Using Home Equity Release to Strengthen Retirement Incomes: Potential and Challenges*

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Abstract

Using comprehensive administrative data on Danish retirees' wealth, this paper documents how home-equity holdings vary across age, income, and wealth groups. We show—using simulated equity-extraction scenarios—that accessing home equity could substantially increase retirement replacement rates throughout the socioeconomic distribution. These findings suggest that policies facilitating home-equity extraction, such as expanded access to reverse mortgages, could meaningfully improve retirement liquidity, particularly for middle- and high-income households.

Keywords: Pensions, home equity, replacement rates, reverse mortgage

JEL Classification: H55, J26, R31

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1 Introduction

A key objective of a pension system is to prevent retirees from experiencing a decline in their standard of living after leaving the labour market. This goal is typically pursued through benefits provided by public pension schemes ("pillar 1") and payouts from occupational pension savings ("pillar 2"). Some retirees can also convert their accumulated wealth into annuitized income streams through private pension arrangements ("pillar 3"). Together, these mechanisms create a positive correlation between wealth and the ability to maintain pre-retirement living standards.

However, in practice, households typically face a significant drop in income at retirement, which can affect their standard of living. Mandatory pension schemes have replacement rates—defined as the ratio of (gross or net) income before and after retirement—of around 50% in OECD countries (OECD, 2022). Even though retirees generally require a lower income to maintain similar living standards due to reduced work- and family-related expenses (e.g., commuting, meals, childcare), such a decline can still have undesired effects on consumption choices. At the same time, evidence suggests that households' financial wealth remains relatively stable upon retirement, largely because a substantial share is held as home equity (Poterba et al., 2011a,b; Suari-Andreu et al., 2019).

Presumably, releasing this component of wealth could make a meaningful contribution to smoothing the transition from working life into retirement. Doing so would effectively transform housing wealth into a "pillar 4" of the pension system, providing a complementary financial resource that allows retirees to diversify their income sources and become more resilient to economic fluctuations.

Studies of housing wealth at retirement are often constrained by the lack of highly granular data. This paper seeks to fill this gap by providing new and more precise evidence on the resources available to households at retirement. Specifically, we draw on detailed information from the Danish income and wealth registers for the years 2014–2018. These data allow us to examine sources of income and wealth with an exceptionally high degree of accuracy.

Thanks to our dataset, we can assess the extent to which home equity can help sustain retirees'

purchasing power. More precisely, we measure (a) the net wealth composition of individuals across the age distribution and (b) how converting home equity into life annuities could affect replacement rates across income and wealth groups. Although our analysis focuses on Denmark, we believe that the data-driven insights are relevant for other countries characterized by high homeownership rates and ageing populations.

To the best of our knowledge, this is the first study to provide a data-driven analysis capable of measuring the effect of home equity on pension replacement rates and examining how this effect varies across socioeconomic groups. In contrast to other studies (e.g., Crawford and O'Dea, 2012; Knoef et al., 2016), we do not investigate how households save for retirement or whether these savings are sufficient to maintain purchasing power in old age. Instead, we assess whether—and to what extent—housing wealth can help prevent a decline in income at retirement.

Our findings suggest that releasing home equity can substantially support retirees' purchasing power, with the largest gains accruing to wealthier and higher-income households. While this pattern does not align with traditional distributional objectives, it could be mitigated by reducing public pension benefits for well-off retirees and reallocating the savings to those with greater need. In addition, substituting public transfers with home equity would reduce the wealth available for bequests, thereby limiting the intergenerational persistence of wealth inequality.

The remainder of the paper is structured as follows. Section II situates our contribution within the related literature and outlines the features of the Danish pension system most relevant to our analysis. Section III describes the data and provides an initial overview of the potential for home equity to support households' purchasing power. Section IV presents the main results based on a simple annuitization scheme, followed by a sensitivity analysis in Section V. Section VI concludes.

2 The Context of the Paper

Related Literature

This paper relates to the growing literature on the role of housing in ageing economies, which typically examines the welfare effects of releasing home equity at retirement. Several studies employ theoretical frameworks—such as life-cycle models with overlapping generations and heterogeneous agents (e.g., Cocco and Lopes, 2020; Nakajima and Telyukova, 2017, 2020; Been et al., 2022)—to highlight the importance of home production, work-related expenses, and publicly funded health-care expenditures. Other contributions document a negative correlation between elderly households' expenditures and their housing wealth (Doling and Elsinga, 2012; Delfani et al., 2014) and argue that releasing home equity can expand the purchasing power of the least well-off (Munnell et al., 2017).

There is also a strand of research suggesting that individuals are reluctant to release their home equity for consumption purposes (Venti and Wise, 2000; Fisher et al., 2007; Davidoff, 2009; Poterba et al., 2011a; French et al., 2018), even though doing so could help them avoid the high levels of precautionary saving implied by pension systems (Poterba, 2014). One explanation is that homeownership provides insurance against risks associated with ageing—such as widowhood, illness, and rent risk (Delfani et al., 2014; Addoum, 2017; Sinai and Souleles, 2005). Other studies highlight the role of behavioural barriers that discourage individuals from entering contracts such as reverse mortgages (Davidoff et al., 2017; Hanewald et al., 2020; Hanewald and Bateman, 2024).

The gap in the literature that this study seeks to fill is the lack of accurate measurement of home equity as a potential supplement to more conventional pension pay-outs. Our work is conducted in the spirit of Poterba et al. (2011a), who report the distribution of wealth in the United States based on a 2008 survey of households aged 65–69. They find that non-annuitized wealth accounts for roughly half of total wealth (54.1%). Moreover, their evidence shows that home equity represents a substantial share of non-annuitized net worth for households in this age group—31%

of non-annuitized wealth and 47.9% of all real estate.

Our contribution differs from Poterba et al. (2011a) in two important ways. First, our microdata covers the entire Danish population, allowing us to avoid well-known issues associated with survey data, such as self-selection, attrition, and misreporting. Second, their study does not examine how the role of home equity varies with individuals' wealth positions or pre-retirement incomes. As a result, it does not identify the extent to which payouts from home equity can compensate for the loss of purchasing power at retirement. In contrast, we provide evidence that focuses precisely on the potential role of housing wealth in a country where homeowners' equity represents a larger share of total wealth—about 39% in the overall population and 28% at retirement, compared with roughly 15% in the US.

It is worth noting that studies grounded in the life-cycle hypothesis have already provided empirical evidence on how households save for retirement. For example, Crawford and O'Dea (2012) and Knoef et al. (2016) examine how household heterogeneity shapes the distribution of savings across asset classes and assess the share of the population at risk of undersaving. Our study extends this literature by directly documenting how home equity—which represents a sizeable share of household wealth, far larger than liquid assets or other investments—can be used to sustain purchasing power at retirement.

The Danish Pension System

The Danish pension system follows the standard three-pillar model (World Bank, 1994). The first pillar consists of tax-financed, defined-benefit (DB) entitlements—including a basic flat-rate pension and means-tested supplements—operated on a pay-as-you-go (PAYG) basis. The second pillar is fully funded and comprises two components: (a) a compulsory labour-market supplementary pension to which all wage earners and recipients of transfer payments contribute, and (b) occupational pension schemes (OPs) established through employment contracts or collective agreements between social partners. The third pillar consists of flexible and voluntary individual

savings schemes arranged through banks and insurance companies.[1]

The Danish pension system has attracted considerable international attention for achieving broad coverage and adequate benefits while maintaining long-run fiscal sustainability.[2] These outcomes can be attributed primarily to the introduction of occupational pension (OP) schemes, complemented by an active reform agenda over recent decades. Notably, since 2006 an indexation mechanism has linked the statutory retirement age to changes in life expectancy. In the long run, this mechanism is designed to ensure that each cohort enjoys an expected remaining lifetime of 14.5 years after retirement (Jensen et al., 2021).

Ideally, a pension system should enable individuals to smooth consumption over their entire lifetime. For this to be feasible, pension pay-outs must bear a reasonable relation to individuals' pre-retirement income to avoid sharp declines in purchasing power at retirement. A useful summary measure is the replacement rate, defined as the ratio of pension income in retirement to pre-retirement disposable income.[3] A replacement rate below 100% is generally considered sufficient because consumption typically declines at retirement for several reasons (see, e.g., Agarwal et al., 2015). Work-related expenses such as commuting and meals away from home disappear, and many family-related costs—such as childcare or mortgage repayments—tend to be lower. However, there is no broad consensus on what constitutes an optimal replacement rate.[4]

Denmark has one of the highest average replacement rates among OECD countries (OECD, 2022).[5] It has, however, been documented that replacement rates are declining across the income

[1] Andersen et al. (2022) offers a thorough description of the Danish pension system as well as an in-depth analysis of its performance.

[2] The Mercer Pension Index, which evaluates pension systems worldwide, has consistently placed Denmark among the top three (see, e.g., Mercer, 2025).

[3] In Denmark, disposable income is calculated by summing all income sources (wages and salaries, transfers, pensions, dividend and interest income, rental income) and subtracting specific expenditures such as taxes, interest-rate expenses, and alimony.

[4] Schulz and Carrin (1972) suggest that a 70% replacement rate should be considered the benchmark. Dudel et al. (2016) estimate that, in Germany, about 86% of net income is required. This value may vary depending on household characteristics (Schmied, 2023). Fehr and Uhde (2013) show that even a replacement rate as low as 50% might be sufficient.

[5] A high replacement rate does not necessarily imply that overall living standards in retirement are higher in Denmark than in other countries. Rather, it should be understood as an indicator of the generosity of the Danish pension system, which reinforces the relevance of our findings. Countries like Denmark, which already exhibit high replacement rates, can benefit substantially from unlocking part of the resources currently tied up in the pension system and reallocating them to other areas of public expenditure.

distribution (Jensen and Hansen, 2022). In particular, the downward trend in replacement rates at higher income levels suggests that supplementing pension income with an additional source may be attractive for specific segments of retirees.[6]

3 Data

Definitions and Sources

To construct our measures of replacement rates and home equity, we use individual-level income and wealth data from the Danish Income Register and the Danish Wealth Register of Statistics Denmark for the years 2014–2018. This dataset enables us to examine variation in replacement rates across the wealth and income distribution with exceptionally high granularity.[7]

Specifically, we compute replacement rates as follows: we retain all individuals who were 65 years old in 2015 and calculate the ratio of their net income from pensions and transfers at age 68 (in 2018) to their average income at ages 57–59 (2007–2009).[8] We then refine the dataset by excluding individuals with very low or negative pre-retirement income, as well as retirees who may still have been employed—at least partially—at age 68. The final dataset contains 42,810 individuals.[9] Unfortunately, register data on wealth are only available from 2014 onward, which restricts our analysis to a single cohort of individuals.

The numerator of the replacement rate includes: (i) private pensions, defined as the sum of occupational pensions (second pillar) and private pensions (third pillar); (ii) public pensions, corresponding to the PAYG means-tested component (first pillar); and (iii) other public transfers to the elderly, which can be interpreted as income-support mechanisms that compensate for low

[6] It should be noted that the existence of an "optimal" replacement rate remains contested, and the literature reports different values depending on a range of underlying assumptions and household characteristics (see, for example, Heer, 2018).

[7] The Appendix contains more details on data sources and data definitions.

[8] The use of an average of years just prior to retirement is necessary to avoid possible jumps in income just ahead of retirement due to, for example, part-time and retirement anticipation schemes.

[9] A detailed explanation of this procedure and comparison between the different datasets are contained in the Appendix.

occupational-pension payouts.

The denominator, disposable income during the last five years before retirement, is defined as total earnings—including wages, public transfers, and the imputed rental value of owner-occupied housing—minus taxes, interest expenses, alimony payments, and similar deductions.

The fact that the replacement rate is based on income rather than consumption has important implications. As noted above, social security systems should not aim for a 100% replacement rate, since many expenses decline after retirement, effectively increasing retirees' purchasing power for other types of consumption. This means that the actual decline in retirees' living standards is smaller than what the replacement rate alone would suggest. Nevertheless, home equity extraction can still play a meaningful role in supporting retirees' expenditures and can serve as an alternative to government transfers.

In the paper we will discuss how replacement rates vary along with the distribution of wealth. This is defined as gross wealth, therefore including all liquid (including financial assets and bank liquidity) and illiquid (e.g., house, vehicles, and other equities). Given the relevance of housing wealth, it is worth having more detail on how these are calculated by Statistics Denmark. The starting point is the evaluation made from the Danish Property Assessment Authority (DPAA, in Danish, *Vurderingsstyrelsen*), which is then adjusted with market values imputed using sales statistics and the register of buildings and dwellings. The motivation for this adjustment is that the DPAA evaluates all Danish real estate properties for tax purposes, but these evaluations are less affected by economic and financial fluctuations compared to market prices. Consequently, Statistics Denmark adjusts housing wealth based on DSAA assessments with a market value approximation to fill the gap between estimated values and market values,[10] resulting in a measure of house wealth as close as possible to the one we could obtain by using the market value.[11]

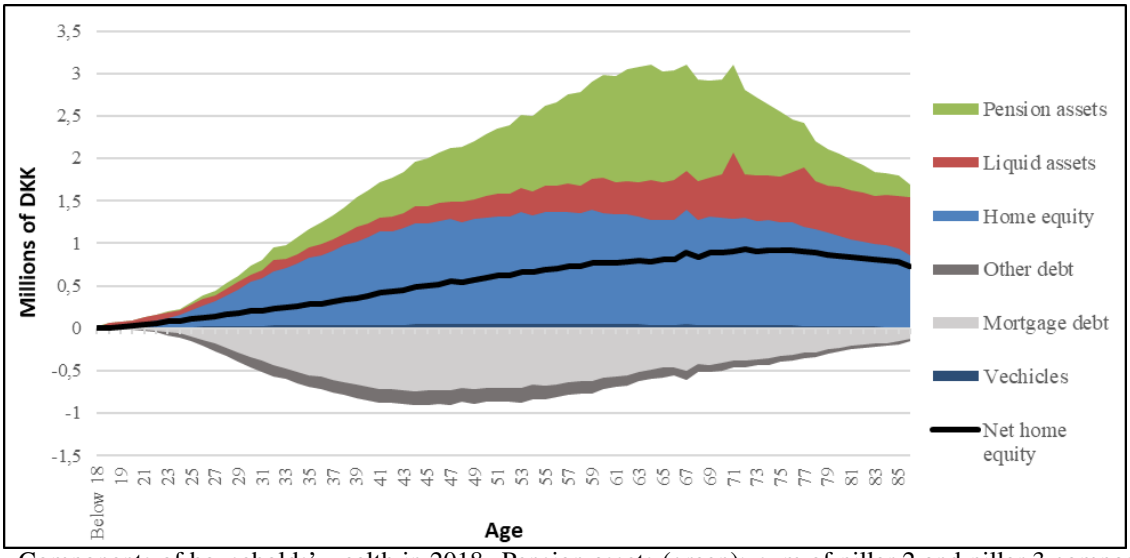
[10] Market prices are, in fact, non-existent for many properties, as it is revealed only when the house is sold.

[11] However, it is still possible that Statistics Denmark under- or overestimates property values. If this is the case, banks would not lend the exact amounts implied by our simulations, potentially limiting take-up to a certain share of the value reported by Statistics Denmark—for example, 80%. Even under such discrepancies, our main conclusions remain unchanged. Our analysis focuses on the potential for extracting housing equity to support consumption in retirement, and the implications of a lower take-up rate can be seen in our sensitivity analysis, where we simulate the effect of a reduction in available housing equity, which is equivalent to a lower feasible take-up.

Descriptive Patterns

In Denmark, housing makes up roughly 40% of total household wealth, falling to about 28% at retirement.[12] To zoom in on these aggregate values, Figure 1 displays the components of household wealth in 2018 for the Danish population across age.

Figure 1: The wealth components across different ages, 2018



Notes. Components of households' wealth in 2018. Pension assets (green): sum of pillar 2 and pillar 3 components; Liquid assets (red): financial assets and bank liquidity; Home equity (light blue): housing and shelters; Vehicles (dark blue): cars & others; Mortgage debt (light grey): debt related to a mortgage; Other debt (dark grey): any other loans of debt; Net equity (black line): Total assets minus total debt. All values are per household.
Source: Statistics Denmark.

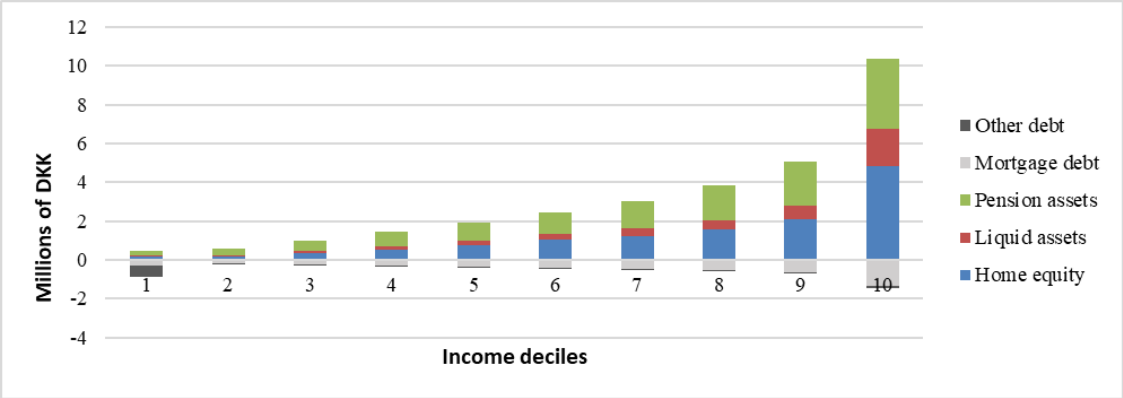
Consistent with the predictions of life-cycle models (see, e.g., Cocco et al., 2005), the cross-sectional data show that wealth rises across age cohorts until retirement and then declines. However—and this is central to our discussion—wealth does not fall during retirement to the extent one would expect if households behaved strictly according to the 'pure' life-cycle model. Specifically, while pension assets rise among younger cohorts and then decline rapidly once individuals enter retirement, home equity increases quickly early in life and subsequently stabilises, showing only a modest reduction in the oldest cohorts. Liquid assets, by contrast, begin to grow later in the life cycle and are the only asset class that increases steadily throughout the entire age

[12] This is a larger share than in the US where housing wealth represents about 15% of total wealth (see Poterba et al., 2011a).

distribution.

Debt exhibits a pattern like that of assets: it tends to rise among younger cohorts, remains relatively stable in middle-aged groups, and then declines in older cohorts. The combined effect of sustained accumulation of housing wealth and the gradual reduction in debt is that net home equity continues to increase well into older age. Given the central role of housing in total wealth, the correlation between home equity and total wealth is substantial: in 2015 it was 0.28 for the entire population and 0.65 at age 65. Moreover, higher-income elderly households hold larger amounts of home equity despite also carrying higher levels of debt (see Figure 2). This implies that wealth across all asset categories—as well as debt—rises with income deciles. After netting assets and liabilities, the pattern remains unchanged: wealthier elderly households hold the largest amounts of net housing wealth.

Figure 2: Average wealth of 65-year-olds in 2018 over income deciles

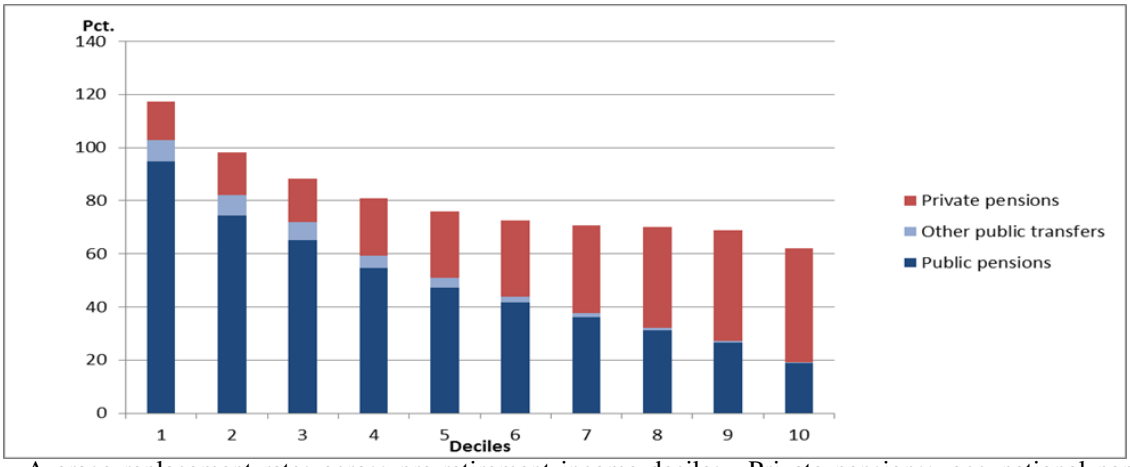


Notes. Components of households' wealth in 2018 over income deciles at 65 years. Pension assets (green): sum of pillar 2 and pillar 3 components; Liquid assets (red): financial assets and bank liquidity; Home equity (light blue): housing and shelters; Mortgage debt (light grey): debt related to a mortgage; Other debt (dark grey): any other loans of debt. All values are per household.
Source: Statistics Denmark.

Investigating how replacement rates vary with pre-retirement income and wealth is essential for identifying who stands to benefit most from releasing home equity. Figure 3 shows that replacement rates decline across the lower half of the pre-retirement income distribution (deciles 1–6) and then stabilise at around 70%. This pattern arises because, from the 6th decile onward, the growth in private pension savings offsets the reduction in public transfer payments and the public component

of pensions. As a result, the sharp decline in replacement rates that would occur if retirees relied solely on "pillar 1" benefits is substantially dampened.

Figure 3: Net replacement rates over the income deciles

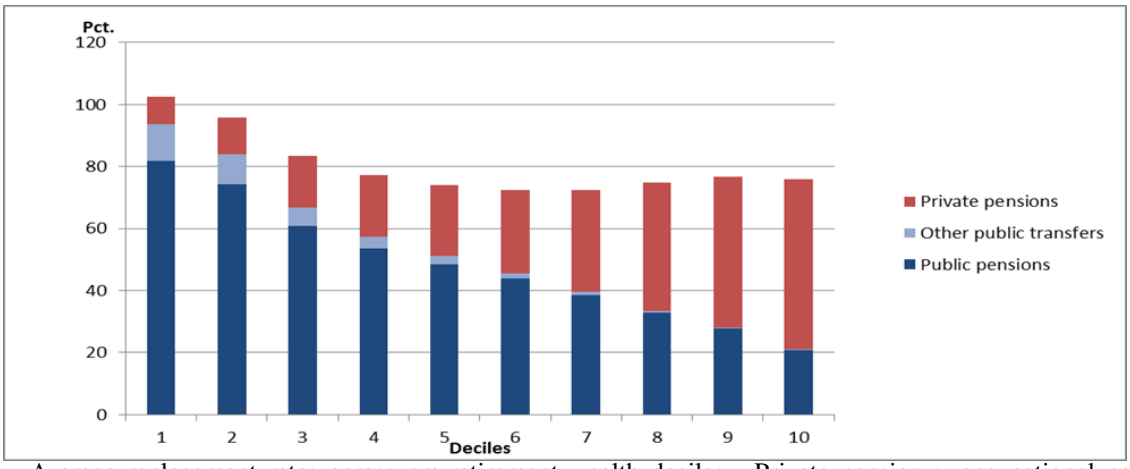


Notes. Average replacement rates across pre-retirement income deciles. Private pensions: occupational pensions (second pillar) + private pensions (third pillar); Public pensions: PAYG basic pension plus means-tested component (first pillar); Other public transfers: any transfer payment from the general government to the elderly (supplementary pension benefits). Replacement rates are computed as the ratio of the income of individuals as 68-year-olds to their average income from 57 to 59 years old. Individuals with a very low or negative income before retirement and retirees who might still have been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

We also examine how replacement rates vary across the wealth distribution. Figure 4 shows that, in this case, replacement rates follow a U-shaped pattern: they decline across the lower wealth deciles and then rise in the upper part of the distribution, with a marked acceleration in the highest deciles. The figure further indicates that the contribution of private pensions to replacement rates is larger in the top wealth deciles than in the corresponding income deciles.

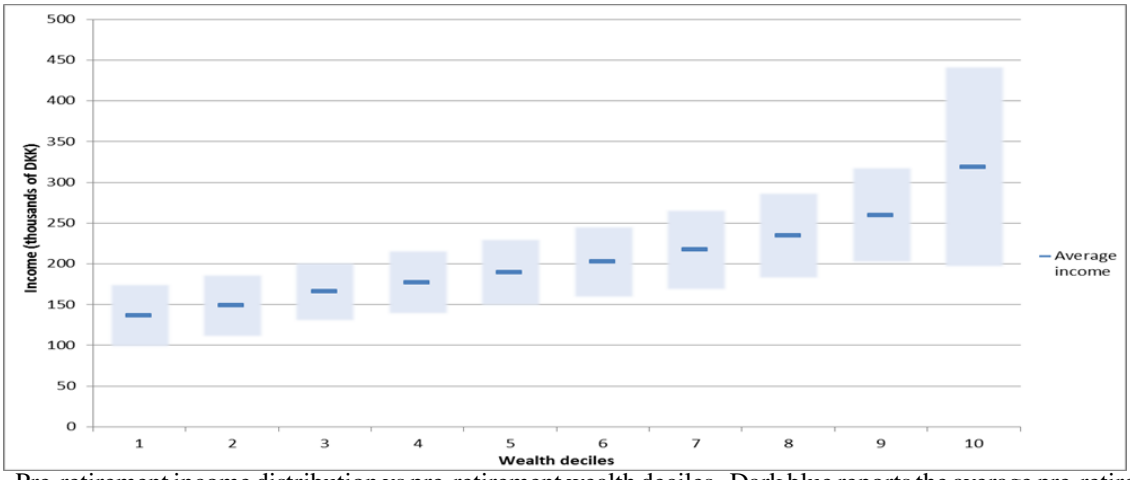
The different behaviour of replacement rates in the highest deciles of the wealth and income distributions may appear counter-intuitive at first, since one would generally expect a strong correspondence between higher incomes and greater wealth, given that wealth is often viewed as the cumulative outcome of lifetime saving. However, higher income is not the only pathway to higher wealth (Lusardi and Mitchell, 2007). This is consistent with the evidence in Figure 5, which shows that although disposable income rises with wealth, the relationship becomes noticeably weaker in the top decile.

Figure 4: Net replacement rates across wealth deciles



Notes. Average replacement rates across pre-retirement wealth deciles. Private pensions: occupational pension (second pillar) + private pension (third pillar); Public pensions: PAYG basic pensions plus means-tested component (first pillar); Other public transfers: any transfer payment from the general government to the elderly (supplementary pension benefits). Replacement rates are computed as the ratio of the income of individuals as 68-year-olds to their average income from 57–59 years old. Individuals with a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

Figure 5: The distribution of income over the wealth deciles



Notes. Pre-retirement income distribution vs pre-retirement wealth deciles. Dark blue reports the average pre-retirement income (from 57 to 59 years old) of the pre-retirement wealth decile, while light blue squares are the standard deviations. Individuals with a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

4 Housing Payoffs and Replacement Rates

The Annuitization Scheme

To formally discuss the role of housing wealth as a pension device, we need to define an annuitization scheme.[13] In our simple scheme each individual, p, receives in every period a fraction c of the net home equity at retirement $H_i^{eq,p}$ (equal to the gross home equity minus the debt secured against the house) equal to:

$$c^p = \frac{H_i^{eq,p}}{\sum_{t=i}^{T} s_t (1+R)^t} \tag{1}$$

R is the interest rate, taken as exogenously given, t as the time when individuals receive the payments, with $t = i$ being the age of retirement and $t = T$ being the expected time of death,[14] s_t the probability of survival to age t. It is worth noting that in this model, higher interest rates result in lower pay-outs.

This scheme relies on several assumptions, some of which will be relaxed with a "ceteris paribus" approach in the sensitivity analysis section. First, we assume $H_i^{eq,p}$ is exogenous and, consequently, the house's market value does not fluctuate. Otherwise, this would impact net home equity and, therefore, pay-outs.[15] Also, we decided to use a conservative definition of the debt secured against the house, as its perimeter includes all the loans secured against the house, which includes other elements in addition to mortgage debt.[16]

Second, since the survival probability of individuals is unobserved, at the aggregate level we used the expected years-to-death obtained using the 5-year mortality table from Statistics Denmark (HISB9). This gives us an average remaining lifetime at 65 of 18.9 years—which we round up to 20

[13] Because we adopt a standard definition to derive the annuitizations, here we present the main features of our model and discuss the most relevant assumptions. Its derivation is reported in Appendix C.

[14] In other words, the individual p has a life expectation T.

[15] This assumption will be relaxed in the sensitivity analysis of the model, where we assume that house prices and, thus, home equity, display a fall of about 18%. This is equivalent to the fall that Danish house prices experienced during the 2008 financial crisis.

[16] For example, debt includes the estimated value of taxes on income and wealth which are secured against the house.

years.[17] Third, we assume that the markets are competitive and complete, and that the no-arbitrage condition holds. Thus, the price of the loan will equal the marginal cost, which is the market interest rate, which is set to zero in our baseline, in line with the prevalent interest rate in the last decade.

Finally, we assume that home equity can be effectively released through a scheme allowing individuals to convert $H_i^{eq,p}$ into annuities, and that individuals release their home equity in full at retirement by transferring all their home equity to another subject.

Our annuitization scheme can therefore be viewed as a simplified form of a reverse mortgage, such as the American Home Equity Conversion Mortgage for Seniors (HECM). In a reverse mortgage, the household retains ownership of the home but effectively sells its future housing equity to borrow funds from a lender, typically a bank. The loan can be disbursed either as an annuity or as a lump-sum payment. Regardless of the disbursement type, there is no repayment of principal or interest during the homeowner's lifetime; instead, the loan is settled with the value of the house when the owners die or move out.

Addressing Income and Wealth Distribution

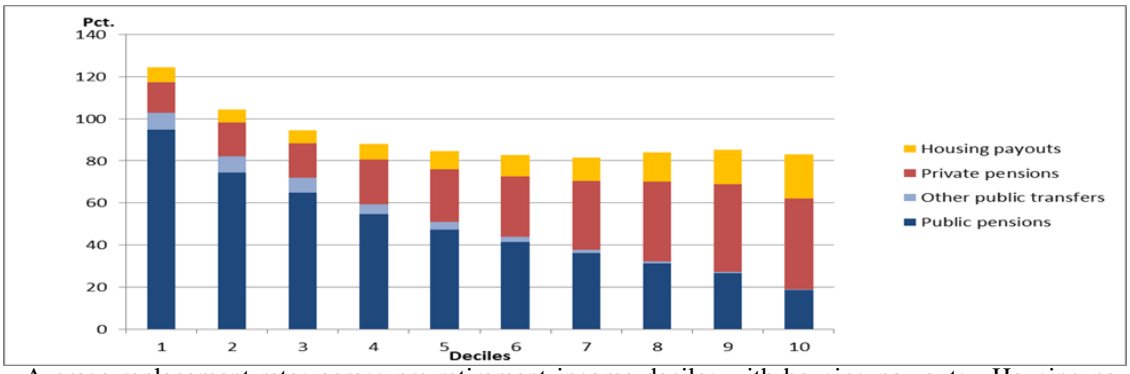
We simulate the pay-outs of housing equity with the scheme described above and add this new income stream to what we have presented in Section III. Figure 6 reports the results of this experiment.

We then examine how the distribution of replacement rates changes across wealth deciles once housing income is included (see Figure 7). In this case, replacement rates rise substantially for most of the population, with the effect being even more pronounced for the wealthiest households than for the highest earners.

Table 1 summarises this pattern by comparing the increase in replacement rates due to home equity across wealth and income deciles. The effect of home equity on replacement rates rises monotonically with wealth, while along the income distribution it declines up to the third decile and

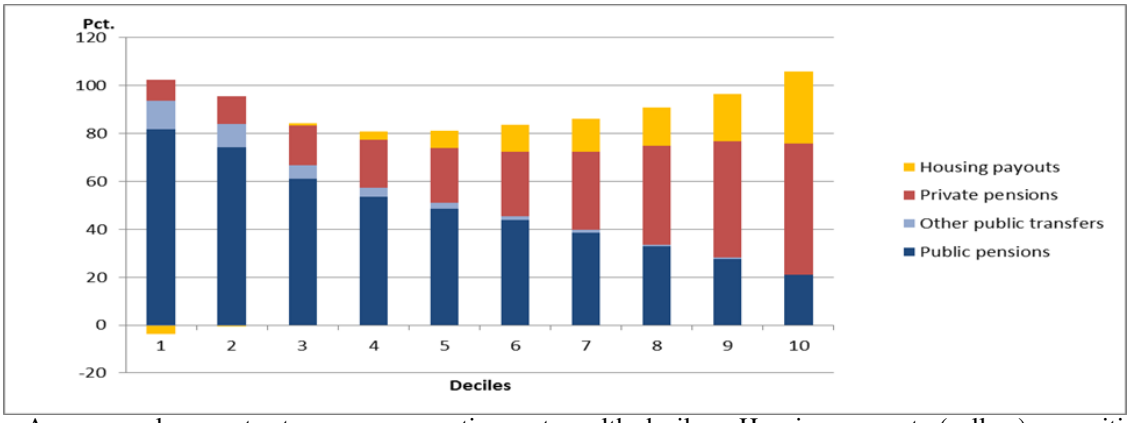
[17] This rounding is not strictly necessary, but like the use of mortgage debt instead of secured loans, it will produce more conservative estimates while creating more intuitive estimates compared to the population average of 18.9.

Figure 6: Net replacement rates over the income deciles—including housing



Notes. Average replacement rates across pre-retirement income deciles with housing pay-outs. Housing pay-outs: annuitization of housing equity based on Equation (1); Private pensions: occupational pension (second pillar) + private pension (third pillar); Public pensions: PAYG basic and means-tested components (first pillar); Other public transfer (light blue): any transfer payment from the general government to the individual received. Replacement rates are computed as the ratio of the income of individuals as 68-year-olds to their average income from 57–59 years old. Individuals that have a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

Figure 7: Net replacement rates over the wealth deciles—including housing



Notes. Average replacement rates across pre-retirement wealth deciles. Housing pay-outs (yellow): annuitization of housing equity according to Equation (1); Private pensions (red): occupational pension (second pillar) + private pension (third pillar); Public pensions (dark blue): PAYG means tested component (first pillar, coinciding with the Danish concept of "Offentlige pensioner"); Other public transfer (light blue): any transfer from the general government the individual received (zero pillar, coinciding with the Danish concept of "Øvrige overførsler"). Replacement rates are computed as the ratio between the income of individuals as 68-year-olds with their average income from 57–59 years old. Individuals that have a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

increases thereafter. Moreover, the growth observed across wealth deciles is substantially larger than the variation across income deciles.

Table 1: Effect of housing pay-outs on replacement rates over income and wealth deciles

Deciles	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Effect over income	7.04%	6.30%	6.13%	7.29%	8.43%	10.00%	11.11%	13.76%	16.52%	21.27%
Effect over wealth	-3.62%	-0.61%	0.79%	3.72%	7.21%	11.19%	13.86%	15.84%	19.84%	30.09%

Notes. Change in replacement rates due to housing pay-outs over pre-retirement income and wealth deciles. Housing pay-outs are the annuitization of housing equity according to Equation (1); Replacement rates are computed as the ratio between the income of individuals as 68-year-olds with their average income from 57–59 years old. Individuals that have a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

This pattern reflects the strong link between total wealth and housing. Because housing wealth accounts for a large share of overall wealth, individuals with low or negative home equity tend to appear at the bottom of the wealth distribution. The same does not necessarily hold for income: low-income individuals may still possess substantial housing wealth, for example through inheritance. As a result, when we examine income and wealth distributions separately, the retirees who benefit most from releasing home equity are those at the bottom and top of the income distribution and those at the top of the wealth distribution.

5 Checking the Sensitivity of Individuals' Home Equity

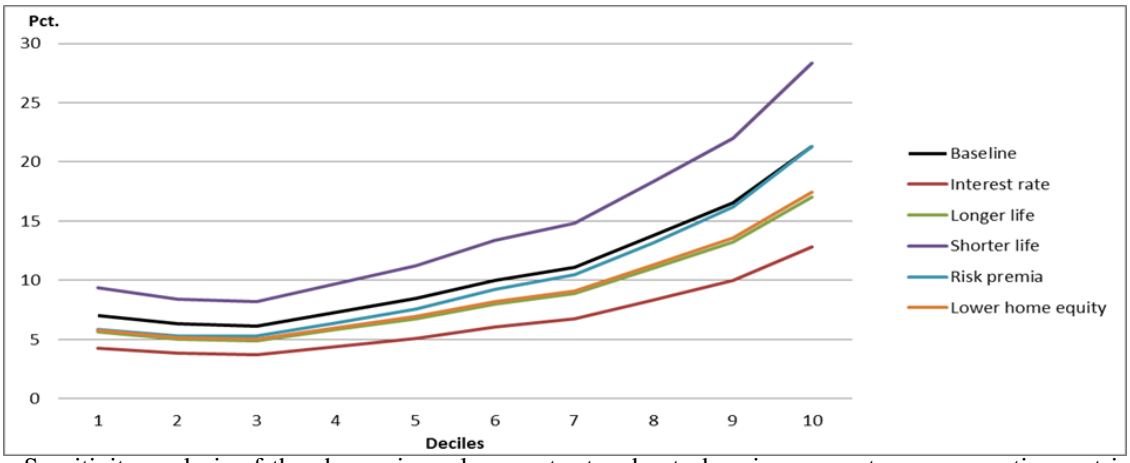
The measurement of housing pay-outs is subject to considerable uncertainty, owing to the wide range of factors that influence potential outcomes. The most significant of these include interest rates, house price fluctuations, changes in rules governing reverse mortgages, demographics, changes in tax rules (on income, pension, housing, wealth, bequests etc.) and changes in individuals' risk profile.

In this section, we assess the role of key variables in determining the pay-outs that home equity can provide at retirement. To do so, we vary the calibration of the following parameters: 1) the level of interest rates; 2) the length of remaining life at retirement age; 3) the invariability of interest

rates to individuals' income and wealth; and 4) the level of housing equity.

The results of these experiments are presented in Figures 8 and 9. As in Table 1, the figures illustrate the effect of housing pay-outs on replacement rates across income deciles (Figure 8) and wealth deciles (Figure 9) under six alternative calibrations of the model. These include: the baseline specification (black line); an interest rate set equal to the historical average of the 10-year Danish sovereign yield, approximately 4.8% (red line); life expectancy at retirement fixed at 25 years (green line) and 15 years (purple line); the introduction of a risk premium, implemented as a 0.2-percentage-point increase in interest rates for each lower income or wealth decile (light blue line); and an 18% reduction in housing equity, corresponding to the decline observed during the 2008 financial crisis from peak to trough (orange line).[18]

Figure 8: Sensitivity of housing pay-outs along income deciles



Notes. Sensitivity analysis of the change in replacement rates due to housing pay-outs over pre-retirement income deciles. Baseline (black): Housing pay-outs based on Equation (1) where individuals annuitize their home in full over a period of 20 years and with a 0% interest rate; Interest rate (red): interest rate is set to 4.8%, the historical average of 10 years Danish sovereign yield; Longer life (green): life expectancy at retirement of 25 years; Shorter life (purple): life expectancy at retirement of 15 years; Risk premia (light blue): presence of a risk premium consisting of an increase in interest rates of 0.2% for each lower decile in income; Lower home equity (orange): home equity is reduced by 18%. Replacement rates are computed as the ratio of the income of individuals as 68-year-olds to their average income from 57–59 years old. Individuals that have a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

Figure 8 shows that changes in the model's assumptions affect both the level of the housing pay-out contribution to replacement rates and its slope across income deciles. Relative to the baseline,

[18] Another interpretation of this is that the maximum take-up of mortgage loans is reduced to about 80%.

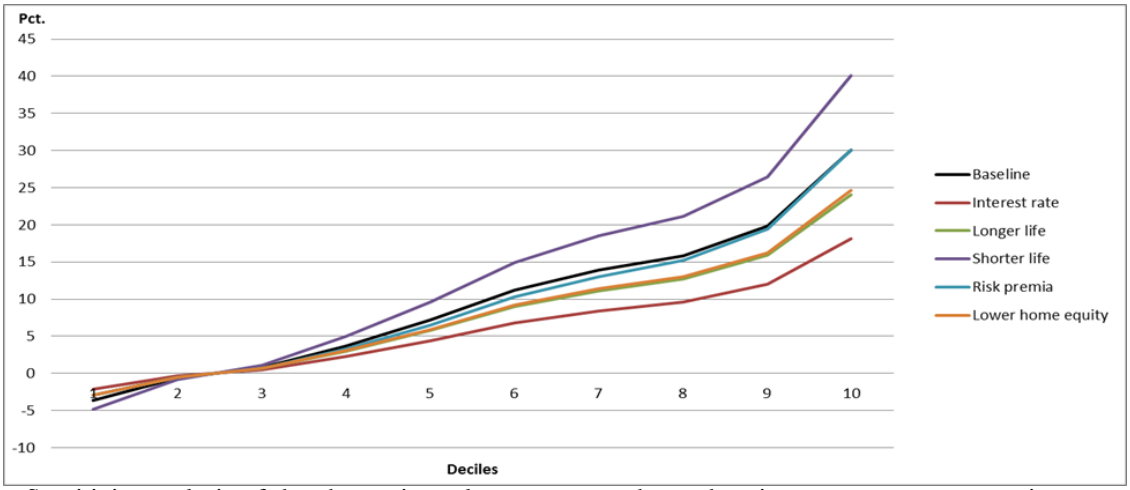
higher interest rates, lower housing equity, and longer remaining life expectancy all reduce the size of the housing pay-out and dampen its growth across the income distribution. This occurs because, all else equal, annual payments decline when housing equity falls—either directly through a price shock or indirectly through higher interest rates that increase the discount factor of the payment stream. Payments also decline when the same equity and interest rate levels must be spread over a longer horizon. The reduction is more pronounced at higher income levels, as it is proportional to the amount of housing equity held, which increases with income.

Symmetrically to the longer-life scenario, a shorter remaining life expectancy increases both the level of annuity payments and the slope of the curve. Finally, the introduction of a risk premium—linked to individual income—does not affect the benefits of the highest income decile but amplifies the reduction for lower-income groups. This occurs because the highest decile faces no increase in the interest rate, as its risk premium is assumed to be zero. Moving down the income distribution, the risk premium rises, leading to progressively lower benefits.

As Figure 9 shows, the effect of housing equity on replacement rates across wealth deciles closely mirrors the patterns observed for income deciles. Beyond the third decile of the wealth distribution, higher interest rates, lower housing equity, and longer remaining life expectancy all reduce the size of the housing pay-out contribution and flatten its growth relative to the baseline. Conversely, a shorter life expectancy increases both the level of the contribution and the slope of the curve. The introduction of risk premia affects only the slope, as the premium varies across wealth deciles but does not alter the baseline level of housing equity.

However, these effects become negligible for the second decile of the wealth distribution, while they reverse for the first decile: a reduction in life expectancy at retirement leads to the largest decline in the replacement rate, whereas an increase in interest rates produces only a modest negative effect. This pattern arises because individuals in the first wealth decile, on average, hold negative housing equity—that is, they still carry housing debt. A shorter remaining life expectancy therefore reduces their income, as the outstanding debt must be repaid over a shorter horizon. By contrast, an increase in interest rates mitigates the decline in income, since it raises the discount

Figure 9: Sensitivity of housing pay-outs along wealth deciles



Notes. Sensitivity analysis of the change in replacement rates due to housing pay-outs over pre-retirement wealth deciles. Baseline (black): Housing pay-outs based on Equation (1) where individuals annuitize their home in full over a period of 20 years and with a 0% interest rate; Interest rate (red): interest rate is set to 4.8%, the historical average of 10 years Danish sovereign yield; Longer life (green): life expectancy at retirement of 25 years; Shorter life (purple): life expectancy at retirement of 15 years; Risk premia (light blue): presence of a risk premium consisting in an increase of the interest rates of 0.2% for each lower decile in wealth; Lower home equity (orange): home equity is reduced by 18%. Replacement rates are computed as the ratio of the income of individuals as 68-year-olds to their average income from 57–59 years old. Individuals that have a very low or negative income before retirement and retirees who might have still been employed, even partially, at the age of 68, have been excluded. The final dataset consists of a total of 42,810 individuals.
Source: Statistics Denmark.

factor applied to the stream of outgoing payments.

6 Concluding Remarks

Population ageing poses significant challenges to pension systems in industrialised countries. These challenges are typically addressed through pension reforms, such as increasing the role of privately funded schemes or adjusting the retirement age in line with longevity trends. At the same time, older individuals often hold substantial amounts of non-annuitized wealth, particularly in the form of home equity. If part of this equity can be converted into income during retirement, individuals may be able to improve their standard of living in old age.

In this paper, we have examined the potential effects of introducing a reverse-mortgage-type mechanism on retirees' replacement rates. Our analysis draws on a novel income and wealth

database, which provides high-granularity information on the composition of households' resources. Using these data, we simulated the impact of housing equity on replacement rates through a simple modelling framework.

Our analysis yields several key findings. First, consistent with evidence from the US (Poterba et al., 2011a), we find that housing represents the largest component of wealth for the median Danish individual. Second, we show that households around the median of the wealth distribution exhibit the lowest replacement rates, indicating that they experience the greatest decline in purchasing power upon retirement. Third, we document that replacement rates fall sharply in the lowest income deciles and then stabilise further up the distribution, reflecting the increasing importance of private pensions and other capital income at higher income levels.

Finally, we find that housing pay-outs do not affect replacement rates uniformly across the population. Housing pay-outs do not increase monotonically with income, implying that individuals at the extremes of the income distribution—both low and high earners—may benefit more from such a mechanism than those closer to the median. By contrast, housing pay-outs do increase monotonically with wealth, indicating that the poorest segments of the population are unable to extract equity from their homes.

The overarching policy implication of this study is that housing pay-outs can serve as a useful instrument for sustaining the purchasing power of specific groups of retirees. This mechanism appears particularly relevant for low- to middle-income individuals situated around the median of the wealth distribution. However, our results also indicate that individuals at the top of the income and wealth distributions ultimately benefit the most from the release of home equity.

Therefore, the home equity extraction can sustain the purchasing power of those retirees who usually lose a large share of their income at retirement, helping them to smooth such a reduction. The increase in inequality that this would generate can be offset by lowering the level of public pensions allocated to these retirees. In other words, the extraction of home equity would allow a faster reduction of public pensions across wealth deciles. In this way, housing would become the fourth pillar of the pension system, raising the purchasing power of all retirees, allowing the public

system to focus more on sustaining the poorest segments of the population.

The potential pay-outs from housing wealth are sizeable, amounting to roughly 1.5% of GDP in recent years. If extracted in full, they would represent a meaningful increase in retirees' expenditure capacity. However, such a release of housing equity would also generate significant general-equilibrium effects, including upward pressure on housing prices and interest rates, reduced savings in other retirement schemes, and increased systemic risk. These broader macroeconomic implications lie beyond the scope of the present analysis.

This paper highlights only one of the many dimensions of housing-wealth distribution that merit further investigation in order to fully understand who stands to benefit from equity-extraction mechanisms. Housing wealth may vary substantially across locations—for example, being higher in urban areas and lower in rural regions—as well as across educational groups or between genders. More importantly, our analysis leaves open several questions regarding the design of equity-extraction mechanisms and the ways in which the ability to draw on home equity might influence retirees' portfolio choices. Although these issues lie beyond the scope of the present study, they represent promising avenues for future research.

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Appendix A: Data Definition

The following table details the definition of the data employed in the paper, including sources and granularity.

Table 2: Data Definitions and Sources

Variable	Definition	Source and granularity
Income (and its components)	Disposable income: the total amount of earnings (including public transfers, e.g., pensions, and the rental value of own house) minus taxes, interest rate expenses, alimony, etc.	Denmark Statistics, individual level
Wealth (and its components)	Wealth is defined as gross wealth.	Denmark Statistics, individual level
Debt (and its components)	Debt is defined as debt wealth.	Denmark Statistics, individual level
House wealth, $H_i^{w,p}$	A value imputed by Statistics Danmark, which is a weighted average between the values estimated by the Danish Property Assessment Authority and the market price.	Denmark Statistics, individual level
House debt, $H_i^{d,p}$	The total value of debt that has the house as collateral.	Denmark Statistics, individual level
Home equity, $H_i^{eq,p}$	$H_i^{w,p}$ minus $H_i^{d,p}$.	Own calculation on data from Denmark Statistics, individual level
Replacement rates	The replacement rates are calculated as the ratio between the income from pension (total or broken into components) at retirement (68 years in 2018) and the average income from 57–59 years old (that is, in years 2007–2009) for the same individual.	Own calculation on data from Denmark Statistics, individual level

Appendix B: A Comparison Between the Raw and the Cleaned Datasets

We compute the replacement rate in the following way: we retain all individuals who were 65 years old in 2015 and divide their incomes as 68-year-olds (i.e., in 2018) with their average incomes from 57–59 years old (2007–2009). The latter step is performed by matching data on income with data on wealth. To exclude retirees who might have still been employed, even partially, at the age of 68, we only retain individuals who did not get any remuneration, working income, income from their firm, or unemployment benefits in 2018. After these adjustments, our dataset consists of 45,064 individuals.

The distribution of replacement rate suffers from the presence of outliers because some individuals have a very low or negative income before retirement. This results in very large replacement rates, which can become asymptotically infinite and negative replacement rates.

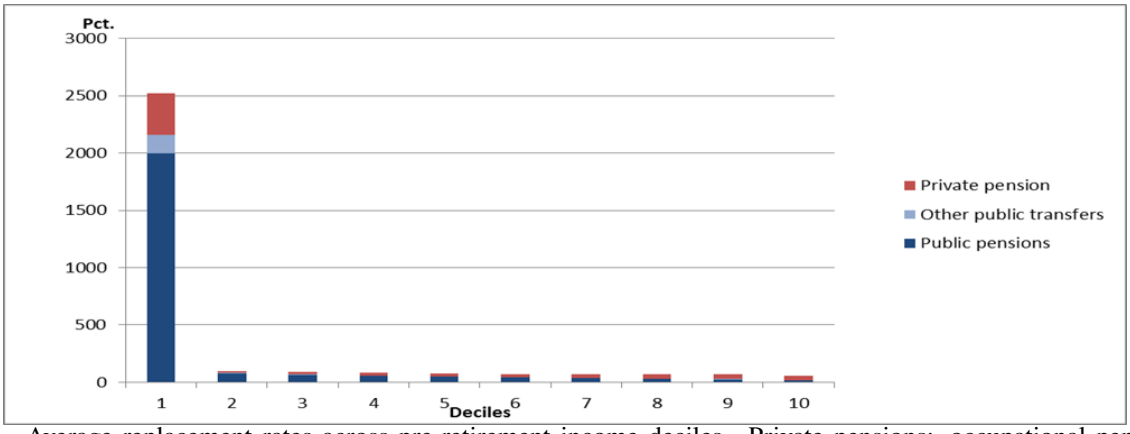
Figure A.1 presents the results when we exclude negative and zero pre-retirement income. The net replacement rates are falling as income gets higher. Indeed, the replacement rate in the first decile is very large and off-scale compared to all other deciles because of the presence of individuals with a close-to-zero pre-retirement income. This is also confirmed by the fact that the transfer from the public pension scheme is the largest driver of these results.

The presence of these outliers may bias our inference: therefore, we remove them from the dataset by excluding the 5% of extreme observations—i.e., we removed the top and bottom 2.5% of replacement rates values. In this way, we filter out unreliable observations while preserving a meaningful dataset.[19]

After these adjustments, our dataset consists of 42,810 individuals. The difference in replacement rates between the raw and the trimmed datasets is reported in Table A.1: the estimated average replacement rates differ only marginally—the exceptions being in the first and the last deciles as

[19] As a robustness check, we performed the same procedure on each decile, and then aggregated the data. Results available upon request.

Figure 10: Net replacement rates over the income deciles



Notes. Average replacement rates across pre-retirement income deciles. Private pensions: occupational pensions (second pillar) + private pensions (third pillar); Public pensions: PAYG basic pension plus means-tested component (first pillar); Other public transfers: any transfer payment from the general government to the elderly (supplementary pension benefits). Replacement rates are computed as the ratio of the income of individuals as 68-year-olds to their average income from 57 to 59 years old. The final dataset consists of a total of 45,064 individuals.
Source: Statistics Denmark.

expected. This is reassuring for the robustness of our inferences.

Table 3: Net replacement rates across income deciles before and after removing outliers

Dataset	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Entire Dataset	2795.10	105.96	95.36	88.51	84.92	82.59	82.72	82.83	84.18	81.64
Excluding Outliers	125.30	105.31	95.19	88.84	85.31	82.87	82.02	83.27	84.51	83.07

Notes. Average replacement rates across pre-retirement income deciles in the full dataset and the dataset polished of outliers.
Source: Statistics Denmark.

Appendix C: Conceptualizing Home Equity

This Appendix presents the derivation of our annuitization scheme. To discuss the role of housing wealth as a pension device, we need to define the concept of net home equity. Defining $H_i^{w,p}$ as the *market* value of the house (or gross home equity) and $H_i^{db,p}$ as the loans secured against it the p-th individual, then at the time of retirement i the net home equity $H_i^{eq,p}$ is given by:

$$H_i^{eq,p} = H_i^{w,p} - H_i^{db,p} \tag{2}$$

The net home equity is the principal of a payment stream over the remaining lifetime, where each payment, c, is discounted by an interest rate, R, taken as exogenously given. Individuals withdraw the equity just before retirement, i.e., they receive interest on the first payment. Then, defining t as the time when individuals receive the payments, with $t = 0$ being the age of retirement and $t = T$ being the expected time of death s_t the probability of survival to age t, and under no-arbitrage conditions, they will receive the following payments stream:

$$H_i^{eq,p} = c\, s_{T-i}(1+R)^{T-i} + c\, s_{T-i-1}(1+R)^{T-i-1} + \cdots + c\, s_2(1+R)^2 + c\, s_1(1+R) \tag{3}$$

Thus, the payment c that each individual will obtain in each period can be defined as:

$$c = \frac{H_i^{eq,p}}{\alpha} \tag{4}$$

where

$$\alpha = \frac{1}{\sum_{t=i}^{T} s_t(1+R)^t} \tag{5}$$

At the aggregate level, we estimate the pay-outs at time t as:

$$PH_t = \sum_{i=0}^{t} 1_{[E[L_i]<t-i]} \frac{1}{\alpha_i} \left(S_i^{eq} H_i^{eq}\right) \tag{6}$$

where PH_t denotes pay-out in housing at time t, $E[L_i]$ is the average life expectancy for an individual who is about to retire at the time i, α_i is the α at the time i, calculated with the annuity formula, S_i^{eq} is the share of net home equity for those who retire at time i, H_i^{eq} is the amount of net home equity in the economy at time i. In what follows, we will interchangeably use the terms net home equity and home equity.

Appendix D: Housing Wealth as a Share of GDP

To get a feel for how much a release of home equity would matter relative to the total economy, we ran simulations on DREAM ("Danish Rational Economic Agents Model"), which is a dynamic general equilibrium model for the Danish economy. DREAM is widely used in analyses of medium-to-long-term consequences of economic policy on the Danish economy. The model features overlapping generations of households that plan their behaviour in a way consistent with rational expectations.

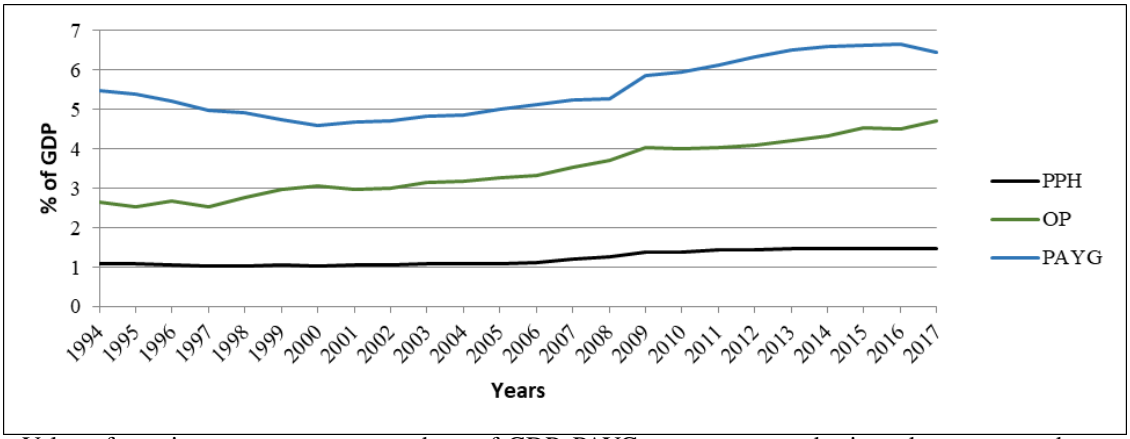
Figure D.1 shows that the potential pay-outs of housing wealth are sizeable, though not as large as the occupational pension (OP) scheme and the pay-as-you-go (PAYG) scheme. Specifically, over the period 1994–2017, it would have amounted to a share of about 1% of GDP in the first decade, increasing to about 1.5% in recent years.[20]

If such amount is translated into income, it will make a significant contribution to sustain consumption and, therefore, it will potentially have a major impact on the economy.

This increase in expenditure capacity may well have considerable general equilibrium effects, including an upward pressure on housing prices and interest rates, a reduction of savings in other retirement schemes, an increase in systemic risk, etc. Despite being highly relevant, studying these effects are beyond the aim of this paper and is referred to as future research. Instead, our focus is on understanding how the transformation of home equity into income affects the specific retiree and which retirees benefit the most from transforming housing into a pension device.

[20]To estimate the potential of transforming housing wealth into a pension device, we assume that the distribution of home equity across generations is stable over time. This is a crucial assumption since this type of reform is a drawn-out process, namely about 15 years corresponding to the expected lifetime at retirement. Therefore, we assume that the people at retirement constantly own 2.36% of total home equity, which is the average amount owned in the period 2014–2018 by households at 65 years old.

Figure 11: The composition of pension benefits (as share of GDP), 1994–2020.



Notes. Value of pensions components as a share of GDP. PAYG: pay-as-you-go basic and means-tested component (pillar 1); OP: occupational pensions; PPH: potential pay-outs based on housing wealth. Data are obtained with simulations of a dynamic general equilibrium model for the Danish economy, DREAM ("Danish Rational Economic Agents Model"), which features overlapping generations of households that plan their behaviour in a way consistent with rational expectations.
Source: DREAM.