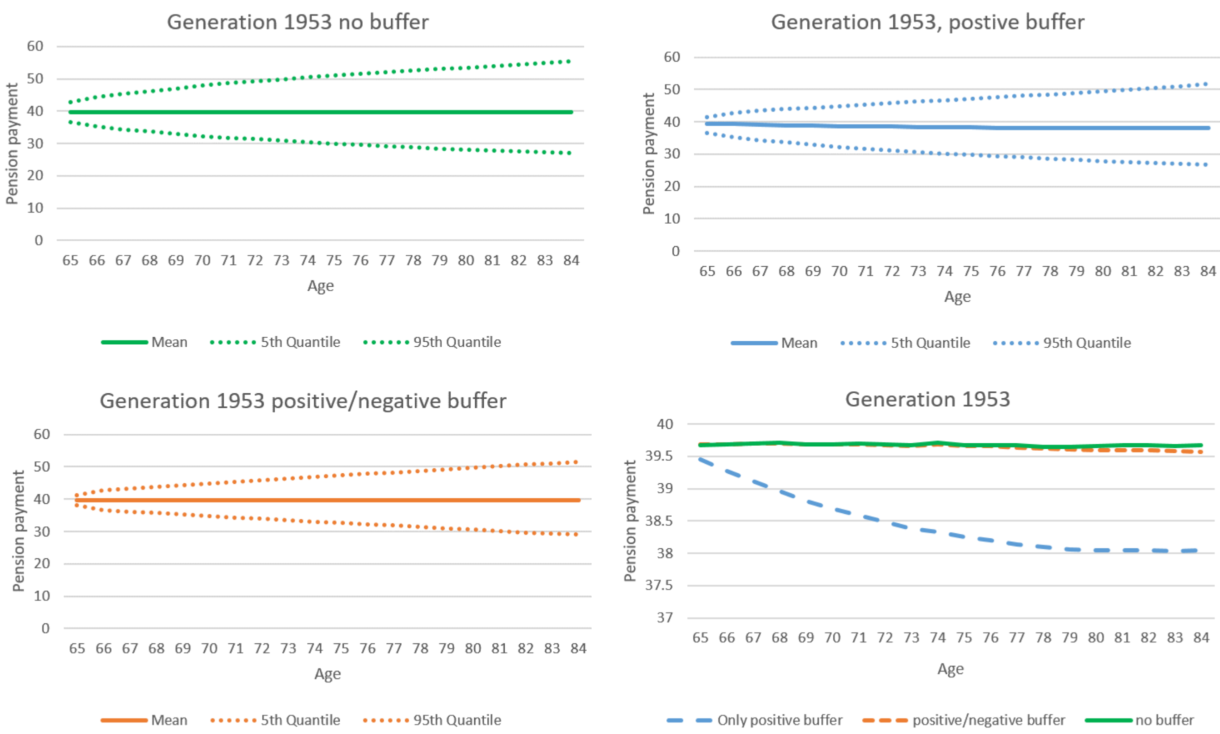

Figure B.15: Average pension benefits generation 1953

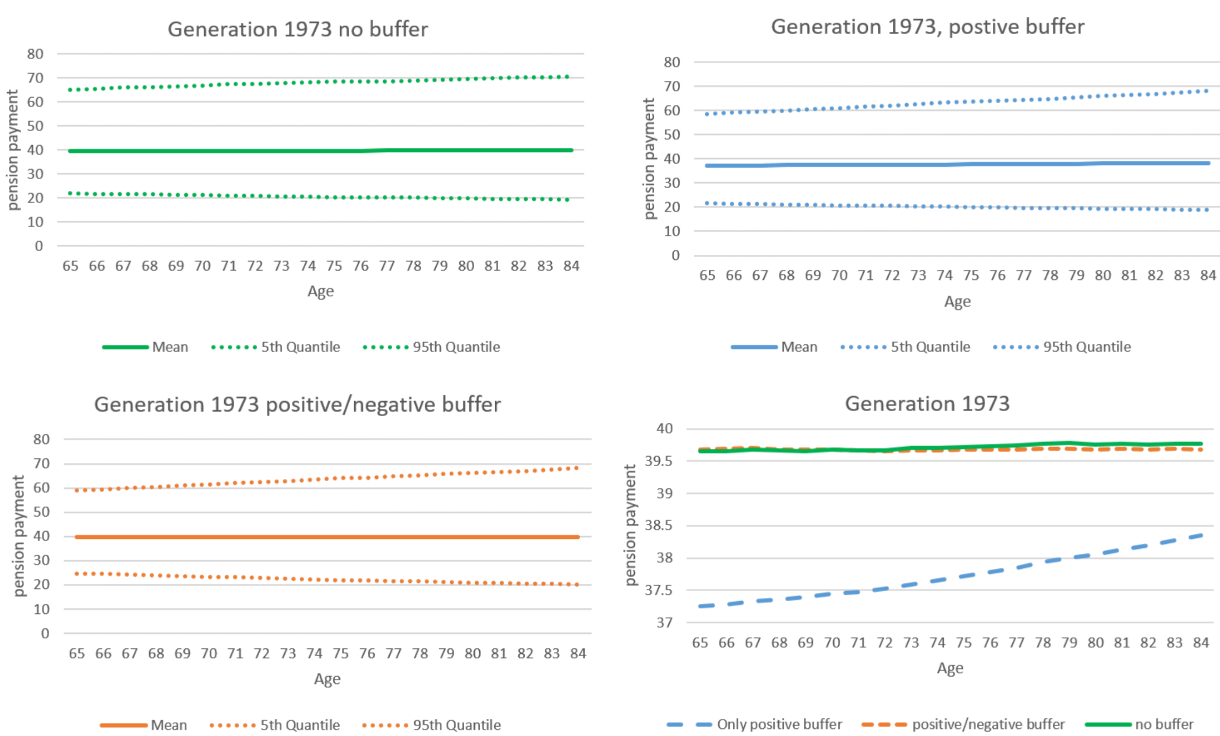

Figure B.16: Average pension benefits generation 1973

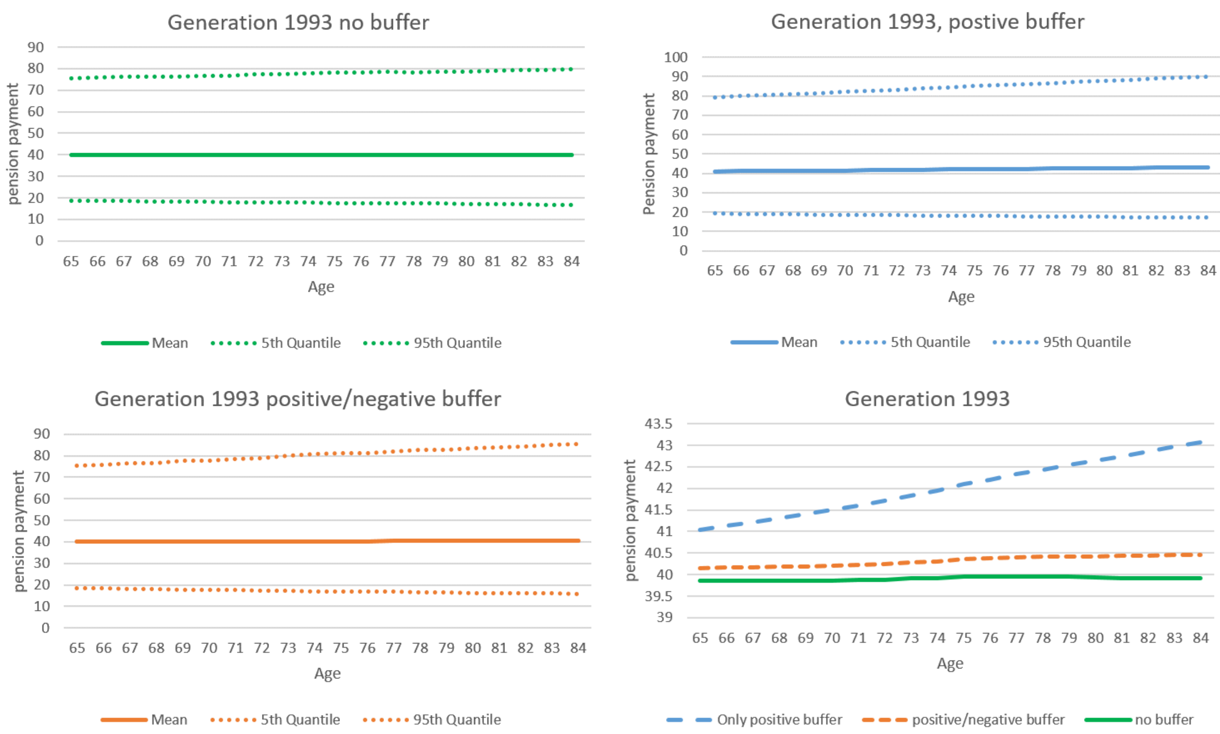

Figure B.17: Average pension benefits generation 1993

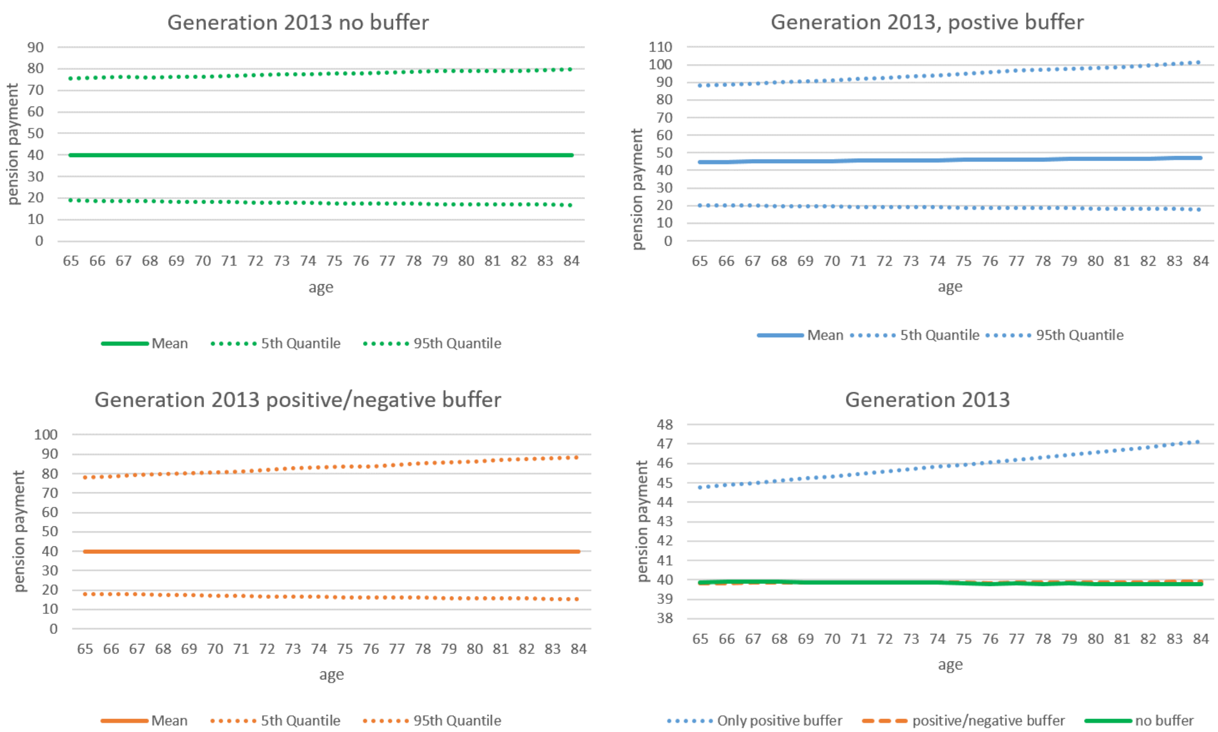

Figure B.18: Average pension benefits generation 2013

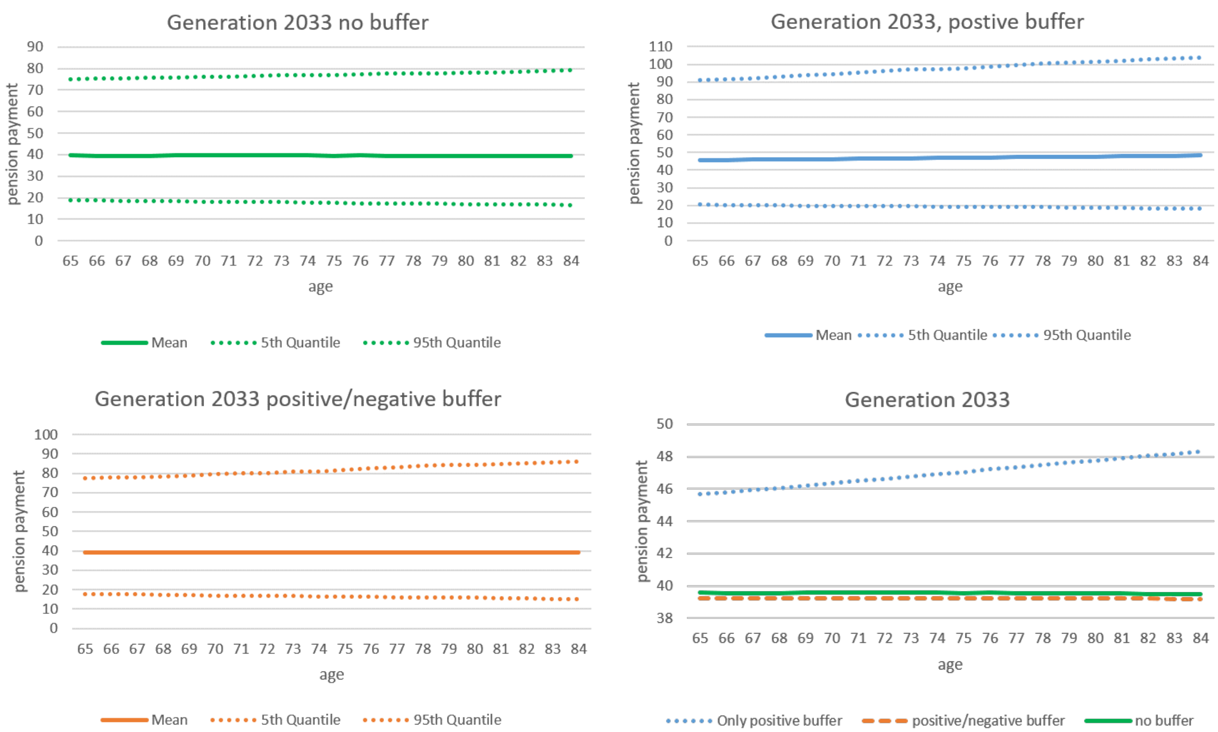

Figure B.19: Average pension benefits generation 2033

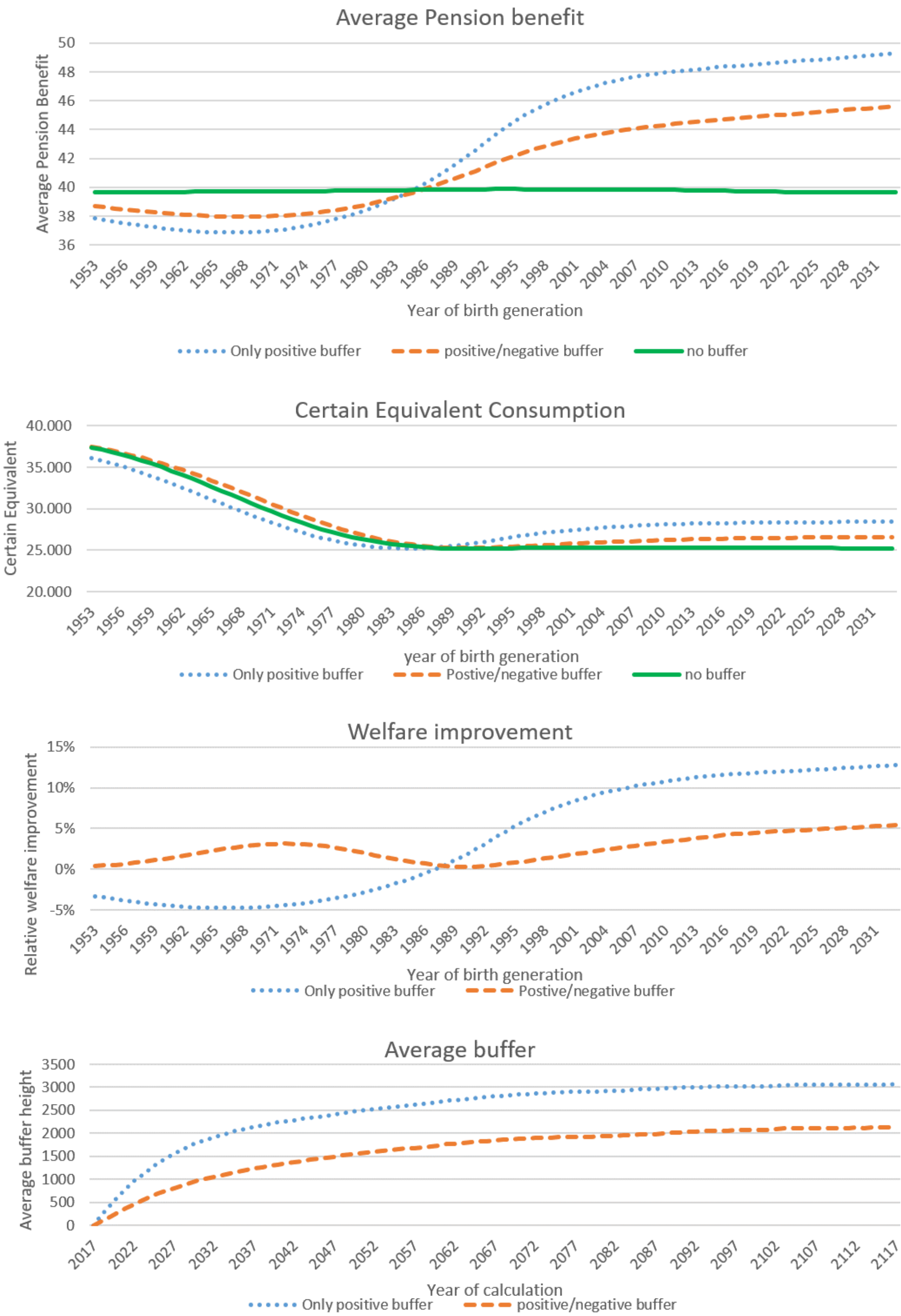

Figure B.20: Overvieuw strategy IV-C-R with adding returns to buffer from 70^{th} interval

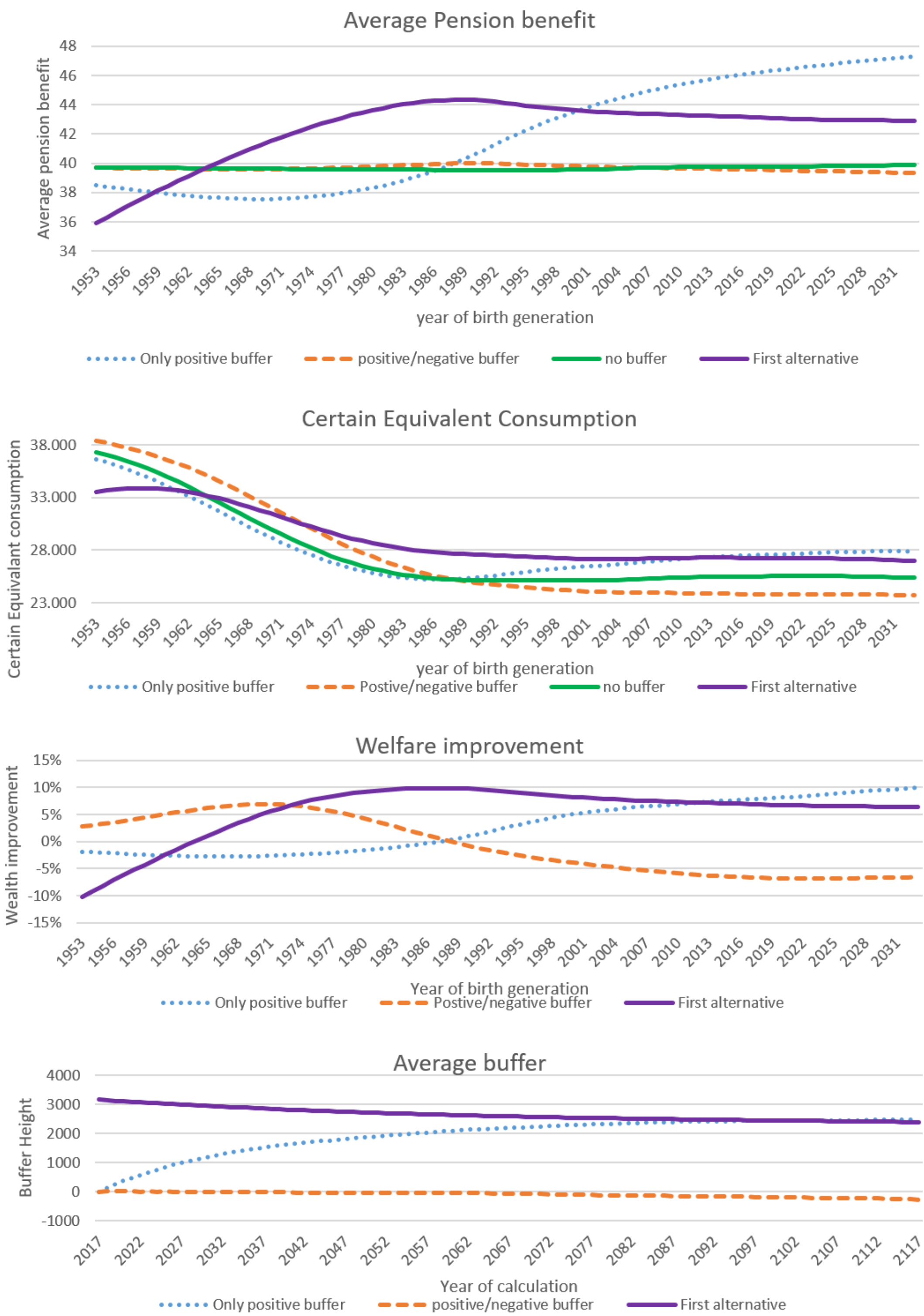

Figure B.21: Overview of this initial model and alternative 1

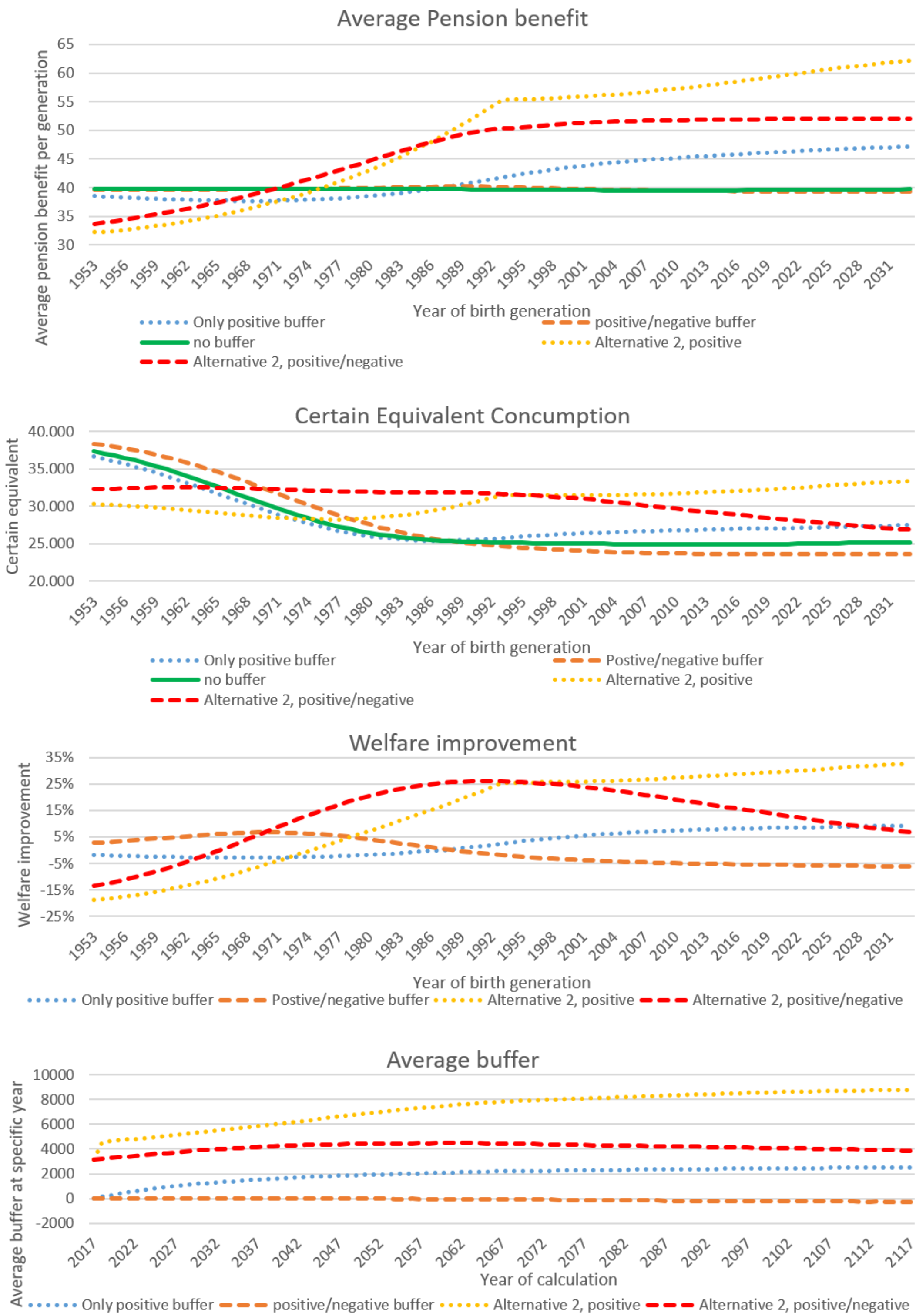

Figure B.22: Overview of this initial model and alternative 2

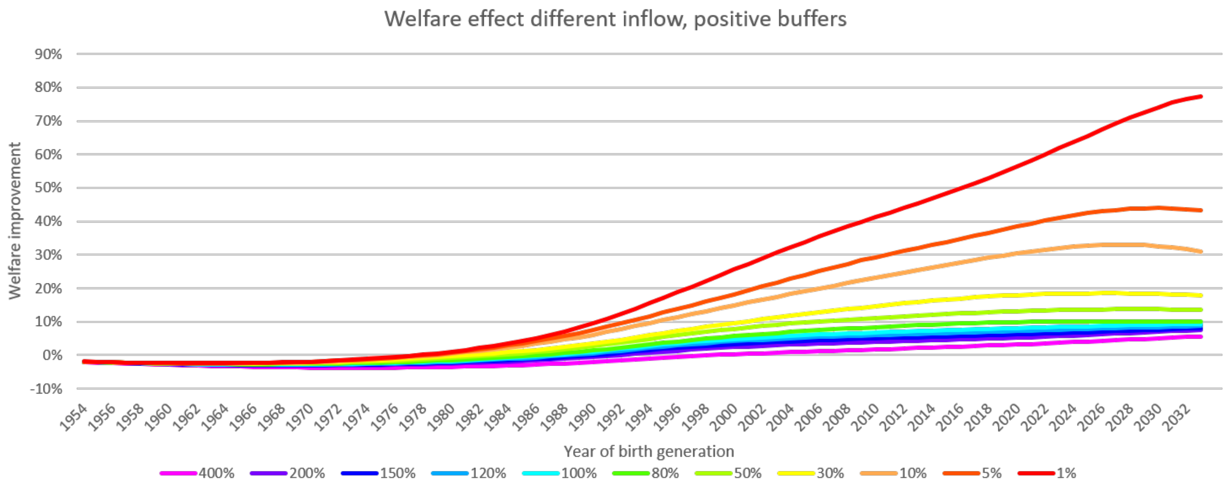

Figure B.23: Welfare effects changing premium inflow

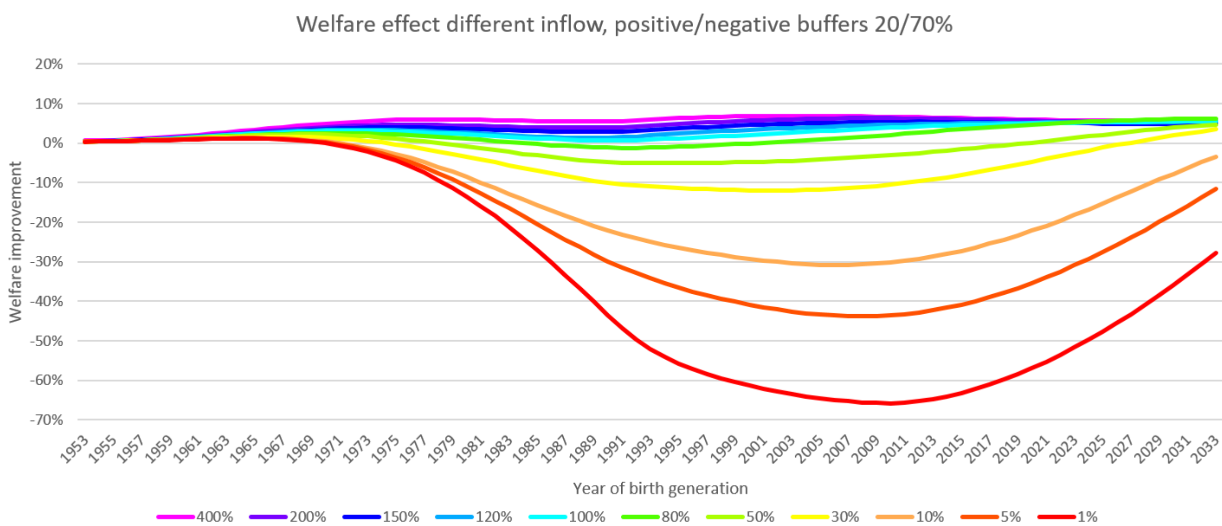

Figure B.24: Welfare effects changing premium inflow with 20/70 percentile buffer rules

Figure B.25: Welfare effects risk free rate

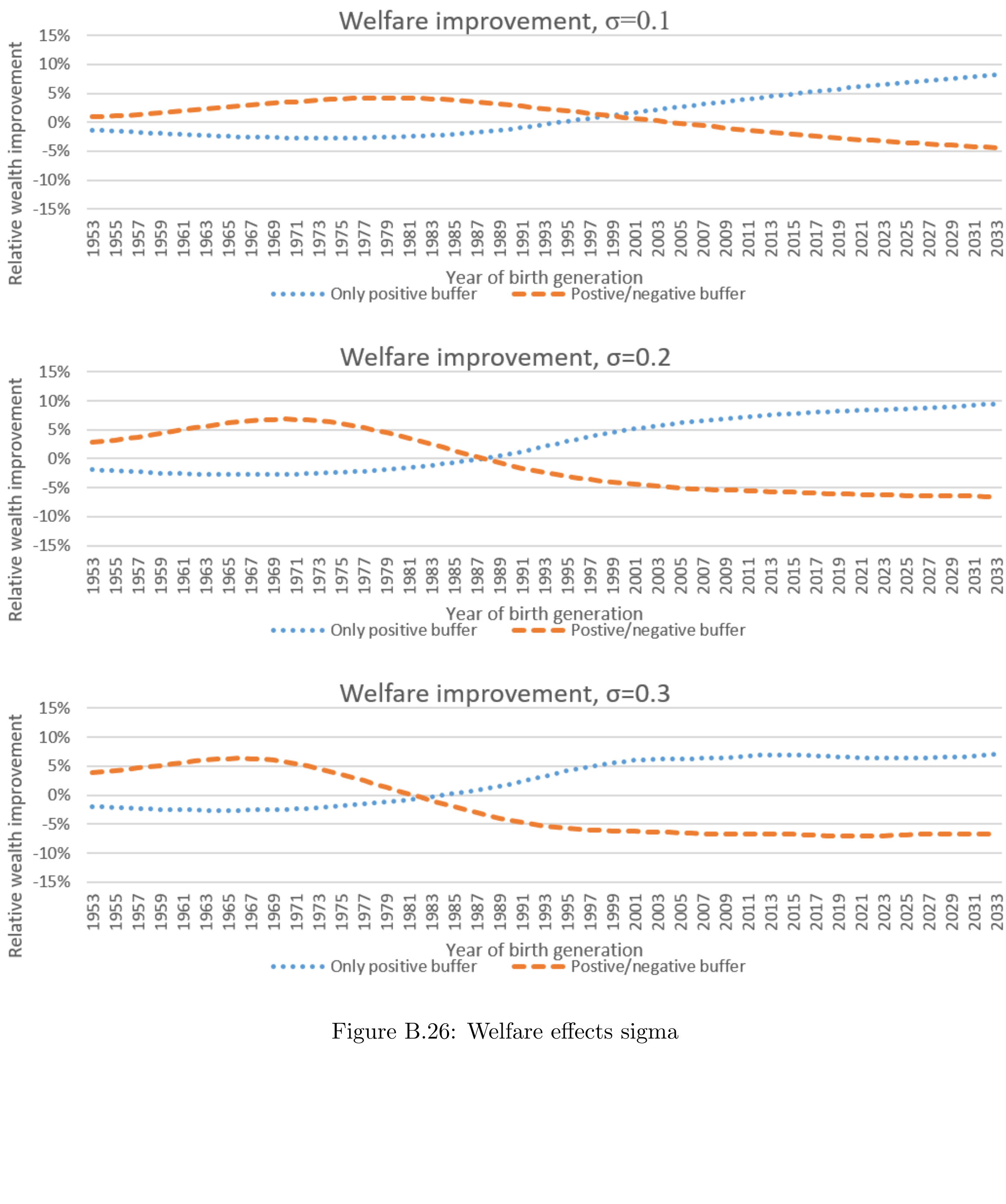

Figure B.26: Welfare effects sigma

Figure B.27: Welfare effects sigma with constant risk premium

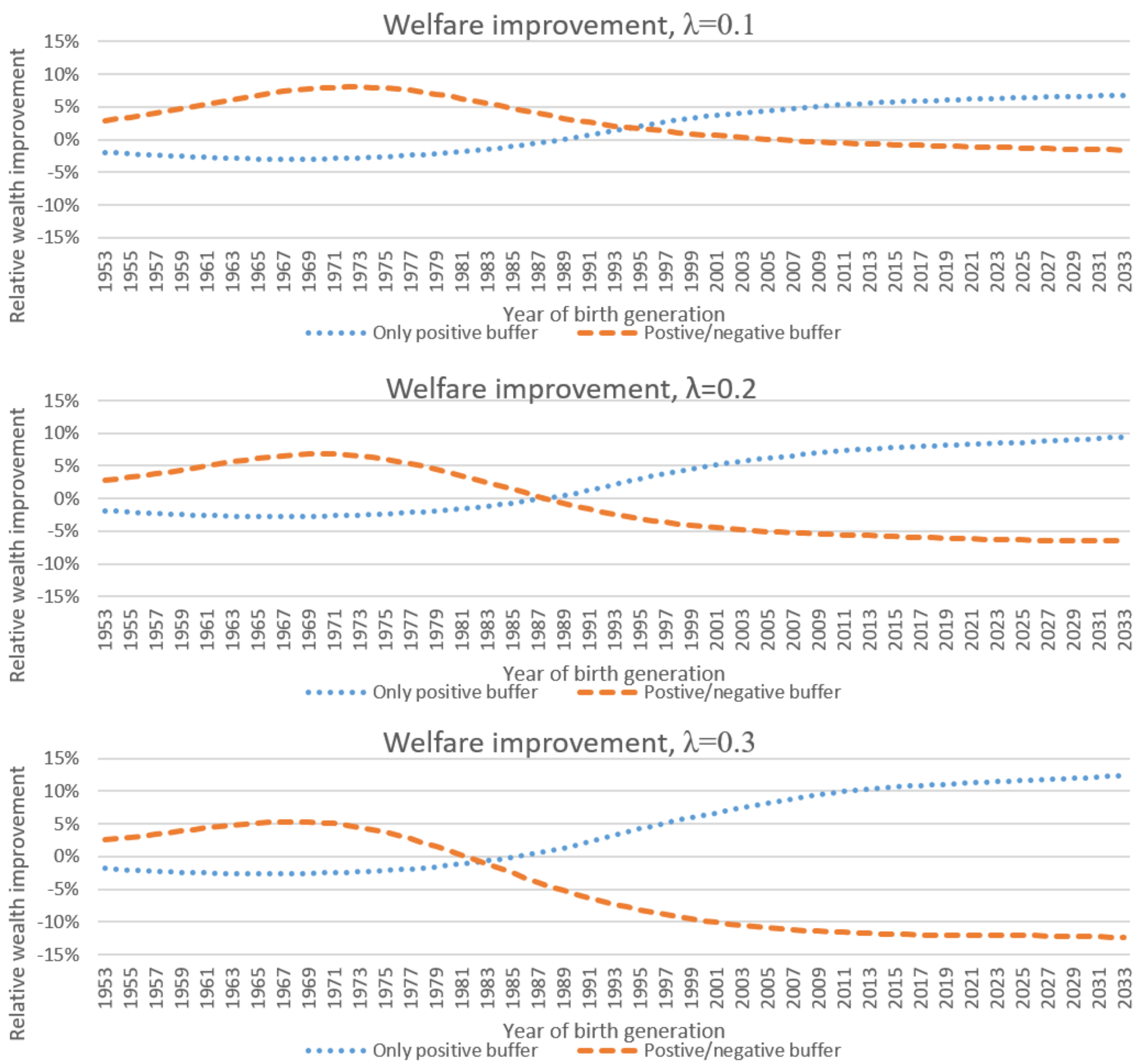

Figure B.28: Welfare effects λ

Figure B.29: Welfare effects risk aversion parameter

Figure B.30: Welfare effects live cycle

Figure B.31: Welfare effects upper and lower percentile (symmetric)

Figure B.32: Welfare effects upper and lower percentile (a-symmetric)

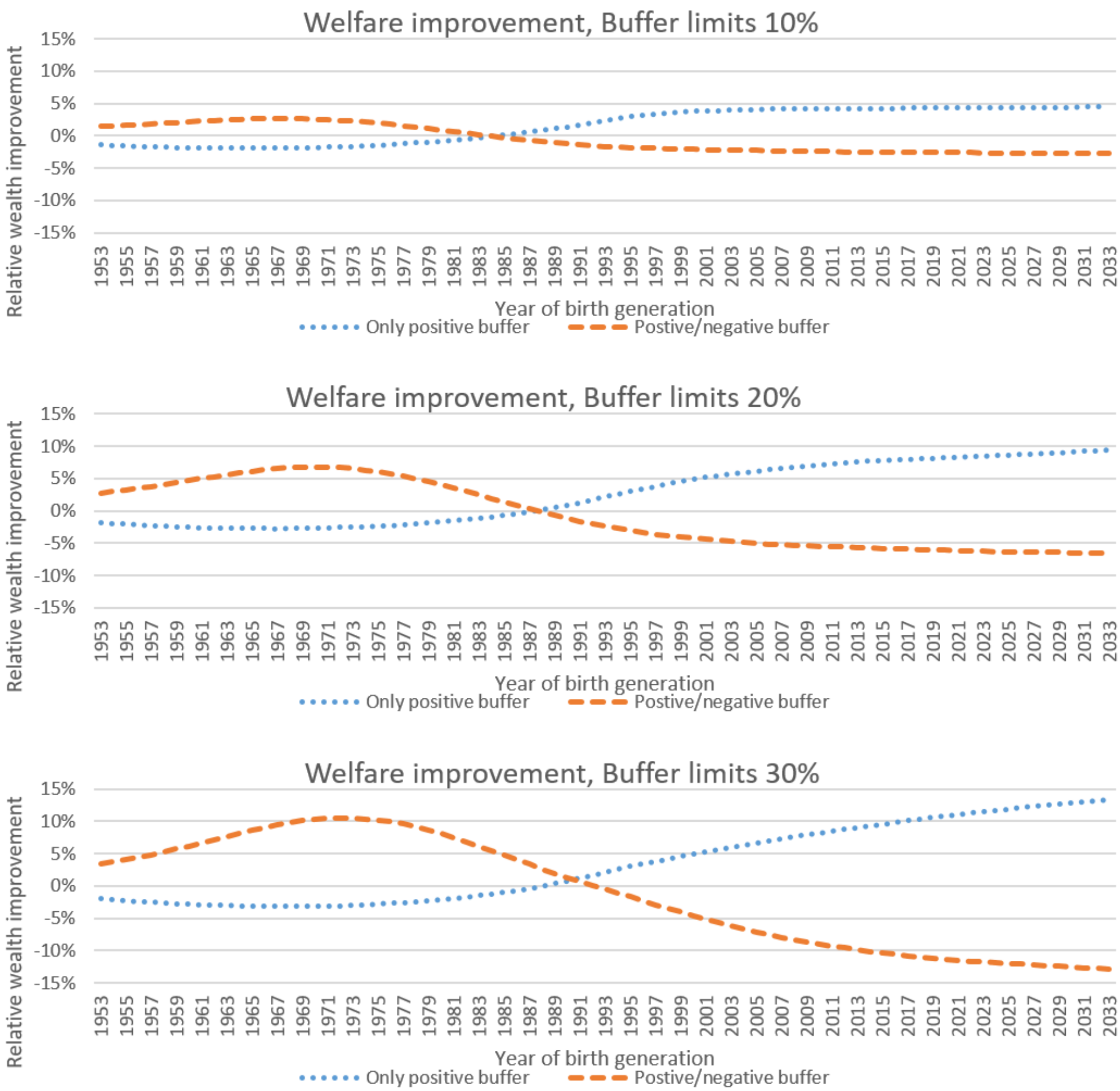

Figure B.33: Welfare effects buffer limits

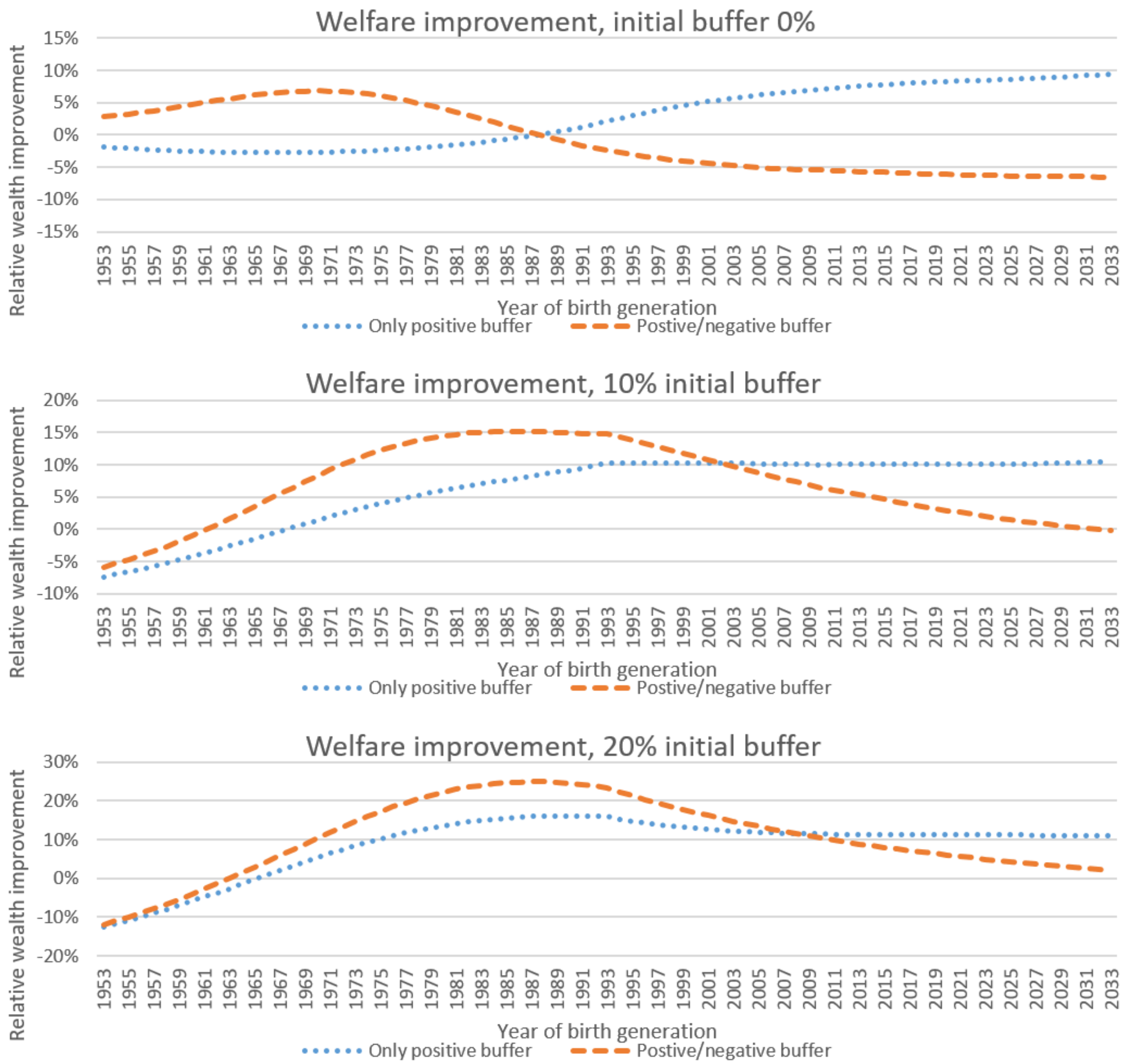

Figure B.34: Welfare effects initial buffer