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Abstract Using a life-cycle model and a representative sample of households, we analyze the extent to which using home equity leads to (heterogeneity in) welfare gains over the life cycle. The most policy-feasible option to borrow against 50% of home equity over the life cycle leads to median (average) welfare gains of 7% (11%). However, we find substantial heterogeneity with half of the households facing a welfare gain between 3% and 13%. Much of this heterogeneity is explained by heterogeneity in households' income and (housing) wealth and less so by heterogeneity in their demographics or preferences for consumption smoothing and time.

Key words: Life Cycle Model, Welfare effects, Housing wealth, Heterogeneity.

JEL Codes: D14, D15, D61, E21, H55, J32.

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1 Introduction

Much research has been devoted to consumption and savings decisions in the life-cycle model (LCM), with a particular interest in the decumulation of wealth at retirement.[1] One of the key observations in the literature is that households decumulate wealth too slowly in retirement according to the life-cycle model [Love, Palumbo, and Smith, 2009, Poterba, Venti, and Wise, 2011, De Nardi, French, and Jones, 2016]. Thus far, one of the main drivers suggested by the literature, next to bequest motives [Dynan, Skinner, and Zeldes, 2002], is the role of uncertain out-of-pocket medical expenses at older ages [De Nardi, French, and Jones, 2014, Ameriks, Briggs, Caplin, Shapiro, and Tonetti, 2020] and its interaction with bequest motives [Lockwood, 2018]. Many studies, like Cocco [2005] and Yao and Zhang [2005], show the importance of homeownership for life cycle consumption and savings decisions. However, relatively few papers have considered the illiquidity of housing wealth as a viable reason for the slow decumulation of wealth in retirement [Suari-Andreu, Alessie, and Angelini, 2019].

Poterba et al. [2011] show that housing is an important illiquid asset that is conserved until very late in life. In line with this, Cocco [2013] is the first to highlight the importance of alternative mortgage products and argues that products that are characterized by low initial mortgage payments (relative to loan amount) can achieve better life cycle consumption smoothing for those with high and relatively certain expected future income. Moreover, Nakajima and Telyukova [2020] show that dissaving in retirement is much slower among homeowners than among renters. This is due to the fact that homeowners prefer to stay in their home, but cannot easily borrow against their housing wealth. Nakajima and Telyukova [2017] shows that liquidating housing wealth through reverse mortgages leads to welfare gains for the average retired homeowner. However, actual take-up rates of reverse mortgages are still low among this group [Achou, 2021].

This paper is the first to quantify welfare gains over the life cycle from liquidating housing

[1] i.e. the Retirement-Savings Puzzle.

wealth using a representative sample of households from a combination of administrative and survey data. We hypothesize that there is substantial heterogeneity in welfare gains from releasing housing wealth. We compare the situation of illiquid housing to several scenarios that involve different degrees for using housing wealth to finance consumption.

Our analysis builds forth upon Cocco [2013] and Nakajima and Telyukova [2017], with the premise that the house can be both a savings-device during the accumulation period and an income-device during retirement similar to traditional (pension) savings accounts. However, current mortgage products make it hard for the house to function like regular savings accounts. Since we are primarily interested in the role of home equity in life cycle consumption smoothing, we focus on homeowners and assume homeownership to be exogenous, similar to Yogo [2016].[2] We analyze the welfare gains of increased possibilities to liquidate home equity over the life cycle. As such, this paper focuses on the welfare gains from consumption smoothing and, more particularly, of consuming too little over the life cycle due to liquidity constraints. This contrasts papers that use life-cycle models to calculate the optimality of savings.[3]

Nakajima and Telyukova [2017] show that the welfare gains from reverse mortgages are substantial for retirees.[4] Compared to Nakajima and Telyukova [2017], we make three substantial contributions. Firstly, the model calculates welfare gains for a representative sample of households over the life cycle. Whereas Nakajima and Telyukova [2017] focus on retirees, we also investigate the possibility to liquidate (part of the) housing wealth before retirement. This allows us to analyze within-population heterogeneity in welfare gains from liquidating housing wealth to finance consumption over one's complete life cycle. Secondly,

[2]In Section 2.2, we explain that in the highly subsidized and regulated Dutch housing market the choices for renting versus homeownership is limited. The social housing market is only available for vulnerable households and the private rental market is very small and relatively expensive compared to owning a house. Therefore, the assumption for homeownership to be exogenous seems quite in line with the actual situation.

[3]E.g. Scholz, Seshadri, and Khitatrakun [2006], Crawford and O'Dea [2020], Ciurila, Van Heuvelen, Luginbuhl, and Smid [2020].

[4]For an overview of the problems and prospects of reverse mortgages for financing consumption in retirement we refer to Caplin [2002].

in addition to a traditional reverse mortgages, we analyze financial products in which households (partly) sell their house with a rent-back arrangement. Thirdly, we try to understand the drivers of the (heterogeneity in) welfare effects by focusing on 1) heterogeneity in households' actual income and wealth, and 2) heterogeneity in preferences. Our LCM calculates welfare effects given households' elicited preference parameters. This allows us to investigate the extent to which heterogeneity in preferences for smoothing and time drive any heterogeneity in welfare gains for our representative sample of homeowners. Additionally, we show the importance of the strength of bequest motives for welfare effects, which is important as bequests are often not considered in models calculating optimal savings [Scholz et al., 2006, Crawford and O'Dea, 2020, Ciurila et al., 2020]. Including such heterogeneity among actual households goes beyond models that include heterogeneity by allowing for a heterogeneous agent, like Bovenberg, Koijen, Nijman, and Teulings [2007], or models that use a representative agent with actual data as input into the model, like Scholz et al. [2006], Ciurila et al. [2020], Ciurila, De Kok, Ter Rele, and Zwaneveld [2022]. Gomes [2020] mentions incorporating more household heterogeneity as the prime direction for future research in portfolio decisions over the life cycle.

Using actual households allows us to study the heterogeneity in outcomes in a representative sample. Such heterogeneity is of importance as welfare gains and losses are non-linear in the size of the deviation [Browning and Crossley, 2001]. Our approach allows us to estimate the distribution of welfare gains and losses of homeowners, who differ in age, income, and wealth. Data on age, income, and wealth are derived from high-quality administrative records of Dutch households. Moreover, we allow the sample of homeowners to differ in their preferences for intertemporal consumption smoothing and time. Kapteyn and Teppa [2011] and Von Gaudecker, Van Soest, and Wengstrom [2011] show that heterogeneity in preferences, such as for risk, is large and can explain households' portfolio decisions. Information regarding smoothing and time preferences come from representative survey data of Dutch households. As far as we know, we are the first to combine administrative and stated preferences information to address a population's heterogeneity among households in welfare analyses. As such, our paper follows the main direction for future research as outlined by Gomes [2020].

We use a unique combination of administrative data and elicited preferences from survey data for Dutch households. The administrative data reduces issues with self-reported income and wealth compared to the survey data in other studies. The Netherlands is an interesting case because of high mandatory pension accumulation, universal coverage of (long term) health care insurance with internationally low out-of-pocket medical spending, and a highly subsidized and regulated housing market that typically consists of many households owning a home.[5] This combination implies that Dutch households accumulate relatively many assets in illiquid wealth whilst having relatively low costs at the end of life. Following the approach of Scholz et al. [2006], Ciurila et al. [2020] find that the majority of the Dutch households save more than optimally according to the life cycle model and that most of these savings are illiquid.[6] According to the Mercer Global Pension Index [Mercer, 2009-2020], the lack of flexibility in choices is one of the main threats to the Dutch pension system that otherwise outperforms other pension systems in terms of adequacy and sustainability.

Our results suggest that selling (part of) the house with a rent-back arrangement at retirement leads to welfare gains for the average household of about 3%. Welfare gains exist because liquidating housing equity allows households to smooth consumption over the life-cycle (and avoid unintended bequests). For the median household, these welfare gains are much smaller and close to zero. However, there is large heterogeneity in welfare consequences for different households. For some households, this variant even leads to welfare losses.

[5] Hence, the welfare gains from liquidating housing wealth may be interpreted as an upper bound for countries with less regulated pension, (long term) health care insurance, and housing markets.

[6] This is consistent with empirical evidence from Knoef, Been, Alessie, Caminada, Goudswaard, and Kalwij [2016], Been and Goudswaard [2021] and Van Ooijen, Alessie, and Kalwij [2015], Suari-Andreu et al. [2019] showing that Dutch households have high net replacement rates, do not decrease spending, and do not decumulate wealth at retirement, respectively.

Allowing households to borrow against their housing wealth, at most either 50% or 100%, leads to more substantial welfare gains for the average and median household. These variants can not lead to welfare losses as they are an option and not mandatory. We argue that the 50%-variant is most feasible to implement. For the median (average) household borrowing against 50% of housing wealth leads to a welfare gain of about 7% (11%). Welfare gains are larger for the first-best option of borrowing against 100% of housing wealth: 11% (19%).

Nonetheless, there is large heterogeneity in the welfare consequences among households; half of the households face a welfare gain between 3% and 13% in the most feasible variant. Much of this heterogeneity comes from households' differences in combinations of income and (housing) wealth. We find no empirical evidence for preferences regarding consumption smoothing and time driving this heterogeneity in welfare effects: Firstly, allowing for heterogeneity in these parameters do not statistically explain welfare effects. Secondly, our welfare effects are relatively insensitive to different values assumed for consumption smoothing and time preferences. However, we do find that the strength of the bequest motive is an important factor in determining the welfare gains and their size.

The structure of this paper is as follows. We explain the institutional context in Section 2. Section 3 describes the data. Section 4 introduces the life-cycle model that is used for our welfare analysis. Section 5 obtains the welfare effects from different scenarios for liquidating housing wealth. Our model and results are put in perspective in Section 6. Section 7 evaluates the relevance of our results for policy regarding pension savings and housing. Section 8 concludes.

2 Institutional framework

2.1 The Dutch Pensions system

The Dutch pension system consists of three pillars. The first is a pay-as-you-go system and involves a flat-rate public pension benefit for all residents as from the statutory retirement age onwards. The level of the public pension is linked to the net minimum wage and depends on the number of years that a person has resided in the Netherlands. Couples each receive 50% of the net minimum wage, and single pensioners receive 70% of the net minimum wage. The public pension is proportionately cut for those who have not always lived in the Netherlands in the 50 years before the statutory retirement age. For people with a low pension income and almost no wealth, the first pillar is topped up with means tested social assistance to guarantee a social minimum. Taking into account all income components of households, the first pension pillar provides about 36% of all available income in retirement for the median household [Knoef et al., 2016]. In the Netherlands, the statutory retirement age was 65 until January 2013. From January 2013, the statutory retirement age gradually increased to 66 in 2018 and gradually increases further to 67. For future cohorts, the statutory retirement age is linked to average life expectancy.

The Dutch second pillar consists of capital-funded occupational pensions, of which the primary responsibility lies with employers and employees. Occupational pensions in the Netherlands have a mandatory nature, such that 90% of all employees have a pension scheme with their employer.[7] Occupational pensions mainly consist of defined benefit (DB) pension plans, but the number of defined contribution (DC) plans (or hybrid) have been increasing over time. Until the beginning of the 21st century, most pension plans aimed to pay a pension income of 70% of final gross wage from the age of 65 onwards if an employee had worked fulltime for at least 40 years. From 2003 onwards, pension funds have lowered their ambition,

[7] https://www.rijksoverheid.nl/onderwerpen/pensioen/opbouw-pensioenstelsel.

and they now aim to pay 70% of the average career salary, instead of 70% of the final gross salary (including public pension benefits). The rule-of-thumb is that full-time employees work about 1 out of 5 work days per week for their pension in terms of mandatory contributions. Taking into account all income components of households, the second pension pillar provides about 29% of all available income in retirement for the median household [Knoef et al., 2016]. The rest is from housing and individual savings.

The financial crisis in 2008 has shown that the Dutch pension system is vulnerable to shocks in financial markets. Many pension funds had difficulties achieving their indexation ambitions, and several funds were even compelled to cut nominal pension rights. Currently, pension funds still suffer from low interest rates. To lower the maximal tax deductible pension contribution and to increase the financial sustainability of pension funds, annual tax-favored pension accruals have been reduced from 2.25% to 2.15% and further to 1.875% of the pension base. This means that the percentage by which pensions are built up each year is reduced and that one has to work more years to achieve the same pension income. On the other hand, the age that forms the basis for the determination of the pension premiums increased from 65 to 67 as of 2014 which implies more years of accrual to match the lower accrual rates.

The third pillar is formed by private individual pension products (such as life annuities) and other private savings. Until a major tax reform in 2001, everyone could buy life annuities at tax beneficial terms up to a certain limit (e.g., pension contributions up to 2,808 euro were fiscally attractive in the year 2000). After the tax reform, this limit was reduced in 2002 to 1,069 euro, and only the self-employed and individuals with a gap in their pension entitlements were allowed to buy life annuities at fiscally attractive terms up to higher amounts. As a consequence, wealth held in these annuities is small in the Netherlands, on average. Other sources of retirement income are housing wealth or an extension of working life on a part-time or full-time basis. Especially housing wealth is an important component of total wealth available in retirement. Using representative administrative data for the Dutch population, Knoef et al. [2016] show that net housing wealth is about 65% (62%) of average (median) households' total wealth. Taking into account all income components of households, housing wealth provides about 11% of all available income in retirement for the median household if we assume that the value of the home equals the imputed rental income. This is even more than 20% if housing wealth is assumed to being annuitized to an income stream at retirement [Knoef et al., 2016].

2.2 The Dutch Housing market

The Dutch housing market roughly exists of three types of housing: homeownership, social rent, and private rent. Homeownership is stimulated through several favourable tax treatments of owner-occupied housing through mortgage interest deductibles and tax exemptions on repaid mortgage debt in the tax system.

The largest favorable tax treatment in terms of effects on public finance is mortgage interest deductibles (*hypotheekrenteaftrek*). Until 2017, up to about 52% of paid interest on the mortgage could be deducted from income taxes for a time span of 30 years. From 2017, this percentage is reduced in yearly steps to 37.05% in 2023. Currently, this percentage is at 41.2%. One of the main reasons to reduce the stimulus for homeownership is the argument that it disrupts the housing market. Even recently, the OECD [2021] has argued that these favorable tax treatments primarily benefit the wealthy and should be reconsidered from a public finance perspective, but also because it drives the large growth in housing prices observed in the Netherlands. As a consequence of stimulating homeownership, about 57% of all housing is owner-occupied housing in the Netherlands in 2020.[8] Another consequence of the mortgage interest deductions, which are allowed for a maximum of 30 years, is that redemptions of the mortgage are not stimulated. As of the early 2010s, policy has introduced

[8] https://www.cbs.nl/nl-nl/cijfers/detail/82900NED

mandatory increased redemption of households mortgages by no longer allowing (parts of) mortgages to be redemption-free. Together with the high mandatory contributions to second pillar pensions, homeowners are stimulated to accumulate a sizeable portion of illiquid wealth at the retirement age.

Whereas homeownership is stimulated through tax deductions, social rent receives heavy subsidies directly. Social rent applies to housing with a rent of at most 711 euros per month (2018). Anyone is potentially eligible for this type of housing. However, 80% of social rent housing should be devoted to households with a family income of at most 36,698 euros per year (2018). Only 10% is allowed to go to households with a family income beyond 41,056 euros per year. The attractiveness of social rent is further stimulated through housing benefits (*huurtoeslag*) provided by the central government to social renters with both a low household income and wealth below a certain threshold. Due to the large demand for social rent, most municipalities face long waiting lists for allocating households to social renting homes.

Due to the highly subsidized options of homeownership and social rent, private rent (with a rent of more 711 euros per month) is often relatively expensive and not an option for many households.[9] Therefore, this type of housing covers only about 13% of the total housing market in the Netherlands in 2020.[10]

Those who are eligible for social rent usually do not have the option for private rent or homeownership. Similarly, those who are not eligible for social rent usually choose homeownership for tax reasons. Additionally, frictions and transfer taxes limit flows in the Dutch housing market. The combination of a highly subsidized and regulated housing market makes households' want to maximize their opportunity to take on mortgage debt (and buy a house).[11] This justifies assuming homeownership to be exogenous in our model as the

[9] It is common practice that landlords of private renting also ask for a monthly gross income that is at least four times as high as the gross monthly rent [Verberk, Warnaar, and Bos, 2019].

[10] https://www.cbs.nl/nl-nl/cijfers/detail/82900NED

[11] An example: *A single-person household with an indefinite labor contract and a gross labor income of 70,000 euros per year has a marginal income tax rate of 51.95% and allows for a maximum mortgage of 368,600 euros (ING Mortgage Calculator). Assume this person is buying a house of the average house price of about 290,000*

percentage of households who actually endogenously choose between rent and homeownership is relatively small as it is rational to maximize the opportunity to take on mortgage debt.

2.3 Health insurance in the Netherlands

All Dutch citizens are required to purchase statutory health insurance from private insurers. The insurers are required to accept all applicants for their basic health insurance. The financing of the health care is primarily public through mandatory basic health insurance premiums and income-dependent premiums in income taxes. The default health insurance includes physician, home nursing, hospital and mental health care, as well as prescription drugs. Next to the purchase of the health insurance in the form of paying a monthly premium, insurees pay for annual deductibles and coinsurance or co-payments on selected services and drugs. The government finances the coverage for children up to age of eighteen. Long-term care is arranged through a special law (*Wet langdurige zorg* successor of the *Algemene Wet Bijzondere Ziektekosten*) which makes long-term care available to all Dutch citizens, regardless of type of private health insurance. Hence, due to the mandatory nature of health insurance coverage, including long-term care, the coverage of health care insurance is high and out-of-pocket health spending low compared to other countries. Therefore, access to health care is less of an issue in the Netherlands than, for example, in the US with lower health insurance coverage and higher out-of-pocket health spending.

As a consequence, it is less important to model health spending as opposed to Scholz et al. [2006], De Nardi et al. [2014], Yogo [2016], Nakajima and Telyukova [2017], Ameriks et al. [2020]. In the US, health expenses are found to be the most important driver of retirement savings [De Nardi et al., 2014] and bequests and long-term care are found to strongly interact

euros. With a mortgage interest rate of 4%, the monthly interest costs are $(0.04*290,000*(1-0.5195)*1/12=)$ *464 euros. Given the income, the person is ineligible for social rent. The average rent in the private housing market is about 1,100 euros per month (not eligible for rent allowances).*

[Ameriks, Chaplin, Laufer, and Van Nieuwerburgh, 2011]. More specifically, home equity is found to be used as a substitute for long-term care insurance [Davidoff, 2010, Achou, 2021]. Kopecky and Koreshkova [2014] show that taking away the risk of nursing home expenses substantially decreases savings of American households. In the Netherlands, saving for health expenses in old-age is relatively minor. Due to the means-tested nature of long-term care, saving for care is even discouraged in the Netherlands. Van Ooijen, De Bresser, and Knoef [2018] show that elderly who face an adverse health shock do not substantially increase (decrease) out-of-pocket health (other types of) spending. This suggests that out-of-pocket health spending is of minor importance for analyzing Dutch households' life cycle decisions.

3 Data

3.1 Data sources and selection

To simulate the welfare effects of liquidating housing wealth for a representative sample of Dutch households, we use households' characteristics from two merged data sets. Firstly, we use administrative data from Statistics Netherlands with information regarding income and wealth. Secondly, we use survey data from the Dutch *Longitudinal Internet Studies for the Social Sciences* (LISS) panel with information on preferences regarding consumption smoothing and time.

3.1.1 Administrative data

To avoid reporting biases in income and wealth such as present in survey data, we use high quality administrative data from Statistics Netherlands to identify households' income as well as wealth in various types of assets. We take the 2018 *Integral wealth data* which includes the whole Dutch population in 2018, i.e. about 17 million individuals. Information regarding income and wealth reported in these data comes from the national tax office and is complemented with information from banks and pension funds.

The dataset contains detailed information on personal and household income, both gross and net. Different types of wealth are considered in the data including housing wealth, savings accounts, stocks/bonds, company wealth, and movable property. Additionally, there is information on debt which allows us to compute net wealth. In particular, mortgage debt and non-mortgage debt are considered.

Since state pensions and occupational pension wealth are important in the Netherlands, we add information from the 2018 *Pension entitlements statistics*. These data provide us with persons' wealth accumulated through occupational pensions. Together with the detailed information on personal wealth, this gives an almost complete picture of households' wealth. We miss wealth accumulation through voluntary pension products, i.e. third pillar, but Knoef et al. [2016] have shown that this wealth component is fairly small compared to total wealth.

3.1.2 LISS survey

LISS is a reoccurring panel that is administered by Centerdata at Tilburg University. The panel is recruited through address based sampling (no self selection), and households without a computer and/or internet connection receive an internet connection and computer free of charge. This household panel, representative for the Dutch population, receives online questionnaires each month on different topics. When respondents complete a questionnaire they receive a monthly incentive. The response rate is generally around 80%. In this study we use data about pension ambitions, collected in May and June 2018.

We select homeowners and merge the LISS data with administrative data from Statistics Netherlands. This leaves us with 3,892 households. Unfortunately, the preference questions regarding risk (i.e. the inverse of preferences for smoothing in a setting without risk) and time are not answered by every respondent. Using both risk and time preferences we are left with 933 households. Empirically, we find no evidence for systematic differences between respondents that did or did not fill out these preferences questions.

Regarding preferences, respondents answer the following questions. Firstly, respondents are asked about their risk aversion by responding to the following statement on a 7-scale ranging from "totally agree" to "totally disagree":

Q_{risk}: *I am willing to take the risk to lose money if there is chance that I will win money.*

Respondents' average is $\overline{Q_{\text{risk}}} = 3.5$ on a scale from 1 to 7 with a standard deviation of 1.7. Secondly, people are asked about their time preference:

Q_{time}: *I am willing to spend money now without thinking too much about what the future brings.*

Respondents' average is $\overline{Q_{\text{time}}} = 3.4$ on a scale from 1 to 7 with a standard deviation of 1.7.

The distribution of responses these qualitative questions to elicit preferences is comparable to the distribution elicited by more quantitative questions in Goossens and Knoef [2021] which may imply that potential issues regarding qualitative elicitation, such as respondents being overly inclined to choose the middle-answer, may not be a big issue in our application.

3.2 Summary statistics

Table 1 shows summary statistics regarding personal and household characteristics, income, (housing) wealth, and preferences. Based on the standard deviation relative to the mean, we observe that households are especially heterogeneous with respect to income and wealth in Table 1.

Table 1. Summary statistics.

	N	*Mean*	*SD*
Characteristics			
Female (0, 1)	3,892	0.532	0.499
Number of children (0-6)	3,892	0.127	0.307
Immigrant (0, 1)	3,892	0.227	0.572
Immigrant gen. (1-2)	588	1.503	0.500
Couple (0, 1)	3,892	0.680	0.467
Age (cont.)	3,892	51.173	16.958
Age partner (cont.)	2,647	51.408	14.943
Income & Wealth (cont.)			
Personal income (gross)	3,892	39,148	31,474
Personal income (gross) partner	2,646	39,984	33,810
Accumulated pensions	3,892	5,741	9,645
Accumulated pensions partner	2,646	6,520	10.497
Projected pension income	3,892	11,093	14,448
Projected pension income partner	2,647	12,319	14,969
Total HH wealth	3,892	256.385	584.362
HH housing wealth	3,892	287.084	155.835
Mortgage debt	3,892	154.654	135.436
Preferences			
Consumption smoothing (1-7)	934	3.475	1.685
Time (1-7)	973	3.358	1.686

4 Model

4.1 Model set-up

As our basis for the welfare analysis we use the life-cycle model extended with a bequest motive. For tractability of our results for a representative sample of households, we use a deterministic setting similar to Koijen, Van Nieuwerburgh, and Yogo [2016], except for mortality risk:[12]

- Mortality risk is the single demographic risk. Mortality probabilities are as observed in 2019 by age and gender. Independent mortality realizations by household member.
- No marriage, no separation, no children in the household,[13] and no other life events.
- No income risk: Until retirement, real income is expected to remain in the same income percentile for each age.[14] Future pension income equals currently projected old age pension. This includes state and occupational pensions.
- No financial market risk: deterministic return on assets.
- No housing market risk: deterministic return on housing, deterministic mortgage rates, and deterministic rental rates. No redemption on mortgage debt, unless stated otherwise.

Compared to Nakajima and Telyukova [2017], the biggest differences between our model setup and theirs is that we do not model endogenous homeownership, house price risk, health risk,

[12]Future analyses can extend our stylized setting by allowing for other risks, such as income risk [Scholz et al., 2006, Bayer, Luetticke, Pham-Dao, and Tjaden, 2019] and financial market risk [Bovenberg et al., 2007].

[13]Recent empirical evidence shows that the role of children in explaining the life-cycle consumption profile is less important than previously thought in the literature [Gant, 2022]

[14]Assuming no income risk implies that households hold lower wealth as precautionary savings. However, in the case of the Netherlands, this is not an extreme assumption as precautionary savings levels are relatively low because of generous unemployment insurance benefits [Alessie and Kapteyn, 2001]. Most unemployed receive a replacement rate of 70% for at least 24 months after which unemployed can opt for welfare benefits. Mastrogiacomo and Alessie [2014] find that precautionary savings do not count for more than 30% of savings among Dutch households.

and medical expenses. In contrast, whereas Nakajima and Telyukova [2017] only consider households aged 65 and over, we consider all households as from the age of 20.

At the end of each period $t = 0, 1, \ldots, T$, we define the following parameters for each household:

- (y_t) household net income (after housing costs). Consists of liquid income and illiquid income (return on housing assets). Assigned just before consumption decision in period t.
- (c_t) consumption, consumed just after receiving net income y_t.
- (p_t) mortality probability, just after consumption decision ($p_T = 1$).
- (π_t) probability of survival up to period t $\left(\pi_t = \prod_{s=0}^{t-1}(1-p_s), \pi_0 = 1\right)$.
- (h_t^m) housing assets as collateral for mortgages (i.e., face value of mortgage debt outstanding).
- (h_t^o) housing assets without mortgage.
- (h_t^r) rented housing assets.
- (a_t) net total assets (liquid assets + housing assets without mortgage h^o).

The value of the house is $\overline{h}_t = h_t^m + h_t^o + h_t^r$.

Note that housing assets with mortgage (h^m) are, like rented housing assets (h^r), not included in net total assets (a), because the net value of this asset is zero by the equally sized mortgage debt.

We define the following constants:

- $(\overline{a}_0)$ initial net total assets.
- (h_0^m) initial mortgage debt.
- (β) discount parameter, i.e. heterogeneous time preference: β_i.

- (r) real return on liquid assets $(a_{t-1} - h^o_{t-1})$.

- (r^h) real return on housing assets $(h^m_{t-1} + h^o_{t-1})$.

- (r^r) real rental rate on rented assets h^r_{t-1}.

- (r^m) mortgage rate on h^m_{t-1} (without redemption).

Household net income $y = y^{hh} + y^h - y^m - y^r$ consists of:

- y^{hh}_t disposable household income.

- $y^h_t = \left(h^m_{t-1} + h^o_{t-1}\right) r^h$ return on housing.

- $y^m_t = h^m_{t-1} r^m$ mortgage payment.

- $y^r_t = h^r_{t-1} r^r$ rent.

The value of the collateral of the mortgage (h^m) is predetermined. As such, returns on this asset are assigned to the owned housing assets h^o,

$$h^o_t = h^o_{t-1} + y^h_t = h^o_{t-1} + r^h \left(h^m_{t-1} + h^o_{t-1}\right).$$

At the end of each period, the order of events is (i) receive y_t and return on liquid assets, (ii) consume c_t, (iii) new value of total assets a_t, (iv) survive or die with probability p_t. In case of dying at the end of period t, assets a_t are left as a bequest. Utility from consumption and bequests are as in Ameriks et al. [2020]:

$$u(c) = \begin{cases} \frac{c^{1-\gamma}}{1-\gamma} & \gamma \neq 1 \\ \ln(c) & \gamma = 1 \end{cases} \qquad v(a) = \begin{cases} \frac{\theta^{-\gamma}(a+\kappa)^{1-\gamma}}{1-\gamma} & \gamma \neq 1 \\ \frac{1}{\theta}\ln(a+\kappa) & \gamma = 1. \end{cases}$$

The analysis in this paper restricts its focus on variants in which households continue to inhabit their current house (as a homeowner or renter) until all household members have passed away. In other words: the variants that we consider do not differ from each other in terms of âĂŸhousing consumptionâĂŹ, which allows us to abstract from a separation between housing consumption and other consumption in the utility function.[15] Hence, we assume that housing is solely an investment good and not a consumption good.

In the utility function $u(c)$, γ yields the risk parameter. In the case of a CRRA utility function and no risk, like in our life-cycle model, the risk parameter γ and the intertemporal elasticity of substitution are inversely related: $IES = 1/\gamma$. Therefore, different values of γ can be interpreted as the heterogeneity in households' willingness to substitute their current consumption against future consumption. Here, the larger γ the stronger the preference for intertemporal consumption smoothing: $IES = 1/\gamma = 0$ means full intertemporal smoothing of consumption. In Table 2, we show the conversion from Q_{risk} to reasonable values of γ.

In the bequest function $v(a)$, γ has the same interpretation as in $u(c)$, θ yields the bequest scaling factor, and κ the bequest translation in euros.

4.2 Single-person households

Single-person households maximize the objective function[16]

$$U(a_1, \ldots, a_T) = \sum_{t=1}^{T} \beta^t \pi_t \left[T_0^{\gamma} u(c_t) + p_t v(a_t) \right] \tag{4.1}$$

[15]This also abstracts from possible misallocation between housing and other consumption over the life-cycle. Downsizing housing consumption after retirement âĂŞ or when the children have left home - could be another source of freeing up illiquid capital in housing, but empirical evidence shows that downsizing happens only marginally in countries with large institutional rigidities [Banks, Blundell, Oldfield, and Smith, 2012], such as the Netherlands.

[16]The utility function $u(c)$ is on annualized consumption (c_t/T_0) with T_0 the length of a simulation period in years. This ensures that utility from annual consumption and from the bequest motive are in line with previous literature. In (4.1), we have used $T_0 u\left(\frac{c}{T_0}\right) = T_0 \frac{(c/T_0)^{1-\gamma}}{1-\gamma} = T_0^{\gamma} \frac{c^{1-\gamma}}{1-\gamma} = T_0^{\gamma} u(c)$.

subject to the budget constraints

$$a_0 = \overline{a}_0 \tag{4.2}$$

$$a_t = a_{t-1} + r\left[a_{t-1} - h^o_{t-1}\right]^+ + r^m\left[a_{t-1} - h^o_{t-1}\right]^- + y_t - c_t. \tag{4.3}$$

with $[x]^+ = \max(x,0)$ and $[x]^- = \min(x,0)$.

4.3 Two-person households

For a household with initially (at least) two persons, we consider the respondent of the survey and its partner as a two-person household. State (i, j) is characterized by

- $i = j$: both persons are still alive at start-of-period $i = j$.
- $i < j$: person 1 has died before period i, person 2 alive at start-of-period j.
- $i > j$: person 1 alive at start-of-period i, person 2 has died before period j.

Define for state (i, j)

- π_{ij} probability that state (i, j) occurs
- p_{ij} probability that household ceases to exist after state (i, j)
  - $i = j$: probability that both household members die simultaneously at end-of-period when in state (i, j)
  - $i \neq j$: probability that remaining person dies at end-of-period when in state (i, j)
- χ_k equivalence factor of k-person household ($k \in \{1,2\}$)
- y_{ij} disposable household income in state (i, j), received just before consumption decision
- $n_{ij} = 1 + 1_{(i=j)}$: number of household members (excluding children)

- $t_{ij} = \max(i, j)$: time period

- $\text{prev}_{ij} = \begin{cases} (i-1, j-1) & i = j \\ (i-1, j) & i > j \\ (i, j-1) & i < j. \end{cases}$

With prev_{ij} the previous period state. For each couple, the simulation starts from state $(0,0)$ where both household members are alive at the start of the period. Possible transitions from state (i, j) are with probability

- $p_{ij\to(i+1,j+1)}$: if both persons survive during the period. This type of transitions can only occur as long as both persons are still alive, thus as long as $i = j$.

- $p_{ij\to(i+1,j)}$: if only person 1 survives. This transition is only possible as long as person 1 is alive.

- $p_{ij\to(i,j+1)}$: if only person 2 survives. This transition is only possible as long as person 2 is alive.

- $p_{ij\to\varnothing}$: stop after state (i, j) if the last person dies in state (i, j).

It is natural to assume that the probabilities of death depend on age and gender, and are predetermined (i.e., state independent).

Two-person households maximize the following objective function:[17]

$$U(a_{00}, \ldots, a_{TT}) = \sum_{i=0}^{T} \sum_{j=0}^{T} \beta^{t_{ij}} \pi_{ij} \left[n_{ij} T_0^{\gamma} u\left(\frac{c_{ij}}{\chi_{n_{ij}}}\right) + p_{ij\to\varnothing} v(a_{ij}) \right] \tag{4.4}$$

subject to the budget constraints

$$a_{00} = \bar{a}_0 \tag{4.5}$$

[17]See footnote 16 why T_0^{γ} is included in (4.4).

and for each state $(i,j) \neq (0,0)$ with $i,j \in \{0,\ldots,T\}$,

$$a_{ij} = a_{\text{prev}_{ij}} + r\left[a_{\text{prev}_{ij}} - h^o_{\text{prev}_{ij}}\right]^+ + r^m\left[a_{\text{prev}_{ij}} - h^o_{\text{prev}_{ij}}\right]^- + y_{ij} - c_{ij}. \tag{4.6}$$

4.4 Certainty Equivalent Consumption

First, we compute the optimal utility $U^* := U(a^*)$ over the remaining lifetime. Utility U^* consists of utility ($u(c^*_t)$) from the optimal consumption path (c^*_t) and utility from bequests ($u(a^*_t)$).

Second, we obtain from U^* the Certainty Equivalent Consumption (CEQ) per period (c_{CEQ}). Here, 'certainty equivalent' refers to a constant stream of consumption. To prevent a situation in which households with a higher utility from bequests would naturally have a lower c_{CEQ}, we define c_{CEQ} in such a way that bequests do not give utility for the certainty equivalent (though the optimal utility U^* does include utility from bequests). We specify this procedure below.

Define the inverted CRRA utility function u^{-1}

$$u^{-1}(x) = \begin{cases} ((1-\gamma)x)^{\frac{1}{1-\gamma}} & \gamma \neq 1 \\ \exp(x) & \gamma = 1. \end{cases} \tag{4.7}$$

The utility from the consumption stream c_{CEQ} must be equal to the previously computed optimal lifetime utility U^*. For single-person households,

$$U^* = \sum_{i=0}^{T} \beta^{t_i}\pi_i u(c_{CEQ}), \tag{4.8}$$

which implies

$$c_{CEQ} = u^{-1}\left(\frac{U^*}{\sum_{t=1}^{T}\beta^t\pi_t}\right). \tag{4.9}$$

Similarly for two-person households:

$$U^* = \sum_{i=0}^{T} \sum_{j=0}^{T} \beta^{t_{ij}} \pi_{ij} n_{ij} u\left(\frac{c_{CEQ}}{\chi_{n_{ij}}}\right), \tag{4.10}$$

which implies

$$c_{CEQ} = u^{-1}\left(\frac{U^* + \sum_{i=0}^{T} \sum_{j=0}^{T} \beta^{t_{ij}} \pi_{ij} n_{ij} \ln\left(\chi_{n_{ij}}\right)}{\sum_{i=0}^{T} \sum_{j=0}^{T} \beta^{t_{ij}} \pi_{ij} n_{ij}}\right). \tag{4.11}$$

4.5 Parameters and exogenous variables

Table 2 contains parameters and exogenous variables and shows what parameter values we assume and what information we use for exogenous variables. The summary statistics of the exogenous variables can be found in Table 1. The heterogeneous preferences are taken from the two preferences questions Q_{risk} and Q_{time} available in LISS and described in section 3.1.2.

In our model, each period t represents $T_0 = 3$ years. The return parameters are annualized to ease comparability with other literature. The return on liquid assets r equals the real return on housing assets r^h. This means that substituting housing assets for liquid assets (or vice versa) affects the financial liquidity of the household, but not the return on assets. The rental rate r^r equals the mortgage rate r^m. Thus, renting and buying with mortgage debt have the same initial cost $r^r = r^m$. However, buying a house with a mortgage provides a future return r^h on the collateral.[18]

In Figures 4 and 5 in Appendix C, we show the distribution of γ_i and β_i, based on respondents' choices to $Q_{i,\text{risk}}$ and $Q_{i,\text{time}}$, respectively. The figures indicate that the modus of heterogeneous parameters is close to the homogeneous parameters assumed, but that heterogeneity in preferences exists among respondents. The distribution of the heterogeneous parameter values is close to the distribution of parameter values that are quantitatively elicited

[18]A mortgage borrower bears some economic risk, which is not in our model. Still, it is widely accepted that home owners have a tax favourable position in the Netherlands (Section 2.2).

from households by Goossens and Knoef [2021]. Since γ is in the range of 0.5 to 3.5, the inverse relationship with the *IES* implies values in the range of 0.29 to 2 which is consistent with the contemporary literature [Ameriks et al., 2020]. Also, with recent estimates for the Netherlands [Been and Goudswaard, 2021, Been, Suari-Andreu, Knoef, and Alessie, 2021].

For the bequest parameters θ and κ, we take values from Ameriks et al. [2020]. For the conversion from US dollars to euros in κ, we assume a conversion rate of 0.85. For the equivalence factor χ, we take values from Nakajima and Telyukova [2017]. This equivalence scale for singles and couples is the same as the official scale used by Statistics Netherlands.

In Section 5.4, we show the sensitivity of our results to different values of the preference parameters γ, β, and θ. In the case of γ and β, we present sensitivity checks for both different homogenous values and heterogeneous values.

Table 2. Overview of parameter and exogenous variables.

Parameter	*Homogeneous preferences*	*Heterogeneous preferences*
Smoothing preference	$\gamma = 2.26$ (mean(γ_i) $\sim$ Koijen et al. [2016])	$\gamma_i = 4 - \frac{1}{2}Q_{i,\text{risk}}$ from LISS survey June 2018.
Time discount	$\beta = 0.97$ per annum (Crawford and O'Dea [2020], middle and higher educated, multiple year steps)	$\beta_i = 0.97\hat{}\{\frac{Q_{i,\text{time}}}{\overline{Q}_{\text{time}}}\}$ from LISS survey June 2018.
Bequest scaling factor	$\theta = 1.09$ [Ameriks et al., 2020].	
Bequest translation	$\kappa = 0.85 \cdot 7.83 \cdot 10^3$ euros [Ameriks et al., 2020].	
Real return on liquid assets	$r = 1\%$ per annum.	
Real return on housing assets	$r^h = 1\%$ per annum.	
Rental rate	$r^r = 2\%$ per annum.	
Real mortgage rate	$r^m = 2\%$ per annum.	
Equivalence factors	$\chi_1 = 1$ and $\chi_2 = 1.37$ [Nakajima and Telyukova, 2017].	
Initial net total assets	$\overline{a}_{0i}$ from Statistics Netherlands, measured on 1 January 2018.	
Initial mortgage debt	h^m_{0i} from Statistics Netherlands, measured on 1 January 2018.	
Initial owned housing	h^o_{0i} from Statistics Netherlands, measured on 1 January 2018.	
Projected income	y^{hh}_t (See Appendix B).	
Projected pension	(c1_schat from Statistics Netherlands, measured on 1 January 2018.	

4.6 Four variants to release housing wealth

This section explains and motivates four cases (variants $V1ab - V2ab$) that allow households to liquidate housing wealth in our life-cycle model compared to the baseline $V0$ of no short selling of housing wealth ($a_t \geq h^o_t$):

- $V1$: **Sell house and start renting at state pension age**
  - $V1a$: rent 50% by selling 50% of housing wealth $h^o + h^m$.
  - $V1b$: rent 100% by selling all housing wealth $h^o + h^m$.
- $V2$: **Option to borrow against home equity over the life-cycle**
  - $V2a$: Short selling ($a_t \geq 0.5h^o_t$) allowed up to 50% of housing assets h^o_t.
  - $V2b$: Short selling ($a_t \geq 0$) allowed up to 100% of housing assets h^o_t.

The base case $V0$ is characterized by the feature that households cannot use their housing wealth h^o for consumption during their lifetimes. This is close to the actual situation in the Netherlands: Firstly, Statistics Netherlands shows that less than 4% of the 60+ population moved in 2017 which implies that most households did not sell their house to increase their wealth liquidity.[19] Secondly, the Dutch Financial Market Authorities (AFM) reports that no more than 4,000 households had taken out a reverse mortgage during the period January 2018-July 2019.[20] The result is that housing wealth remains illiquid and largely accrues to heirs in the form of an - unintentional - bequest. This constraint hinders an optimal distribution of assets a_t across consumption and bequests, and produces suboptimal outcomes for most households (the constraint is not binding only for households with relatively low housing wealth h^o and/or a relatively high bequest motive). The four variants $V1ab - V2ab$ all alleviate this constraint, but in different ways and up to a different extent.

Variants $V1$ and $V2$ can be considered as two extreme options in which there is no room for flexibility in $V1$ and there is a lot of flexibility in $V2$. Variant $V1$ implies housing wealth is liquidated at the state pension age by selling the house. In $V2$ liquidating housing wealth by

[19] https://www.cbs.nl/nl-nl/longread/statistische-trends/2020/een-analyse-van-het-verhuisgedrag-van-ze

[20] https://www.afm.nl/nl-nl/professionals/nieuws/2020/december/verzilverhypotheken-moeten-productontwikkeling-verbeteren?

borrowing against home equity (instead of selling) can be exerted at any point in the life-cycle. Since $V2$ is an option and not an obligation to liquidate, welfare gains are never negative. In $V1$ welfare losses are possible because the gains from increased consumption may be smaller than the losses from fewer bequests and/or returns on housing assets. Below, we provide a detailed explanation of the different variants.

4.6.1 Variants of $V1$

Variants $V1a$ and $V1b$ alleviate the constraint of the base case by selling the house and subsequently renting it at the retirement date. In $V1a$, the household rents 50% of the house during retirement, by selling 50% of the house at the retirement date. In $V1b$, the household fully rents the house during retirement, by fully selling it at the state pension age (or equivalently, renting another house of equal size and quality, thus without changing housing consumption). The sale of the house takes place at one particular point in time, viz retirement. The motivation is that a change in the ownership structure of a house is likely to occur at one particular moment, and not step-by-step or gradually over time. The choice for the moment that the house is sold (the state pension age) is somewhat arbitrarily, but may be regarded as a natural point in the life cycle of a household to make such a big one-time decision, and can be part of retirement planning.

Variants $V1a$ and $V1b$ have the advantage that they allow households to use their housing wealth h^o (partially or fully) for consumption, and thus alleviate the constraint of the base case. However, both variants also come with a disadvantage in comparison to the base case, namely that the households are unable (or only partially able) to reap the benefits from homeownership âĂŞ e.g. the risk premium on housing assets - after the sale of the house. In our model, the benefits from homeownership take the form of the real return on housing assets. To see this, note that the parameter values feature the property that $r^r = r^m > r$, $r = r^h$ and $r^h > 0$. This choice of the model parameters results in the situation in which renting a house is less attractive than buying the same house with a redemption-free mortgage. This difference can be explained by the risk premium on housing capital, or by savings on maintenance costs which tend to be higher for renters due to transaction costs and moral hazard in caretaking and maintenance of the home (see section 2.2). The difference between both strategies is taken to be 1% per annum: this extra return on housing assets happens to be equal to the capital gain due to rising house prices in our parameter settings. It may be noted that this extra return is tied to owning the housing assets, and adds thus to illiquid wealth only. Changing from ownership to renting thus does not influence available income for households. In this regard, the decision to rent the home does not free any income available for consumption over the life-cycle.[21] It may, however, avoid any unintentional bequests due to illiquid housing and thus free capital locked up in the home, and in that manner increase the means available for consumption. This advantage of larger liquidity has to be weighed against the disadvantage of missing the extra return on housing capital. The balance between the advantage and disadvantage may be different for each household depending on e.g. whether they envisage unintentional bequests that they would like to avoid. The advantage of freeing liquidity may be expected to dominate for households with substantial unintentional bequests, while for households with an interior solution for bequest the disadvantage of the missed return on housing assets will dominate.

4.6.2 Variants of $V2$

Variants $V2a$ and $V2b$ alleviate the constraint of the base case in a different way, namely by allowing the household to borrow against housing wealth h^o. In other words: the household is able to use housing wealth h^o as collateral for a loan that can be used for consumption. In the case of variant $V2a$, up to 50% of housing wealth h^o can be borrowed against, while this is allowed up to 100% in variant $V2b$. Compared to variants $V1$, variants $V2$ are an option to

[21] It does, however, increase welfare as also unintentional bequests add to the welfare of households, but less so than making the capital available for consumption during lifetime.

exercise and not an obligation.[22]

Variants $V2a$ and $V2b$ have an important advantage over variants $V1a$ and $V1b$, respectively, namely that housing wealth h^o can be used for consumption while at the same time the household continues to fully reap the benefits from homeownership. In our model setting, this implies that the household can continue to fully benefit from the real return r^h on the full value of the house during the decumulation phase - be it illiquid - , while at the same time âĂŸeating up the houseâĂŹ. Another advantage of variants $V2a$ and $V2b$ in comparison to $V1a$ and $V1b$ is that the benefits from âĂŸeating up the houseâĂŹ can also be reaped before the retirement date (the moment of the sale of the house in variants $V1a$ and $V1b$). In this respect, these variants stand for more flexible arrangements in the mortgage market, allowing for greater flexibility over the life-cycle.

Variant $V2b$ can be interpreted as the âĂŸfirst bestâĂŹ (upper limit) situation: it fully alleviates the constraint of the base case while not introducing the two suboptimal features of renting (missing out on the benefits of homeownership, and suboptimal intertemporal consumption). In variant $V2a$, the welfare gains from variants $V2b$ are âĂŸtruncatedâĂŹ for households for whom the optimal borrowing against house wealth h^o exceeds 50%. At the same time, variant $V2b$ may not be feasible in practice in the presence of house price risk. After all, the issuer of the loan that enables the household to use housing wealth h^o for consumption will typically require the household to preserve a certain level of equity (own funds) as a buffer against a fall in house prices. This prevents a situation in which the household passes away with a negative wealth in an economic scenario in which house prices fall and do not recover during the lifetime of the household. Indeed, it is observed in practice that reverse annuities enable households to use housing wealth h^o for consumption only up to a certain extent. Therefore, the variant $V2a$, or a mix between $V2a$ and $V2b$, may be

[22]Our variant $V2$ is somewhat comparable to existing mortgage rules in Australia which have a redraw facility. This redraw facility implies that households can access the extra principal repayments they have made on their mortgage.

considered as more realistic in most institutional settings. Variant $V2b$ may only be realistic, for example, in a setting in which a government-backed entity provides a ‘no negative equity guarantee’ to stimulate the market for reverse mortgages.

4.6.3 Comparison of variants

Notice that reverse mortgages may be an implementation device for all variants $V1a - V2b$. Reverse mortgages exist in many different forms. Variants $V1a$ and $V1b$ can be representative for a reverse mortgage in which the issuer of the reverse mortgage acquires partial of full ownership of the house, and thus reaps the benefit of rises in the value of the house price (and also the downward risks associated). On the other hand, variants $V2a$ and $V2b$ can be regarded as representative for reverse mortgages in which the household remains the full owner of the house and fully reaps the benefits from house price rises as well as the associated risk of house price losses. In variants $V1a$ and $V1b$, welfare gains are by definition smaller in comparison to variants $V2a$ and $V2b$, because two suboptimal features of renting are introduced (missing out on the benefits of homeownership, and suboptimal intertemporal consumption before and after retirement). In variants $V1a$ and $V1b$, the welfare effect can even be negative for some households if the disadvantages associated with the renting construction dominate the advantages of freeing capital included in the house. In this situation, the household could decide not to switch to renting and avoid this welfare loss. Nonetheless, we show the welfare effects for $V1a$ and $V1b$ for all households including those with negative welfare effects. The results in which negative welfare effects are avoided in variants $V1a$ and $V1b$ (because these people will in practice not choose for $V1a$ and $V1b$) are simply the same with negative welfare effects âĂŸtruncatedâĂŹ at zero.

5 Results

5.1 Consumption and wealth paths over the life-cycle

In this section, we show how the different variants lead to different consumption paths over the life-cycle compared to the baseline. These consumption paths are important to understand the welfare effects we obtain in the following sections as welfare effects are calculated using certainty equivalent consumption.

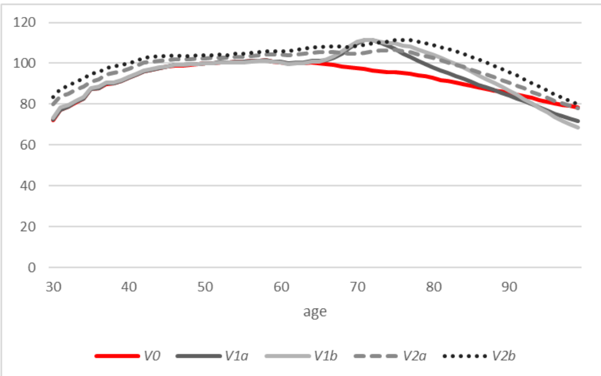
In Figure 1a we show that variants $V1a$ and $V1b$ (based on homogeneous parameters and the full sample) generate increases in consumption from the age of 65, which is assumed to be the date at which households sell their house in these variants. In contrast, variants $V2a$ and $V2b$ already generate increases in consumption earlier in the life-cycle, because households do not wait until the age of 65 to make their housing wealth liquid. Overall, this results in higher life-cycle consumption paths in variants $V2a$ and $V2b$ than in variants $V1a$ and $V1b$. Around the age of 90 the consumption in variants $V1a$ and $V1b$ drop below the red line. Those households with a longer life especially miss out on the benefits of homeownership (see Table 2). For these households missing out the accumulated benefits of homeownership of 1% per annum is relatively costly.

Similarly, Figure 1b shows the development of net wealth. Consistent with the consumption paths, net wealth decreases more in variants $V2a$ and $V2b$ than in variants $V1a$ and $V1b$ in order to finance the increase in consumption. In Figure 1c, we show the development of illiquid wealth in the different variants. The household keeps ownership of the home in variants ($V2$) and, therefore, shows the same development as the baseline case $V0$. In these scenarios, illiquid wealth increases because of increasing house prices. In variants $V1$, the home is sold upon retirement. In variant $V1a$, the household reaps the benefits of house price increase as they still own half of the house. The development of bequests in the different variants are shown in Figure 1d. In the baseline scenario $V0$, home equity is not used to finance consumption which implies that it is translated into a bequest at the end of life. Bequests are smallest in the variants $V1b$ and $V2b$. In these variants, 100% of the home is used to finance consumption. The bequest is smallest in $V2b$ as home equity if used to finance consumption over the life cycle. In the case of $V1b$, the bequest is higher than in variant $V2b$, because the household may have had less opportunity to use home equity for consumption as home equity is freed up as of the retirement age.

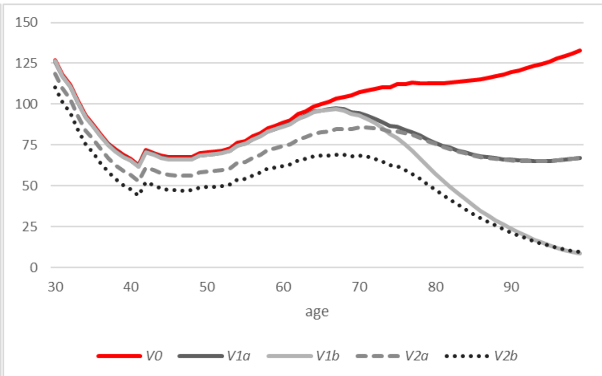
Patterns of consumption and wealth are similar if we look at medians instead of means (see Figures 6a-6d in the Appendix) and if we assume (i) homogeneous parameters and (ii) heterogeneous parameters in preferences for smoothing and time.

Figure 1. Life-cycle patterns of consumption and wealth (variant $V0$ at age 65 = 100).

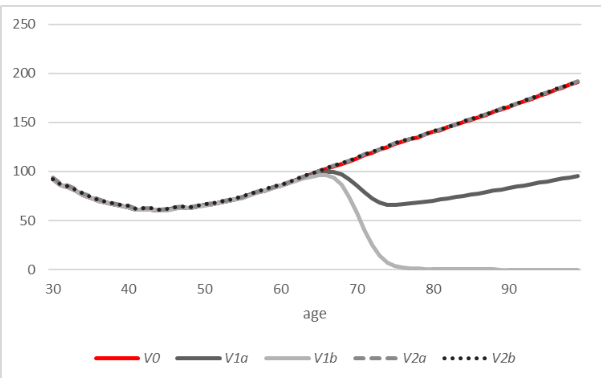
(a) Mean consumption (c_t)



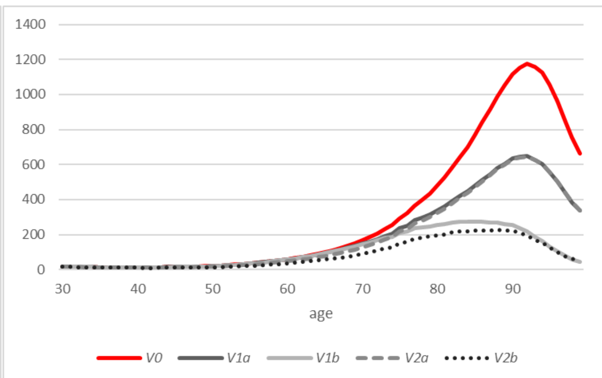
(b) Mean wealth (a_t)



(c) Mean illiquid wealth (h_t^o)



(d) Mean bequest (a_t conditional on household's death)



5.2 Welfare gains with homogeneous preferences

In this section, we present the welfare effects of $V1$ and $V2$, taking into account the financial situation of the representative sample of the Dutch population (using administrative data), and assuming the "*Homogeneous preferences*" from Table 2. Welfare effects are expressed in percentage changes in the Certainty Equivalent Consumption (CEQ) over the remaining life cycle relative to the baseline of no selling or short selling of housing wealth. This baseline is the outcome of optimizing households' choices in the life-cycle model without allowing the households to liquidate their housing wealth.

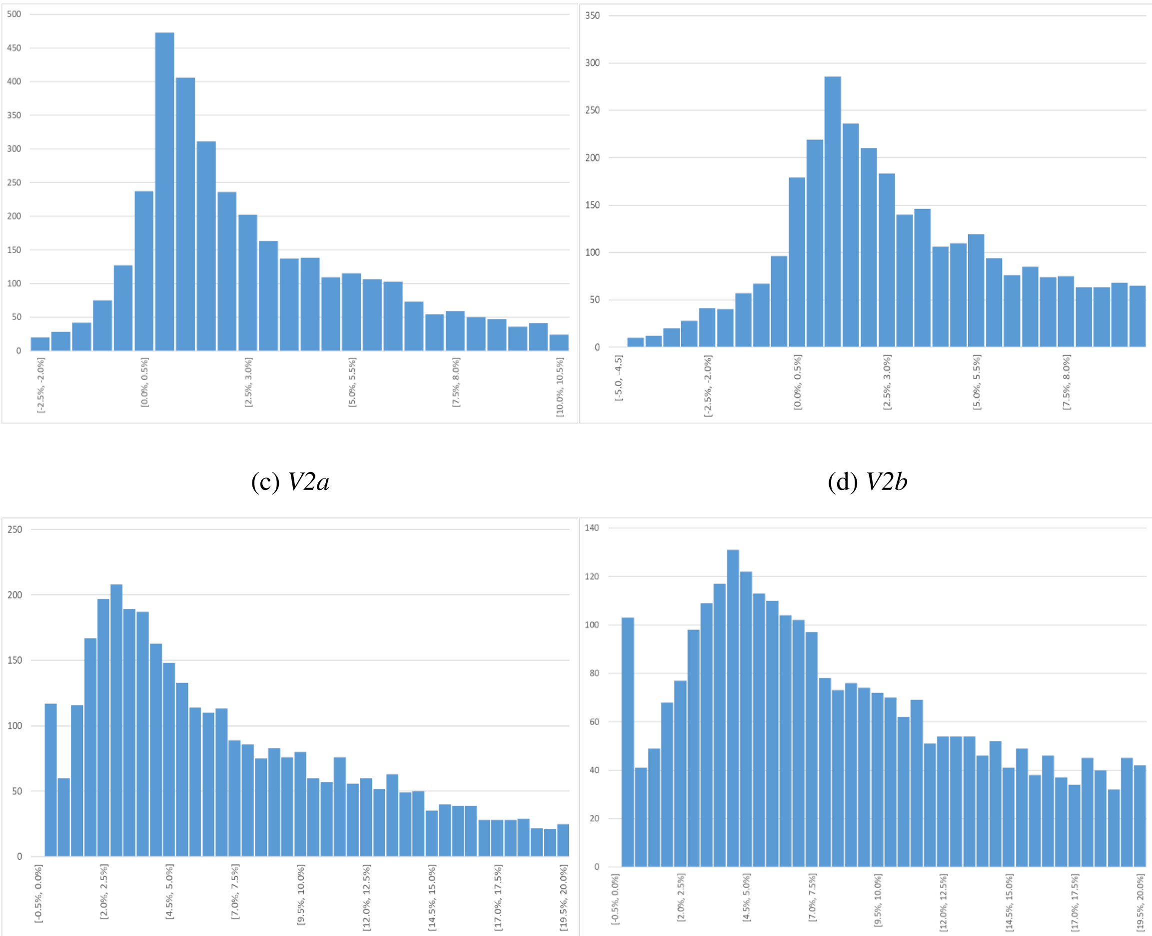
In Table 3 we show the simulated welfare effects of variants $V1a$-$V2b$. In particular, we show the mean and median effects as well as the welfare effect for the bottom quarter (P25) and the top quarter (P75) of the welfare effects distribution. The table provides some interesting patterns. Firstly, mean effects are bigger than median effects which suggests the existence of outliers at the top-end of the welfare effects distribution. This applies to all variants $V1a$-$V2b$. On average, we find the largest welfare gains for $V2b$ (18.6%), $V2a$ (11.2%), $V1b$ (6.9%) and $V1a$ (4.3%), respectively. This patterns is similar for the median household: $V2b$ (10.9%), $V2a$ (6.6%), $V1b$ (3.7%) and $V1a$ (2.3%). However, P25 and P75 suggest that there is substantial heterogeneity among households. In the case of $V2b$, 50% of the households face a welfare gain between 5.3% and 20.1%. In Appendix F, we show that these welfare gains are robust to using a sample of households aged 30+ only.

Table 3. Welfare effects (%) of $V1a - V2b$.

	$V1a$	$V1b$	$V2a$	$V2b$
Mean	4.3	6.9	11.2	18.6
Median	2.3	3.7	6.6	10.9
P25	0.9	1.3	3.3	5.3
P75	5.6	9.0	13.1	20.1

To investigate this heterogeneity further, we analyze the distribution of the welfare consequences in Figures 2a-2d.

Figure 2. Distribution of welfare effects (Y-axis: number of households, X-axis: welfare change (%))



(a) *V1a* (b) *V1b* (c) *V2a* (d) *V2b*

Figure 2a shows that most of the households face a welfare gain if they sell 50% of their housing wealth at retirement. However, for most households the welfare gain is only small and close to zero. A small selection of households face substantial welfare gains in this variant with welfare gains around 10%. In contrast, we also observe a non-negligible number of households that face a welfare loss from this variant: 9.0% of households face a welfare loss in variant $V1a$. Welfare losses can be explained by missing real returns on housing assets.

Similar to variant $V1a$, Figure 2b shows that most of the households face a welfare gain in case they sell 100% of their housing wealth at retirement. Contrasting variant $V1a$, we observe somewhat more extreme welfare gains and losses in variant $V1b$. This is reasonable as $V1a$ and $V1b$ are similar variants, with $V1b$ being the more extreme variant. The bulk of the households face a welfare gain close to 2%. 10.8% of households face a welfare loss in variant $V1b$. Although $V1b$ can be considered the more extreme variant of $V1a$, the welfare gains from $V1b$ are not always larger than the welfare gains from $V1a$. So, variant $V1b$ does not dominate $V1a$ in terms of welfare gains.

Contrasting variants $V1a$ and $V1b$, variant $V2a$ does not produce welfare losses. This is due to the fact that households do not have to sell their house, but have the option to borrow against their housing wealth instead. Hence, they do not miss out on real returns on their housing wealth. Many households face welfare gains between 2-5%, but welfare gains are shown to be heterogeneous and can be as large as 20%. For 1.1% of the households welfare does not change in variant $V2a$ compared to $V0$. Although $V2a$ can be considered to be more flexible than variants $V1a$ and $V1b$, the welfare gains from $V2b$ are not always larger than the welfare gains from either $V1a$ or $V1b$. So, variant $V2ab$ does not dominate $V1a$ or $V1b$ in terms of welfare gains.

Similar to variant $V2a$, Figure 2d suggests that most of the households face a welfare gain (and, hence, use the option) if they can use the option to borrow against 100% of their housing wealth (1.1% of households face a welfare loss of zero in variant $V2b$). Contrasting variant $V2a$, we observe more extreme welfare gains in variant $V2b$. This is reasonable as $V2a$ and $V2b$ are similar variants with $V2b$ allowing for more borrowing. Again, although many households face a welfare gain close to zero, welfare gains are largely heterogeneous. The welfare gains from $V2b$ are always at least as big as the welfare gains from $V1a$ for each household. So, variant $V2b$ dominates $V2a$ in terms of welfare gains.

Although Table 3 and Figures 2a-2d show that different variants to treat housing wealth over the life cycle lead to different welfare gains, on average, the table and figures also show that the actual welfare gain is largely heterogeneous among households. This proves that focusing on a representative household only will lead to a substantial loss of information. In fact, our results show that it is important to take into account households' heterogeneity which cannot be obtained by assuming a single representative agent in the life cycle model. Even in the case we assume homogeneous parameters for all the different households, as we have shown in this section.

5.3 Welfare gains with heterogeneous preferences

In the previous section we have shown that welfare gains from the different variants to treat housing wealth over the life cycle are largely heterogeneous among a representative group of households. So far, we have assumed homogeneous parameters for these households. In this section, we analyze the importance of taking into account households' heterogeneity in preferences for consumption smoothing and time and see if this matters for the simulated welfare effects. For details regarding the parameters, we refer to the column "*Heterogeneous preferences*" in Table 2.

In Table 4, we present the welfare consequences of variants $V1a - V2b$ when we take into account households' heterogeneity in preferences for smoothing and time. Adding heterogeneity in preferences compared to homogeneous parameters decreases the size of the welfare gain for the average household, but the differences with assuming homogeneous preferences are fairly small. If anything, allowing for heterogeneity in preferences for consumption smoothing and time slightly compresses the size of the welfare gains. An important takeaway for these results is that simulated welfare gains with heterogeneous preference parameters are quite similar to the welfare gains with homogeneous preference parameters.[23] Hence, whereas allowing for heterogeneity in the financial situation of

[23] In Appendix F, we show that these welfare gains are robust to using a sample of households aged 30+ only.

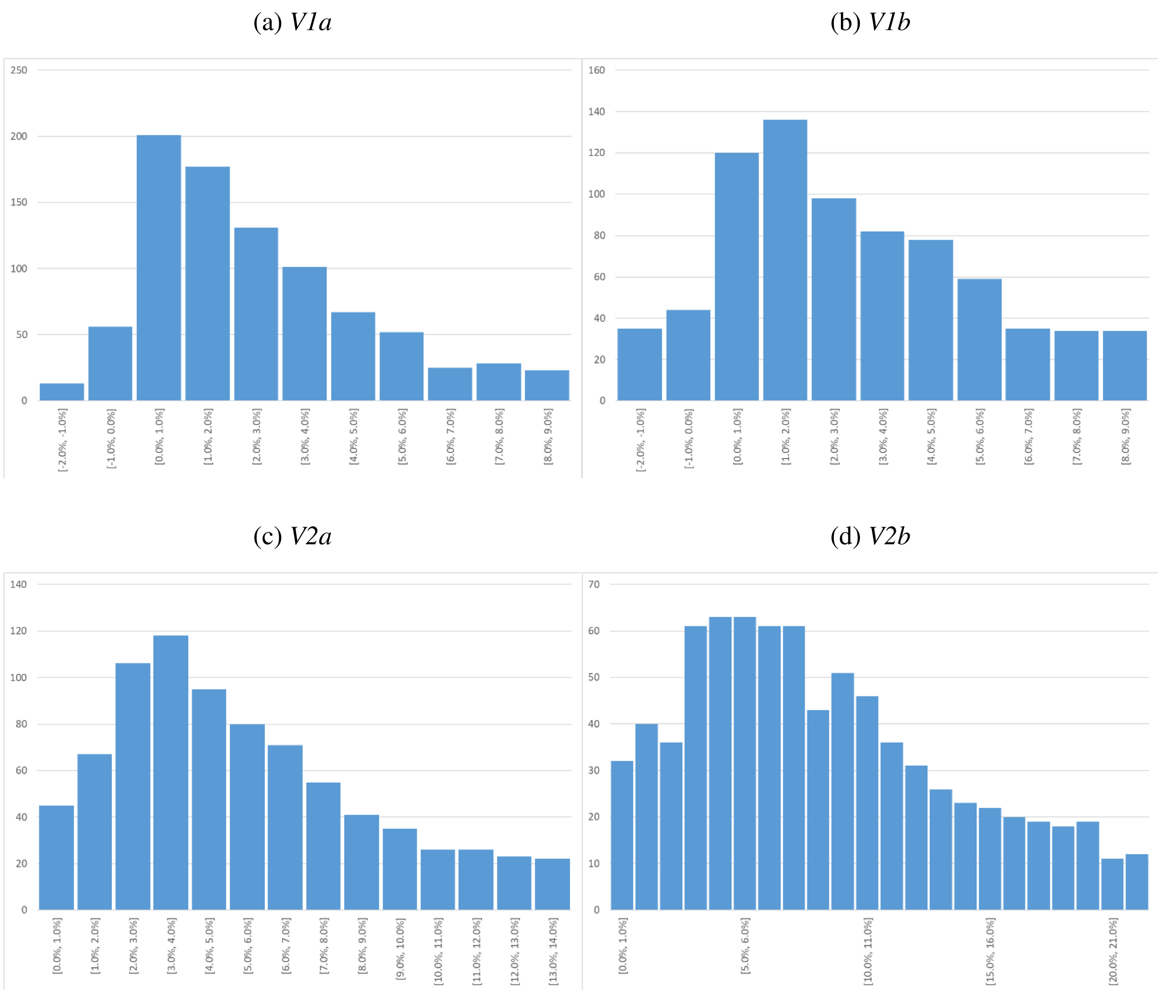
households appeared important, allowing for heterogeneous preferences regarding consumption smoothing and time seems less important.

Table 4. Welfare effects (%) of $V1a - V2b$ with heterogeneous risk and time parameters.

	$V1a$	$V1b$	$V2a$	$V2b$
Mean				
Heterogeneous	2.9	4.7	8.1	13.2
Homogeneous	3.2	5.0	9.4	14.6
Median				
Heterogeneous	2.0	3.1	5.4	9.0
Homogeneous	2.1	3.3	5.4	9.0
P25				
Heterogeneous	0.8	1.0	3.1	4.9
Homogeneous	0.9	1.2	3.2	5.0
P75				
Heterogeneous	4.1	6.6	9.4	15.7
Homogeneous	4.3	6.7	9.5	16.0

Similar to Figures 2a-2d, we find substantial heterogeneity among the sample for who we calculate welfare gains based on heterogeneous parameters (see Figures 3a-3d). Figures 2a-2d primarily show more extreme cases in a larger sample.

Figure 3. Distribution of welfare effects (Y-axis: number of households, X-axis: welfare change (%))



5.4 Sensitivity of welfare gains to γ, β, and θ

There has been no consensus in the literature on the size of the *IES* $(1/\gamma)$. The literature typically finds estimates of $0.4 \leq IES \leq 0.8$, but recent evidence from Rogerson and Wallenius [2016] suggests that these values of the *IES* are too low and that the *IES* is likely to be above unity. Empirical estimates for the Netherlands from Kapteyn and Teppa [2003], Been and Goudswaard [2021], Been et al. [2021] suggest that $0.5 \leq IES \leq 0.8$ (i.e. $1.25 \leq \gamma \leq 2$). To show the sensitivity of our simulated welfare effects to the choice of γ, we present the simulated welfare effects for $\gamma \in \{1,2,5\}$ in Table 5. Table 5 shows the sensitivity of our results to assuming $IES \in \{0.2, 0.5, 1.0\}$ which covers the range of commonly found values for the intertemporal elasticity of substitution of consumption and leisure. The sensitivity analyses show that welfare gains are larger with higher (lower) values of γ $(1/\gamma)$ in all variants considered, i.e. welfare gains of liquidating housing wealth are larger if more smoothing of consumption is preferred. That is because the different variants allow for more consumption smoothing which is more valued with a higher γ.

Similarly, we consider $\beta \in \{0.92, 0.99\}$ to test the sensitivity of our results to assumptions regarding the time preference. The sensitivity checks in Table 5 show that a higher value of β results in a relatively lower welfare gain. Hence, welfare gains from liquidating housing wealth are larger when households put less weight on future consumption and more weight on current consumption. Liquidating housing wealth allows households to take consumption from the future to the present which is only interesting for those with sufficiently strong preferences for current consumption.

Additionally, we analyze the sensitivity of our results to assuming $\theta = 0.25$, i.e. a larger marginal benefit from bequests. Following the most recent empirical evidence from Ameriks et al. [2020], we have assumed $\theta = 1.09$ which implies that the marginal utility of bequests are fairly small. Koijen et al. [2016], Nakajima and Telyukova [2017], Lockwood [2018], and Nakajima and Telyukova [2020] suggest $\theta < 1$ implying a larger marginal utility of bequests.[24] By assuming $\theta = 1.09$, we may overestimate the welfare gains compared to $\theta < 1$. However, Nakajima and Telyukova [2020] argue that the parameter values of the bequest motive are of little importance to their results. Most importantly, the bequest parameters should imply that bequests are a luxury good ($\kappa > 0$) which is the consensus in the literature.[25] Our sensitivity analysis in Table 5 shows that $\theta = 0.25$ results in smaller welfare

[24] Lockwood [2018] finds $\theta = 0.95$. Nakajima and Telyukova [2017] and Nakajima and Telyukova [2020] even find $\theta = 0.22$ and $\theta = 0.38$, respectively.

[25] See, among others, Dynan et al. [2002], De Nardi [2004], Kopczuk and Lupton [2007], DeNardi and Yang [2014], Gan, Gong, Hurd, and McFadden [2015], Lockwood [2018], Ameriks et al. [2020].

gains in the variants considered due to a much higher marginal benefit from bequests. Our main conclusions that borrowing against housing wealth leads to larger welfare gains than selling the house at retirement and that welfare gains are largely heterogeneous are not altered because of $\theta = 0.25$. However, welfare gains are substantially smaller than with assuming $\theta = 1.09$ and can even lead to more substantial welfare losses in variants $V1a$ and $V1b$ because the bequest is smaller than preferred. Although different assumptions regarding γ and β lead to different sizes of the welfare gains, the sign of the welfare effect (gain/loss) is largely subject to the size of θ. Hence, the strength of the bequest motive is an important factor in determining the welfare gains and their size from liquidating housing wealth for consumption.

Table 5 shows three interesting patterns that make economically sense when assuming different parameters in the welfare analyses of the four aforementioned variants. Firstly, the sensitivity analyses show that welfare gains are larger with lower values of β in all variants considered, i.e. welfare gains of liquidating housing wealth are larger if more weight is given to current consumption. Secondly, the sensitivity analyses show that welfare gains are larger with higher values of γ in all variants considered, i.e. welfare gains of liquidating housing wealth are larger if more smoothing of consumption is assumed. Thirdly, welfare gains are larger if the marginal benefits from bequests are smaller, i.e. those with little preferences to bequeath can liquidate their housing wealth and use this to finance consumption at the cost of wealth at the end of life. However, regardless of the exact parameters values, we find 1) largest welfare gains in the scenario in which households can borrow against their housing wealth over the life-cycle and 2) substantial heterogeneity in welfare gains among households.

Table 5. Welfare effects (%) of $V1a$-$V2b$ for different values of γ, β, and θ.

	$V1a$	$V1b$	$V2a$	$V2b$
A. Homogeneous β & γ				
Baseline: $\beta = 0.97$ & $\gamma = 2.26$ & $\theta = 1.09$				
Mean	4.3	6.9	11.2	18.6
Median	2.3	3.7	6.6	10.9
P25	0.9	1.3	3.3	5.3
P75	5.6	9.0	13.1	20.1
$\beta = 0.97$ & $\underline{\gamma = 1.0}$ & $\theta = 1.09$				
Mean	3.8	5.8	1.8	15.3
Median	1.9	2.7	0.0	9.0
P25	0.7	0.7	0.0	4.1
P75	4.7	7.5	0.0	18.4
$\beta = 0.97$ & $\underline{\gamma = 2.0}$ & $\theta = 1.09$				
Mean	4.3	6.7	10.9	17.9
Median	2.3	3.5	6.5	10.4
P25	0.9	1.2	3.2	5.1
P75	5.6	8.9	13.0	21.7
$\beta = 0.97$ & $\underline{\gamma = 5.0}$ & $\theta = 1.09$				
Mean	3.5	7.4	13.8	23.4
Median	1.8	3.9	7.1	12.8
P25	0.5	1.3	3.7	6.3
P75	4.5	9.6	14.0	25.8
$\underline{\beta = 0.92}$ & $\gamma = 2.26$ & $\theta = 1.09$				
Mean	4.7	8.5	14.9	24.1
Median	1.7	3.3	8.9	15.0
P25	0.5	0.8	3.9	7.0
P75	6.1	12.0	17.5	28.7
$\underline{\beta = 0.99}$ & $\gamma = 2.26$ & $\theta = 1.09$				
Mean	3.9	6.3	10.5	17.5
Median	2.1	3.4	6.2	10.3
P25	0.8	1.0	3.3	5.1
P75	5.1	8.4	12.4	20.9
$\beta = 0.97$ & $\gamma = 2.26$ & $\underline{\theta = 0.25}$				
Mean	2.2	0.5	8.4	11.0
Median	0.7	-0.8	3.9	4.7
P25	-0.5	-2.2	0.0	1.6
P75	3.3	1.7	9.2	11.5
B. Heterogeneous β_i **&** γ_i				
β_i & γ_i & $\theta = 1.09$				
Mean	2.9	4.7	8.1	13.2
Median	2.0	3.1	5.4	9.0
P25	0.8	1.0	3.1	4.9
P75	4.1	6.6	9.4	15.7
β_i & γ_i & $\theta = 0.25$				
Mean	1.5	0.1	5.9	7.7
Median	0.5	-0.8	3.1	3.9
P25	-0.5	-2.2	0.0	1.6
P75	2.4	0.9	6.9	8.5

5.5 Heterogeneous welfare gains by groups

In the remainder of this section, we analyze the heterogeneity in welfare gains for different socio-demographic groups. More specifically, we estimate an OLS model to present the correlation between households' characteristics and their calculated welfare gains based on homogeneous parameters.[26] The estimated coefficients should be interpreted as: coefficient $\times$ 100 = Δ welfare (%). For a univariate analysis of the heterogeneity in welfare gains, we refer to Appendix E.

Table 6 shows that welfare gains are especially present among those households with higher net housing wealth and lower current income and projected pension income. These are the households whose consumption is most constrained by their income and illiquid wealth and who can substantially increase consumption by making housing wealth liquid. We find little to no effects of households' characteristics and preferences for consumption smoothing and time in the multivariate analysis. This is consistent with our other analyses to address the importance of preferences regarding consumption smoothing and time[27]: estimated welfare effects are relatively insensitive to different parameter values of consumption smoothing and time. From this we can reasonably conclude that the insensitivity of welfare effects to heterogeneity in preference parameters is unlikely to be driven by a possible lack of variation in responses in the reduced sample.

[26]The results with heterogeneous preference parameters are similar and can be found in Appendix G.

[27]This is also consistent with the analysis of Scholz et al. [2006], who find no significant correlations between households' characteristics, such as having (grand)children, and optimal wealth holdings. Similarly, regression analyses of Scholz et al. [2006] do not show strong correlation between planned bequests and optimal wealth holdings.

Table 6. Estimation results of the welfare gains (fractions) by variant $V1a - V2b$.

	$V1a$	$V1b$	$V2a$	$V2b$
Female	0.000	0.002	-0.001	-0.001
	(0.002)	(0.003)	(0.008)	(0.009)
Immigrant (1st gen.)	0.003	0.003	0.002	0.003
	(0.006)	(0.006)	(0.010)	(0.011)
Immigrant (2nd gen.)	0.011	0.012	0.006	0.006
	(0.008)	(0.010)	(0.014)	(0.017)
Couple	0.011*	0.026***	-0.002	0.010
	(0.004)	(0.006)	(0.021)	(0.022)
Age	-0.001	-0.003*	-0.018	-0.021*
	(0.001)	(0.001)	(0.009)	(0.010)
Age sq.	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Number of children	0.000	0.000	0.004	0.005
	(0.001)	(0.001)	(0.004)	(0.004)
Gross HH inc. (log)	-0.028**	-0.040**	-0.046	-0.066*
	(0.009)	(0.011)	(0.024)	(0.026)
Housing value (log)	0.025***	0.048***	0.076***	0.128***
	(0.004)	(0.006)	(0.007)	(0.009)
LTV	-0.027***	-0.054***	-0.050**	-0.072***
	(0.006)	(0.011)	(0.016)	(0.020)
Pension accruals (log)	-0.002	-0.007	0.092	0.086
	(0.014)	(0.015)	(0.067)	(0.070)
Proj. pension inc. HH (log)	-0.009	-0.021*	-0.114	-0.148*
	(0.008)	(0.009)	(0.064)	(0.066)
Risk preference	0.002	0.001	0.006	0.007
	(0.001)	(0.002)	(0.003)	(0.004)
Time preference	0.001	-0.001	0.005	0.006
	(0.001)	(0.002)	(0.004)	(0.005)
Const.	0.136*	0.237**	0.334**	0.397**
	(0.068)	(0.079)	(0.109)	(0.127)
N	923	923	923	923
Adj. R-sq.	0.362	0.529	0.258	0.408

* Significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level. Robust standard errors are reported in parentheses.

6 Discussion

Our model identifies clear welfare effects of alternative options for liquidating housing wealth and shows that welfare effects are heterogeneous for a representative sample of households. These results are based on several simplifying assumptions. In this section, we explain how enriching our model with more realistic assumptions can affect the calculated welfare effects.

Firstly, except for mortality risk, our model abstracts from stochastics in income,[28] financial markets, and housing markets. Hence, we assume deterministic income growth (and, therefore, deterministic pension accumulation), deterministic returns on financial assets, deterministic returns on housing, deterministic mortgage interest rates, and deterministic rental rates. Including one or more of these stochastic elements substantially complicates the model, but combining population-wide heterogeneity with uncertainty is an interesting direction for future research.

Introducing these types of uncertainty in the model can have two opposing effects on our welfare gains. On the one hand, it implies that households need more precautionary savings. Especially, if they are relatively risk averse. Therefore, households may consume less of the increased consumption potential in the four variants we presented. Our sensitivity analysis suggests that introducing precautionary savings (by assuming $\theta = 0.25$ instead of $\theta = 1.09$ thereby effectively increasing preferences for holding wealth at the end of life) compresses the welfare gains from liquidating housing equity. This approach is in line with Hurd [1989] who finds that bequests are largely unintended 'leftovers' from precautionary savings. Therefore, without making a fully stochastic model, we conclude that introducing precautionary savings decreases the welfare gains from liquidating housing equity. On the other hand, introducing uncertainty might also imply more positive welfare gains, as households can benefit from liquidating housing wealth after an adverse income shocks (such as unemployment).

Secondly, except for mortality, our model abstracts from household transitions such as marriage, separation, and children. Introducing children in the household most likely increases the consumption needs during the prime age of the parents. Therefore, we would expect that introducing children in the model would increase the demand for liquidating housing wealth before retirement and increase the welfare gains from variants $V2a - V2b$. Compared to a model with children, our current model is likely to underestimate the welfare

[28] This includes abstracting from uncertainty in human capital accumulation. This may be important for portfolio decisions [Benzoni, Collin-Dufresne, and Goldstein, 2005].

gains from variants $V2a - V2b$. Marriage and separation have less clear effects *a priori*. Introducing marriage and separation would add another channel of uncertainty in households' income, both positive and negative uncertainty. Marriage and separation might also imply the need for additional spending throughout the life-course which would increase the demand for more liquid wealth. Nonetheless, our current analysis has shown that single households and couple households do not differ a lot in their welfare effects from variants $V2a - V2b$.

Thirdly, we have assumed exogeneity in housing choices in our model following Yogo [2016]. Especially, because we specifically focus on homeowners who can use their housing wealth to finance consumption over the life-cycle. In contrast, Nakajima and Telyukova [2017] allow homeownership versus renting to be endogenous in their model. Given the high subsidies and regulation in Dutch housing market that we outlined in Section 2.2, households are inclined to buy a home if they can and we expect that homeowners are on average more affluent households than renters. Since our results indicate that welfare gains are particularly large among households with a high housing value and low LTV, i.e. more affluent households, we expect that welfare gains would have been lower among renting households if they would have had the opportunity to buy.

Fourthly, we have assumed a common parameterization of the CRRA utility function. However, households may have preferences that are not fully captured by the utility function assumed. One such preference that is not taken into account is habit formation in consumption. Evidence on the existence of habit formation is mixed [Havranek, Rusnak, and Sokolova, 2017]. For example, Dynan [2000] find no evidence for habit formation among US households. In contrast, Carrasco, Labeaga, and Lopez-Salido [2005] and Guariglia and Rossi [2002] find evidence in favor of habit formation in Spain and the UK, respectively. Alessie and Teppa [2010] find empirical evidence in favor of habit formation among Dutch households. However, they also find that the magnitude of habit formation coefficient is small. This makes it unlikely that allowing for habit formation alters the main results of our analysis.

7 Policy

A major source of saving for many households consists of home equity [Knoef et al., 2016]. Together with (quasi)mandatory occupational pensions this is the major source of retirement income for many households [Knoef et al., 2016]. In several respects occupational pensions and home equity are similar: both are illiquid, provide income until death, and are usually tax favoured. In the Netherlands the implicit tax subsidy on second pillar pensions is estimated at about 25 percent [Westerhout, Van de Ven, Van Ewijk, and Draper, 2004], and a similar subsidy is found for housing [Van Ewijk and Lejour, 2021]. There is one important difference between pensions and housing: pensions provide an annuity until death while home equity offers housing services until death but also leaves a capital at death: home equity tends to be locked up in the house and usually falls to heirs when the owner dies.

This illiquid nature of both pensions and home capital raises a number of issues. On the positive side it provides a commitment mechanism for retirement saving that helps to cure any individual failure to save for pensions. Also, many governments promote private pension saving in order to alleviate pressure on first pillar pensions that are usually financed in a PAYG fashion. However, it also reduces the flexibility of savings over the life-cycle leading to suboptimal consumption patterns both before and after retirement. There is ample evidence from a variety of countries that many households in the end save âĂŸtoo muchâĂŹ for retirement,[29] in particular if pensions and housing wealth are taken together [Knoef et al., 2016]. Then consumption at younger ages is constrained relative to income after retirement leading to unnecessary welfare losses.

In the pre-retirement period consumption may be distorted by existing pension

[29] Over-saving has been widely documented in Denmark, the Netherlands, and Sweden [Rostberg, Andersson, and Lindh, 2005, Knoef et al., 2016, Sorensen, Billig, Lever, Menard, and Settergren, 2016], but also in countries with lower levels of mandatory retirement savings such as the US [Mitchell and Moore, 1998, Browning and Crossley, 2001, Scholz et al., 2006, Haveman, Holden, Romanov, and Wolfe, 2007, Skinner, 2007, Love, Smith, and McNair, 2008, Biggs, 2019], the UK [Crawford and O'Dea, 2020], Canada [Vettesse, 2013], Australia [Guest and McDonald, 1998], New Zealand [Scobie, Gibson, and Trinh, 2004], and Switzerland [Buetler, 2009].

arrangements together with mandatory repayments of the mortgage. In particular, younger households raising children may be constrained too much if they are forced to participate in pension arrangements and at the same time have to invest in their home. Ciurila et al. [2022] show that welfare gains (up to about 3%) are possible if pension saving does not burden younger households too much and can be relegated to later in active life. After retirement, the income from pensions and housing wealth may not concur with individual preferences, especially for households with a strong time preference. Finally, also the bequest may be distorted when the capital locked up in the house leads to unintentional bequests [Hurd, 1989].

Our analysis takes these distortions together and aims to provide an overall assessment of aggregate gains in welfare that are possible at an aggregate level. We focus on the illiquidity of housing wealth and consider four alternatives for freeing equity locked up in the housing wealth of households and show that this potentially leads to substantial welfare gains in the aggregate. Making housing equity more malleable can avoid problems of oversaving in the pre-retirement period [Scholz et al., 2006], allows for greater flexibility of consumption after retirement [Bonekamp and Van Soest, 2021], and avoids unintentional bequests when home equity cannot be mobilised before death [Hurd, 1989]. We focus on the financing side, and take housing consumption as given; freeing capital by selling the home and moving to a smaller house falls beyond the scope of our analysis. Compared to Ciurila et al. [2022] who analyze the welfare effects of postponing mandatory pension accumulation to later in life, we show that borrowing against home equity over the life cycle may lead to even more substantial welfare gains on average (3% versus 11%, both based on calculations of certainty equivalent consumption).

This leads to a number of observations with respect to policy. These considerations may concern policies with respect to housing capital as well as pensions. First, measures should be taken to improve the liquidity of home equity whilst taking into account the myopic behavior of households (and, hence, undersaving). Second, on the pension side, one could think of measures to avoid oversaving in particular for homeowners that also build up housing wealth. Third, question marks can be put at the large tax subsidies on both housing and pensions, in particular if both not taken together in a comprehensive framework. Fourth and final, policy can be tailored to those households that benefit most from more liquidity of their housing wealth. We briefly discuss each of the possible routes for a solution:

1. Improving liquidity of housing wealth.

In addition to allowing for more flexible financing schemes in the tax code, one may consider more direct measures to improve liquidity of housing wealth. One of the key problems is the lack of well-developed markets for reverse mortgages. One issue may concern the tax treatment of this type of mortgages with low or zero tax subsidies. Next to this, insurance companies are reluctant to take the residual risk due to both moral hazard âĂŞ less incentive for caretaking by the owner âĂŞ and uncertainty in house prices which may lead to a lack of collateral at the moment of death. On this latter aspect the government may consider to design a national arrangement for promoting a market for reinsurance, or taking over this risk by a national arrangement. Furthermore, there is a lack of well-developed markets for other options that allow households to (partially) use their housing wealth for consumption, such as partially owning a house together with institutional investors and/or pension funds.

2. Integrating pensions and housing savings.

The second route is to adopt rules for pension savings allowing for greater flexibility in pension saving, or directly stimulating direct exchange between pension saving and investing in housing by integrating investments in the own home in pensions. A good example for this is the Swiss system where âĂŞ up to some limit âĂŞ households can exchange pension contributions for investing in the own home. And conversely, when the house is sold one has to invest back again in the pension fund so that total savings are not affected.

3. Developing a more comprehensive tax framework for housing and pensions.

Some incentive for illiquid savings through pensions and home equity can be motivated by suboptimal voluntary individual savings due to individual behavioral failures, and from a macroeconomic wish to encourage private saving in an aging society. However, a too large subsidy may lead to suboptimal consumption patterns over the life-cycle for some households that may lead to considerable welfare losses. Our analysis confirms that especially homeowning households that also build up considerable âĂŞ mandatory - pensions end up with a suboptimal allocation of consumption. One way to mitigate this is to design a comprehensive framework for all sources of capital accumulation by households. Given the similarities between pensions and housing an obvious solution would be to take these types of saving together in the tax rules, for example applying a common cap for maximum savings in pensions and housing together (see also Van Ewijk and Lejour [2021]). Furthermore, the tax rules of the financing of housing could be made more flexible, allowing for varying mortgage borrowing over the life-cycle, for example by also allowing of some non-redeemable debt. For example, in the Netherlands, households are forced to redeem debt fully at a fixed rate over a 30 years period at maximum to be eligible for the tax subsidy.

4. Tailoring mandatory savings policies to households.

Introducing flexibility in the "one-size-fits-all" pension policy is one of the main policy recommendations for the Netherlands from Mercer [2009-2020]. In this paper, we analyzed how increased flexility in using home equity to finance consumption leads to welfare gains. Hence, tailoring policy towards homeowners with substantial (illiquid) wealth helps to prevent oversaving (i.e. consuming too little over the life cycle). However, our estimated welfare effects show that there is large heterogeneity among households. Letting households use their home equity for consumption does not lead to welfare improvements for all households per se.

Moreover, our analysis has shown that there is no dominant liquidation strategy that is best for all households. We conclude that using home equity positively increases the flexibility in pension systems, on average, but households' differential economic situation and preferences regarding bequests should be strongly taken into account in the design. For example by, having multiple options to choose from in liquidating home equity. This should include options that are in-between illiquid housing wealth and the two current extremes of either selling the house (100%) or taking a (100%) reverse mortgage. These options may be conditional on observable characteristics, such as income and (illiquid) wealth in order to prevent issues of myopia and undersaving.

8 Conclusions

This paper analyzes the extent to which different variants to liquidate home equity leads to welfare improvements for households by solving liquidity constraints for consumption. Moreover, the paper analyzes the welfare effects for a representative sample of the population and investigates the welfare effects for particular subgroups. To analyze such heterogeneity in welfare effects, we use a Life-Cycle Model (LCM) with two sources of heterogeneity: 1) we use administrative data for a representative sample of households from the Netherlands and 2) we allow for heterogeneous preferences for smoothing and time in the LCM elicited in survey data from the Netherlands. These sources of heterogeneity enrich the LCM beyond heterogeneous-agents models and allow us to study the population-wide distribution of welfare effects.

To analyze the welfare effects of liquidating housing wealth, we consider four variants in which households either sell (50% of) their house at retirement or borrow against (50% of) households' housing wealth over the life-cycle. Our results suggest that borrowing against households' housing wealth over the life-cycle leads to larger welfare gains than selling the home at retirement. We consider the option to borrow against 50% of households' housing wealth over the life-cycle as the most feasible option, compared to borrowing against 100% of households' housing wealth, that leads to the largest welfare gains: Median (average) welfare gains are about 7% (11%). However, we find substantial heterogeneity in welfare gains among households with a welfare gain between 3% and 13% for half of the households. Nonetheless, welfare gains can be as large as 20%, although the bulk of the welfare gains is around 2%.

Regressing the welfare effects on households' characteristics indicates that much of the heterogeneity we find among households is explained by heterogeneity in households' income and (housing) wealth. Our analyses indicate that allowing for heterogeneity in preferences for consumption smoothing and time is relatively unimportant in explaining households' heterogeneous welfare effects. This is confirmed by the relatively small effects of assuming different values for consumption smoothing and time on estimated welfare effects. The distributions of welfare effects are very similar for homogeneous and heterogeneous preferences in consumption smoothing and time. However, our results do suggest that households' bequest motive is an important factor in determining the sign and size of welfare effects.

Academically, our results are interesting as they outline a road map to further increase heterogeneity in LCM's and welfare analyses. Moreover, our results suggest that heterogeneity in consumptions smoothing and time parameters in the LCM may be of less importance than allowing for income and wealth information from actual households. For policy, our results are interesting as they suggest that (most) households will be better off with less illiquid and more liquid wealth. Based on this result, policy makers need to rethink the role of mandatory pension savings combined with mandatory mortgage repayments whilst keeping in mind issues regarding myopia to avoid undersaving. More tailor-made policy regarding mandatory savings and mortgage repayments could avoid problems with oversaving which has been widely documented across countries, including countries with lower levels of mandatory retirement savings than in the Netherlands, such as the UK and the US.

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Appendices

A Derivations of the gradient and Hessian

To ease computations for the maximization problem of single households: The gradient of U (Equation 4.8) follows from ($t = 0, \ldots, T-1$)

$$\frac{1}{\beta^t \pi_t} \frac{\partial U}{\partial a_t} = -u^{'}(c_t) + p_t v^{'}(a_t) + \beta(1-p_t)\left[(1+r)\, 1_{a_{t-1} \geq h^o_{t-1}} + (1+r^m)\, 1_{a_{t-1} < h^o_{t-1}}\right] u'(c_{t+1}) \tag{A.1}$$

$$\frac{1}{\beta^T \pi_T} \frac{\partial U}{\partial a_T} = -u'(c_T) + p_T v'(a_T). \tag{A.2}$$

The Hessian of U follows from ($t = 0, \ldots, T$)

$$\frac{1}{\beta^t \pi_t} \frac{\partial^2 U}{\partial a_t^2} = u^{''}(c_t) + p_t v^{''}(a_t) + \beta(1-p_t)\left[(1+r)^2\, 1_{a_{t-1} \geq h^o_{t-1}} + (1+r^m)^2\, 1_{a_{t-1} < h^o_{t-1}}\right] u^{''}(c_{t+1}) \tag{A.3}$$

$$\frac{1}{\beta^T \pi_T} \frac{\partial^2 U}{\partial a_T^2} = u^{''}(c_T) + p_T v^{''}(a_T), \tag{A.4}$$

and for the off-diagonal elements ($t = 1, \ldots, T$)

$$\frac{1}{\beta^t \pi_t} \frac{\partial^2 U}{\partial a_t a_{t-1}} = -\left[(1+r)^2\, 1_{a_{t-1} \geq h^o_{t-1}} + (1+r^m)^2\, 1_{a_{t-1} < h^o_{t-1}}\right] u^{''}(c_t), \tag{A.5}$$

and for $i \notin \{-1, 0, 1\}$ ($t = i, \ldots, T$)

$$\frac{\partial^2 U}{\partial a_t \partial a_{t+i}} = 0. \tag{A.6}$$

To ease computations for the maximization problem of two-person households, the gradient of

U follows from ($i, j \in \{0, \dots, T\}$):

$$\frac{1}{\beta^{t_{ij}}\pi_{ij}}\frac{\partial U}{\partial a_{ij}} = -\frac{n_{ij}}{\chi_{n_{ij}}}u^{'}\left(\frac{c_{ij}}{\chi_{n_{ij}}}\right) + p_{ij\to\varnothing}v^{'}(a_{ij}) + \beta\left[(1+r)\,1_{a_{ij}>h^{o}_{ij}} + (1+r^{m})\,1_{h^{o}_{ij}>a_{ij}}\right]$$
$$\left[p_{ij\to(i+1,j+1)}\frac{n_{i+1,j+1}}{\chi_{n_{i+1,j+1}}}u^{'}\left(\frac{c_{i+1,j+1}}{\chi_{n_{i+1,j+1}}}\right) + p_{ij\to(i+1,j)}\frac{n_{i+1,j}}{\chi_{n_{i+1,j}}}u^{'}\left(\frac{c_{i+1,j}}{\chi_{n_{i+1,j}}}\right) + p_{ij\to(i,j+1)}\frac{n_{i,j+1}}{\chi_{n_{i,j+1}}}u^{'}\left(\frac{c_{i,j+1}}{\chi_{n_{i,j+1}}}\right)\right] \tag{A.7}$$

where $p_{ij\to(T+1,j)} = p_{ij\to(i,T+1)} = 0$.

For the diagonal elements and off-diagonal elements respectively, the Hessian of U follows from ($i, j \in \{0, \dots, T\}$) and $(i, j) \neq (0,0)$):

$$\frac{1}{\beta^{t_{ij}}\pi_{ij}}\frac{\partial^2 U}{\partial a_{ij}^2} = \frac{n_{ij}}{\chi^2_{n_{ij}}}u^{''}\left(\frac{c_{ij}}{\chi_{n_{ij}}}\right) + p_{ij\to\varnothing}v^{''}(a_{ij}) + \beta\left[(1+r)^2\,1_{a_{ij}>h^{o}_{ij}} + (1+r^{m})^2\,1_{h^{o}_{ij}>a_{ij}}\right]$$
$$\left[p_{ij\to(i+1,j+1)}\frac{n_{i+1,j+1}}{\chi^2_{n_{i+1,j+1}}}u^{''}\left(\frac{c_{i+1,j+1}}{\chi_{n_{i+1,j+1}}}\right) + p_{ij\to(i+1,j)}\frac{n_{i+1,j}}{\chi^2_{n_{i+1,j}}}u^{''}\left(\frac{c_{i+1,j}}{\chi_{n_{i+1,j}}}\right) + p_{ij\to(i,j+1)}\frac{n_{i,j+1}}{\chi^2_{n_{i,j+1}}}u^{''}\left(\frac{c_{i,j+1}}{\chi_{n_{i,j+1}}}\right)\right] \tag{A.8}$$

$$\frac{1}{\beta^{t_{ij}}\pi_{ij}}\frac{\partial^2 U}{\partial a_{ij}\partial a_{\text{prev}_{ij}}} = -\beta\left[(1+r)\,1_{a_{\text{prev}_{ij}}>h_{\text{prev}_{ij}}} + (1+r^{m})\,1_{h_{\text{prev}_{ij}}>a_{\text{prev}_{ij}}}\right]p_{\text{prev}_{ij}\to ij}\frac{n_{ij}}{\chi^2_{n_{ij}}}u^{''}\left(\frac{c_{ij}}{\chi_{n_{ij}}}\right) \tag{A.9}$$

if $(i, j) \neq (k,l)$, $(k,l) \neq \text{prev}_{ij}$ and $(i, j) \neq \text{prev}_{kl}$.

$$\frac{\partial^2 U}{\partial a_{ij}\partial a_{kl}} = 0.$$

B Disposable income process

The pension age of each household member coincides with the corresponding expected statutory pension age.[30] Until this pension age, young individuals are expected to remain in the initial age-specific percentile of personal income. After that, individuals start receiving the statutory first pillar pension ('AOW') and the second pillar income. The latter equals the initially projected second pillar pension income (so called 'attainable pension'), which

[30] https://www.rijksoverheid.nl/documenten/publicaties/2019/09/25/overzicht-aow-leeftijd-lange-termijn

includes projected future pension accruals.

Since, the consumption decision is based on *disposable* household income, we estimate disposable household income y^d from gross household income y by imposing a certain income tax schedule.[31] Denote $\tilde{y}_i = \ln(y_i/\text{median}(y))$. Using all households i in the LISS survey we estimate the tax schedule

$$\text{logit}\left(\frac{y_i^d}{y_i}\right) = b_0 + b_1\tilde{y}_i + \frac{b_2}{2!}\tilde{y}_i^2 + \frac{b_3}{3!}\tilde{y}_i^3 + \varepsilon_i, \tag{B.1}$$

where $\text{logit}(x) = \ln(x/(1-x))$. Notice that b_i with $i \in \{0,1,2,3\}$ denotes the i-th derivative of $\text{logit}\left(y_i^d/y_i\right)$ with respect to $\ln(y_i)$, measured at the median income $y_i = \text{median}(y)$.

The income tax schedule differs between single and two-person households (e.g., income-related combination tax credit), and before and after the statutory pension age (e.g., first pillar pension contributions are only paid before the statutory pension age). Therefore, the logit regression (B.1) is estimated four times. For single-person households and two-person households separately, and within both groups separately for respondents before (y) and after (o) the statutory pension age (66 in 2018).

For each household, initial gross household income y is the aggregate personal gross income of the considered household members.[32] Subsequently, disposable household income y^d is estimated by using the corresponding set of coefficients in Table 7. More specifically, disposable income y_{it}^d of an n-person household i ($n \in \{1,2\}$) in age category $A \in \{y,o\}$ with gross income y_{it} is in each projected year t estimated by

$$\hat{y}_{it}^d = y_{it}\,\text{logit}^{-1}\left(\hat{b}_0^{(n,A)} + \hat{b}_1^{(n,A)}\tilde{y}_{it} + \frac{\hat{b}_2^{(n,A)}}{2!}\tilde{y}_{it}^2 + \frac{\hat{b}_3^{(n,A)}}{3!}\tilde{y}_{it}^3\right) \tag{B.2}$$

[31] Disposable household income and gross household income are from inhbestinkh and inhbrutinkh in INHATAB file, respectively.

[32] Personal gross income is from inppersink in the INPATAB file.

where

$$\text{logit}^{-1}(x) = \frac{\exp(x)}{1+\exp(x)}.$$

Let $\tau_i := 1 - \frac{y_i^d}{y_i}$ denote the effective tax rate of household i. Differentiating (B.1) with respect to y_i and applying the chain rule implies the following marginal effect for the effective tax rate,

$$\frac{\partial \tau_i}{\partial \tilde{y}} = \frac{b_1 + b_2\tilde{y}_i + \frac{1}{2}b_3\tilde{y}_i^2}{\frac{\partial}{\partial \tau_i}\text{logit}\,(1-\tau_i)} = -\frac{b_1 + b_2\tilde{y}_i + \frac{1}{2}b_3\tilde{y}_i^2}{\frac{1}{\tau_i} + \frac{1}{1-\tau_i}} = -\left(b_1 + b_2\tilde{y}_i + \frac{1}{2}b_3\tilde{y}_i^2\right)\tau_i(1-\tau_i). \tag{B.3}$$

We can estimate the marginal effective tax rate at the median income $\tilde{y}_i = \ln(y_i/\text{median}(y)) = 0$:

$$\left.\frac{\partial \tau}{\partial \tilde{y}}\right|_{y_i=\text{median}(y)} = -\left.\hat{b}_1^{n,A}\hat{\tau}(1-\hat{\tau})\right|_{y_i=\text{median}(y)} \tag{B.4}$$

$$= -\hat{b}_1^{n,A}\text{logit}^{-1}\left(\hat{b}_0^{n,A}\right)\left(1-\text{logit}^{-1}\left(\hat{b}_0^{n,A}\right)\right) \tag{B.5}$$

$$= -\frac{\hat{b}_1^{n,A}\exp(\hat{b}_0^{n,A})}{\left(1+\exp(\hat{b}_0^{n,A})\right)^2} \tag{B.6}$$

$$= -\frac{\hat{b}_1^{n,A}}{2+\exp(-\hat{b}_0^{n,A})+\exp(\hat{b}_0^{n,A})}. \tag{B.7}$$

The estimation results of the income process are shown in Table 7, including the marginal effective tax rate evaluated at the median income of the group: $\left.\frac{\partial \tau}{\partial \tilde{y}}\right|_{y_i=\text{median}(y)}$. The effective marginal tax rate is to be interpreted as a one percent increase in gross income leads to a $\left.\frac{\partial \tau}{\partial \tilde{y}}\right|_{y_i=\text{median}(y)} \times 100$ percent increase in the effective tax rate, at the median income. So, for non-retired single-person households with a median income, a one percent increase in gross income leads to a 17.6 percent increase in the effective tax rate. We find that this marginal effective tax rate is higher for retirees than non-retirees which is intuitive by the lower tax rate in the first tax bracket of retirees. Also, the marginal effective tax rate is larger for single-person than for two-person households.

Table 7. Estimation results of the income process.

	y, single-person	y, two-person	o, single-person	o, two-person
$\tilde{y}_i$	-0.719***	-0.619***	-1.693***	-1.136***
	(0.047)	(0.029)	(0.095)	(0.035)
$\tilde{y}_i^2$	0.682***	0.411***	-0.004	0.772***
	(0.102)	(0.064)	(0.262)	(0.181)
$\tilde{y}_i^3$	0.674***	0.748***	4.121***	-0.102
	(0.173)	(0.131)	(0.963)	(0.314)
Const.	0.304***	0.305***	1.408***	1.318***
	(0.016)	(0.008)	(0.022)	(0.015)
$\left.\frac{\partial\tau}{\partial\tilde{y}}\right\|_{y_i=\text{median}(y)}$	0.176	0.151	0.267	0.189
Median(y)	59,563	101,781	39,650	53,017
N	477	2,026	352	548
Adj. R-sq.	0.575	0.399	0.693	0.722

* Significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level. Robust standard errors are reported in parentheses.

C Heterogeneous parameter values

Figure 4. Distribution (y-axis: density) of γ_i based on $Q_{i,\text{risk}}$ ($N = 934$).

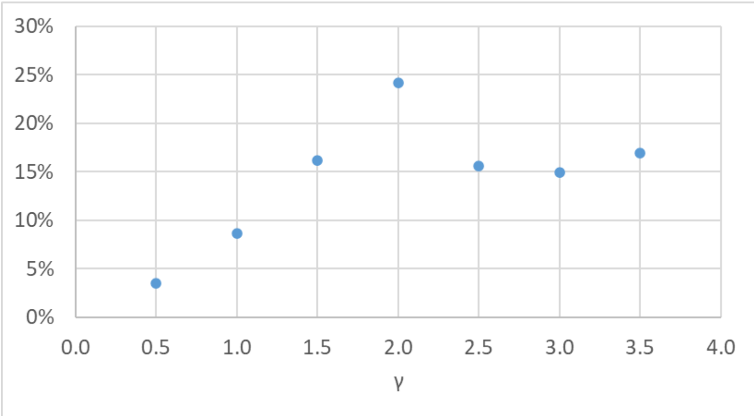
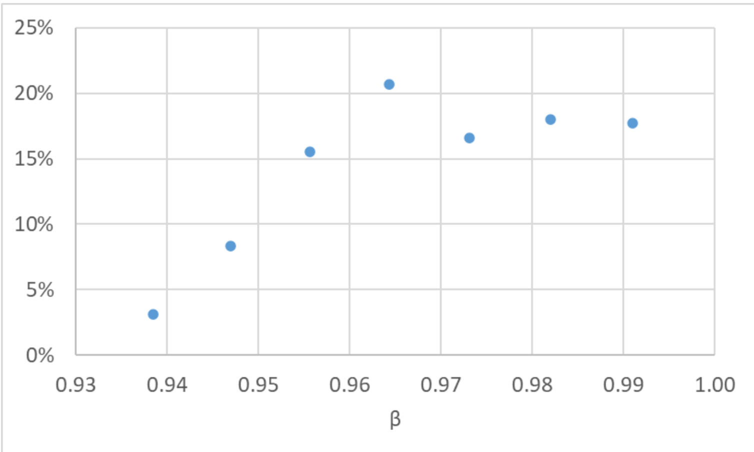


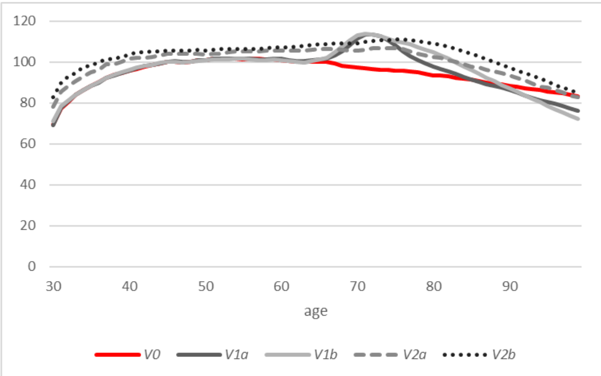
Figure 5. Distribution (y-axis: density) of β_i based on $Q_{i,\text{time}}$ ($N = 973$).



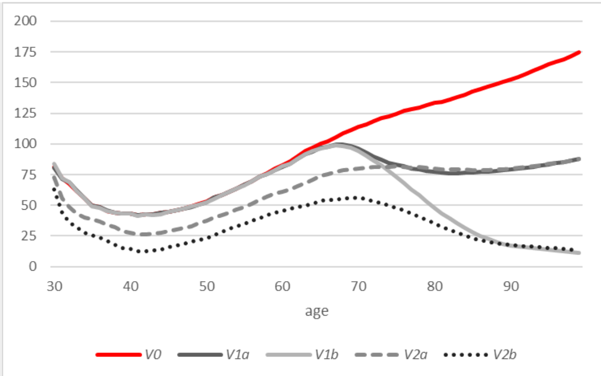
D Patterns of consumption and wealth

Figure 6. Life-cycle patterns of consumption and wealth (variant $V0$ at age $65 = 100$).

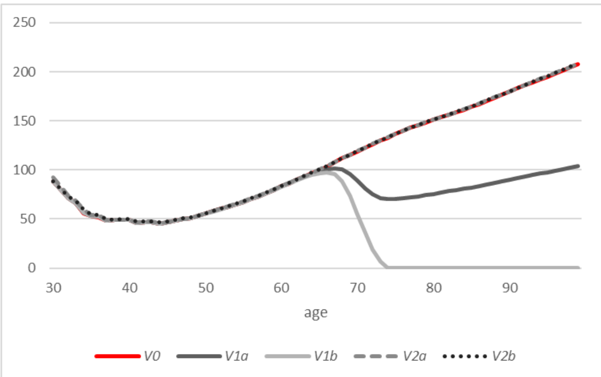
(a) Median consumption (c_t)



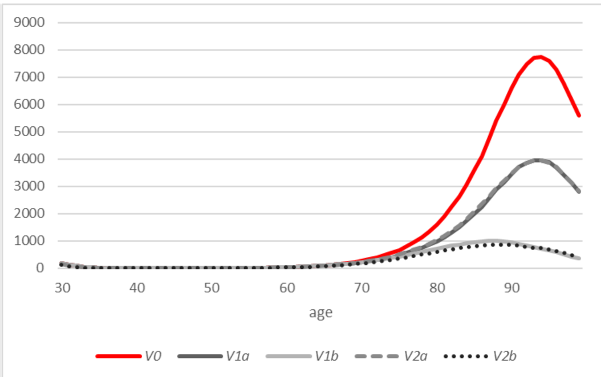
(b) Median wealth (a_t)



(c) Median illiquid wealth (h_t^o)



(d) Median bequest (a_t conditional on household's dead)



E Univariate heterogeneity in welfare gains

In Table 8, we analyze the welfare effects for discrete characteristics of the households. The results in the table suggest that the heterogeneity in welfare gains is fairly similar across different subgroups, although the results suggest that welfare gains are smaller for couples, immigrants, households with children, and those with a higher γ_i and β_i.

Table 8. Welfare effects (%) of $V1a - V2b$ by subgroups.

	$V1a$	$V1b$	$V2a$	$V2b$
All ($N = 3,855$)				
Mean	4.3	6.9	11.2	18.6
Median	2.3	3.7	6.6	10.9
P25	0.9	1.3	3.3	5.3
P75	5.6	9.0	13.1	20.1
Women ($N = 2,053$)				
Mean	4.5	7.2	11.0	18.3
Median	2.3	3.6	6.5	10.8
P25	0.9	1.3	3.3	5.4
P75	5.7	9.2	13.5	22.7
Couple ($N = 2,640$)				
Mean	3.5	6.0	8.7	14.5
Median	2.0	3.2	5.6	9.4
P25	0.8	1.2	2.9	4.9
P75	4.7	8.2	11.3	18.9
1st gen. immigr. ($N = 288$)				
Mean	4.1	6.5	10.1	16.5
Median	1.8	3.0	6.0	9.8
P25	0.7	0.8	3.0	4.5
P75	4.8	8.2	12.1	20.1
2nd gen. immigr. ($N = 290$)				
Mean	3.8	6.2	12.5	21.1
Median	1.7	2.7	5.5	9.0
P25	0.0	0.9	2.8	4.4
P75	4.4	6.8	11.5	20.9
No children ($N = 2,225$)				
Mean	5.6	9.2	12.5	20.7
Median	3.5	5.7	9.3	15.0
P25	1.1	1.6	4.2	6.5
P75	7.5	12.3	15.9	26.9
$Q_{i,risk} = 1$ ($\gamma = 3.5$) ($N = 158$)				
Mean	3.2	5.2	7.8	12.9
Median	2.3	3.7	6.0	9.9
P25	1.0	1.2	3.0	5.7
P75	4.5	7.4	9.8	16.8
$Q_{i,time} = 1$ ($\beta = 0.992$) ($N = 172$)				
Mean	3.8	6.4	9.3	15.4
Median	2.7	4.2	6.7	11.2
P25	1.1	1.4	3.5	5.5
P75	5.4	9.8	12.8	21.3

We analyze the welfare effects for continuous characteristics of the households in the figures below. The results suggest that welfare gains are especially large among households with low income, high housing wealth, low loan-to-value (LTV; mortgage debt / housing value), and low projected pension income. The intuition is that illiquid wealth relative to income is large for these households. The observation that households with a low projected income are most likely to benefit from liquidating housing wealth is consistent with findings of Buetler and Teppa [2007] who show that a low accumulation of retirement assets is strongly associated with preferences for a lump sum payout upon retirement. Also, the results suggest that welfare gains are smallest for prime age households and largest among retirees. Prime age households may benefit less, because (i) they have a large base welfare by their long remaining lifetime, and (ii) their base wealth is more liquid by their higher income.

Figure 7. Welfare gains by age for $V1a$ (upper left), $V1b$ (upper right), $V2a$ (bottom left), $V2b$ (bottom right).

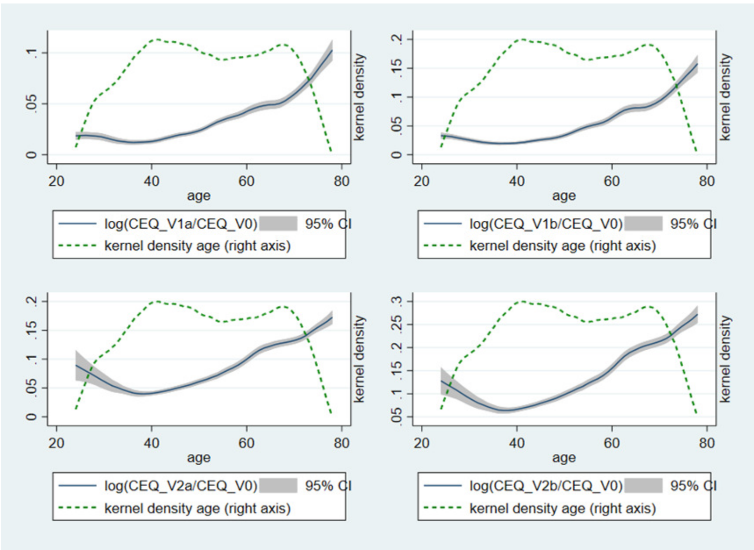


Figure 8. Welfare gains by disposable income for $V1a$ (upper left), $V1b$ (upper right), $V2a$ (bottom left), $V2b$ (bottom right).

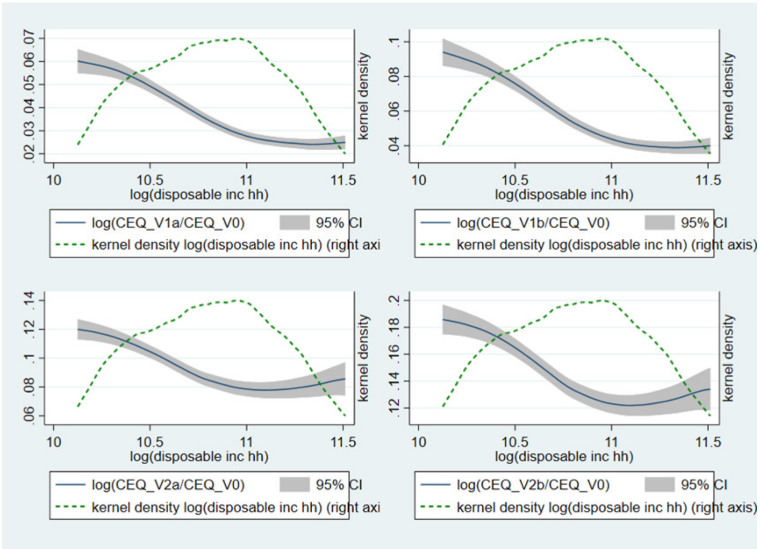


Figure 9. Welfare gains by housing wealth for $V1a$ (upper left), $V1b$ (upper right), $V2a$ (bottom left), $V2b$ (bottom right).

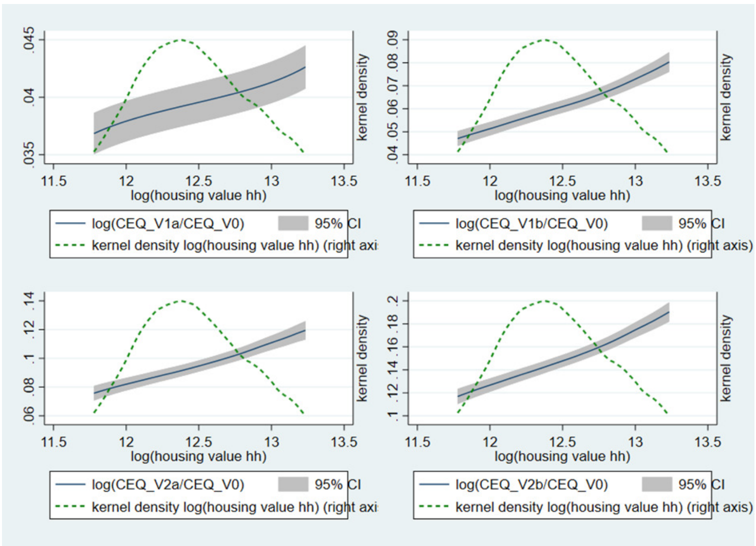


Figure 10. Welfare gains by LTV for $V1a$ (upper left), $V1b$ (upper right), $V2a$ (bottom left), $V2b$ (bottom right).

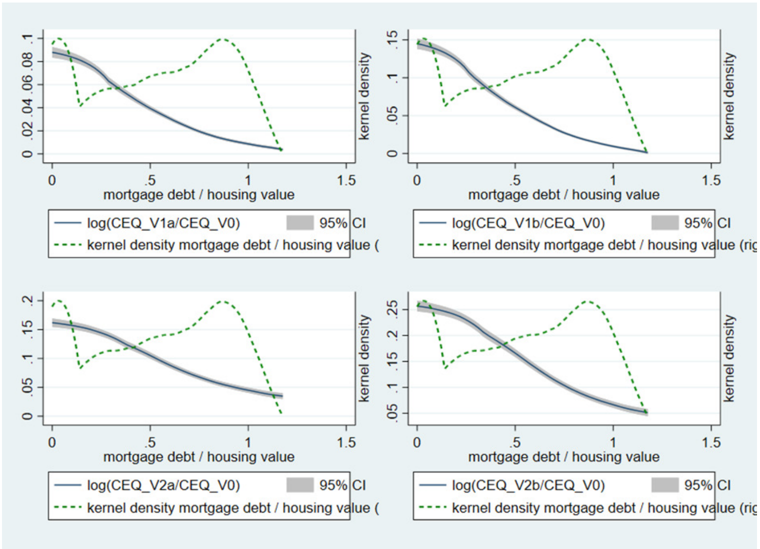


Figure 11. Welfare gains by pension accruals for $V1a$ (upper left), $V1b$ (upper right), $V2a$ (bottom left), $V2b$ (bottom right).

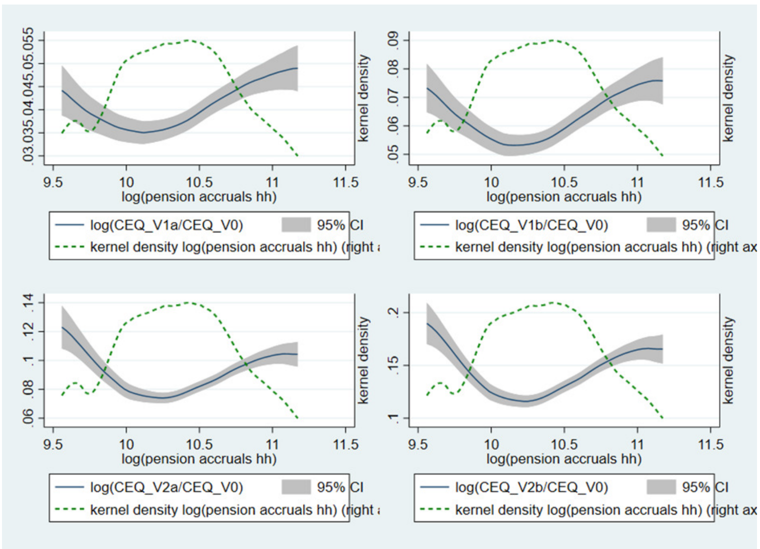
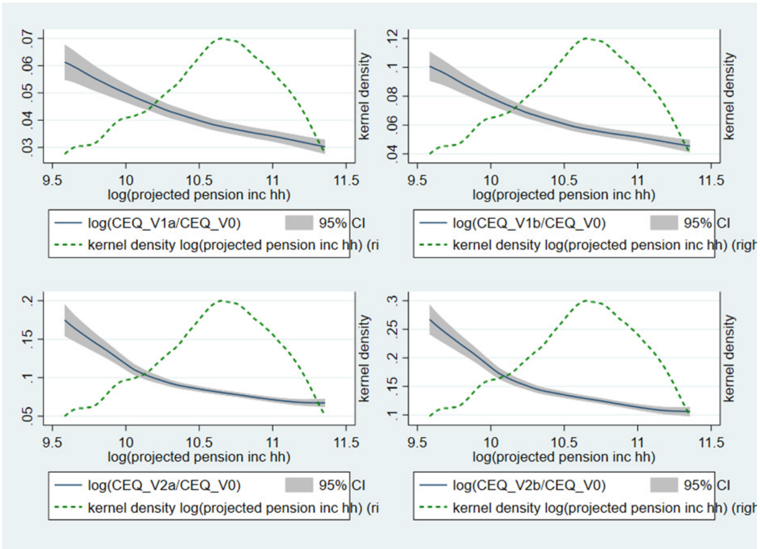


Figure 12. Welfare gains by projected pension income for $V1a$ (upper left), $V1b$ (upper right), $V2a$ (bottom left), $V2b$ (bottom right).



In Table 8 and Figures 7-12, we use welfare gains calculated with homogeneous preference parameters. However, the observed patterns are similar for (i) welfare gains calculated using homogeneous preferences for the sample with preference parameters ($N = 933$) and (ii) welfare gains calculated using heterogeneous preferences ($N = 933$). This is consistent with our observations in Table 4 and Figures 3a-3d which suggest that heterogeneous preferences add little extra variation in welfare gains.

F Welfare gains for households aged 30+

Table 9. Welfare effects (%) of $V1a - V2b$ ($N = 3,419$).

	$V1a$	$V1b$	$V2a$	$V2b$
Mean	4.5	7.2	10.2	16.9
Median	2.5	3.9	6.6	10.9
P25	0.9	1.2	3.3	5.3
P75	5.9	9.5	13.1	22.1

Table 10. Welfare effects (%) of $V1a - V2b$ with heterogeneous parameters ($N = 894$).

	$V1a$	$V1b$	$V2a$	$V2b$
Mean				
Heterogeneous	3.0	4.8	7.8	12.8
Homogeneous	3.3	5.2	8.0	13.1
Median				
Heterogeneous	2.1	3.2	5.5	9.1
Homogeneous	2.2	3.4	5.5	9.3
P25				
Heterogeneous	0.9	1.1	3.1	5.0
Homogeneous	1.0	1.3	3.2	5.1
P75				
Heterogeneous	4.2	6.7	9.4	16.0
Homogeneous	4.4	7.0	9.5	16.1

G Estimation results with and without (heterogeneous) preference parameters

Table 11. Estimation results of the welfare gains (fractions) by variant $V1a - V2b$, heterogeneous preference parameters.

	$V1a$	$V1b$	$V2a$	$V2b$
Female	0.000	0.002	-0.007	-0.007
	(0.002)	(0.003)	(0.008)	(0.009)
Immigrant (1st gen.)	0.003	0.003	0.002	0.003
	(0.006)	(0.006)	(0.010)	(0.011)
Immigrant (2nd gen.)	0.011	0.012	0.006	0.006
	(0.008)	(0.010)	(0.014)	(0.017)
Couple	0.011*	0.026***	-0.002	0.010
	(0.004)	(0.006)	(0.021)	(0.022)
Age	-0.001	-0.003*	-0.018	-0.021*
	(0.001)	(0.001)	(0.009)	(0.010)
Age sq.	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Number of children	0.000	0.000	0.004	0.005
	(0.001)	(0.001)	(0.004)	(0.004)
Gross HH inc. (log)	-0.028**	-0.040**	-0.046	-0.066*
	(0.009)	(0.011)	(0.024)	(0.026)
Housing value (log)	0.025***	0.048***	0.076***	0.128***
	(0.004)	(0.006)	(0.007)	(0.009)
LTV	-0.027**	-0.038**	-0.044**	-0.054**
	(0.005)	(0.007)	(0.012)	(0.015)
Pension accruals (log)	-0.027**	-0.054**	-0.050**	-0.072**
	(0.006)	(0.011)	(0.016)	(0.020)
Proj. pension inc. HH (log)	-0.002	-0.007	0.092	0.086
	(0.014)	(0.015)	(0.067)	(0.070)
Risk preference	0.002	0.001	0.005	0.006
	(0.001)	(0.002)	(0.003)	(0.004)
Time preference	0.001	-0.001	0.005	0.006
	(0.001)	(0.002)	(0.004)	(0.005)
Const.	0.136*	0.237**	0.334**	0.397**
	(0.068)	(0.079)	(0.109)	(0.127)
N	923	923	923	923
Adj. R-sq.	0.362	0.529	0.258	0.408

* Significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level. Robust standard errors are reported in parentheses.