Network for Studies on Pensions, Aging and Retirement

NETSPAR ACADEMIC SERIES

Health inequalities and the progressivity of retirement programs

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RM 07/2020-001

Health inequalities and the progressivity of retirement programs

Research Master Thesis

to obtain the degree of Master of Science at the
University of Groningen
in accordance with the
rules and regulations of the Board of Examiners
from the Faculty of Economics and Business.

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Health inequalities and the progressivity of retirement programs

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July 2020

Abstract

In this paper, we quantify how much welfare the retirement programs, that finance retirement income and long-term care (LTC) use, redistribute across socioeconomic groups due to the inequalities in LTC needs and mortality. We furthermore examine the extent to which saving for a bequest and co-payments for LTC use moderate this redistribution, because the co-payments are progressive in assets and put an implicit tax on bequest saving. To this end, we develop a dynamic life-cycle model for singles and couples in the Netherlands that explicitly accounts for socioeconomic differences in LTC needs and mortality, bequest saving and co-payments for LTC use. We calibrate our model to match unique population data on Dutch asset profiles for the period 2006 to 2015. Our results suggest that bequests form a particularly strong saving motive for the households with the highest socioeconomic status. Driven by lower LTC needs and mortality for households holds with a higher socioeconomic status, we establish that retirement programs redistribute welfare, measured in certainty equivalent consumption units, from households with lower socioeconomic status to households with higher socioeconomic status. We additionally find for higher socioeconomic groups that their lower LTC needs reduce the implicit tax that LTC co-payments puts on their preferred bequest saving. Bequest saving therefore explains the excess welfare gain for the higher socioeconomic groups that arises from socioeconomic inequalities in LTC needs and mortality.

Key Words: *Socioeconomic inequalities, Long-term care and Mortality risk, Retirement programs, Couples' life-cycle model.*
JEL Classification: *D14, D64, H55, I14, J26*

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Preface

Background

This document contains my Research Master thesis for the track Business Analytics and Econometrics at the Faculty for Economics and Business, the University of Groningen. The thesis complies with the rules and regulations of the Board of Examiners set out for the academic year 2019-2020. This thesis is the final examination (worth 30 ECTS) of my curriculum that I started in Summer 2017.

Acknowledgements

Without the support of my family, friends, fellow students, lecturers, my supervisors and other researchers I would not have come this far. It is now my turn to acknowledge you for your support.

First, my supervisors Max, Raun and Rob guided me through the research master and acquainted me with all the ins and outs of doing research that you cannot learn straightaway from textbooks. They provided me with the freedom to visit conferences, to do my own research under their keen eye and above all they unconditionally supported with all the choices I made and the barriers I had to overcome personally and within academia. You were there for me, and I greatly appreciate that. We will definitely continue the solid cooperation during my P.hd. trajectory.

The method that I apply in this thesis, life-cycle modelling, is not taught at Dutch universities. I developed my skills on solving dynamic structural models by taking part in the course Advanced Computational Economics from Maurice Hofmann and Prof. Hans Fehr at the University of Würzburg. I would like to thank them for giving me the opportunity to follow their unique course, with inherent textbook, to be able to build life-cycle models. I definitely need this again during my P.hd..

A supportive environment is indispensable to bring out the best in each other, day

in, day out. My fellow research master students created this supportive environment for me and made me feel comfortable in the group. For my part, the term research master students may therefore interchangeably be used with "friends". Also my friends outside academia and family supported me with more than research alone and we had great times throughout all the years that we know each other. These bonds have grown steadily over the time and I hope these will remain. To respect everyone and to act properly, I will not mention any of your names. My friends and family know whom I am referring to.

Contents

1 Introduction

Socioeconomic inequalities in health and mortality increase (Bennett et al., 2015; Auerbach et al., 2017), which has important implications for the fairness of retirement programs, particularly after retirement. Yet, a negative association between mortality with socioeconomic status (SES) is well-documented (Deaton, 2002; Smith, 2007; Chetty et al., 2016), and this implies that high SES households can longer collect benefits from programs that finance retirement income. At the same time there exists a negative association between long-term care (LTC) needs and SES (Ilinca et al., 2017; Jones et al., 2018; Rodrigues et al., 2018; Garcia-Gomez et al., 2019; Tenand et al., 2020a; van der Vaart et al., 2020a), and this implies that high SES households contribute for a shorter time to LTC provision when this demands co-payments upon use. The SES gradients in LTC needs and mortality thus introduce a regressive element to progressive retirement programs.

While the SES gradients in LTC needs and mortality are widely established, how heavily retirement programs redistribute welfare between SES groups through these joint health differences received far less attention. We address this question in our paper for retirement programs that finance retirement income and that provide LTC. We furthermore examine the extent to which saving for a bequest and LTC co-payments moderate this redistribution, because LTC co-payments that are progressive in assets may put an implicit tax on bequest saving.

To model the fairness of retirement programs, an integrated system of retirement programs that finances retirement income and LTC needs should be considered. Also progressive contributions via taxation or co-payments, which finances the retirement system, should be taken into account. To this end, we develop a dynamic life-cycle model of couples and single-person households that entails the entire life-cycle and incorporates both the contributionary and benefit phase of these retirement programs. The model explicitly accounts for differences in LTC needs and mortality by SES groups through giving every SES group an uncertain perspective on lower LTC needs and higher remaining life-expectancy, while this perspective is best for the highest SES group. The transition from a couple to a single-person household solely happens through death and not through divorce or remarriage. Furthermore, our model allows households that comprise a couple to have lower LTC needs and thus lower LTC co-payments, because the spouse may provide informal care to the household member in need (Nihtilä and Martikainen, 2008). Within the model, households save to finance future consumption or to leave as a bequest when dead. Retirement income and public LTC insurance, that demands income- and asset-dependent co-payments, protect households' consumption and bequests against the health-related risks in the model. We account for the bequest motive, because bequests are widely established as a luxury good and provide an explanation to why high-income households substantially save until late in life (De Nardi, 2004). Furthermore, LTC co-payments put an implicit tax on bequest saving and the interplay between the two may therefore moderate a welfare redistribution when health differences exist. Different SES groups consequently attach different value to these programs because of their preferences and inherent differences in health, and our life-cycle model relates this value to a welfare estimate.

We estimate our model to match administrative data on Dutch asset profiles of retired households for the period 2006 to 2015. We estimate three important behavioral parameters for our life-cycle model: the subjective discount factor, the strength of the bequest motive, and the extent to which bequests are a luxury good (cf. Lockwood, 2018). We estimate a subjective discount factor of 0.948, implying modest preference for current consumption. We estimate a marginal propensity to bequeath of 99 cents of every euro above an asset level of €26,900 and this implies that mainly the households with high asset holdings care about bequests and that this provides a strong motive to save for them.

A reliable welfare analyses necessitates well-identified behavioral parameters and the Netherlands provides a unique case to estimate and identify these parameters. In a system with mainly private insurance, such as in the U.S., a proper modeling of dynamic and potentially health-dependent preferences would have been indispensable to study the welfare effects. In the Dutch case that explicit modelling is less relevant, because generous retirement income plans and the universal and comprehensive nature of LTC insurance in the Netherlands gives only limited room for individual decisions and consequently welfare inequality arising from this. For our research we emulate the Dutch public LTC system of 2012, that demands a co-payment rate of 75% of taxable income and 4% of assets for a yearly LTC stay (Tenand et al., 2020b). Part of the income and assets is exempted and the co-payments are capped, so the system is seemingly generous and allows for limited private saving for LTC co-payments.

To address how heavily differences in LTC needs and mortality affect the distribution of welfare, we use our life-cycle model to carry out a counterfactual analysis. In the counterfactual case we assume that every SES group faces the LTC needs and mortality risk of the bottom lifetime income group, who have highest LTC needs and mortality. The introduction of the counterfactual may induce a behavioural (saving) response and therefore have welfare implications. Apart from any other behavioral effects, the choice for our counterfactual and baseline induces a pure income effect. Contrary to the counterfactual, differential mortality exists in the baseline case and this generates a positive income effect for any SES group, because high-income households are mainly the survivors in a SES group when households age. Given the income and behavioral effects, we can consequently calculate with our life-cycle model how much welfare they gain or lose due to their own LTC needs and mortality risk (baseline case) compared to the more pessimistic assumption on their risks. As a second step, we would like to understand how LTC co-payments and bequests moderate this redistribution, because the LTC co-payments put an implicit tax on leaving a bequest. We therefore redo the welfare analysis while we one-by-one remove the LTC co-payments and a bequest saving motive from the estimated life-cycle model.

We find a strong SES gradient in mortality, and a more modest gradient in LTC needs, particularly for females. Given this finding, our welfare results are fourfold. First, taken together the differences in LTC needs and mortality, we establish a welfare gain for the highest SES group of 1.09 percentage points in the level of yearly certainty equivalent consumption, while this is only 0.37 percentage points for the lowest SES group. Hence, higher SES groups indeed seem to benefit from their better perspective on lower LTC needs and a longer lifetime. Due to a positive income effect and the perspective on lower LTC needs and co-payments, every SES group experiences a positive welfare gain. However, the lowest SES groups see part of the additional income taxed by LTC co-payments. This additional taxation is less likely for higher SES groups, who see their co-payments already capped under the counterfactual and therefore do not have to pay an additional co-payment over the additional income. Moreover, high SES households see the implicit tax of LTC co-payments on bequests decrease under the baseline scenario, because they spend a shorter time with LTC. The high SES households can use the additional resources to consume and bequeathe and therefore have a larger welfare gain. We shut down the existence of LTC co-payments in a second step to disentangle which part of the welfare gains stems for LTC co-payments and which part from bequest saving. These co-payments explain 38% (23%) of the welfare gain for low (high) SES households. Still, a substantial part of the welfare gain of high SES households is unexplained, because these households can use the income effect to leave a larger bequest that is important for them. In a third step, we examine the role of a bequest motive and accordingly shut down its existence in the life-cycle. Households then no longer save to leave a bequest. A bequest saving motive explains 41% (65%) of the welfare gain for low (high) SES households, which is in line with that a bequest motive is more important to high SES households. Once the bequest motive is removed from the model, high SES households can no longer exploit the income effect to leave a larger bequest. They furthermore can no longer exploit their below-average LTC needs that puts a lower implicit tax on bequest saving. Moreover it makes neither sense for them under the counterfactual nor under baseline case to hold assets until late in life, because these will be taxed by LTC co-payments and they obtain no welfare from a bequest anymore. Their welfare gain thus tremendously decreases when they no longer save for a bequest. Lastly, we simultaneously shut down the LTC co-payments and bequest saving motive from the life-cycle model, and consequently see the welfare gains reduce to 0.08 and 0.01 percentage points for the low and high SES group. The welfare gains that results from joint differences in LTC needs and mortality then thus vanishes. Hence, the engine behind the stronger welfare gain for high SES groups is the complex interplay between LTC co-payments and a bequest saving motive.

The remainder of the paper is organized as follows. Section 1.1 presents the current state of literature. Section 2 describes the institutional context. Section 3 describes the life-cycle model. Section 4 provides the estimation procedure. Section 5 describes the data. Section 6 shows the data profiles and first-step estimation results. Section 7 discusses the second-step estimation results. Section 8 performs the counterfactual policy experiment. Section 9 discusses and concludes.

1.1 Relation to the literature

Our study connects with the broad strand of literature that examines inequality in benefits of retirement programs. The results from such analysis depend, to a certain degree, on the retirement program that is studied. For example, Liebman (2001) studies, amongst others, the inequality in social security income for the U.S. and they report that a substantial fraction of the high-income individuals receives higher net transfers than their low-income counterparts do. For Medicare, which covers care needs after retirement in the U.S. and basically serves as a social safety net for the households with lower income, Bhattacharya and Lakdawalla (2006) documents an opposite pattern in lifetime benefits that favors the households with lower income. Given the inequality within these two social insurance programs, Auerbach et al. (2017) finds that little inequality exists within an integrated system of social insurances when using net lifetime benefits as their measure on inequality.

A second class of studies measures inequality rather in welfare levels and adopts a life-cycle or utility approach for this. Such approach addresses the critique from Bernheim (1987) which states that the evaluation of lifetime benefits of social insurance benefits neglects that some (risk-averse) households attach some additional value, in the form of personal asset holdings, to the protection offered by social insurance. Using a life-cycle approach, De Nardi et al. (2016) shows that the Medicaid benefit system is progressive in income. A finding that McClellan and Skinner (2006) documents for the Medicare system in the U.S. when adopting a life-cycle framework. Likewise Groneck and Wallenius (2020) develops a life-cycle model on saving to explain progressivity of social security income in the U.S.. They document that for a given marital status, the replacement rate of social security income declines when the education level is becomes higher. The result of an analysis on inequality within the welfare state thus depends on the accounting approach that a study uses. We select the life-cycle approach because our analysis involves a welfare comparison to a case that health differences do not exist. This counterfactual may induce a behavioural (saving) response and we therefore select a life-cycle rather than accounting approach.

An important contribution of our study is that we simultaneously investigate how inequalities in LTC use and mortality affect fairness within the retirement programs. We furthermore unify the different retirement programs in a life-cycle framework and we incorporate both a contributionary and benefit phase of these programs, that includes both progressive taxation and co-payments. We analyze the degree of redistribution caused by health inequalities in a setting with universal and comprehensive retirement programs, which limits the individual decision to privately save or insure against the health risks. Contrary to for example the U.S. setting, we do not have to model this individual decision. We can therefore provide a more complete picture on inequality that exists within the welfare state and the interference with individual decisions is limited.

We develop a life-cycle model for singles and couples and therefore our study links to the emerging but still scarce strand of literature that explains singles' and couples' saving decision. The necessity to distinguish between household types is shown in Kotlikoff and Spivak (1981) and Brown and Poterba (1999) who use a basic life-cycle model to explain that annuitizing wealth is more valuable to singles who do not have to care about surviving spouse' welfare. Hurd (1999) extends their life-cycle model by making bequests to next generations intended rather than accidental but does not provide a significant support for an intention to leave a bequest. More recently, De Nardi et al. (2015) expanded the life-cycle model of Hurd (1999) with uncertain LTC use and uses the model to explain why savings in the U.S. drop upon the death of the first spouse. Their model explains a large share of this wealth decline with high medical and burial expenses in the year of spousal death. It is thus important to distinguish between singles and couples in the life-cycle model, because households members may be caring about each others welfare when widowed. Our modelling approach extends these existing approaches through that we not only incorporate life-expectancy differences between couples and singles but also explicitly account for the joint dependence in LTC needs of household members within our life-cycle model. Our study then contributes to existing literature, because we explicitly take into account the role of the spouse as an informal care provider to the household member who is in need of LTC.

2 Retirement programs in the Netherlands

2.1 LTC provision[1]

While universal public LTC insurance is non-existent in the United States, the Dutch public care system can be viewed as the other extreme with an (almost) universal public LTC scheme where access to benefits is based on needs and not on income.[2]

The Netherlands was the first country that introduced a universal mandatory social health insurance scheme in 1968, for covering a broad range of LTC services provided in a variety of care settings (Schut and van den Berg, 2010). Nowadays, public expenditures are 2.6% of GDP which is among the highest in Europe European Commission (2018). These high expenditures, on the other hand, go along with a comprehensive coverage: the major share of more than 70% of elderly people are covered by publicly funded LTC

[1] This subsection is a modified version of earlier work of ours: van der Vaart et al. (2020a)

[2] In Europe, also Sweden, Denmark, Austria and Germany have universal public LTC systems, see European Commission (2014) for a description of the European systems.

(European Commission, 2014). Privately paid services only play a marginal role.[3]

Social protection for LTC is subject to an eligibility test. Tests are mainly based on the functional limitations and the health status of the applicant. Eligibility is not means-tested, implying that income or wealth is not considered (Tenand et al., 2020a). Relatives, if present, are expected to provide some minimum personal care to their disabled relative and they actually seem to do so (Mot, 2010; Bakx et al., 2015).

Until 2014, the financing of the LTC system fully operated via a social insurance scheme and general taxation. Around 90% of total costs are covered by mandatory social security contributions and general government revenues (Schut et al., 2013). The mandatory social security contribution is 12.15% of the income below a maximum €32,738 in 2010. In 2012, only 8% was financed through co-payments (Maarse and Jeurissen, 2016). Co-payments increase with income and assets and are higher for nursing home use than for home care use. The yearly (median) co-payment that households made for home care equalled 1% of their disposable income in 2011 in the Netherlands compared to 56% when a household member was in need of nursing home care (see Wouterse et al., 2020).

Overall, the Dutch LTC system provided generous public care coverage until 2014 and therefore provided limited grounds for inequalities in the use of LTC depending on SES (see for example Rodrigues et al., 2018).[4,5] At the same time, there are only modest out-of pocket expenditures for LTC. For the case of the Netherlands, it is thus likely that the need for LTC – manifesting in limitations with activities of daily living – in large parts coincides with the actual care use. Moreover, in a system with only private insurance, a proper modeling of dynamic and potentially health-dependent preferences and adverse selection is indispensable to study insurance decisions. In contrast, the universal nature of LTC insurance in the Netherlands gives only limited room for individual decisions.

After 2014, major reforms of the LTC insurance scheme were implemented accompanied

[3]Less than 0.1% of total expenditures for LTC are private, see Tenand et al. (2020a).

[4]For a study on countries with less generous systems, Spain and the Phillipinnes, see for example Van de Poel et al. (2012); García-Gómez et al. (2015).

[5]Depending on the data used and the definition of LTC use there are however some studies that document that low SES groups are modestly favored within the Dutch institutional framework, even when accounting for differences in LTC needs (Tenand et al., 2020a).

by substantial budget cuts. The reforms implied stricter eligibility criteria for nursing-home care to encourage people with lighter LTC needs to age at home rather than in expensive nursing homes. At the same time, the provision of LTC at home also became less generous: personal circumstances such as the availability of an supporting environment are now considered when deciding about the provision of care. Consequently, our analysis focuses on the period until 2014.

2.2 The Dutch pension system

The Dutch pension system is a true three pillar system and belongs to the most generous pension systems across all OECD countries (OECD, 2013). While the gross replacement rate in 2017 for the median household was 70% over the first two pension pillars, the replacement rate increases to 105% when third pillar benefits and other sources of income are counted as well (Knoef et al., 2017).

2.2.1 First pillar pension

The first pillar (Dutch: AOW, Old-Age Pension act) grants a flat rate benefit. The gross income of retirees consisted for 35% of this source of income in 2017 (Statistics Netherlands, 2019). An individual qualifies for this benefit when the statutory retirement is reached (age 65 until 2012). For every year of residency in the Netherlands an individual accrues 2% of the full benefit when aged between 15 and 65 years old. That full benefit is 100% of the net minimum wage for a couple in (€18,600 in 2010) while 70% for a single. The first pillar gives limited rise to inequality based on its benefit level, because it offers the same benefit to everybody. In other countries, such as the U.S., the benefit rate is linked to the working history of a participant and therefore can provide more grounds to inequality.

The system is pay-as-you go (PAYG) financed. The contribution function is concave and the contribution rate is fixed at 17.9% for any taxable income below €$32,738$ (in 2010). The beneficiaries do not have to pay this contributionary amount.

Facing the excessive burden of an aging population, the Dutch government announced to gradually increase the statutory retirement age as of 2012 to 67 years in 2024. The statutory retirement age will be linked to the life-expectancy after 2024. As our analysis mainly covers the period before 2012, we are not concerned that this policy reform will change our results by much.

2.2.2 Second and third pillar pension

Second and third pillar pension benefits supplement the first pillar pension and consist 36% of the gross income of retirees in 2017 (Statistics Netherlands, 2019). Second pillar pension is the most important source of the two, contributing to 90% of the assets available for these private pension supplements (see Karpowicz, 2019).

The second pillar pension is an occupational pension. Participation is often made mandatory through the collective labor agreement that is industry- and occupation-specific. The pension scheme therefore covers over more than 90% of the non self-employed in the Netherlands (Bovenberg and Nijman, 2019). The employer and the employee both contribute to this pension, which is generally administered by large pension funds and insurance companies.

Second pillar pension arrangements are closely related to first pillar pension and often designed so that the combined benefit of the two grants a maximum replacement rate of 75% of gross average lifetime income (Knoef et al., 2017). For every year worked a participant accrues up to 1.875% in pension of the difference between gross earnings and the so-called franchise. The franchise is the part of the earnings that will be replaced by first pillar pension and which henceforth does not have to be replaced by second pillar pension. When having worked full time for 40 years, the total pension would thus be 75% of the average gross lifetime earnings.

The second pillar pension system is fully funded and can be classified as a hybrid defined benefit (DB) system. The benefit structure for the second pillar pension is often a deferred 'variable' annuity. While the annuity guarantees some final benefit, this benefit can change over time depending on the funding rate of it, for example when the macro-economic conditions and henceforth investment climate has changed.

Until 2006 there also existed tax-favoured early retirement schemes in the Netherlands which employees could opt for once turned 60 years old (VUT-regeling). This early retirement scheme was financed with a industry- or occupation-specific PAYG system, which was also the reason to gradually phase out the generous scheme. An aging population would make the system financially and fiscally unsustainable in the future. Even though the system was formally abolished in 2006, life-course savings schemes (levensloopregelingen, bridging pensions) were still tax-favoured until 2012 and consequently encouraged early retirement by some working individuals until then.

Third pillar pension arrangements, mainly life contingencies, finance income throughout retirement in the Netherlands to a lesser extent. Participation in these arrangements is voluntary and often seen as a way to supplement retirement income for self-employed who do not participate in the occupational pension schemes. There nevertheless exist not so much differences in the participation rates of the self-employed and the not self-employed in this pension pillar. 28% of the not self-employed owned either a life-long annuity or single premium annuity while 33% of the self-employed did so between 1994 and 2008 (Mastrogiacomo and Alessie, 2014).

For two reasons we omit the third pillar pension arrangements from our study and focus on first and second pillar pension only. Participation in third pillar pension is relatively low when compared to that 90% of the labor force is covered by second pillar pension. Furthermore only 10% of the assets available for private pension consists the third pillar arrangements (Karpowicz, 2019). Having said this, we now proceed with describing our life-cycle model.

3 The model

We develop a life-cycle model to understand how retirement programs redistribute welfare when LTC needs and mortality differ across SES groups. We aim to model how households privately save for the financial risks that the retirement programs partially cover. According to the life-cycle model, retirees allocate at any period in time their budget, consisting of current income and assets, to current consumption and savings for future consumption. They obtain utility from consuming goods and leaving a bequest and aim to maximize lifetime utility, or welfare (Ando and Modigliani, 1963).

The life-cycle model consists of the following key ingredients. First, there is a government to whom households make progressive social insurance contributions during working life. These contributions finance first pillar pension and pubic LTC provision after retirement. After retirement the government pays out first pillar pension and partially covers LTC needs. When in need of LTC, households make a co-payment to the government that is progressive in their asset- and income-level. Second, in addition to first pillar pension, households accrue second pillar pension entitlements during working-age and these accrued benefits are paid out after retirement. We exclude third pillar pension benefits, which is motivated by the observation that this pillar seems, contrary to the U.S. setting, of less importance to the Dutch case. Third, several heterogeneous risks exist in our model. Income is uncertain during working age. At the same time, part of the income throughout working life is deterministic and depends on a permanent income part (referred to as SES) and an age-specific part. After retirement there exists heterogeneity in the risk on being in need of LTC and mortality, and these risks differ with lifetime income and marital status of a household. We support the first dependency with the empirical observation that the risks on having LTC needs and mortality are lower for households with higher average lifetime income (van der Vaart et al., 2020a). We motivate the second dependency with the observation that LTC needs are lower for households in which the spouse can partially cover LTC needs through informal care provision (Nihtilä and Martikainen, 2008).

3.1 Model description

The model starts when a household consisting of a male and female is 25 years old. For simplicity we assume that both members have the same age $j \in (25, \dots, J)$. The household can live up to at most age $J = 100$ and after this age all remaining household members die with certainty. The model contains income, health and mortality as three sources of uncertainty. The state vector $\aleph$ represents the variables that are commonly observed by the household at the beginning of a new period, i.e. after the resolution of last period' uncertainty:

$$\aleph = (j, a_j, h_f, h_m, \theta, \eta_j, \mathrm{DB}_j)',$$

where a_j is the level of household assets, h_f and h_m are the health status of the male and female in the household, θ is a permanent income level, η_j is the uncertain part income and DB_j is the amount of accrued pension benefits in the second pillar.

3.1.1 Preferences

The household holds preferences over household consumption c and bequest or asset level a at different ages. They aim to maximize the expected discounted utility from the consumption flow and bequests at any age j. Following De Nardi et al. (2010) we model the flow utility from consumption as a constant relative risk aversion (CRRA) specification:

$$u\left(\frac{c}{\mathrm{EQ}}\right) = \frac{\frac{c}{\mathrm{EQ}}^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}},$$

with γ equals the intertemporal elasticity of substitution (or $\frac{1}{\gamma}$ being risk aversion). Future utility is discounted at a subjective discount rate β.

EQ is an equivalence scale that makes the household consumption units comparable between single and married households. Because household members can share goods within the household, so-called economies of scale (Chiappori, 2016), they do not need twice (EQ=2) as much consumption to be as well off as a single-person household (Pradhan et al., 2013). An equivalence scale (EQ) incorporates the consumption effect that economies of scale generates, and this scale is therefore below two (Pradhan et al., 2013).

Lastly, the preference for a bequest is captured with the utility function $\mathcal{B}(a)$ (c.f. Lockwood, 2018):

$$\mathcal{B}(a) = \frac{\phi}{1-\phi}^{\frac{1}{\gamma}} \cdot \frac{\left(\frac{\phi}{1-\phi} \cdot c_a + R \cdot a\right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}},$$

where R equals unit value plus the interest rate $(1+r)$. c_a informs on the curvature of the bequest utility and henceforth the extent to which bequests are a luxury good. c_a can be interpreted as the level of wealth above which a bequest is left. ϕ accordingly denotes the marginal propensity to bequeath wealth above this threshold: the strength of the bequest saving motive.

3.1.2 Technology and sources of uncertainty

Income - Households obtain gross income $\widetilde{y}$ during their life-cycle. They pay an income tax over this income, and the government spends this tax on useless consumption. As discussed in Section 2, the households furthermore pay a premium contribution that finances first pillar pension and public LTC provision and this premium is progressive in gross income. Contrary to the contribution for first pillar pension, households make the contribution for public LTC provision after retirement as well (when aged 65 and over). Given these three tax types, gross income $\widetilde{y}$ maps into disposable income y through a net-of-taxes function $\widetilde{\tau}$:

$$y = \widetilde{\tau}(\widetilde{y}).$$

On the other hand, disposable income $\widetilde{y}$ maps into gross income y through the inverse of the net-of-taxes function:

$$\widetilde{y} = \widetilde{\tau}^{-1}(y),$$

or equivalently:

$$\widetilde{y} = y + \mathrm{SI}_{\mathrm{SS}}(y) + \mathrm{SI}_{\mathrm{LTC}}(y) + \tau(y),$$

where the latter equality says that gross income is the sum of disposable income (y), the premium contribution that finances first pillar pension ($\mathrm{SI}_{\mathrm{SS}}(\cdot)$), the premium contribution that finances public LTC provision ($\mathrm{SI}_{\mathrm{LTC}}(\cdot)$) and an income tax ($\tau(\cdot)$).

After rearranging terms, disposable income is equivalently expressed as:

$$y = \widetilde{y} - \mathrm{SI}_{\mathrm{SS}}(y) - \mathrm{SI}_{\mathrm{LTC}}(y) - \tau(y).$$

This in an important equation because it shows that progressive contributions for first pillar pension, contributions for public LTC provision and taxes affect the household budget constraint through their impact on disposable household income.

For the household problem it suffices to only know disposable income y, which they can either consume or save. We are however also interested in the premium contributions, because we will also model the Dutch government whose revenues arising from the contributions do have to be sufficient to meet their actual expenditures on first pillar pension income and public LTC provision. We balance the government budget below.

It was initially also our intention to model disposable rather than gross income explicitly, because in the case of gross income we would have to mimic the Dutch tax system at the household level. This mimicking exercise is complicated given the existence of joint deductibles and we therefore decided to model disposable income. At a later stage we however decided to estimate tax and social insurance contribution functions directly from the data, which lowers the need to stick to modelling disposable income explicitly. In future work we define and model all income and tax functions in gross income terms.

Having said this, we explicitly model income before age 65 in disposable income terms, while we explicitly model income after age 65 in gross income terms. We make the latter choice, because income after retirement is linked to the average lifetime income before age

65 and this pension benefit is defined in gross terms. While we do not have to estimate the tax function $\tau(\cdot)$ before age 65, we have to do so for households aged 65 and over to obtain their disposable household income level.

Households aged between 25 and 65 years old obtain their disposable income, y, from a stochastic income process. We model the income as a nonlinear function consisting of an age-specific income component α_j, a stochastic component η_j and a permanent income effect θ:

$$y_j = \min\{\alpha_j \cdot \exp(\theta + \eta_j); \underline{y}\}, \qquad \text{if } j < 65$$

where households draw their permanent income level $\theta \sim \mathcal{N}(0, \sigma_\theta^2)$ at the beginning of their life cycle. This value is fixed over their life-cycle. $\underline{y}$ is the guaranteed minimum income level. During working age, the stochastic component of income, η_j, consists a persistent part only and is modelled as an AR(1) process (cf. Storesletten et al., 2004):

$$\eta_j = \rho\eta_{j-1} + \epsilon_j \text{ with } \epsilon_j \sim \mathcal{N}(0, \sigma_\epsilon^2),$$

where ϵ_j is the income shock having variance σ_ϵ^2.

During working age households accrue second pillar pension benefits DB at a rate Φ of their disposable household income minus deductibles. Because DB summarizes stochastic income over the life-cycle, DB is another state variable:

$$\mathrm{DB}_{j+1} = \mathrm{DB}_j + \Phi \cdot \underline{d}(y_j),$$

where $\underline{d}(\cdot)$ is the disposable income minus deductibles. The second pillar pension benefit DB in this case guarantees that first and second pillar pension together replace 40 yrs $\cdot\Phi\cdot 100\%$ of the average life-cycle income. We choose $\Phi = 0.01875$, implying a gross replacement rate of 0.75. This in line with maximum possible replacement rate in the Netherlands in 2015 that is documented in Knoef et al. (2017). This way our second pillar pension mimics the pension system described in Section 2.2.2.

Note that a small discrepancy arises here. The gross replacement rate that we here calculate is based on disposable income throughout working life. The second pillar pension benefit that we here calculate is thus an underestimation of the actual second pillar benefit that replaces gross income during working life. In a future version of the work, when we model gross income explicitly, will express the replacement rate in gross terms.

Income becomes deterministic after mandatory retirement at age 65 (c.f. Cagetti, 2003). Households obtain income from their accrued second pillar pension benefit, DB, alongside a government-provided first pillar pension benefit, SS. Gross household income after retirement looks as follows:

$$\widetilde{y}_j = \begin{cases} \mathrm{SS} + \mathrm{DB}_{65}, & \text{if} \quad j \geq 65, H_m \neq \text{ Death and } H_f \neq \text{ Death} \\ 0.7 \cdot \mathrm{SS} + \mathrm{rr}_f \cdot \mathrm{DB}_{65}, & \text{if} \quad j \geq 65, H_m = \text{ Death and } H_f \neq \text{ Death} \\ 0.7 \cdot \mathrm{SS} + \mathrm{rr}_m \cdot \mathrm{DB}_{65}, & \text{if} \quad j \geq 65, H_m \neq \text{ Death and } H_f = \text{ Death,} \end{cases} \tag{1}$$

The first line in (1) represents the retirement income when both household members are alive. The second line represents the household income when the male in the household is death. The social security benefit for the surviving female then drops to 70% of the level for couples. Furthermore the second pillar pension benefit now becomes a survivor pension with a replacement rate rr_f for the couples' benefit. The third row denotes the same case but now for the case that the female in the household is death. The replacement rate for the surviving male, rr_m, may be different from the one for the female, rr_f.

Health and mortality - The male and female in the household face exogenous uncertainty about their health states H_m and H_f: their future LTC needs and lifespan are uncertain. Three health states are modelled for any household member: no need for LTC (No LTC); in need of LTC (LTC); and death (Death).

We assume that a household member is not in need of LTC and survives with certainty during working age. Such age restriction on LTC needs seems plausible, because LTC needs mainly applies to this age group: only 2.5% and 2.8% of the males and females in the Dutch IPO panel use LTC before age 65 (van der Vaart et al., 2020a). Given that males and females are 25 are years old, their respective probabilities to reach age 65 are 0.866 and 0.906 in the period 2005 to 2010 (Het Actuarieel Genootschap, 2013). The largest part of the population thus survives until age 65 and a choice for certain survival until age 65 seems justified. In future work we may however choose to incorporate mortality throughout working life as well to make the life-cycle model more realistic.

After retirement a household member may become in need of LTC and will eventually pass away. Health status uncertainty evolves with transition probabilities that depend on lifetime income (DB), current age (j), the current health state (H_m or H_f) and the existence of a spouse within the household (H_m or H_f). We assume that the health statuses of household members are related, because an alive spouse within the household can provide informal care to the household member in need and a household member therefore need not use formal LTC (Nihtilä and Martikainen, 2008). We impose that future health only depends on fixed lifetime income, current age and current health status so that we can model the health status of the household as a first-order Markov chain.

We accordingly have an age-varying transition matrix $\mathcal{P}(\aleph)$. Let h_m^+ and h_f^+ denote the future health states. The entries $\pi(h_m^+; h_f^+; \aleph)$ of $\mathcal{P}(\aleph)$ are then defined by:

$$\pi(h_m^+; h_f^+; \aleph) := Pr(H_m = h_m^+;\ H_f = h_f^+ | \ \aleph).$$

The survival probability of the household, $\psi(\aleph)$, is defined by:

$$\psi(\aleph) := Pr(H_m = \text{Death};\ H_f = \text{Death} \mid \aleph).$$

LTC use includes nursing home use but not home care which is less expensive and had limited co-payments (see Table 1, Wouterse et al., 2020). In future work we will introduce home care use to the life-cycle model as an additional source of uncertainty.

3.1.3 Contributions for first pillar pension and public LTC provision

We are interested in two parts of the Dutch social insurance system: first pillar pension and public LTC provision. Individuals become entitled to first pillar pension benefits when aged 65 years and older. This system is in part a pay-as-you-go (PAYG) system implying that the current benefits of the eligible population (retirees) are financed by contributions that the current employed make to the system. The individual social insurance contribution in 2010 was a flat rate of 17.9% of the part of taxable income below €32,738, which is €5,860. In theory a two-earners household can thus pay a premium amount of at most €11,720 for first pillar pension.

Similarly, the public care provision is partially financed as a pay-as-you-go (PAYG) system. Contrary to the first pillar pension system, individuals aged 65 and older pay a social insurance premia for LTC provision. The contribution for LTC provision is lower than for first pillar pension benefits. In 2010 the individual social insurance contribution was a flat rate of 12.15% of the part of taxable income below €32,738. A household of two earners can thus pay a premium for LTC provision of at most €7,960.

We do not mimic the system of social insurance premia from 2010, but choose to do this data-driven. A problem that would arise otherwise is that we would have to mimic a social insurance system at the household level, because we measure and define income at the household level rather than at the individual level. In the Dutch case however any member of the household pays taxes and social insurance premia on an individual basis while tax receipts between the couple members may still be inter-related for example because of joint deductibles. This complicates the mimicking the system at the household level so we rather choose to estimate a flexible function that maps disposable household income into the social insurance premium that the household pays for first pillar pension and public care provision.

We map disposable income into social insurance contributions using a logistic function analysed in y (disposable income). This logistic function has the following form:

$$f(y) = c_0 + \frac{\beta_0 - c_0}{1 + e^{-(\frac{y-\beta_1}{\beta_2})}} + \epsilon,$$

where c_0 is the minimum premium contribution, β_0 the maximum contribution, β_1 the rate of exponential in- or decrease (premium rate), β_2 the income level at which a household pays half of the difference between the minimum and maximum contribution level (hard to interpret in presence of β_1) and $\epsilon \sim \mathcal{N}(0, \sigma^2)$ is white noise . A nice feature of this parametric form is that it allows for an asymptotic minimum (c_0) and maximum (β_0) on the contribution level which thus actually exist in the Netherlands.

LTC use furthermore requires a co-pay and poses substantial financial risk to the household. We mimic the co-payment structure from 2012 and assume that if both members are in need of LTC, they pay the amount as if only one members is in need. We do not readily have a co-payments function available for a couple whose members are both in need of LTC. We therefore postpone such function to a future version of the paper.

We use the explicit formula in Wouterse et al. (2018), to model co-payments $m(\cdot)$. These co-payments depend on the asset level a and income level y of the household alongside the health statuses H_m and H_f of the household members (indicating LTC use):

$$m(y, a, H_m, H_f) = \begin{cases} \min[\kappa, \max(\upsilon \cdot y + \zeta \cdot a - \nu), 0] & \text{if } H_m = \text{LTC or } H_f = \text{LTC} \\ 0 & \text{elsewhere,} \end{cases}$$

where κ =€29,000 denotes the maximum co-pay, υ =0.75 the contribution rate for income, ζ = 0.04 the contribution rate for assets and ν = €4,500 the deductible or copay-free base. Note that the co-pay is progressive in both income and assets but is nevertheless concave and capped by κ. Even though the co-payments can increase to a substantial amount of €29,000, recent literature shows that LTC needs and use coincide, and LTC use is therefore less of a private choice. For a discussion on this so-called horizontal equity, which excludes the possibility of differential access by different groups to informal or formal LTC, see Rodrigues et al. (2018).

3.1.4 Government budget constraint

The government collects the social insurance contributions and co-payments for LTC provision and uses these to finance first pillar pension income and LTC provision throughout retirement. Yet it is not guaranteed that the government revenues and expenditures balance, so the government may thus run a deficit or a surplus. Then the government budget for retirement programs is not closed and our analysis on how retirement programs redistribute welfare is incomplete. Groneck and Wallenius (2020) is a study that also uses this government balancing transfer.

To let the government break-even, the government surplus or deficit is redistributed to every household as an additional income-independent subsidy or tax: Tr. TR is the transfer level for a single-person household, while this transfer is twice as large for a couple. Formally:

$$\mathrm{Tr}(H_m, H_f) = \begin{cases} 2 \cdot \mathrm{TR} & \text{if} \quad H_m \neq \text{ Death and } H_f \neq \text{ Death} \\ \mathrm{TR} & \text{if} \quad H_m = \text{ Death or } H_f = \text{ Death} \\ 0 & \quad \text{elsewhere.} \end{cases}$$

In Appendix A.1 we describe the procedure on how the government sets TR.

3.2 Recursive formulation

A period in the model looks as follows. First, households receive exogenous income: they obtain interest on current assets ($(1+r) \cdot a$), they obtain their disposable income (y) from which social insurance contributions ($\mathrm{SI}_{\mathrm{SS}}(\cdot)$ and $\mathrm{SI}_{\mathrm{LTC}}(\cdot)$) are deducted and a they pay a government tax or they obtain subsidy (Tr) that balances the government budget. The government also collects the incurred LTC co-payments ($m(\cdot)$). Some resources may thus flow out of the household. The household then decides how much to save and how much to consume. At the end of the period, uncertain income, health and survival (H_m and H_f) realize for the next period. After this, the decision process starts over.

The household maximizes lifetime utility and decides how much to consume and save for this aim. They face the budget constraint that current consumption and future assets should be financed with their current resources. This budget constraint is given by:

$$a_{j+1} + c_j = R \cdot a_j + y_j - m_j - \mathrm{Tr}_j,$$

and we furthermore impose that assets are non-negative:

$$a_{j+1} \geq 0.$$

The maximization problem is additively separable in age and all uncertainty is Markovian. We can therefore rewrite the household problem as a dynamic programming problem. Since the household has a termination age (J=100), we solve the model recursively with the Bellman principle of optimization. Then, the value function is given by:

$$\begin{aligned}
\mathrm{V}(\aleph) = \max_{c_j, a_{j+1}} \; & \mathrm{u}\left(\frac{c_j}{\mathrm{EQ}(\aleph)}\right) + \beta \cdot \left(\psi_{j+1}(\aleph) \cdot \mathrm{E}[\mathrm{V}(\aleph^+)|\aleph] + (1 - \psi_{j+1}(\aleph)) \cdot \mathcal{B}(a_{j+1})\right) \\
\text{s.t.} \quad & c_j + a_{j+1} = R \cdot a_j + y_j - m_j - \mathrm{Tr}_j, \\
& a_{j+1} \geq 0, \\
& \aleph = (j, a_j, h_f, h_m, \theta, \eta_j, \mathrm{DB}_j)', \\
& \aleph^+ = (j+1, a_{j+1}, h_f^+, h_m^+, \theta, \eta_{j+1}, \mathrm{DB}_{j+1})', \\
& y_j = \widetilde{y}_j - \mathrm{SI}_{\mathrm{SS}}(y_j) - \mathrm{SI}_{\mathrm{LTC}}(y_j) - \tau(y_j) \\
& \theta \sim \mathcal{N}(0, \sigma_\theta^2), \\
& \eta_{j+1} = \rho \cdot \eta_j + \epsilon_{j+1}, \quad \text{with } \epsilon_{j+1} \sim \mathcal{N}(0, \sigma_\epsilon^2), \\
& h_f^+, h_m^+ \sim \mathcal{P}(j),
\end{aligned} \tag{2}$$

where θ and η_{j+1} describe stochastic disposable income y_j before retirement (age 65). We discretize the asset and income grid and subsequently use policy function iteration to solve the model numerically. For policy function iteration we have to know an explicit solution for the modified Euler equation on consumption and bequests. We discuss its derivation in Appendix A.2. This Euler equation on consumption and bequests says that the marginal utility of current consumption is equal to the expected marginal utility of future consumption and bequests.

Since households die with certainty in the last period of the model, we can explicitly derive the optimal allocation of resources over consumption and a bequest in the last period for a household with given state vector $\aleph$. Using the Euler equation and this policy function on future consumption, we can derive current consumption in the first-to-last period . We can recursively apply this procedure until we end up with all consumption policy functions from the beginning (age j = 25) till the end of the model (age J=100). For a given parameter constellation we then know the consumption policy function from which we can consequently simulate asset profiles. We elaborate on the numerical implementation of the life-cycle model in Appendix A.4.

4 Estimation procedure

We estimate the life-cycle model with the two-step Method of Simulated Moments (MSM) (cf. Gourinchas and Parker, 2002; Cagetti, 2003; De Nardi et al., 2010). In a first step we estimate the parameters that we can estimate without the life-cycle model such as the income and health risks. Let these be denoted by $\boldsymbol{\chi}$. These first stage estimates $\boldsymbol{\chi}$ serve as input in a second step with which we estimate the preference parameter vector $\boldsymbol{\Delta} = (\beta, \phi, c_a)'$ using MSM. Given $\boldsymbol{\chi}$ and $\boldsymbol{\Delta}$ we can simulate our life-cycle model and reproduce optimal asset profiles conditional upon age, income level, and current health state (the state vector $\aleph$). The estimation procedure subsequently minimizes the difference between the empirical and simulated asset profiles. Because most of the interaction in our model happens after retirement, we aim to match the asset profiles after retirement. The estimated preference parameter vector $\hat{\boldsymbol{\Delta}}$ yields the best possible match between the empirical and simulated asset profiles across cohorts.

We match median assets for our unbalanced panel conditional upon cohort, age, lifetime income and marital status. We choose to match median assets instead of its mean, because asset distributions are right-skewed and mean asset profiles are highly sensitive to outliers. As our underlying goal is to examine how different SES groups value the welfare state, we match median assets conditional upon lifetime income. Our measure on lifetime income is a measure on average non-asset income after retirement. Because married and singles systematically differ in their income and health risk over the life-cycle, we choose to match the two household types separately. Lastly, we match cohort-specific asset profiles, because cohort effects to working-age income may persist after retirement and lead to distinct asset profiles.

More formally, an alive household type h belongs to birth cohort $\mathrm{bc} \in \mathrm{BC}$ in year $t \in T$ and has marital status $\mathrm{mar} \in \mathrm{Mar}$. Given their lifetime income value we sort these individuals into income quartiles $q \in Q$ and calculate their median asset holdings. Any household type h belongs to the state-space $\mathcal{H} = \mathrm{BC} \cup T \cup \mathrm{Mar} \cup Q$.

Let the median asset level be denoted by a. We would like to produce median asset profiles with our life-cycle model that coincide with their empirical counterparts. The difference between the two gives the moment condition $m_h(\mathbf{\Delta})$ (c.f. Cagetti, 2003):

$$m_h(\mathbf{\Delta}) = \mathbf{E}(y \cdot \{\mathbf{1}(y < 0) - \frac{1}{2}\}|h) = 0,$$
$$\text{with } y = a - a(\boldsymbol{\chi}, \mathbf{\Delta}) \text{ and } h \in \mathcal{H},$$

where $a(\boldsymbol{\chi}, \mathbf{\Delta})$ denotes the simulated median asset level. The second term in the moment equation assures that one measures the deviation between the empirical and simulated moment in absolute terms.

We however do not observe these theoretical moments but their empirical counterparts:

$$\hat{m}_h(\mathbf{\Delta}) = \hat{y} \cdot \{\mathbf{1}(\hat{y} < 0) - \frac{1}{2}\},$$
$$\text{with } \hat{y} = \hat{a} - a(\hat{\boldsymbol{\chi}}, \mathbf{\Delta}) \text{ and } h \in \mathcal{H}, \tag{3}$$

where we replaced the theoretical median asset level a and first-stage parameter vector $\boldsymbol{\chi}$ with their empirical counterparts $\hat{a}$ and $\hat{\boldsymbol{\chi}}$.

The moment condition (3) is still conditional upon household type h. When we have as many moments as we have parameters, we can satisfy (3) with equality, however our number of moment equations exceeds the number of parameters. We therefore have to apply weighting to obtain an unconditional moment function that we minimize. Moment conditions are then matched with possible error that we intuitively minimize.

More formally, we estimate the unknown preference parameters $\boldsymbol{\Delta}$ from the following weighted function (c.f. Cagetti, 2003):

$$\hat{\boldsymbol{\Delta}} := \underset{\boldsymbol{\Delta}}{\operatorname{argmin}} \sum_{h \in \mathcal{H}} \hat{m}_h(\boldsymbol{\Delta}) \cdot \omega(h),$$

where $\omega(h)$ is the weight attached to the specific moment condition for household type h. To obtain a consistent but inefficient estimate $\hat{\boldsymbol{\Delta}}$ one can set $\omega(h)$ equal to the weight of household type h in the entire sample of size N. Intuitively this weight is chosen to down-weight the moments that have highest variance. An efficient choice for the weight $\omega(h)$ would be the inefficient weight multiplied with the density at the median simulated asset level, preferably obtained as a Gaussian Kernel estimate (Powell, 1986). For computational convenience we choose not to do the efficient estimation. This choice delivers us a consistent but inefficient estimate with asymptotic distribution:

$$\sqrt{N}(\hat{\boldsymbol{\Delta}} - \boldsymbol{\Delta}) \xrightarrow{D} \mathcal{N}(0, \boldsymbol{\Omega}),$$

where $\boldsymbol{\Omega}$ denotes the asymptotic variance-covariance matrix. This matrix is defined as:

$$\boldsymbol{\Omega} = \frac{1}{2}^2 \cdot \left(\mathrm{E}\left\{ \left(\frac{\partial \boldsymbol{m}(\boldsymbol{\Delta})}{\partial \boldsymbol{\Delta}'} \right)' \left(\frac{\partial \boldsymbol{m}(\boldsymbol{\Delta})}{\partial \boldsymbol{\Delta}'} \right) \right\} \right)^{-1}, \tag{4}$$

where $\boldsymbol{m}(\boldsymbol{\Delta})$ is the moment vector with respective entries $\hat{m}_h(\boldsymbol{\Delta})$. We have to analyse its empirical counterpart to compute standard errors. We then however face the problem that the functional form for the derivative of the simulated moments, $\frac{\partial m(\boldsymbol{\Delta})}{\partial \boldsymbol{\Delta}'}$, is unknown to us. We therefore estimate that functional form as being a numerical derivative.

In practice our second stage estimation proceeds as follows. We start with calculating the consumption policy functions using policy function iteration, and do this for a grid of preference parameters. We thereafter simulate median assets and compare their performance to the observed counterpart. The parameter set that minimizes the MSM criterion function is used as a warm-start in an algoritm that determines the actual set of preference parameters that minimizes the MSM criterion. We apply an iterative procedure with which we update this 'optimal' estimate using a Gauss-Newton regression approach. We stop updating when the parameter estimates of two consecutive iterations are arbitrarily close.[6]

5 Data

5.1 Income data

We use the Dutch longitudinal income panel study (IPO, Inkomenspanelonderzoek) 1989-2014 from Statistics Netherlands to estimate the unknown parameters before and after retirement for the income processes. The IPO is an unbalanced panel in which attrition only occurs due to migration or death. By adding newborn and migrants at the beginning of the year, the sample is made representative again. The IPO contains demographics on gender, age, marital status and labor market status, and these are measured at the end of the calendar year.

This rich administrative panel data set provides information on gross household income (measured in 2015 euros). For all household members we do also have information on the following separate income components:

[6]With arbitrarily close we mean that the Euclidean norm on the difference between the parameter estimates in two consecutive iterations does not exceed 10^{-5}. With the three parameters that we estimate this means that the average difference between any of the parameters in two consecutive iterations may not exceed $1.8 \cdot 10^{-3}$.

- *Earnings*: the sum of gross labor and business income, excluding capital income.
- *Social insurance*: Public coverage of unemployment and disability as well as welfare, sickness leave and other benefits paid for by social insurance institutions.
- *Pension income*: Social security, second and third pillar pension and public survivor benefits.
- *Allowances*: Rent subsidy, tuition fee subsidies etc.

These components in total sum up to individual gross income. Gross household income is the aggregate of gross income of couple members within a household in a given year. The IPO also contains data on the social insurance contributions and the income taxes that the household pays. Once these are deducted from the gross income, one is left with a disposable income measure that we use to model income uncertainty over the life-cycle.

5.2 Asset data

Our asset holdings data stem from the administrative dataset from Statistics Netherlands (Vehtab, Vermogens van huishoudens) that is available for the years 2006-2015 for the entire population. Even though the observational period is shorter than the IPO, this also comes with an advantage. We can link the asset holdings data to the population equivalent of the IPO data set (INHATAB, Inkomen van huishoudens). We therefore have income and asset holdings data available for any household within the Dutch population from 2006 onwards.

We observe net worth from the asset holdings data. This is the value of all assets (including the house value) minus mortgage and other outstanding debt.[7] We deflate the value of the owned house with a house price index (base year=2015). That house price index is based on the so-called WOZ value of a property that municipalities use

[7] van Ooijen et al. (2015) defines net worth as the value of total assets minus liabilities of the household. Total assets consist the value of the owned house, the assets held in a risky portfolio, assets held in a checking and saving account, business' value, cash and all other outstanding loans. Total debt refers to the current mortgage value, business debt and other borrowed loans.

to calculate certain taxes, such as property tax. The stock values are deflated with a stock price index according to the close price of the Dutch stock exchange AEX in a given year (base year=2015). All other assets are deflated using the consumer price index (base year=2015).

Seminal work on elderly's asset holdings models net worth (see amongst others: De Nardi et al., 2010; Ameriks et al., 2011; Laitner et al., 2018; Nakajima and Telyukova, 2018)). Another measure that could be modelled in our study is the net financial wealth of a household, which excludes the equity value of the house (house value minus current mortgage value). The disadvantage of explaining net worth rather than financial wealth is that the illiquid housing wealth is not readily available for consumption, while the structural model assumes that the illiquid housing equity is available at any time. It should however be stressed that inclusion of illiquid housing wealth in the wealth measure is necessary, because it becomes available to consume or bequeath when some of the household members have to move to a nursing home or when they have both died. We therefore choose to use net worth as our wealth measure over the life-cycle.

5.3 LTC and mortality data

We use the LTC needs and mortality data to model uncertain LTC needs and mortality that households are susceptible to after retirement. For this, we merge the IPO data to administrative data from Statistics Netherlands on LTC needs and mortality for the period 2004-2014. We take the mortality data from the Causes of Death registry and we take the LTC needs data from the Extra- and Intramural Health Care registry 2004-2014.

The administrative data set on LTC needs covers all Dutch individuals who make publicly-covered LTC expenditures in a given year. The Extramural Health Care registry distinguishes two types of formal home care: nursing care and personal care. The Intramural Health Care registry measures on a day-to-day basis whether an individual spends in a facility that provides any of the following types of institutionalised care: nursing and personal care; care of disabled; and mental health care. With the administrative data on LTC needs we can thus exactly measure when and for how long the household has made use of LTC. This data is accordingly used to model LTC needs and mortality uncertainty.

5.4 Econometric considerations

The risk on having LTC needs and mortality varies with the second pillar pension benefit (DB) in our life-cycle model. More specifically, from the steady-state distribution of DB at age 65 in the life-cycle model we calculate four 'lifetime' income quartiles (groups) with which LTC needs and mortality varies.

But how do we measure this pension income or, even better, lifetime income empirically? We ideally look for the lifetime income measure at age 65 as if the household were a couple and their income would remain the same over their entire life-cycle. We could then simply observe their pension income and make income quartiles accordingly. This income measure should be independent of cohort effects, gender effects and marital status effects, because these demographics may otherwise identify a lifetime income group rather than lifetime income itself does this. Cohort, gender and marital status effects are however present in our data and we have to resolve this.

To avoid these undesired effects, we apply the method proposed in De Nardi et al. (2015) who map current income into lifetime income for a household while accounting for age and household composition effects. They do this with a fixed effects regression approach. The identified fixed effect is basically their lifetime income measure. We add another step to this estimation procedure and in that step we map the fixed effect into our lifetime income measure while accounting for gender and cohort effects. This step involves an OLS estimation. We formally describe this procedure in Appendix A.5.

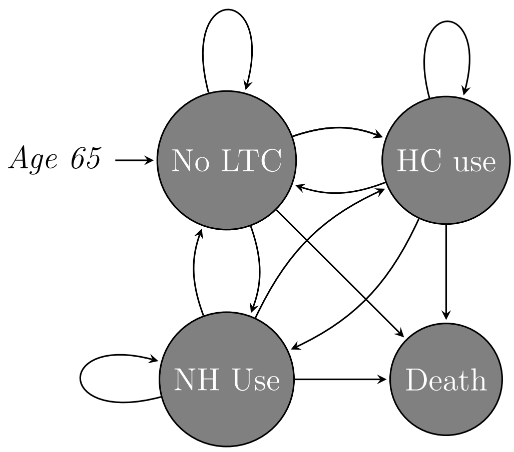
6 Data profiles and first-step estimation results

In this section we describe the data, stochastic processes and parameter values that we use as input in our life-cycle model and which we do not have to estimate with MSM.

6.1 LTC needs and mortality

Differences in LTC needs and mortality lie at the core of our analysis. We model these differences with the multi-state transition model of van der Vaart et al. (2020a) that jointly models LTC needs and mortality. This model assumes that the overall hazard of LTC needs or mortality consists of a common baseline hazard that depends on age, and a proportional hazard that depends on covariates. We allow covariates on lifetime income, marital status and gender to have different impacts on LTC needs and mortality at different ages. We distinguish between four states: no LTC use, being in need of home care (HC) use, being in need of nursing home care (NH) use and death. The possible transitions between these states are shown in Figure 1.

Figure 1: The LTC model



The modelling procedure proceeds in two steps. In a first step we estimate the hazard (transition) rates. In a second step we simulate households through the estimated model. Households enter the simulation model at age 65 when not in need of LTC. For every household member we can calculate the time until they move to the other three states.

The minimum across those three times is considered as the actual or simulated transition. This procedure is repeated until both couple members died. For a complete description of the estimation and simulation procedure we refer to van der Vaart et al. (2020a).

Following this procedure we can construct a sufficient amount of simulated life stories on LTC use and mortality for couples that differ by their lifetime income status. The time it takes whenever a state is reached, depends explicitly on whether the household consists a couple or widow(er). That way we have build in the joint dependence between the health histories of the couple members. We discretize these life histories at fixed age points to obtain transition probabilities that we subsequently feed into our life-cycle model.

As a side-remark, the LTC model in Figure 1 does distinguish between home care use and nursing home care use, whereas the health process in our life-cycle does not. Therefore when we discretize the life histories we pretend as if being in need of home care is the same as being not in need of LTC.

In Table 1 we provide the summary statistics on remaining life-expectancy (RLE) and LTC use for males and females when they consist a couple at age 65 and they are not in need of LTC.[8] At a general level, our results in the first column suggest that females spend more time in need of LTC while at the same time they live longer than males. First, females have a higher probability on using LTC: 58.0% of the females uses LTC (nursing home care) after age 65 while 39.8% of the males does so. Second, conditional upon use, females also spend longer in LTC than males: females on average spend 3.2 years in LTC while males spend 2.1 years in LTC after age 65. Apart from that females live longer and spend more years in LTC, they also spend a longer fraction of their remaining lifetime in LTC: 12.3%. Males only spend 10.0% of their remaining lifetime in LTC.

We find opposite income gradients in LTC needs and remaining life-expectancy. House-

[8]We similarly describe these findings in van der Vaart et al. (2020a). Our current findings are however different because we explicitly focus on households who initially (at age 65) consist a couple. In our earlier work households may also be a single-person household initially (at age 65). Our earlier work furthermore focused on both home care and institutionalised care, while in the current work we focus on institutionalised care only.

Table 1: Simulated remaining life-expectancy and LTC use measures at age 65

	All	Bottom	Second	Third	Top
(a) Males					
Remaining LE (years)	18.7 (18.2;18.9)	16.2 (15.8;16.8)	18.1 (17.7;18.8)	19.3 (18.4;20.0)	20.2 (19.5;20.6)
Years LTC use⋆	2.1 (2.0;2.3)	2.2 (1.9;2.4)	2.4 (2.1;2.8)	2.1 (1.9;2.4)	1.8 (1.3;2.0)
Ratio (%)⋆	10.0 (9.3;10.4)				
Ever uses LTC	39.8% (37.5;41.9)	37.2% (33.5;39.4)	40.0% (37.0;43.1)	42.2% (36.0;45.2)	39.6% (34.2;43.5)
(b) Females					
Remaining LE (years)	23.0 (22.5;23.3)	21.4 (20.3;22.0)	22.9 (22.5;23.2)	23.8 (23.0;24.3)	23.7 (23.0;23.9)
Years LTC use⋆	3.2 (3.0;3.3)	3.4 (3.0;4.0)	3.4 (3.1;3.7)	3.3 (3.0;3.7)	2.7 (2.4;2.9)
Ratio (%)⋆	12.3 (11.7;12.6)				
Ever uses LTC	58.0% (55.2;60.1)	58.3% (53.7;60.8)	58.5% (56.4;60.4)	60.8% (57.5;63.3)	54.3% (50.4;57.2)

Notes: The table shows the point estimates for remaining life expectancy and LTC use at age 65 made conditional upon gender and income. These are population-averaged measures for the life-cycle simulation of 100,000 couples. We represent here the median estimates across 500 bootstrapped samples along with the 2.5^{th} and 97.5^{th} percentile between brackets. ⋆The measure is conditional upon ever using LTC.

holds within the top income quartile make less use of LTC and live longer. Males (females) in the bottom income quartile on average spend 2.2 (3.4) years with LTC while their top income counterparts spend 0.4 (0.7) years less with LTC. Given their lower care needs, males (females) within the top income quartile live 4.0 (2.3) years longer than their bottom income counterparts.

The opposite income gradients in RLE and LTC needs may redistribute welfare from households in the bottom quartile to households in the top income quartile when there exists an integrated system of retirement programs. Households in the top income quartile obtain pension benefits for a longer time and have to make co-payments for LTC use for a relative shorter time than their bottom income counterparts. With our life-cycle model we quantify the exact implications for the distribution of welfare due to these opposite income gradients.

6.2 Asset profiles

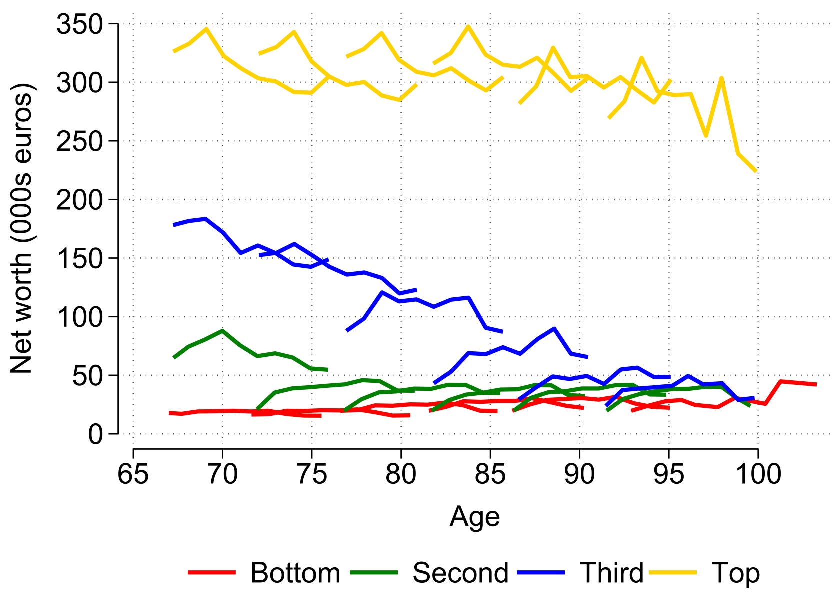
We construct asset profiles from the asset data according to De Nardi et al. (2010); van Ooijen et al. (2015). We sort households into lifetime income groups and marital status groups and track the observational year and birth cohort. We distinguish six birth cohorts: the youngest are aged 65-69 in 2006, the second are aged 70-74 in 2006, the third are aged 75-79 in 2006, the fourth are aged 80-84 in 2006, the fifth are aged 85-89 in 2006 and the oldest are aged 90 and over in 2006. For every group we calculate median net worth for the survivors in a given observational year. Our entire sample comprises 7,457,703 households, and this large sample size results from our administrative data that comprises the entire population.

These asset profiles are shown in Figure 2. Each line represents a different birth cohort and lifetime income quartile. We plot the average age of the birth cohort alongside their median net worth in a given year. We plot married households (panel (a)) and widowed households (panel (b)) separately.

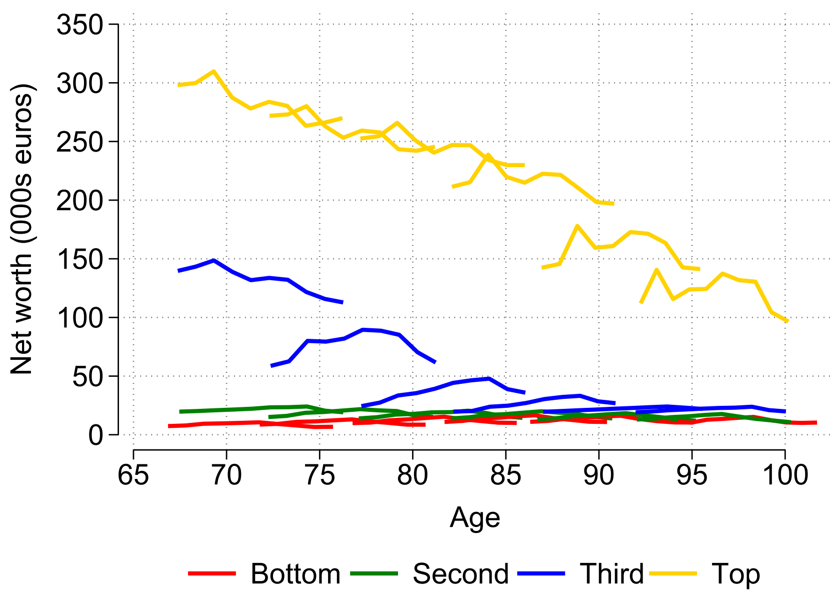
Panel (a) shows that for the two lowest lifetime income groups the asset level is slightly below the Dutch tax-free base for married households' assets: €$50,000$. Their asset profiles are essentially flat. The youngest cohort in the second lifetime income quartile forms an exception to this as they have slightly higher assets and a somewhat decreasing asset profile. A decreasing asset profile is also visible for any cohort that belongs to the third income quartile. The asset profiles of the two youngest cohorts nicely overlap and respectively decline during the observational period from €$178,000$ and €$149,000$ to €$153,000$ and €$123,000$. For the other cohorts in the third income group we do encounter stronger cohort effects, and asset levels are lower for older cohorts. Lastly, for the top lifetime income quartile we encounter similar asset levels and profiles across cohorts and these levels range from €224,000 to €348,000. Apart from saving motives that prevent asset decumulation, the similar asset levels may represent a severe cohort effect. The hump-shape in the asset profile can be explained by that households in this quartile

Figure 2: Median asset profiles by income quartile for married and widowed households 2006-2015

(a) Married:



(b) Widowed:



Notes: Each line represents the asset profile conditional upon birth cohort and income quartile. We distinguish six birth cohort based on the age of the household in 2006: aged 65-69, aged 70-74, aged 75-79, aged 80-84, aged 85-89 and aged 90 and over.

hold a relative larger share of assets in housing equity and stocks, and we deflate these assets with a different measure (stock and house price index) than we do for all other assets (consumer price index). The choice for the different deflator may thus still leave a macro-economic trend -the hump shape- visible in the asset profiles.

Asset profiles for widowed households (panel (b)) look similar to the profiles for married households (panel (a)). Still there are a few exceptions. First, asset levels are modestly lower for widowed than for married households. Second, every cohort in the two bottom income groups now has a flat asset profile that is below the tax-free base for singles' assets: €25,000. Third, we see that the two youngest cohorts in the third income quartile are now susceptible to cohort effects as well, while their asset levels are not really different from their married counterparts. Lastly, for the top income quartile we do find nicely overlapping and decreasing asset profiles for most of the cohorts. Asset profiles of this group seem to be less susceptible to cohort and macro-economic effects when widowed.

We would not like our MSM estimates to pick up any of the cohort or macro-economic effects that are visible in the panels of Figure 2. We therefore restrict our MSM matching to some but not all of the groups. Cohort effects seem strongest for married households and we therefore restrict the MSM estimation of the asset profiles of married households to the profile of the youngest cohorts only. For the widowed households the undesired effects are less apparent and we choose to match asset profiles for all but the oldest cohort. We choose not to match the oldest cohort, because sample sizes decrease tremendously in their very old ages.

6.3 Income profiles

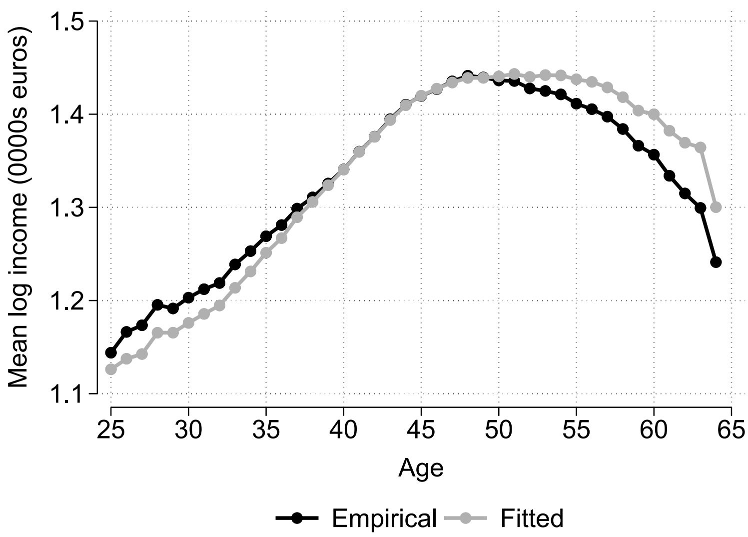
We here estimate the income process before retirement. We therefore consider its logged (uncensored) specification:

$$\log(y_j) = \log(\alpha_j) + \theta + \eta_j, \tag{5}$$

where again j denotes the age, α_j an age-specific effect, θ the permanent income value and η_j the stochastic income component. A year trend is not included in this specification because multicollinearity prevents us from doing so: the permanent income value and age effect add up to the birth year of a household.

In a first step we model the mean of the logged income as a function of an age-specific effect (α_j) and we therefore estimate specification (5) with a fixed effects estimator. To prevent that our parameter estimates mask early retirement schemes, we restrict the analysis to the IPO sample of married households born after 1950 whose income consists for less than 50% of retirement income. The estimation results are given in Figure 3 ($R^2_{\text{within}} = 0.0684$). Figure 3 shows the age-specific mean logged income in the data and our fitted mean logged income.

Figure 3: Deterministic income profile during working-age



The familiar hump-shaped income profile, cf. Mincer (1974), is visible in Figure 3. Income peaks at age 50 and thereafter decreases. This is, amongst others, a consequence of human capital accumulation and decumulation over the life-cycle (building up of working experience). Even though the fitted income profile between ages 35 and 50 closely resembles the data there seems to be a slight underestimation of the income level before age

35 while there is a slight overestimation of the income profile after age 50. A fixed-effects regression by definition matches the age-specific mean income. The two patterns differ here, because we used the averaged fixed-effect rather than the individual-specific effect -which contains cohort effects- to plot the fitted pattern. We do this on purpose because the fitted profile based on the mean fixed-effect is the profile that we actually feed into our life-cycle model.

In a second step we model the combined variance of the permanent income (fixed) effect and income shock ($z_j = \theta + \eta_j$). We apply generalised method-of-moment (GMM) estimation to get an estimate on the persistence of the income process (ρ), variance of the persistent shock (σ^2_ϵ) and variance of the permanent income component (σ^2_θ).

The GMM method aims to match the theoretical and empirical (co)variances of the stochastic income component ($z_t = \theta + \eta_t$) between the years 1989 (t=1) to 2014 (t=26). In Appendix A.6 we derive the theoretical moments and formally describe the GMM procedure.

Table 2: First-stage parameters for the income process ($p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)*

Parameter:	Estimate:	Standard error
ρ	0.933***	(0.0028)
σ^2_θ	0.055***	(0.0016)
σ^2_ϵ	0.019***	(0.0005)
Number of Moments	351	
Observations:	375,938	

Notes: Haider (2001) contains the formula to compute standard errors and these are robust to the unbalanced panel nature of our data.

Table 2 shows the estimates from the procedure described in Appendix A.6. We estimate a highly persistent income process ($\widehat{\rho} = 0.933$) which aligns with existing estimates. All our estimates are remarkably similar to De Nardi et al. (2017) who finds $\widehat{\rho} = 0.923$; $\widehat{\sigma^2_\theta} = 0.042$; $\widehat{\sigma^2_\epsilon} = 0.021$. This gives us some confidence that we have reasonable estimates, especially because De Nardi et al. (2017) models income uncertainty as an AR(1) process as well. Other studies find somewhat different estimates than we do. Even though Blundell et al. (2015) uses the same income measure as we do, they find somewhat more modest estimates for shock persistence (ρ) and variance in the fixed permanent income component (σ_θ^2). Their estimates may differ because their income shocks are age-specific while our estimation procedure does not account for this. Lastly, Groneck and Wallenius (2020) their estimated variation $\widehat{\sigma_\epsilon^2}$ in the income shock is lower (0.0031) than ours. Their estimate is lower, presumably because they allow for a transitory component to the income shock, a model feature that we omit and which inclusion we leave for future work. We compare fitted with observed variances at different years and ages in Appendix B.1.

6.4 Social insurance contributions for first pillar pension and LTC provision

We map disposable income into social insurance contributions for first pillar pension and public LTC provision using a logistic function analysed in y (disposable income). This logistic function has the following form:

$$f(y) = c_0 + \frac{\beta_0 - c_0}{1 + e^{-(\frac{y-\beta_1}{\beta_2})}} + \epsilon, \tag{6}$$

where c_0 is the minimum premium contribution, β_0 the maximum contribution, β_1 the rate of exponential in- or decrease (premium rate), β_2 the income level at which a household pays half of the difference between the minimum and maximum contribution level (hard to interpret in presence of β_1) and $\epsilon \sim \mathcal{N}(0, \sigma^2)$ is white noise . A nice feature of this parametric form is that it allows for an asymptotic minimum (c_0) and maximum (β_0) on the contribution level which actually exist in the Netherlands.

We consider two dependent variables $f(y)$ here: the social insurance contribution for first pillar pension income, $\mathrm{SI}_{\mathrm{SS}}(\cdot)$, and the social insurance contribution for public care provision $\mathrm{SI}_{\mathrm{LTC}}(\cdot)$. We fit the functional form for first pillar pension income only on a subsample of married households below age 65, because they are the only group who contribute for this type of social insurance. The functional form for the social insurance contribution for public care provision is fitted separately for three groups: married households below age 65, married households above age 65 and widowed households above age 65. All these three groups make the social insurance contribution for this type of social insurance.

For the estimation we have IPO data available between 2001 and 2014 on the contributions that households made for first pillar pension and for public LTC provision. We fit the parametric form in (6) with non-linear least squares (NLS) estimation to the data. The results of the fitting exercise are provided in Table 3.

Table 3: Estimates on mapping of disposable income into social contributions at the household level (0000s euros) ($p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)*

	$\widehat{c_0}$	$\widehat{\beta_0}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$	R^2	RMSE
Panel A: First pillar pension (N = 340,640)						
Married, Aged 65-	-0.008**	0.717***	3.153***	1.014***	0.907	0.300
	(0.004)	(0.001)	(0.011)	(0.007)		
Panel B: Public LTC provision (N = 480,094)						
Married, Aged 65-	−0.008***	0.462***	3.164***	1.037***	0.903	0.433
	(0.002)	(0.001)	(0.010)	(0.007)		
Married, Aged 65+	−0.020***	0.382***	3.281***	0.553***		
	(0.002)	(0.002)	(0.010)	(0.010)		
Widowed, Aged 65+	−0.007***	0.308***	2.376***	0.426***		
	(0.002)	(0.002)	(0.009)	(0.008)		

Notes: Panel A. shows the estimates for the social insurance contribution function for first pillar pension. Panel B. shows the estimates for the social insurance contribution function for public LTC provision. $\widehat{\beta_0}$ is the maximum contribution levels that we estimate. The contribution functions are obtained through fitting a logistic (sigmoid) function to the IPO data.

Panel A. considers the social insurance contributions for first pillar pension income.

The minimum contribution level $\widehat{c_0}$ is -0.008 (-80 euros) for first pillar pension. The negative level may be a consequence of some measurement error and we consider its impact on our structural model to be small due to its economic insignificance. The maximum contribution level $\widehat{\beta_0}$ is 0.717 (€7,170) for first pillar pension income. The theoretical maximum contribution of €$11,720$ is above our estimated value. The theoretical maximum is however based on the premise that both household members pay the maximum social insurance premium for first pillar pension, while in practice there may be a prime earner within the household and the other household member may contribute nothing. Likewise we inferred the social insurance contribution for public care provision to be maximum €$7,960$ for a couple, while we estimate respective values of €$4,620$, €$3,820$ and €$3,080$ for married couples below age 65, married couples above age 65 and widowed individuals (Panel B.). This discrepancy stresses why it not always makes sense to mimic the institutional framework in a life-cycle model, but that it is sometimes better to do this data-driven. We graphically depict the contribution functions in Appendix B.3.

6.5 Other first-stage parameters

There is a set of other parameters that we do not have to estimate with the MSM method and which we can set outside the life-cycle model. We either obtain these values from existing literature, or we estimated them from the IPO data. Table 4 presents these parameters and the source that we used to pick the underlying value.

Important to note in Table 4 is that the estimated replacement rate for private pension for males exceeds the replacement rate for females. This may primarily be a consequence of that males are the prime earner within the household during working life and therefore accrue most of the second and third pillar pension benefit within the household. Their pension benefit remains intact after widowhood while females, who have not accrued that benefit, are only entitled to part of the current pension benefit.

Table 4: Other first-stage functions and parameters

	Symbol:	**Value:**	**Source:**
Preferences:			
Equivalence rate (single)	EQ	1	Adopted in recent OECD publications on income inequality (see for example OECD, 2019)
Equivalence rate (couple)	EQ	$\sqrt{2}$	Adopted in recent OECD publications on income inequality (see for example OECD, 2019)
Interest rate	r	0.02	Average 10-year Dutch bond yield 1996-2020
Relative risk aversion	$\frac{1}{\gamma}$	3	Several empirical studies[1]
Income:			
First pillar pension (FP) benefit (€)	SS	18,600	2010 level
Replacement rate males	rr_m	1.071	See Appendix B.2
Replacement rate females	rr_f	0.670	See Appendix B.2
Minimum wage couple (€)	$\underline{y}$	15,500	2010 level
Pension accrual rate	Φ	0.01875	Retirement income is 75% of the average lifetime disposable income
LTC use:			
Yearly LTC cost per user (€)	$\mathrm{LTC}_{\mathrm{cost}}$	58,500	van Ooijen et al. (2015)
Maximum copay for LTC (€)	κ	29,000	Wouterse et al. (2018)
Copay-free base (€)	ν	4,500	Wouterse et al. (2018)
LTC copay rate income	υ	0.75	Wouterse et al. (2018)
LTC copay rate assets	ζ	0.04	Wouterse et al. (2018)
Government:			
Post-retirement tax function	$\widetilde{\tau}(\cdot)$	–	See Appendix B.4
Finance rate of public care provision by contributions and copays	σ_1	0.664	2010 level, Statistics Netherlands[2,3]
Finance rate of first pillar pension income by contributions	σ_2	0.640	2010 level, Statistics Netherlands[2,3]

Notes: [1] Different studies estimate a different $\frac{1}{\gamma}$ depending on the subjective discount rate β that they set. Our picked value $\frac{1}{\gamma} = 3$ is in the ballpark of estimates by Cagetti (2003); De Nardi et al. (2010); Lockwood (2018). [2]Statistics Netherlands (2019), available from: https://www.cbs.nl. [3]Statistics Netherlands (2019), available from: https://opendata.cbs.nl.

The replacement rate for private pension for males exceeds unit value, implying that their pension income does not drop upon widowhood. At the same time their partner leaves the household and a lower consumption level would have sustained their living standard. Hence, from our estimation exercise it actually follows that widowed males their pension benefit overcompensates them, a finding that is recently documented in van der Vaart et al. (2020b).

7 Second-step estimation results

We use these first step estimation results in a second step in which we estimate the preference parameter vector $\mathbf{\Delta} = (\beta, \mathrm{c}_a, \phi)'$ with MSM. Table 5 presents the preference parameters that we estimate with our MSM simulation. We estimate $\hat{\beta} = 0.947$, implying that households generally prefer current over future consumption. The two estimated bequest parameters, $\hat{c}_a$ and $\hat{\phi}$, together imply that the marginal propensity to bequeath is 98.8 cents out of every euro above terminal singles' wealth of €26,880.[9] All parameter estimates are significant, but it should be noted that the standard errors are highly deflated due to the large sample size.

The total additional tax that balances the government budget constraint is $\mathrm{TR} = \mathrm{TR}_{\mathrm{FP}} + \mathrm{TR}_{\mathrm{LTC}}$. An additional tax of $\widehat{\mathrm{TR}}_{\mathrm{FP}} =$ €760 is levied on a single household every year to match the government budget for first pillar pension. For public care provision this amounts to a yearly subsidy of €30, $\widehat{\mathrm{TR}}_{\mathrm{LTC}} =$ -€30. Hence we are quite able to match the government budget for LTC provision, while our model yields slight under-financing of government expenditures on first pillar pension without an additional tax.

The highly significant parameter estimates suggest that we are well able to identify the parameters on consumption and bequest preferences. We identify β from the asset profiles shortly after retirement, because there exists substantial variation in asset levels and profiles across lifetime income groups which cannot be explained by a bequest motive at those ages. A bequest motive does not explain the difference in patterns at this stage

[9]This interpretation holds when a single household is considered, interest rates are absent and subjective discounting does not take place. For the derivation see Appendix A.3, Equation (20).

of the life-cycle, because households are less concerned about leaving a bequest due to relatively low risk on mortality. A bequest motive can however be identified from differences in saving profiles between lifetime income groups at older ages of retirement, because mortality risk has increased then and high-income households consider the bequest motive to be a more relevant saving motive than the households with lower income do.

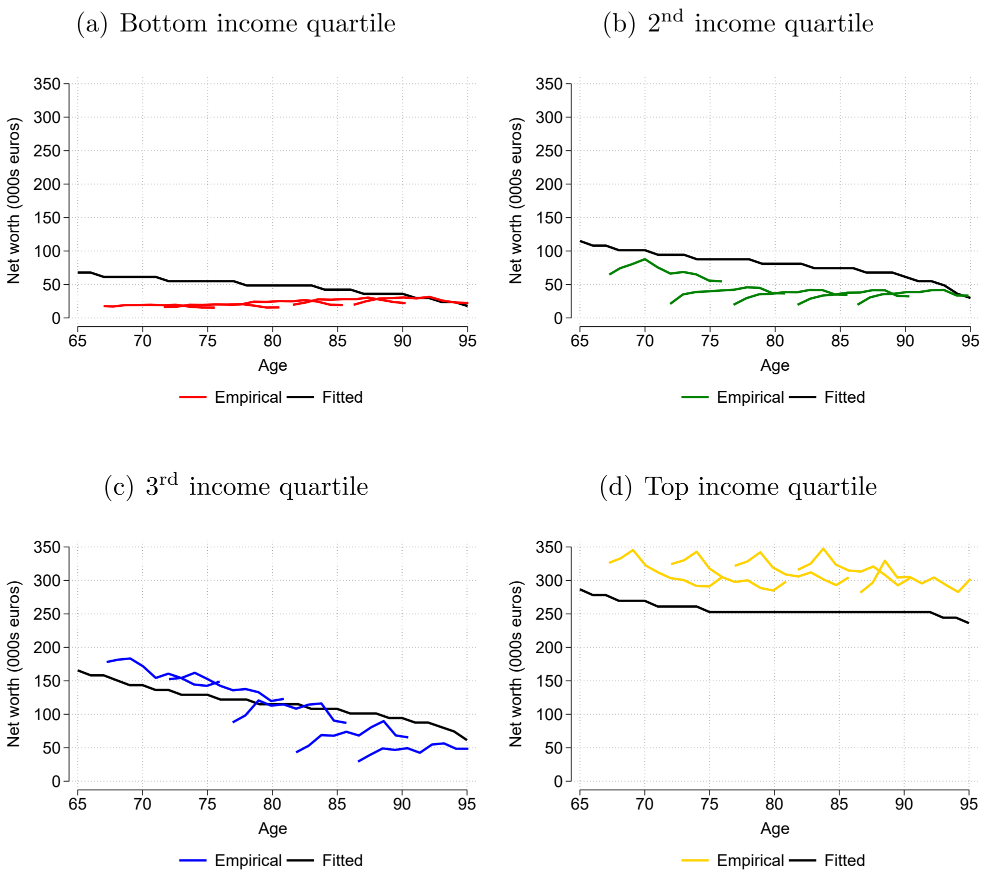
Table 5: Estimated structural parameters for the life-cycle model ($p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)*

Parameter estimate (Δ):	Estimate:	Standard error
$\widehat{\beta}$: subjective discount factor (annual)	0.947***	(0.00002)
$\widehat{\phi}$: bequest motive	0.988***	(0.00007)
$\widehat{c}_a$: bequest motive (€0000s)	2.688***	(0.00057)
$\widehat{\mathrm{TR}}_{\mathrm{FP}}$[1] (€0000s)	0.076	
$\widehat{\mathrm{TR}}_{\mathrm{LTC}}$[1] (€0000s)	-0.003	
Observations:	7,457,703	

Notes: Equation (4) contains the formula to compute standard errors. [1] $\widehat{\mathrm{TR}}_{\mathrm{FP}}$ and $\widehat{\mathrm{TR}}_{\mathrm{LTC}}$ denote the additional endogenous tax (+) or subsidy (-) that the government yearly asks from a single-person household to balance the government budget for first pillar pension income and LTC provision.

Our estimated parameters are within the ballpark of existing studies. There seems to be some agreement within existing literature that β's should range from 0.9 to unit value and our estimate $\widehat{\beta} = 0.947$ fits in this range. De Nardi et al. (2010), Lockwood (2018), and Nakajima and Telyukova (2018) respectively find a terminal wealth level of €48,000, €18,000 and €55,000 (in 2015 euros) above which the bequest motive plays a role. Our estimated threshold wealth of $\hat{c}_a$ =€26,600 fits in this range. Our estimated marginal propensity to bequeath ($\hat{\phi} = 0.988$) is above the range of estmates that these studies document: $\hat{\phi} = 0.43$, $\hat{\phi} = 0.96$ and $\hat{\phi} = 0.60$. It does have to be noted that Lockwood (2018) has an explicit exclusion restriction for a bequest motive, namely low private LTC insurance ownership rates at any wealth level, and henceforth their estimated $\hat{\phi} = 0.96$ serves as the most reasonable landmark for our estimates.

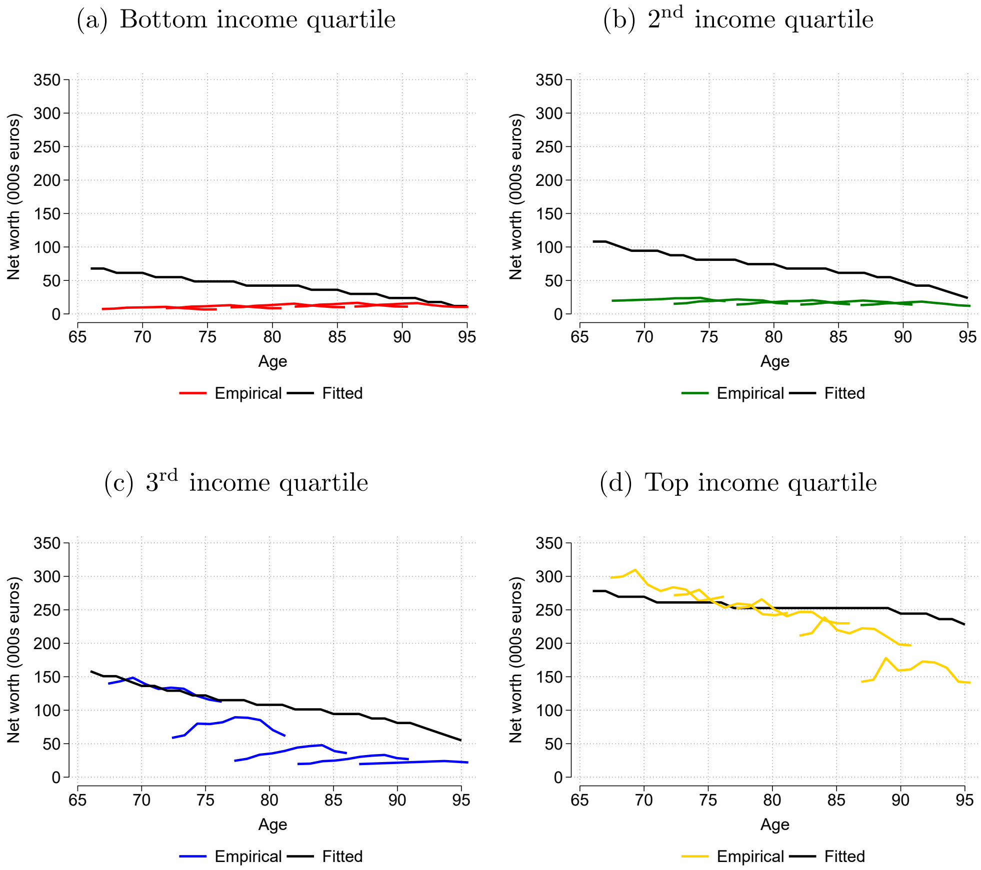
Figure 4: Fitted median asset profiles for married households 2006-2015



Notes: Each line represents the asset profile conditional upon birth cohort. We distinguish six birth cohort based on the age of the household in 2006: aged 65-69, aged 70-74, aged 75-79, aged 80-84, aged 85-89 and aged 90 and over.

In Figure 4 we present the empirical asset profiles alongside their simulated counterparts (black lines) for married households. Our life-cycle model reproduces the low asset levels quite well for the bottom and second income quartile. There is however still some gap between the fitted and observed profile which we hope to resolve in future work, for example by examining whether lower income groups are more impatient and therefore hold fewer assets (suggested in van der Pol, 2011). Median asset holdings by the two top income quartiles seem to be matched quite well even though we only target the youngest cohorts. The model-generated asset profile for the top income quartile is rather flat because the bequest motive is mainly active for them while their propensity to bequeath is strong.

Figure 5: Fitted median asset profiles for widowed households 2006-2015



Notes: Each line represents the asset profile conditional upon birth cohort. We distinguish six birth cohort based on the age of the household in 2006: aged 65-69, aged 70-74, aged 75-79, aged 80-84, aged 85-89 and aged 90 and over.

In Figure 5 we present the same figure but now for widowed households. Again the asset levels of the two bottom income groups are slightly overestimated. The match of the asset profile of the third income quartile is worse for widowed households than for married households. While we closely resemble the asset profile for the two youngest cohorts there is an apparent mismatch for the older cohorts, for whom we also observe a cohort effect in their empirical profile. The top income quartile hardly decumulates assets according to our life-cycle model. In the data there is however some asset decumulation visible. We may resolute this mismatch in future work by letting the subjective discount factor β depend on income status.[10]

Even though for some income groups we under- or overestimate the asset profile for some cohorts, the general picture on asset profiles seem to be reproduced by our MSM estimation. This good fit is a prerequisite for counterfactual analysis that we will apply now.

8 Results from counterfactual health experiment

In this section we quantify how much welfare the retirement programs, used to finance retirement income and public LTC provision, redistribute across SES groups due to the joint inequalities in LTC needs and mortality. The redistribution takes place through channels that are all linked to the retirement programs, especially when these programs demand income and asset-tested LTC co-payments that affect the households' saving decision. We therefore also examine extent to which saving for a bequest and LTC co-payments moderate this redistribution, because LTC co-payments that are progressive in assets may put an implicit tax on bequest saving.

For the analysis it is important to note that several channels feature a redistribution of welfare across income groups. First, there are the social insurance contributions throughout working life. These govern a progressive redistribution of welfare from high- to low-income households. This redistributive mechanism is however of less importance to our analysis, because the health risks that we consider, involve the period after working life when the contributions are generally lower. Second, there exist co-payments which have to be paid conditional upon LTC use. Those co-payments are progressive in income and assets. Third, there exists a negative income gradient in LTC use that leads to a regressive redistribution of welfare from the low- to the high-income households in our model. Due to the negative

[10] If we do so, we can allow higher income households to be more patient than they are now, at the same time this additional saving may lower our current estimate on the bequest motive. Their asset profile would then have a higher level at age 65 but be less flat than is the case now.

income gradient in LTC use, high-income households have to make co-payments for LTC use for a shorter amount of time than their low-income counterparts. The income gradient in remaining life-expectancy is a fourth redistributive mechanism and is, amongst others, operative through its impact on marital status. High-income households live longer and are married and single for a longer time. The higher longevity is especially important for single males who have a replacement rate of private pension income that exceeds unit value (see Appendix B.2). Their survivor benefits are not adjusted for their changed household status. Lower consumption would have sustained their welfare level (less mouths to feed), so their survivor pension overcompensates their spousal loss. Due to the income gradient in remaining life-expectancy, high-income single males enjoy this overcompensation for a longer time than their low-income counterparts and consequently may see their welfare improve further because they can spend the additional resources on consumption or to leave as a bequest.

For this analysis we have to compare the welfare levels that households reach when the income gradients in LTC use and mortality are present and when these are absent. The latter involves a (non-existent) counterfactual case which we can only address with our estimated life-cycle model. For the counterfactual case we make a more pessimistic assumption about how long different lifetime income groups will live and how much LTC care needs, they will have, i.e. we give every household the health risks of the bottom lifetime income group. With this counterfactual case we simultaneously shut down the income gradient in LTC use and mortality and calculate the consequent welfare levels that different SES groups reach. Because there are then opposite redistributive mechanisms at work, we are not able to infer on the welfare implications of the income gradients upfront.

In addition to all the redistributive mechanisms that we discussed, the comparison of the baseline with its counterfactual introduces a positive pure income effect for any SES group. Contrary to the counterfactual, differential mortality exists in the baseline case and this generates a positive income effect for any SES group, because high-income households are mainly the survivors in a SES group when households age. Average income within a SES group thus increases with age due to this differential mortality and consequently income at older ages will be higher under the baseline than under the counterfactual case.

We perform the analysis while conditioning upon the permanent income level that households draw at the beginning of their life-cycle. This means that our analysis not only comprises the benefits that households obtain, but that also takes into account the subsidization to finance the public and private insurances. Our analysis then furthermore incorporates the anticipated effects of becoming eligible to retirement income and public LTC provision. The four groups that we consider, represent the 12.5$^{\text{th}}$, 37.5$^{\text{th}}$, 62.5$^{\text{th}}$ and 87.5$^{\text{th}}$ percentile of distribution of θ, i.e. the median within every permanent income quartile. We refer to these groups as socio-economic status (SES) groups. We construct them based on income quartiles to align its definition with lifetime benefit groups.

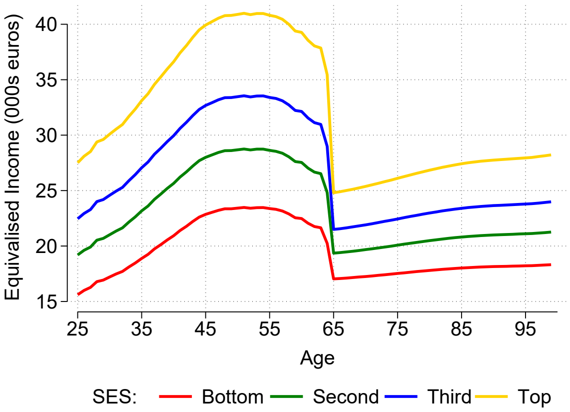
8.1 Life-cycle profiles under the baseline and counterfactual scenario

Before we calculate the welfare levels for any of the SES groups, we start with computing the consumption and asset profile under **the baseline case**, i.e. when differences in LTC needs and mortality exist, and under **the counterfactual case**, i.e. when every household has the health profile of the bottom lifetime income group. We furthermore calculate the income profiles and co-payment levels under both scenarios. The asset, consumption, income and LTC co-payment profiles together provide intuition on how retirement programs redistribute welfare (arising from consumption and bequests) across SES groups due to the income gradients in LTC needs and mortality.

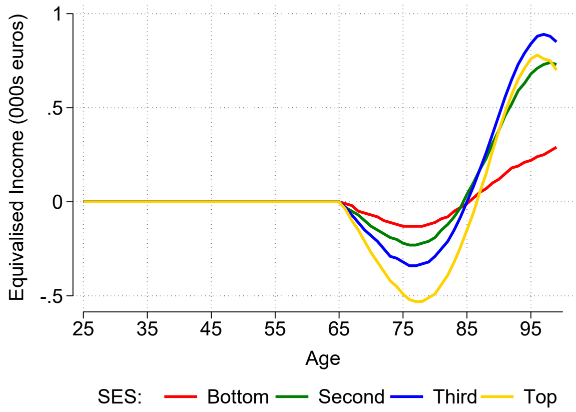
We present these profiles in Figure 6. The left panels in this figure show the profiles under the counterfactual case when differences in LTC needs and mortality do not exist. The right panels show how a given profile changes when differences in LTC needs and mortality do exist and an income gradient in LTC needs and mortality is present (baseline case).

Figure 6: Income, LTC co-payments, assets and consumption profiles under the counterfactual (left panels) and baseline scenario (right panels)

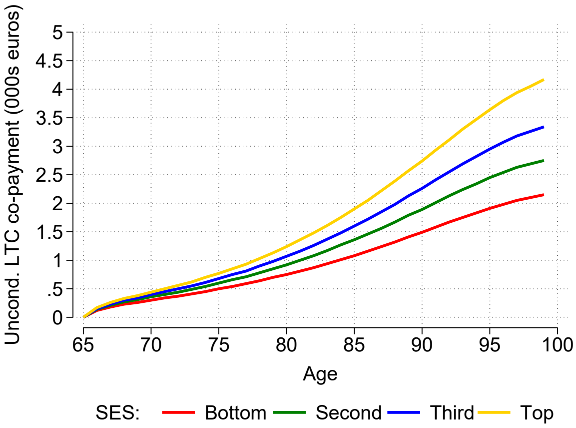
(a) Counterfactual - mean income



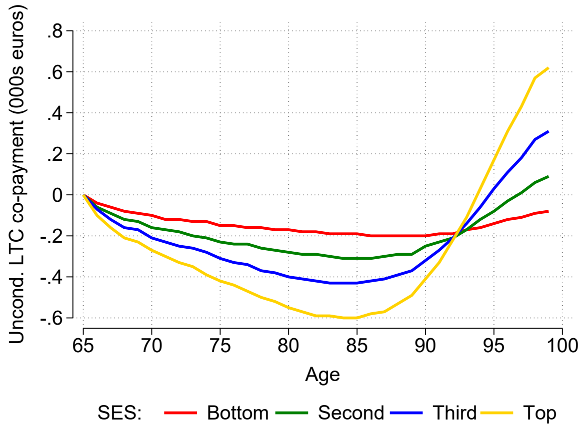
(a) Baseline - difference compared to counterfactual



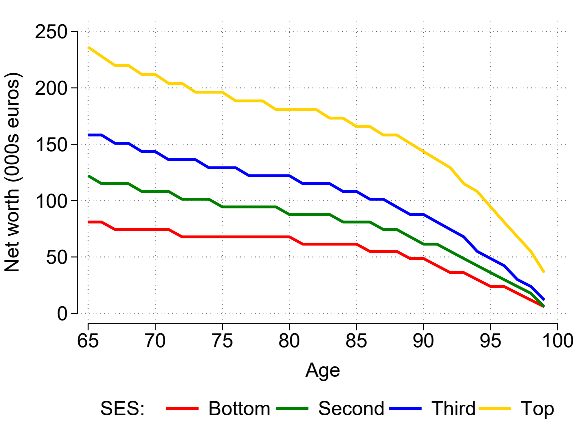
(b) Counterfactual - mean co-payments



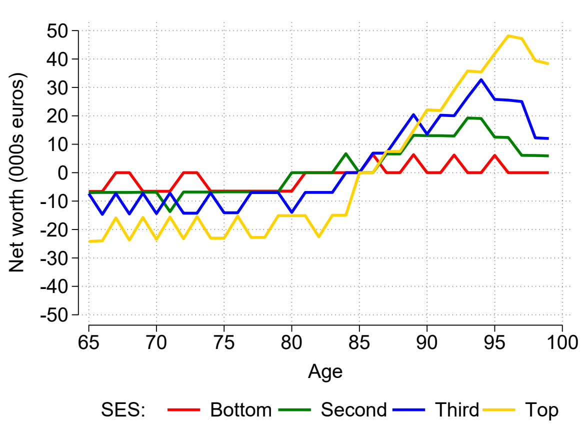
(b) Baseline - difference compared to counterfactual



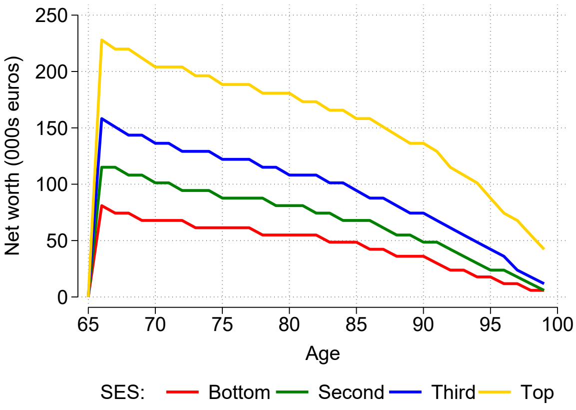
(c) Counterfactual - median assets (married)



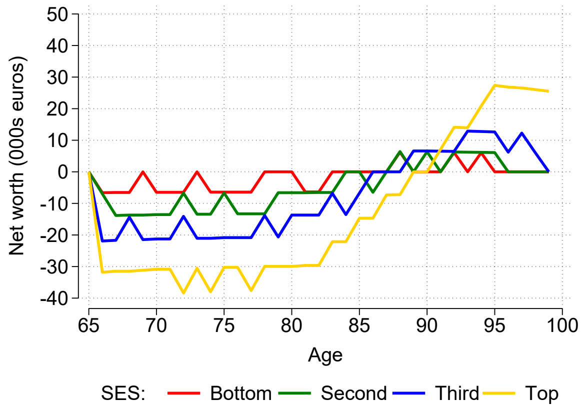
(c) Baseline - difference compared to counterfactual



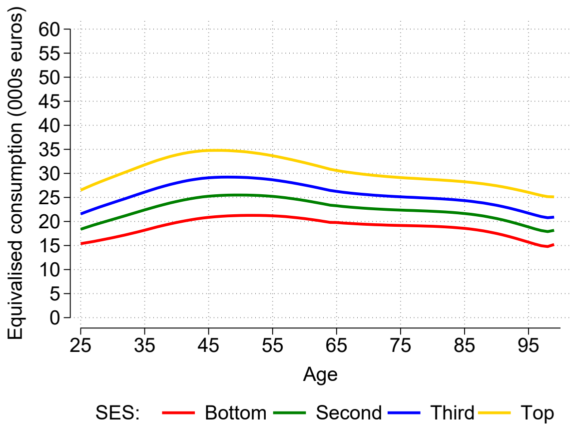
(d) Counterfactual - median assets (widowed)



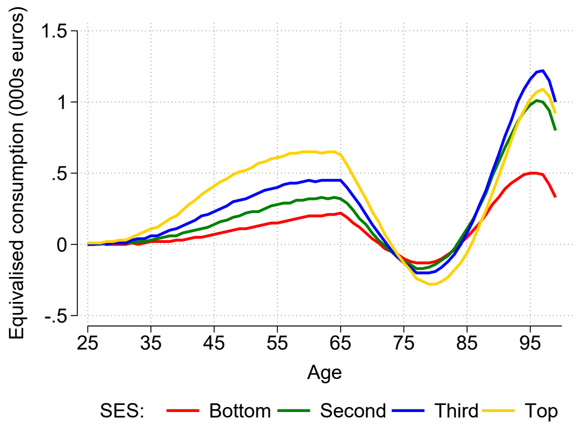
(d) Baseline - difference compared to counterfactual



(e) Counterfactual - mean consumption



(e) Baseline - difference compared to counterfactual



Notes: Each line represents the profile conditional upon SES. The left panel always denotes the profile for the counterfactual case (when there are no differences in LTC needs and mortality). The right panel presents the difference between the baseline and counterfactual scenario for the variable presented in the left panel. Panel (a) presents the profile for mean equivalised household income. Panel (b) presents the mean unconditional co-payments that households make for LTC use. Panel (c) presents the median asset profiles of married households. Panel (d) presents the median asset profiles of widowed households. Panel (e) presents the mean profiles on equivalised household consumption

In panel (a) we present the income profile under the two scenarios. We divide the household income by the equivalence rate to back out the effect that households of larger size have higher income by construction. In the left panel it is important to note that income increases after retirement, because the share of single males increases in the population while the replacement rate of their survivor benefits exceeds the equivalence rate. Income in the right panel (baseline case) is lower until age 85, because households under the counterfactual die at a younger age and thus over-compensated single males appear at this younger age while this does not happen in the baseline case. The mortality in the baseline scenario catches up with the mortality in the counterfactual case after age 85. Then widowed males appear in the baseline case and there furthermore becomes a pure income effect operative in the baseline case due to differential mortality. Therefore income after age 85 is higher under the baseline case.

The income in (a) maps one-to-one into the income-tested co-payments in (b). Therefore the result in the right panels of (a) and (b) look similar. Important to note is that lower SES groups have lower unconditional co-payments under the baseline scenario at any age. Under the baseline scenario they have a perspective on the better health of higher lifetime income groups while under the counterfactual case they face the health risk of the lowest lifetime income group implying more LTC needs and co-payments. For most, but not all, ages the LTC co-payments are lower under the baseline than under the counterfactual case for higher SES groups. Higher survival under the baseline case however exposes them to more LTC risk in very old ages and therefore their LTC co-payments may be higher then. All in all, the lower co-payments for low SES households for any age suggest that we will likely find a positive welfare effect resulting from the baseline case for them.

The result in the right panel of (b) however also mitigates a response in asset holdings, because LTC co-payments are asset-tested and higher asset holdings under the baseline imply higher co-payments. We present the difference in asset holdings between the baseline and counterfactual case in the right panels of (c) and (d). These panels indeed suggest a strongest asset response for the top SES group, and this response is in part linked to the income effect from panel (a). Especially after age 85, the top SES group seem to have larger asset holdings under the baseline scenario. To understand this result even better one should realize that this is the group who mainly save to leave a bequest and therefore extract much utility (welfare) from leaving an additional bequest. Due to more income (panel (a)) they can leave a larger bequest. Furthermore the LTC co-payments put an implicit tax on bequest saving, and this implicit tax is lower under the baseline scenario in which they have lower LTC needs. Thus, the income gradient in LTC needs and mortality drives high SES households to leave a larger bequest, and this will in turn generate a positive welfare effect for them.

Lastly, we provide the equivalised consumption profiles for households in Figure 6. The left panel of (e) shows the consumption profile under the counterfactual case. The consumption profile is (weakly) hump-shaped which is also widely observed in literature (see for example Carroll, 1997; Gourinchas and Parker, 2002). The right panel of (e) shows the consumption profile when LTC needs and mortality differ over lifetime income groups. Before age 65, any household can permit a higher consumption level, because any household anticipates the perspective on the (better) health risks of a high lifetime benefit group, and thus lower LTC co-payments, under the baseline scenario. All SES groups will thus likely experience a positive welfare effect from the baseline case with differences in LTC needs and mortality. Short after retirement the pattern reverses and consumption is lower under the baseline case, presumably because equivalised household income is higher under the counterfactual case (panel b). After age 85 the difference in consumption switches sign for the last time and consumption in the baseline case exceeds that of the counterfactual case. One of the reasons for this is that income and assets after age 85 are higher in the baseline case (right panel in (a), (c) and (d)). Furthermore, unconditional LTC co-payments are lower under the baseline case until age 93 due to lower LTC needs. Even though any SES group benefits from the existence of differences in LTC needs and mortality, we cannot draw an unambiguous conclusion from the consumption profiles in panel (e) on which SES group perceives the largest welfare effect from the income gradients.

8.2 Measuring welfare

The channels that we discussed here affect the asset holdings and consumption profiles -henceforth welfare- of the households. We ideally would like to summarize these asset profiles and consumption levels into a single welfare measure.

We measure welfare as certainty equivalent consumption (CEC) and this measure is commonly used to conduct welfare analyses (see for example Chetty and Szeidl, 2007; Handel, 2013; Luttmer and Samwick, 2018). Households obtain utility from consumption and leaving a bequest (assets). Lifetime utility is the expected discounted sum of utilities at the start of the life-cycle (age 25). We use the lifetime utility to compute our measure on welfare. Because utility itself is unitless, we derive the so-called CEC from the lifetime utility measure. Households expect the lifetime utility in a world that is uncertain, i.e. when there exist income and health risks. The CEC is then the level of fixed consumption that households would require to reach this level of lifetime utility in a world that is not uncertain.

We formally derive the CEC level $\widetilde{c}$ in the following steps. First, we calculate expected lifetime utility $\mathrm{E}(U_{25})$ at age 25:

$$\begin{aligned}\mathrm{E}(U_{25}) = \mathrm{E}\Bigg[& u\left(\frac{c_{25}}{\mathrm{EQ}_{25}}\right) + (1-\psi_{26})\cdot\mathcal{B}(a_{26}) \\ & + \sum_{\overline{a}=26}^{99}\beta^{\overline{a}-25}\left(\prod_{s=26}^{\overline{a}}\psi_s\right)\left\{u\left(\frac{c_{\overline{a}}}{\mathrm{EQ}_{\overline{a}}}\right) + \beta\cdot(1-\psi_{\overline{a}+1})\cdot\mathcal{B}(a_{\overline{a}+1})\right\}\Bigg],\end{aligned}$$

where c denotes the consumption level, EQ the equivalence rate, $u(\cdot)$ the utility flow from consumption, a the asset level, $\mathcal{B}(\cdot)$ the utility flow from bequests , $\psi_{\overline{a}+1}$ the conditional survival probability of reaching age $\overline{a}+1$ and U_{25} the lifetime utility level. Households expect the lifetime utility in a world that is uncertain.

Let $\widetilde{U}_{25}(\widetilde{c})$ denote the lifetime utility level that is reached with the (fixed) CEC level $\widetilde{c}$.

This value excludes any uncertainties and is calculated as follows:

$$\widetilde{U}_{25}(\widetilde{c}) = \mathrm{E}_{25}\left[u\left(\frac{\widetilde{c}}{\mathrm{EQ}_{25}}\right) + \sum_{\bar{a}=26}^{99} \beta^{\bar{a}-25}\left(\prod_{s=26}^{\bar{a}} \psi_s\right) u\left(\frac{\widetilde{c}}{\mathrm{EQ}_{\bar{a}}}\right)\right].$$

As a last step, the CEC level $\widetilde{c}$ sets the lifetime utilities in a complete certain and an uncertain world equal, and meets:

$$\widetilde{c} = \widetilde{U}_{25}^{-1}(\mathrm{E}(U_{25})). \tag{7}$$

Similar to the profiles that we depict in Figure 6, we calculate this welfare measure conditional upon the permanent income level (SES) that households draw at the beginning of their life-cycle. This means that our welfare measure not only comprises the benefits that households obtain, but that this measure then also takes into account the subsidization to finance the public and private insurances. Our welfare measure then furthermore incorporates the anticipated effects of becoming eligible to retirement income and public LTC provision.

8.3 Welfare analysis

Table 6 contains the calculated CEC amounts for the SES groups. This is calculated for the counterfactual case in which we give every household the health risk of the bottom lifetime income group. Table 7 presents the change in CEC levels when households can differ in their LTC needs and mortality (baseline case).

The first row in Table 6 shows the CEC amounts for our benchmark specification, that is the life-cycle model that we estimated with the MSM and whose results we present in the left panels of Figure 6. The CEC increases from a yearly amount of €22,400 for the lowest SES group to €37,100 for the highest SES group, because of the positive correlation between permanent income (SES) and income over the life-cycle. To get a sense how risk-averse households are, we present in the bottom row the difference between average household consumption, including an uncertain nature, and the CEC, assuming a certain nature. The relative difference is largest for the lowest SES group, 14.3%, and they are thus willing to sacrifice most consumption units to take away uncertain LTC needs and uncertain income.

Table 6: Certainty equivalent consumption (000s€) - Counterfactual

	Permanent income level (SES)			
	Bottom	2^{nd}	3^{rd}	Top
Benchmark model	22.4	26.9	31.0	37.1
Model without LTC co-payments	22.7	27.2	31.4	37.6
Model without bequest saving	22.9	27.8	32.4	39.5
Model without LTC co-payments and bequest saving	23.2	28.2	32.9	40.1
Difference between average household consumption and CEC (benchmark model)	14.3%	13.7%	12.7%	11.6%

Notes: This table contains the certainty equivalent consumption (CEC) amounts that different permanent income (SES) groups obtain under the counterfactual when every households has the same health risks of the bottom lifetime income group. We calculate this amount cf. equation (7). Each row provides another counterfactual situation regarding the life-cycle. The first row contains the CECs that follow from the benchmark specification that we estimate with MSM. The second row assumes that households in the estimated model do not have to make LTC co-payments any longer and we calculate the CECs from that life-cycle model accordingly. The third row assumes that households no longer save with a bequest motive in the estimated life-cycle model and produces CECs accordingly. The fourth row combines the counterfactuals from the second and third row and uses that life-cycle model to produce the according CEC amounts. The last row presents by how much the average household consumption differs from the CEC amount under the benchmark specification.

We are not only interested how much welfare the income gradients in LTC use and mortality redistribute across SES groups, but also how this happens. From the results in Figure 6 it became clear that the interplay between LTC co-payments and bequests can moderate this redistribution. For that reason we will also apply the counterfactual analysis while we one-by-one shut down the existence of co-payments and bequests in our estimated life-cycle model. We then assume away the existence of LTC co-payments or a bequest saving motive in our estimated specification (we however do not re-estimate the model) and then reproduce the CEC amounts that follow from that counterfactual specification. That way we can examine the differential impact that co-payments for

LTC use and bequests have to the redistribution of welfare that arises from the income gradients.

The CEC level for the model without the existence of LTC co-payments is shown in the second row of Table 6. The CEC level increases somewhat for every SES group because households no longer have to save for LTC co-payments. They can now spend the additional resources on consumption or leave them as a larger bequest.

The third row of Table 6 shows the CEC levels when households do not save with a bequest motive but only save to finance future consumption. The CEC level lies considerably higher for the highest SES group when they do not have to save for a bequest. A bequest motive mainly applies to them, because bequests are a luxury good. Moreover, the bequest motive is a particular strong saving motive for them given our estimated preference parameters in the life-cycle model. LTC co-payments put an implicit tax on their bequest saving in the benchmark specification. Their bequest saving motive is however so strong that they are willing to pay the implicit tax. When they no longer have this bequest saving motive, they can spend down their (relatively high) assets before LTC needs arise and therefore prevent the implicit tax. The released assets can be used on consumption and consequently the CEC level lies considerably higher for higher SES groups when they do not have to save for a bequest.

Lastly, the fourth row in Table 6 shuts down the existence of bequest saving and LTC co-payments simultaneously. The change in CEC level is then approximately the same as the combined changes in CEC that we report in the second and third row of Table 6.

Table 7 shows how the CEC levels in Table 6 change when higher lifetime income households do have a lower risk on LTC needs and mortality. In this way we quantify how much welfare the retirement programs, used to finance retirement income and public LTC provision, redistribute across SES groups due to the joint inequalities in LTC needs and mortality.

Table 7: Certainty equivalent consumption - Difference between baseline compared to counterfactual.

	Permanent income level (SES)			
	Bottom	2^{nd}	3^{rd}	Top
Benchmark model	0.37%	0.51%	0.72%	1.09%
Model without LTC co-payments	0.23%	0.37%	0.54%	0.84%
Model without bequest saving	0.22%	0.25%	0.30%	0.38%
Model without LTC co-payments and bequest saving	0.08%	0.06%	0.04%	0.01%

Notes: This table contains the relative difference between the certainty equivalent consumption (CEC) in the baseline and counterfactual case (see Table 6 for the level estimates for the CEC in the counterfactual case). Each row provides another counterfactual situation regarding the life-cycle. The first row contains the CECs that follow from the benchmark specification that we estimate with MSM. The second row assumes that households in the estimated model do not have to make LTC co-payments any longer and we calculate the CECs from that life-cycle model accordingly. This explains to what extent LTC co-payments moderate the redistribution that we present in the first row. The third row assumes that households no longer save with a bequest motive in life-cycle model and produces CECs accordingly. This explains to what extent a bequest motive moderates the redistribution that we present in the first row. The fourth row combines the counterfactuals from the second and third row and uses that life-cycle model to produce the according CEC amounts.

The first row in Table 7 shows the welfare gain that households perceive when they save for a bequest and face uncertain LTC co-payments. Due to a positive income effect and the perspective on lower LTC needs and co-payments, every SES group experiences a positive welfare gain. The effect of the income gradient in LTC needs and mortality is however strongest for highest SES group, who see their CEC -henceforth welfare- level increase by 1.09 percentage points. At the same time, the lowest SES group sees its CEC level only increase by 0.37 percentage points. For two reasons this difference may exist. The lowest SES group see part of the income effect being taxed by LTC co-payments, while this effective tax may be lower for higher SES who already pay the maximum contribution under the counterfactual. At the same time, LTC co-payments put an implicit tax on bequest saving, because co-payments are asset-dependent. In the baseline scenario higher SES groups have lower LTC needs and spend a shorter time in LTC. This in turn lowers the implicit tax that co-payments put on their high-prefered bequest saving. The higher SES groups may use these additional resources to spend on consumption or to leave a larger bequest which they strongly prefer. They therefore may see a larger welfare gain than other SES groups do.

The second row of Table 7 shows how this welfare changes when households no longer have to make the LTC co-payments. This thus explain to what extent LTC co-payments moderate a welfare redistribution that arises from differences in LTC needs and mortality. When doing this, the welfare gain drops by 0.14 (0.25) percentage points for the lowest (highest) SES group when compared to their original welfare gain. Their welfare gain is now 38% (23%) lower compared to the welfare gain when LTC co-payments exist. Co-payments for LTC needs are thus a (relative) stronger driver for the welfare gain for low SES groups than it is for high SES groups. We already inferred on this when discussing the result in panel (b) of Figure 6. When health differences do exist, lowest SES groups have lower LTC co-payments at any age while this is not true for the highest SES groups. A substantial part of the welfare gain of the high SES households is left unexplained by co-payments, because there still remains a pure income effect that high SES households can use to leave a -to them- strongly preferred bequest.

Still, co-payments do not explain why high SES groups encounter a larger welfare gain from differences in LTC needs and mortality. We therefore examine the explicit role that bequests play here. Panels (c) and (d) in Figure 6 already showed that mainly high SES households can leave a larger bequest under the baseline case, caused by their relatively low LTC needs and relatively high income late in life.

Accordingly, the third row of Table 7 shows that when a bequest saving motive is absent, households with low (high) SES see their welfare gain from health differences drop with 0.15 (0.71) percentage points compared to the benchmark case. Their current welfare gain is 41% (65%) lower than their welfare gain at the benchmark. High SES households thus gain relatively much welfare from health differences due to their strong bequest saving motive. In the life-cycle without bequest saving, the high SES households can no longer exploit the income effect to leave a larger bequest. Furthermore, they can no longer benefit from their lower needs which would otherwise lower the implicit tax on bequest saving and leaving this bequest. Moreover, both in the counterfactual and baseline case households will spend down their assets before LTC needs arise, because they have no motivation to keep them throughout LTC use when the asset holdings (bequests) are taxed by LTC co-payments. Taken together, these three reasons explain why bequests are a strong moderator for the relatively large welfare gain that high SES households obtain from their lower LTC needs and mortality.

As a last step we shut down the existence of co-payments and bequest saving at once. This result is shown in the fourth row of Table 7 . The welfare gain from differences in LTC needs and mortality drops to 0.08 (0.01) percentage points and thus nearly vanishes. According to our life-cycle model, co-payments and bequest saving thus jointly explain why higher SES households perceive a larger welfare gain from differences LTC needs and mortality than the lower SES groups do.

9 Discussion & Conclusion

A long strand of literature established a negative relation between SES and mortality (see for example Deaton, 2002). There furthermore exists agreement upon a negative relationship between SES and LTC needs in literature nowadays (see for example Rodrigues et al., 2018). These SES gradients in LTC needs and mortality have implications for the welfare redistribution that takes place through retirement programs that finance retirement income and LTC use. In this paper we have quantified how much welfare these retirement programs redistribute across SES groups due to the inequalities in LTC needs and mortality. We furthermore examined how co-payments for LTC needs and bequest saving moderate this redistribution.

To determine these welfare effects, we have used a life-cycle model on consumption and saving that spans the entire life-cycle for the Dutch population of couples aged 25 and older. We emulated the LTC co-payment system of 2012 that demands a limited co-payment which is progressive in income and assets. Households face uncertain income, survival and LTC needs over their life-cycle. We calibrated the model to unique Dutch administrative data on asset holdings between 2006 and 2015. The calibration exercise was used to estimate preference parameters on subjective discounting and a bequest motive. We find that households have a modest preference for current consumption (subjective discount rate $\beta = 0.948$) and are willing to bequeath 99 cents of every euro above terminal wealth level €26,800. Households with high income and assets in the Netherlands thus have a strong preference for leaving a bequest and they save accordingly.

Our identified bequest motive is at odds with existing U.S. literature, saying that high medical expenditures by the households with most income and assets are sufficient to explain their slow wealth draw-down, while a bequest saving motive is less relevant to the explanation (see for example De Nardi et al., 2010; Ameriks et al., 2011; Kopecky and Koreshkova, 2014). This explanation can however not be seen as a mere fact of bequests being unimportant but may reflect actual difficulties with identifying a bequest motive within the U.S. institutional setting. U.S. savings data alone need not separately identify precautionary and bequest motives because households with most income and assets save for both uses at the same time (Dynan et al., 2004). Because a precautionary motive and therefore private insurance might be less relevant in countries with more generous public LTC programs, such as the Netherlands, we may be better able to identify the bequest motive here. Our well-identified bequest motive implies a strong saving motive for households with high asset holdings and income, and turned out to be an important explanation to why retirement programs redistribute across SES groups due to the inequalities in LTC needs and mortality.

We used our estimated life-cycle model in a counterfactual experiment to quantify this welfare redistribution and we find that mainly high SES households benefit from their lower LTC needs and mortality. While low SES households reach a yearly certainty equivalent consumption level that is 0.37% higher when health differences exist, this increases to 1.09% for the highest SES groups. This amounts to 0.22 and 0.64 years of additional consumption for respectively low and high SES households.[11] These welfare gains are substantial given that the gains involve (modest) financial risks that only occur very late in life.

A bequest saving motive and LTC co-payments play an important role to why this redistribution occurs and to why higher SES households obtain a larger welfare gain from retirement programs when health differences exist. The highest SES group holds a rather strong bequest motive and any financial risk that endangers their bequest size consequently has large welfare implications for them. They voluntarily hold many assets until late in life and asset-dependent co-payments put an implicit tax on their bequest saving. Due to their lower LTC needs they however face this implicit tax for a shorter time then would be the case for lower SES households. Their lower LTC needs accordingly provide them a welfare gain and thus introduce a regressive element to retirement programs. Such welfare gain remains when LTC co-payments are made more progressive in assets, because the high SES households then can still exploit their lower LTC needs to leave a larger bequest. To reduce the regressive element of health inequalities, future fiscal policy may therefore be more tailored towards limiting the bequest saving motive of high SES households.

Our results and conclusions should be interpreted with proper care, because our developed life-cycle model is not completed yet and our counterfactual experiment will be extended in future work. First, the conclusions that we draw are based on joint inequalities in LTC needs and mortality rather than that we analyse these inequalities in isolation. Consider for example that LTC entry is the driving mechanism behind our results rather than that this is the mortality when in need of LTC. To reduce welfare inequalities that arise otherwise, policy-makers would like to develop (cost) effective policy that targets on the former source of inequality. In future work we will implement an appropriate counterfactual experiment to disentangle the differential impact that inequalities in LTC needs and mortality have to the redistribution of welfare through retirement programs.

[11] Based on authors' calculation. An average males expects to live for 18.7 years conditional upon being 65 years old. At the start of the life-cycle this amounts to 58.7 years. Then for low (high) SES households the welfare gain in years of consumption is: $\frac{0.37\%}{100} \times 58.7 = 0.22$ ($\frac{1.09\%}{100} \times 58.7 = 0.64$).

Second, we restrict ourselves to institutionalised care and exclude home care as a source of uncertainty in our model. On the one hand, such choice seems justified because the financial risk of home care use is negligible, while institutionalised care demands substantial co-payments (Wouterse et al., 2020). On the other hand, home care can be provided relatively easy by a relative and therefore be substituted by informal care use. As home care use then involves a choice (behavioral response), inclusion of this type of care may be actually necessary in a life-cycle model to come to well-grounded conclusions. Lastly, there is an apparent mismatch in the asset levels of the elderly with higher income. Cohort effects, such as the decision to buy or sell a house or other property, plays an important role here. The housing decision is especially important in the context of LTC use, because households may have to liquidize their housing wealth before moving into a nursing home. The explicit inclusion of housing wealth in the life-cycle model may thus lead to new insights that are relevant to keep the Dutch welfare state fiscally sustainable in the future. We refer to the end of this section for an additional overview on what we may include in a future version of the life-cycle model as well.

The extent to which differences in LTC and mortality redistribute welfare, gains relevance in the context of aging societies, especially in Northern European countries with generous retirement programs. Driven by increasing life-expectancy and more LTC needs, European countries will see their share of public LTC spending increase from 1.6% to 2.7% of the GDP between 2015 and 2060 (European Commission, 2018), forcing them to reform. At the same time, many European countries already implemented reforms to keep their first pillar pension system fiscally sustainable. The implemented and future measures will demand more self-responsibility of retirees in covering LTC needs and in financing retirement income and expenditures. Because SES groups differ in their possibilities to cover these needs themselves, the policy instruments may hit different SES groups disproportionally hard. Especially, because our findings confirm that in the current situation the high SES groups disproportionally benefit from a better perspective on lower LTC needs and a longer lifespan. Given the differences in LTC needs and mortality, future research could add to our study and shine light on how the design of retirement can be changed such that a redistribution of welfare due to inequalities in LTC needs and mortality is reduced. In light of the future challenges to keep the system fiscally sustainable, this research avenue could tremendously help the ongoing debate on how to reform the welfare state properly.

For future work

Some parts of our life-cycle model are not finished yet and our results therefore have to be considered with proper care. First, we only fit our life-cycle model to the asset profiles for some but not all cohorts of retired households. We have to restrict to retired households only, because we do not feed in cohort-dependent risk processes in our life-cycle. Second, we introduced a government tax that balances the government budget for retirement programs within the estimated model. We however did not recalculate this transfer when we shut down the existence of LTC co-payments. This obviously lead to that the current transfer is insufficient to match the government budget, and we leave the calculation of the new transfer for future work. Third, the income uncertainty solely consists a persistent component and does not consist a transitory component in our model. Part of the persistent component that we estimate may thus actually be a transitory component. As households can effectively hold buffer stock savings to counteract this idiosyncratic income risk to consumption (Deaton, 1991), we may have to include this shock type in future work to generate more realistic asset profiles. Fourth, households need not prefer social insurance over private coverage in the current model setting, which may be counter-intuitive. One of the reasons for this is that we do not allow for population growth and productivity growth in our model, which are generally the engines for the preference for a social insurance scheme, such as first pillar pension, over private coverage. In future work we may extend our life-cycle model with these features. Fifth, in future work we may aim to sharper pin down the bequest saving motive. The asset data allow me to go beyond the usual approach to only match median asset holdings and estimate parameters exploiting the whole distribution as income-rich are well-represented in the data. In addition, I may use administrative data on realized bequests that can be linked to the IPO dataset. I could therefore match observed bequests with model-generated bequests better then. Sixth, the LTC co-payment function that we introduced in our work is the LTC co-payment that single-person households pays after they have spend more than four months in a nursing home (hoge eigen bijdrage). In future work we will also mimic the LTC co-payment function that reflects the situation in the first four months of a nursing home stay. Furthermore, we will then also construct a LTC co-payment function for the case when both household members are in need of LTC. We can do this data-driven likewise we have constructed the social insurance contribution functions for first pillar pension income and LTC provision. Lastly, we face the well-known problem that we cannot separately identify the attitude towards risk and time preference and choose to pick the attitude towards risk (Gollier, 2001). Our results thus have to be interpreted conditional upon the risk aversion parameter that we take ($\gamma = 3$). We hope to cover these modelling issues in future work, but for now we made some simplifying assumptions to keep the problem computationally tractable.

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Appendices

A Mathematical appendix

A.1 Government budget constraint

The government collects the social insurance contributions and co-payments for LTC provision and uses these to finance social security income and LTC provision throughout retirement. Yet it is not guaranteed that the government revenues and expenditures balance, so the government may thus have a deficit or surplus. To let the government break-even, we add another degree of freedom: the government surplus (deficit) is redistributed to every household as an additional income-independent subsidy (tax): TR.

To see how this works, first consider the government expenditures. For a household of given size and age, the (full) governmental LTC expenditures, $\text{EXP}_{\text{LTC}}(\cdot)$, are given by:

$$\text{EXP}_{\text{LTC}}(H_m, H_f) = \begin{cases} 2 \cdot \text{LTC}_{\text{cost}}, & \text{if } H_m = \text{LTC and } H_f = \text{LTC}, \\ \text{LTC}_{\text{cost}}, & \text{if } H_m = \text{LTC or } H_f = \text{LTC}, \\ 0 & \text{elsewhere}, \end{cases}$$

where LTC_{cost} is the cost of an individual stay in a nursing home for a year. This government expenditure depends on whether both, one or no household members are in need of LTC.

For a household of given size and age, the government expenditures on first pillar pension payments, $\text{EXP}_{\text{SS}}(\cdot)$, are given by:

$$\text{EXP}_{\text{SS}}(j, H_m, H_f) = \begin{cases} SS & \text{if } j \geq 65,\ H_m \neq \text{Death and } H_f \neq \text{Death}, \\ 0.7 \cdot SS & \text{if } j \geq 65,\ H_m = \text{Death or } H_f = \text{Death}, \\ 0 & \text{elsewhere}, \end{cases}$$

and depend on whether both, one or no couple members are alive and older than 65.

Aggregated government expenditures consist the sum of all expenditures made for the entire population. The joint population distribution $f(\aleph)$ defines the population. This is the unconditional distribution over disposable income (y), health status of both couple members (H_m, H_f), the assets (a) of a household, and the age of the household (j). The aggregated (total) government expenditures, GE, is integrated over this density and given by:

$$\text{GE} = \int_{\aleph} f(\aleph) \cdot \left(\sigma_1 \cdot \text{EXP}_{\text{LTC}}(\cdot) + \sigma_2 \cdot \text{EXP}_{\text{SS}}(\cdot) \right) \mathrm{d}\aleph,$$

where σ_1 and σ_2 reflect the share of government expenditures that are financed through social insurance and user contributions but not with general taxation. We exclude general taxation because we do not explicitly model general tax payments in our model.

To finance the expenditures, the government obtains revenue from social insurance contributions, copayments and an additional endogenous transfer Tr. The transfer is defined as follows:

$$\mathrm{Tr}(H_m, H_f) = \begin{cases} 2 \cdot \mathrm{TR} & \text{if} \quad H_m \neq \text{ Death and } H_f \neq \text{ Death} \\ \mathrm{TR} & \text{if} \quad H_m = \text{ Death or } H_f = \text{ Death} \\ 0 & \quad \text{elsewhere,} \end{cases}$$

and is thus twice as large for couples than for singles.

Then government revenues, GR, are given by:

$$\mathrm{GR}(\mathrm{TR}) = \int_{\aleph} f(\aleph) \cdot \Big(\mathrm{SI}_{\mathrm{LTC}}(\cdot) + \mathrm{SI}_{\mathrm{SS}}(\cdot) + m(\cdot) + \mathrm{Tr}(\mathrm{TR}, \cdot) \Big) \, \mathrm{d}\aleph$$

which consists the sum of social insurance contribution, co-payments for LTC and an additional tax that balances the government budget constraint. The government sets the transfer level TR according to:

$$\mathrm{GE} = \mathrm{GR}(\mathrm{TR})$$

A.2 Closed-form solution on consumption policy function

In this section, I elaborate on how the households determine their consumption policy functions. For this I use the Bellmann principle of maximization which recursively solves the household optimization problem from the last to the first period of the life-cycle. The objective function is the value function in this case. The value function of a household in any state $\aleph$ is given by:

$$\begin{aligned} \mathrm{V}(\aleph) = \max_{c_j, a_{j+1}} \; & \mathrm{u}\left(\frac{c_j}{\mathrm{EQ}(\aleph)} \right) + \beta \cdot \Big(\psi_{j+1}(\aleph) \cdot \mathrm{E}[\mathrm{V}(\aleph^+) | \aleph] + (1 - \psi_{j+1}(\aleph)) \cdot \mathcal{B}(a_{j+1}) \Big) \\ \text{s.t.} \quad & a_{j+1} + c_j = R \cdot a_j + y_j - m_j - \mathrm{Tr}_j, \\ & a_{j+1} \geq 0, \\ & \aleph = (j, a_j, h_f, h_m, \theta, \eta_j, \mathrm{DB}_j)' \\ & \aleph^+ = (j+1, a_{j+1}, h_f^+, h_m^+, \theta, \eta_{j+1}, \mathrm{DB}_{j+1})' \end{aligned}$$

$$
\begin{aligned}
&y_j = \widetilde{y}_j - \mathrm{SI}_{\mathrm{SS}}(y_j) - \mathrm{SI}_{\mathrm{LTC}}(y_j) - \tau(y_j) \\
&\theta \sim \mathcal{N}(0, \sigma_\theta^2) \\
&\eta_{j+1} = \rho \eta_j + \epsilon_{j+1}, \quad \text{with } \epsilon_{j+1} \sim \mathcal{N}(0, \sigma_\epsilon^2), \\
&h_f^+, h_m^+ \sim \mathcal{P}(j).
\end{aligned} \tag{8}
$$

The Lagrangian corresponding to (8) reads as:

$$
\begin{aligned}
\max_{c_j, a_{j+1}, \lambda} \mathcal{L}(\cdot) = \; & \mathrm{u}\left(\frac{c_j}{\mathrm{EQ}(\aleph)}\right) + \beta \cdot \left(\psi_{j+1}(\aleph) \cdot \mathrm{E}[\mathrm{V}(\aleph^+)|\aleph] + (1 - \psi_{j+1}(\aleph)) \cdot \mathcal{B}(a_{j+1})\right) \\
& + \lambda \left\{ R \cdot a_j + y_j - m_j - \mathrm{Tr}_j - a_{j+1} - c_j \right\},
\end{aligned} \tag{9}
$$

which has the following first order constraints:

$$
\frac{\partial \mathcal{L}(\cdot)}{\partial c_j} := \frac{1}{\mathrm{EQ}(\aleph)} \cdot u'\left(\frac{c_j}{\mathrm{EQ}(\aleph)}\right) - \lambda = 0 \tag{10}
$$

$$
\frac{\partial \mathcal{L}(\cdot)}{\partial a_{j+1}} := \beta \cdot \left(\psi_{j+1}(\aleph) \cdot \mathrm{E}[\mathrm{V}_{a_{j+1}}(\aleph^+)|\aleph] + (1 - \psi_{j+1}(\aleph)) \cdot \mathcal{B}_{a_{j+1}}(a_{j+1})\right) - \lambda = 0 \tag{11}
$$

$$
\frac{\partial \mathcal{L}(\cdot)}{\partial \lambda} := R \cdot a_j + y_j - m_j - \mathrm{Tr}_j - a_{j+1} - c_j = 0 \tag{12}
$$

Note that $\mathrm{V}(\aleph)$ in (8) is an optimum, so is the Lagrangian in (9) when analyzed in $c_j(\aleph)$, $a_{j+1}(\aleph)$ and $\lambda(\aleph)$. This line of reasoning links to the envelope theorem that we can apply:

$$
\mathrm{V}_{a_j}(\aleph) = \frac{\partial \mathrm{V}}{\partial a_j}(\aleph) = \frac{\partial \mathcal{L}(\cdot)}{\partial a_j}\Big|_{c_j(\aleph), a_{j+1}(\aleph), \lambda(\aleph)} = \lambda(\aleph) \cdot R,
$$

which obviously has to hold as well in the next period:

$$
\mathrm{V}_{a_{j+1}}(\aleph^+) = \frac{\partial \mathrm{V}}{\partial a_{j+1}}(\aleph^+) = \frac{\partial \mathcal{L}(\cdot)}{\partial a_{j+1}}\Big|_{c_{j+1}(\aleph^+), a_{j+2}(\aleph^+), \lambda(\aleph^+)} = \lambda(\aleph^+) \cdot R, \tag{13}
$$

Furthermore, (10) holds optimally as well in the future :

$$
\frac{1}{\mathrm{EQ}(\aleph^+)} \cdot u'\left(\frac{c_{j+1}(\aleph^+)}{\mathrm{EQ}(\aleph^+)}\right) = \lambda(\aleph^+) \tag{14}
$$

Combining (13) and (14) yields:

$$
\mathrm{V}_{a_{j+1}}(\aleph^+) = \frac{1}{\mathrm{EQ}(\aleph^+)} \cdot u'\left(\frac{c_{j+1}(\aleph^+)}{\mathrm{EQ}(\aleph^+)}\right) \cdot R \tag{15}
$$

Using the expression in (15) we can build the modified Euler equation that describes the evolution of consumption and assets over time. This equation is obtained by combining (10), (11) and (15), while (12) simultaneously holds (together with the non-negativity constraint of assets). We then get the following system of equations that describes the consumption decision completely, a modified version of the Euler equation on consumption and bequests:

$$\begin{aligned}\frac{1}{\mathrm{EQ}(\aleph)} \cdot u'\left(\frac{c_j(\aleph)}{\mathrm{EQ}(\aleph)}\right) = \beta \cdot \Bigg(& \psi_{j+1}(\aleph) \cdot R \cdot \mathrm{E}[\frac{1}{\mathrm{EQ}(\aleph^+)} \cdot u'\left(\frac{c_{j+1}(\aleph^+)}{\mathrm{EQ}(\aleph^+)}\right) | \aleph] \\ &+ (1 - \psi_{j+1}(\aleph)) \cdot \mathcal{B}_{a_{j+1}}(a_{j+1}(\aleph))\Bigg) \\ \text{with:}& \end{aligned} \tag{16}$$

$$\begin{aligned} a_{j+1}(\aleph) &= R \cdot a_j + y_j - m_j - \mathrm{Tr}_j - c_j(\aleph) \\ a_{j+1}(\aleph) &\geq 0 \\ \aleph &= (j, a_j, h_f, h_m, \theta, \eta_j)' \\ \aleph^+ &= (j+1, a_{j+1}, h_f^+, h_m^+, \theta, \eta_{j+1})' \\ y_j &= \widetilde{y}_j - \mathrm{SI}_{\mathrm{SS}}(y_j) - \mathrm{SI}_{\mathrm{LTC}}(y_j) - \tau(y_j) \\ \theta &\sim \mathcal{N}(0, \sigma_\theta^2) \\ \eta_{j+1} &= \rho\eta_j + \epsilon_{j+1} \text{with } \epsilon_{j+1} \sim \mathcal{N}(0, \sigma_\epsilon^2), \\ h_f^+, h_m^+ &\sim \mathcal{P}(j) \end{aligned}$$

This system can be recursively solved if we know the solution for the last period.

A.3 Terminal period solution

We now solve the dynamic program problem for the terminal period while realizing that the household will not be around in the next period ($\psi_{J+1} = 0$), but can bequeath. The terminal period solution of (16) at state $\aleph$ is given by:

$$\begin{aligned}\frac{1}{\mathrm{EQ}(\aleph)} \cdot u'\left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)}\right) &= \beta \cdot \mathcal{B}_{a_{J+1}}(a_{J+1}(\aleph)) \\ a_{J+1}(\aleph) &= R \cdot a_J + y_J - m_J - \mathrm{Tr}_J - c_J(\aleph) \\ &= \mu - c_J(\aleph) \\ a_{J+1}(\aleph) &\geq 0, \end{aligned} \tag{17}$$

where μ is the total wealth holding at age J that is split over consumption and a certain bequest.

To solve the system we have to consider three cases: $\phi = 0$ (no bequest), $\phi \in (0,1)$ (some wealth above threshold c_a is bequeathed) and $\phi = 1$ (all wealth above threshold c_a is bequeathed). We distinguish three cases for the marginal utility of leaving a bequest:

$$\mathcal{B}_{a_{J+1}}(a_{J+1}) = \begin{cases} 0, & \text{if } \phi = 0 \\ \frac{\phi}{1-\phi}^{\frac{1}{\gamma}} \cdot R \cdot \left(\frac{\phi}{1-\phi} c_a + R \cdot a_{J+1} \right)^{-\frac{1}{\gamma}}, & \text{if } \phi \in (0,1) \\ c_a^{-\frac{1}{\gamma}} \cdot R, & \text{if } \phi = 1. \end{cases}$$

If $\phi = 0$ the Euler equation in (17) becomes:

$$\begin{aligned} \frac{1}{\mathrm{EQ}(\aleph)} \cdot u'\left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)} \right) &= \beta \cdot \mathcal{B}_{a_{J+1}}(a_{J+1}(\aleph)) \rightarrow \\ \frac{1}{\mathrm{EQ}(\aleph)} \cdot \left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)} \right)^{-\frac{1}{\gamma}} &> \beta \cdot 0 \rightarrow \end{aligned}$$

$$\begin{aligned} c_J(\aleph, \mu) &= \mu \\ a_{J+1}(\aleph, \mu) &= 0 \end{aligned} \tag{18}$$

where the latter two equalities stem from the budget constraint in (17) and henceforth no bequest is left: $a_{J+1}(\aleph, \mu) = 0$.

If $\phi = 1$ the Euler equation in (17) becomes:

$$\begin{aligned} \frac{1}{\mathrm{EQ}(\aleph)} \cdot u'\left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)} \right) &= \beta \cdot \mathcal{B}_{a_{J+1}}(a_{J+1}(\aleph)) \rightarrow \\ \frac{1}{\mathrm{EQ}(\aleph)} \cdot \left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)} \right)^{-\frac{1}{\gamma}} &= \beta \cdot c_a^{-\frac{1}{\gamma}} \cdot R \rightarrow \\ c_J(\aleph)^{-\frac{1}{\gamma}} &= \beta \cdot R \cdot (\mathrm{EQ}(\aleph))^{1-\frac{1}{\gamma}} \cdot c_a^{-\frac{1}{\gamma}} \rightarrow \\ c_J^*(\aleph) &= (\beta \cdot R)^{-\gamma} \cdot (\mathrm{EQ}(\aleph))^{1-\gamma} \cdot c_a \rightarrow \end{aligned}$$

$$\begin{aligned} c_J(\aleph, \mu) &= \min(c_J^*(\aleph), \mu) \\ a_{J+1}(\aleph, \mu) &= \max(0, \mu - c_J^*(\aleph)) \end{aligned} \tag{19}$$

where the latter two equalities stem from the budget constraint in (17). It can easily be seen that if the current level of resources, μ, exceeds threshold consumption level $c_J^*(\aleph)$, all resources above the threshold are bequeathed: $a_{J+1}(\aleph,\mu) = \max(0, \mu - c_J^*(\aleph))$ (an extreme case of bequeathing).

If $\phi \in (0,1)$ the Euler equation in (17) becomes:

$$\begin{aligned}
\frac{1}{\mathrm{EQ}(\aleph)} \cdot u'\left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)}\right) &= \beta \cdot \mathcal{B}_{a_{J+1}}(a_{J+1}(\aleph)) \rightarrow \\
\frac{1}{\mathrm{EQ}(\aleph)} \cdot \left(\frac{c_J(\aleph)}{\mathrm{EQ}(\aleph)}\right)^{-\frac{1}{\gamma}} &= \beta \cdot \frac{\phi}{1-\phi}^{\frac{1}{\gamma}} \cdot R \cdot \left(\frac{\phi}{1-\phi} c_a + R \cdot a_{J+1}\right)^{-\frac{1}{\gamma}} \rightarrow \\
c_J(\aleph)^{-\frac{1}{\gamma}} &= \beta \cdot R \cdot (\mathrm{EQ}(\aleph))^{1-\frac{1}{\gamma}} \frac{\phi}{1-\phi}^{\frac{1}{\gamma}} \cdot \left(\frac{\phi}{1-\phi} c_a + R \cdot a_{J+1}\right)^{-\frac{1}{\gamma}} \rightarrow \\
c_J(\aleph) &= (\beta \cdot R)^{-\gamma} \cdot (\mathrm{EQ}(\aleph))^{1-\gamma} \cdot \left(c_a + R \cdot \left(\frac{\phi}{1-\phi}\right)^{-1} \cdot a_{J+1}\right) \rightarrow \\
c_J(\aleph) &= x_1^{-1}(\aleph) \cdot \left(c_a + x_2 \cdot a_{J+1}\right) \rightarrow \\
x_1(\aleph) \cdot c_J(\aleph) &= c_a + x_2 \cdot a_{J+1} \rightarrow \\
x_1(\aleph) \cdot c_J(\aleph) &= c_a + x_2 \cdot (\mu - c_J(\aleph)) \rightarrow \\
(x_1(\aleph) + x_2) \cdot c(\aleph) &= c_a + x_2 \cdot \mu \rightarrow \\
c_J(\aleph) &= \frac{x_1(\aleph)}{x_1(\aleph) + x_2} \cdot \frac{c_a}{x_1(\aleph)} + \frac{x_2}{(x_1(\aleph) + x_2)} \cdot \mu \rightarrow \\
c_J^*(\aleph) &= \left(\frac{x_1(\aleph)}{x_1(\aleph) + x_2} \cdot \widetilde{c_a}(\aleph) + \frac{x_2}{x_1(\aleph) + x_2} \cdot \mu\right) \rightarrow
\end{aligned}$$

$$\begin{aligned}
c_J(\aleph,\mu) &= \min(c_J^*(\aleph), \mu) \\
a_{J+1}(\aleph,\mu) &= \max(0, \frac{x_1(\aleph)}{x_1(\aleph) + x_2} \cdot \{\mu - \widetilde{c_a}(\aleph)\})
\end{aligned} \tag{20}$$

with:

$$\begin{aligned}
x_1^{-1}(\aleph) &= (\beta \cdot R)^{-\gamma} \cdot (\mathrm{EQ}(\aleph))^{1-\gamma} \\
x_2 &= R \cdot \left(\frac{\phi}{1-\phi}\right)^{-1} \\
\widetilde{c_a}(\aleph) &= \frac{c_a}{x_1(\aleph)}
\end{aligned}$$

$\widetilde{c_a}(\aleph)$ is the adjusted consumption level above which the bequest motive becomes active.

A larger family size yields that bequest become more of a luxury good. It can be seen that bequests are zero if current resources (μ) are below level $\widetilde{c_a}(\aleph)$. If resources exceed this level, the marginal propensity to bequeath is $\frac{x_1(\aleph)}{x_1(\aleph)+x_2}$. Both the level above which the bequest motive becomes active, as well as the marginal propensity to bequeath, depend on the household composition, time-preference β and interest rate r.

A.4 Numerical implementation

For the moment suppose that all parameter values are known in the model. We would like to generate saving and consumption profiles conform the introduced structural model. We have the closed-form solution (16) that describes the consumption and asset evolution. We furthermore have a closed-form solution for the consumption and saving decision (policy functions) for the terminal period. We use the two closed-form solutions in our procedure to generate saving and consumption profiles which now proceeds in two steps. We first compute the policy functions $c^{+}(\aleph)$ and $a_{j+1}(\aleph)$ for any point of the state $(\aleph)$ distribution. After having done this, we compute the state distribution and can accordingly provide saving and consumption figures.

We start with the computation of the policy functions $c^{+}(\aleph)$ and $a_{j+1}(\aleph)$. A first problem that arises with this, is that the state space $\aleph = (j, a_j, h_f, h_m, \theta, \eta_j, \mathrm{DB}_j)'$ contains elements that are defined on a continuous domain. These continuously defined state variables consist the amount of assets (a_j), the permanent income (θ), the transitory income component (η_j) and the defined benefit accrual DB_j. We have to discretize the domains on which these state variables are defined.

We choose to discretize the assets (a_j) over a grid $\widehat{\mathcal{A}}$ that runs from €0 to €1,000,000. The asset grid contains 100 values and the growth rate between two successive grid points is 5%. We do not choose for an equidistant grid because policy functions can oscillate and reveal asymptotic behavior for asset levels near zero. An asset grid that shows constant growth between successive grid-points yields an over-representation of low asset values and may be better able to capture the oscillating behavior when assets near zero.

We assume that the permanent income (θ) follows a normal distribution with mean 0 and standard deviation σ_θ. The discretization of the random variable θ allows for four values with equal probability ($p = \frac{1}{4}$): $-1.15 \cdot \sigma_\theta$, $-0.32 \cdot \sigma_\theta$, $+0.32 \cdot \sigma_\theta$ and $+1.15 \cdot \sigma_\theta$. These points are respectively the 12.5$^{\text{th}}$, 37.5$^{\text{th}}$,62.5$^{\text{th}}$ and 87.5$^{\text{th}}$ percentile, and henceforth the median values in the income quartiles.

Lastly we have the transitory income component that follows the AR(1) process:

$$\eta_{j+1} = \rho \cdot \eta_j + \epsilon_{j+1}, \quad \text{with } \epsilon_{j+1} \sim \mathcal{N}(0, \sigma_\epsilon^2). \tag{21}$$

We discretize this process into a three-state Markov chain representation. To do so, we follow the seminal work Rouwenhorst (1995) on decomposing an AR(1) process into a Markov chain. Their approach constructs a Markov chain that has an evenly spaced and symmetric state space around zero value, $\widehat{H}$. First a two-state Markov chain representation is constructed and one iteratively obtains the higher-state Markov chain representations thereafter. The transition probabilities, minimum and maximum possible η-value are set so that the two-state Markov chain preserves the unconditional mean, the unconditional variance and the auto-correlation of the actual process (21). These minimum and maximum state value are the same for the higher-state Markov chain representations. What is still undone is the computation of the transition matrix corresponding to the higher-state representation.[12] This matrix is recursively calculated from the two-state transition matrix. Kopecky and Suen (2010) describes the algorithm to do this.

That study furthermore justifies the choice for a Rouwenhorst (1995) decomposition technique rather than to choose for any other available method. While other approaches break down when the process is highly persistent or when the state matrix is coarse and only a few states can thus be reached from the destination state, Rouwenhorst (1995) succeeds in matching five important moments including the conditional and unconditional mean, the conditional and unconditional variance, and the first-order auto-correlation of process (21) even when the transition matrix is coarse and the income process highly persistent.

We have now completely discretized the state space $\aleph$ and proceed with solving the dynamic programming problem through policy function iteration. We use policy function iteration because a closed-form solution is readily available for the terminal period solution and for the Euler equation of consumption. We start with the closed form solution of the terminal period J that we provided in (18), (19) and (20). We hereafter recursively solve the Euler equation system (16) from period J-1 up to period 1 and calculate the resulting policy functions $c_j(\aleph)$ and $a_{j+1}(\aleph)$. We are ultimately with the policy functions $c_j(\aleph)$ and $a_{j+1}(\aleph)$ defined for any state $\aleph$.

We use the policy functions in a second step in which we calculate summary statistics on assets, consumption levels, earnings, government spending on LTC and social security, and social contributions. For this we need to know the distribution of households over the state space. We can proceed in two ways: simulate a sufficient amount of heterogeneous agents through the structural model and observe the corresponding distribution or we can calculate the distribution of $\aleph$ over the households directly. While several studies simulate a large enough amount of agents through the model (see for example Cagetti, 2003), we

[12] Income after retirement is fixed and depends on the average income over the life-cycle. For this reason the transition matrix becomes the identity matrix after age 64.

choose the latter approach. We choose the latter approach because it can be faster (no need to simulate many agents) as well as it always remains questionable when sample statistics have converged (it remains unknown whether the number of agents is sufficient to let model statistics converge).

The computation approach starts with an initial distribution over the state space (age is 25). This distribution is modified to come up with a distribution over the state space for age 26. Given the current state $\aleph$ at age 25, we know for any household how many assets they choose to possess at age 26. We furthermore know the conditional probability of ending up in a particular health and income state at age 26, conditional upon state $\aleph$. We consequently update the current household distribution over states $\aleph$ while using the health and income transition probabilities as well as the known future asset level. Following this procedure we can come up with a distribution of households over the states at age 26. We can iteratively follow this procedure to finally come up with a distribution of households over the states at age $J = 100$. Having done this we can compute the according age-dependent statistics on assets, consumption levels, earnings, government spending on LTC and social security, and social contributions.

As a side remark, for the initial distribution we assume that every household starts without assets and that the income shock starts at value $\eta = 0$. Absence of an initial income shock is a crucial assumption to identify the income shock process parameters which we do with GMM. Lastly, the health state at onset leaves us with a couple whose members are both without LTC use.

Having calculated the distribution of households over the state space and the according figures on the economic variables, we are still concerned that the government does not match its budget. Reason for this is that assets are a decision variable and co-payments for LTC use depend on the asset level. Co-payments are in turn an endogenous variable which may leave a gap between government budget and revenue. We therefore iteratively calculate the government transfers that would match government expenditures and revenue. In a first step we assume that government transfers are absent. We then let the households make their consumption and saving decisions. The resulting government surplus or deficit per household yields the next step government transfer. This procedure is continued until the government budget balances (the gap is sufficiently small). The necessity to balance the budget is for example addressed in Groneck and Wallenius (2020) as well.

A.5 Inferring Lifetime Income[13]

We could take several routes in constructing the lifetime income empirically. We could for example use the household specific mean income after retirement and construct income quartiles conditional upon being married, birth cohort and gender. Such approach would indirectly control for the birth cohort, gender and marital status effects to income.

These quartiles could be made conditional upon having a spouse, because marital status affects retirement income. Beside that, quartiles may be constructed conditional upon gender, to account for pre-retirement labor supply differences between males and females. Females may leave the labor force at a younger age, for example, because of child birth. Lastly, quartiles could be made birth cohort-specific, to take into account that incomes may have evolved over time. There is however one disadvantage with such approach: marital status varies within households over time. Then ones lifetime income position is paradoxically time-varying as well.

A more refined and robust analysis would take into account this problem of time-varying lifetime income. We therefore construct the lifetime income groups based on the methodology that is proposed in De Nardi et al. (2015). This method basically scraps gender, age, household structure and birth cohort effects from our observed income measure and leaves us with a lifetime income value. That lifetime income value is unique and fixed for any household. We accordingly construct four income groups from the quartiles of this lifetime income value.

Following De Nardi et al. (2015) we first run the following fixed-effects regression:

$$\log(y_{it}) = f_1(\alpha_{\text{it}}) + f_2(g_{\text{i}}, \text{mar}_{\text{it}}) + \delta_{11} \cdot \text{ad}_{\text{it}} + \delta_{12} \cdot c_{\text{it}} + p_i + \epsilon_{\text{it}}, \tag{22}$$

where i indicates the household and t the time period under inspection. We model logaritmized income y_{it} as a function of age, gender, marital status and household composition effects. Age is a continuous measure and denoted by α_{it}. The function $f_1(\cdot)$ is a fourth-order polynomial in age. Gender is binary indicator on being male or female and is denoted by g_{i}. mar_{it} is a binary indicator on whether the household is married or not. The function $f_2(\cdot)$ is a linear mapping and interacts gender with marital status. ad_{it} is a binary indicator whether there are any adults other than the couple members within the household. c_{it} is a binary indicator on whether there are any children in the household.

The fixed effect p_i is the household-specific income effect and may be informative on ones lifetime income position. We therefore use the predicted values $\widehat{p_i}$ from fixed effects

[13] We took the description in this subsection from our earlier -yet unpublished- work (van der Vaart et al., 2020a).

regression (22) to construct a lifetime income value for any household.

The fixed effects regression in (22) has one disadvantage: we can only identify and estimate an overall fixed effect $\widehat{p}_i$ which also includes time-invariant effects to income such as gender- and birth cohort effects. We therefore regress the overall fixed effect $\widehat{p}_i$ in a second step on gender and birth cohort indicators. The residual of that regression, PI_i, would then explain the part of the fixed effect $\widehat{p}_i$ that is not due to gender and birth cohort effects. PI_i can thus be interpreted as ones lifetime income. To arrange things, we run the following (second stage) OLS regression:

$$\widehat{p}_i = \delta_0 + \delta_{21} \cdot g_{\mathrm{i}} + \boldsymbol{\delta'_{22}} \cdot \mathbf{BC}_{\mathrm{i}} + \mathrm{PI}_i,$$

where BC_{i} is a dichotomous vector that refers to the birth cohorts: born before 1919, 1919–1923, ..., 1943–1948. Then the predicted value $\widehat{\mathrm{PI}}_{\mathrm{i}}$ is our household-specific lifetime income measure which is independent from birth cohort, gender, marital status, age and household composition effects. Empirical lifetime income groups are the quartiles of this lifetime income measure $\widehat{\mathrm{PI}}_{\mathrm{i}}$.

A.6 Income uncertainty

We here describe the generalised method-of-moments (GMM) procedure to obtain an estimate for the parameters governing income uncertainty. The stochastic part z_j of the income equation (5) is defined by:

$$z_j = \theta + \eta_j, \text{ with } \theta \sim \mathcal{N}(0, \sigma_\theta^2)$$
$$\eta_j = \rho\eta_{j-1} + \epsilon_j, \text{ with } \epsilon_j \sim \mathcal{N}(0, \sigma_\epsilon^2),$$

where η_j follows an AR(1) process. The income shock only consists a persistent component. This specification differs from the specification in seminal work by Storesletten et al. (2004), because we do not allow for a transitory component as well. In future work we will add the transitory component, because part of the variance due to the transitory component is now ascribed to the persistent component and this is undesirable.

We apply GMM to get an estimate on the persistence of the income process (ρ), variance of the persistent shock (σ_ϵ^2) and variance of the fixed permanent income component (σ_θ^2). The GMM method aims to match the theoretical and empirical (co)variances of the stochastic income component (z_t) between the years 1989 (t=1) to 2014 (t=26). To calculate the empirical (co)variances, we use the stored residuals $\widehat{z}_t$ from the fixed effects regression in (5).

The empirical unconditional variance of the stochastic income component in year t is given by:

$$\mathrm{Var}(\widehat{z}_t) = \sum_{j \in \mathcal{J}} f_{t,j} \cdot \mathrm{Var}(\widehat{z}_{t,j}),$$

where j denotes the age in year t, $\widehat{z}_{t,j}$ the income shock for a household aged j in year t and $f_{t,j}$ the weight of individuals aged j in year t in the entire sample. The weighting takes place to correct standard errors for the unbalanced panel feature that we have (Altonji and Segal, 1996).

The empirical covariance is given by:

$$\mathrm{Cov}(\widehat{z}_t, \widehat{z}_{t+s}) = \sum_{j \in \mathcal{J}} f_{t,j} \cdot \mathrm{Cov}(\widehat{z}_{t,j}, \widehat{z}_{t+s,j}), \qquad \text{with } s > 0.$$

The empircal (co)variances have to be matched with their theoretical counterparts. The theoretical (co)variances can be calculated while noting that z_t can be written as a MA(t) process:

$$z_t = \theta + \sum_{w=0}^{t-1} \rho^w \epsilon_{t-w}.$$

This specification can be used to show that the theoretical unconditional variance of the stochastic income component z_t in year t is given by:

$$\mathrm{Var}(z_t) = \sigma_\theta^2 + \sigma_\epsilon^2 \cdot \sum_{w=0}^{t-1} \rho^{2w},$$

where for parameter identification we have to assume the initial condition that individuals start without an income shock ($\epsilon = 0$) before year t=1. The theoretical covariance between year t and year $t+s$ is:

$$\mathrm{Cov}(z_t, z_{t+s}) = \sigma_\theta^2 + \sigma_\epsilon^2 \cdot \rho^{2s} \cdot \sum_{w=0}^{t-1} \rho^{2w}, \text{ with } s > 0.$$

To go over the GMM method, we have to summarize the empirical and theoretical moments in two distinct matrices whose distance we want to minimize. That distance is represented by so-called moment equations. Let the matrix with theoretical moments be given by:

$$\mathbf{C}(\rho, \sigma_\theta^2, \sigma_\epsilon^2) = \begin{bmatrix} \mathrm{Var}(z_1) & \dots & \mathrm{Cov}(z_1, z_{26}) \\ \vdots & \ddots & \vdots \\ \mathrm{Cov}(z_1, z_{26}) & \dots & \mathrm{Var}(z_{26}), \end{bmatrix}$$

and the matrix with empirical moments:

$$\overline{\mathbf{C}}(\widehat{z}_1,\ldots,\widehat{z}_{26}) = \begin{bmatrix} \mathrm{Var}(\widehat{z}_1) & \ldots & \mathrm{Cov}(\widehat{z}_1,\widehat{z}_{26}) \\ \vdots & \ddots & \vdots \\ \mathrm{Cov}(\widehat{z}_1,\widehat{z}_{26}) & \ldots & \mathrm{Var}(\widehat{z}_{26}). \end{bmatrix}$$

Let the matrix $\mathbf{m}(\rho,\sigma_\theta^2,\sigma_\epsilon^2;\cdot)$ represent moment equations in vectorised form:

$$\mathbf{m}(\rho,\sigma_\theta^2,\sigma_\epsilon^2;\cdot) = \mathrm{vec}(\mathbf{C}(\rho,\sigma_\theta^2,\sigma_\epsilon^2)) - \mathrm{vec}(\overline{\mathbf{C}}(\cdot)),$$

then the GMM estimators are calculated by optimizing the following criterion function:

$$\underset{\rho,\sigma_\theta^2,\sigma_\epsilon^2;\cdot}{\mathrm{argmin}}\, \mathbf{m}'(\rho,\sigma_\theta^2,\sigma_\epsilon^2;\cdot)\widehat{\mathbf{V}}^{-1}\mathbf{m}(\rho,\sigma_\theta^2,\sigma_\epsilon^2;\cdot). \tag{23}$$

where $\widehat{\mathbf{V}}$ in (23) is the empirical equivalent of the asymptotic variance-covariance matrix of the moment equations $\mathbf{m}(\cdot)$. This weighting matrix can be calculated and yields an efficient estimator for the parameters $\rho,\sigma_\theta^2,\sigma_\epsilon^2$. We however choose the identity matrix, because this choice already yields consistent estimates and in finite samples correlation between sampling error in the moment equations and sampling error in an estimated weighing matrix may make parameter estimates biased (Altonji and Segal, 1996).

B Estimates appendix

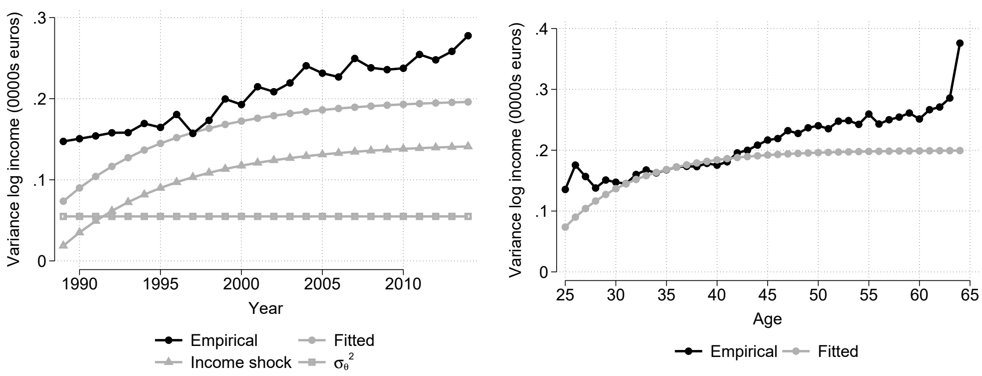
B.1 Income uncertainty fit

We show in Figure 7 the actual and fitted income variances by year and age. Panel (a) provides the figure on the unconditional variance that we aim to match with the GMM method. The fitted variance is decomposed in a part that is due to a permanent income value and a part that is due to the income shock itself. Panel (a) reveals that we structurally underestimate the true income variance. The empirically estimated unconditional variance grows with any year, while the growth in our fitted unconditional variance eventually fades out. That growth fades out is a consequence of the AR(1) structure that we impose on the income uncertainty. Only highly persistent income processes allow for ever growing unconditional variances. A resolution to have ever growing unconditional variances is to allow the income shocks to vary by year. We abstract from this to keep the model parsimonious. Blundell et al. (2015) provides an extensive overview on how time-varying persistent income shocks help fitting the true unconditional income variance . In future work we target on a better fit between the empirical and theoretical income shock process.

Panel (b) provides the unconditional variance by age rather than by year. Similar to the structural underestimation in panel (a) we structurally underestimate the variance for households aged 45 and older. We do have a reasonable good fit for households younger than 45 years old. The latter group comprises 57.8% of our sample so for most of the sample we have a reasonable good fit between the observed and fitted income variances.

Figure 7: Actual and fitted income uncertainty during working age:

(a) By year: (b) By age:



B.2 The replacement rate for second and third pension income

We follow van der Vaart et al. (2020b) to calculate the replacement rate for second and third pension income when a household becomes widowed. We use the IPO data for this and restrict ourselves to households that became widowed during the observational period and for whom we have data from three years before until three years after retirement. We furthermore restrict ourselves to households in which one of the members is at least 65 years old three years before widowhood. The main dependent variable in this analysis is the logged total amount of second and third pension income. Unfortunately we do not separately observe the different pension income streams and we therefore have to stick to this combined measure. The analysis now proceeds in two steps.

An analysis on the replacement rate for second and third pension income involves a comparison between the situation in which the household becomes widowed and the situation in which this would not have occurred. The latter is a counterfactual and we have to address potential bias that could arise from not knowing this counterfactual. In a first step we construct this counterfactual for the widowed household. We match to the widowed household a household that remains married over the same observational period. We use nearest neighbor matching for this and base the matching on observed characteristics three years before widowhood. We match the following characteristics:

retirement status, marital status, gender, age, having children, and sample year. We now thus have the widowed household and a counterfactual situation for every of these households in which they 'remain married'.

In a second step we analyse how the pension income stream changes in the periods surrounding widowhood. For this we use a fixed effects regression approach and use the second and third pillar pension income as our dependent variable. As the independent variable of interest we use a set of binary indicators on the period surrounding widowhood. We apply a fixed effects regression approach because some studies show that individuals with a low socioeconomic status are more likely to become widowed (Bound et al., 1991; Sevak et al., 2003). A fixed effects regression approach addresses potential confounding in this case.

Let $d = 0, 1$ be an indicator on whether the household actually does become widowed. A household becomes widowed in year T. We then estimate the following fixed effects model for individual i in the married- or widowed-group d:

$$y_{idt} = \gamma_{\tilde{t}} + \sum_{t=T-2}^{T+3} \beta_t \cdot widow_{dt} + c_{id} + u_{idt},$$

where the indicator variable '$widow_{dt}$' indicates the time period surrounding widowhood, with t is between $T-2$ and $T+3$. This indicator variable takes value zero if $d = 0$, i.e. when the household remains married. Its associated β-parameters measure the replacement rate for pension income due widowhood at different moments in time. In the analysis, we further account for a common time trend with $\gamma_{\tilde{t}}$ ($\tilde{t}$ denotes the observational year), because income definitions may vary slightly over the years in the data. The parameter c_{id} is a time-invariant effect that is household-specific and we use this to address potential confounding. Lastly, u_{idt} is an idiosyncratic error term.

Our coefficient of interest is β_{T+3}, the change in logged pension income three years after widowhood when compared to three years before widowhood. If we run the analysis separately for males and and females we estimate $\widehat{\beta}_{T+3} = 0.071$ (SE: 0.0143) for males implying that their replacement rate is 1.071. For females we estimate $\widehat{\beta}_{T+3} = -0.330$ (SE: 0.009) implying a replacement rate of 0.670 for them.

The replacement rate for males thus exceeds the replacement rate for females. This may primarily be a consequence of that males are the prime earner within the household during working life and therefore accrue most of the second and third pillar pension benefit within the household. Their pension benefit remains intact after widowhood while females, who have not accrued that benefit, are only entitled to part of the benefit in the form of a survivor pension when widowed.

B.3 Social insurance contribution functions for first pillar pension and public LTC provision

Figure 8: Social insurance contribution functions for first pillar pension and LTC provision for the data period 2001-2014

(a) First pillar pension income (R^2 = 0.907) (b) Public LTC provision (R^2 = 0.903)

Notes: The left panel shows the social insurance contribution function for first pillar pension. The right panel shows the social insurance contribution function for public LTC provision. The red lines denote the maximum contribution levels that actually exist within the Dutch system in 2010. The contribution functions are obtained through fitting a logistic (sigmoid) function to the IPO data.

B.4 Taxation function after retirement

Table 8: Estimates on tax functions for households aged 65+ ($p < 0.1$, ** $p < 0.05$, *** $p < 0.01$)*

	Tax-free base (0000s euros)	Marginal tax rate	R^2
Married	0.626***	0.681***	0.676
(N= 97,823)	(0.007)	(0.002)	
Widowed	0.425***	0.706***	0.658
(N= 59,195)	(0.006)	(0.021)	

We estimate the tax function $\widetilde{\tau}(\cdot)$ for households aged 65 and over. This tax function includes both general tax payments and social insurance contributions. We require this tax function because our life-cycle model expresses first and second pillar pension in gross rather than disposable income terms. We map gross household into disposable household income with a linear model that we estimate with ordinary least squares. The linearity induces that the slope coefficient can be interpreted as the marginal tax rate while the intercept is the tax-free base. We estimate the tax function $\widetilde{\tau}(\cdot)$ separately for married and widowed households. The results of this estimation exercise are shown in Table 8.