Retirement Consumption and Pension Design

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July 18, 2021

Abstract

This paper develops and implements a framework that leverages consumption data to evaluate the welfare effects of pension reforms. Several countries have reformed their pension profiles to incentivize later retirement. Using administrative data in Sweden, we find that such pension reforms entail substantial consumption smoothing costs. On average, individuals retiring later have higher consumption levels than those retiring earlier, implying that recent pension reforms redistributed from low- to high-consumption households. We show that the differences in retirement consumption are mostly driven by differential changes in consumption around retirement, and also that the marginal propensities to consume are the lowest for late retirees. Accounting for selection on health and life expectancy further increases the redistributive cost of recent reforms. The cost of incentivizing later retirement is, however, lowest between the early and normal retirement age, where we document a striking non-monotonicity in consumption levels. We find similar patterns in consumption data from other countries, including the non-monotonicity, suggesting our findings are not unique to Sweden.

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¶We thank Richard Blundell, Peter Diamond, Eric French, Francois Gerard, Xavier Jaravel, Atilla Lindner, Petra Persson and seminar participants at Bonn University, CEPR, Gothenburg University, IFS, LSE, NYU, Stanford University, UC Berkeley, UPenn for helpful discussions and suggestions. We also thank Marion Brouard, Juliette Caucheteux, Henriette Druba, Sebastian Ernst, Miguel Fajardo-Steinhauser, Alice Lapeyre, and Quirin Von Blomberg for outstanding research assistance. We gratefully acknowledge support from ERC grants #679704 and #716485.

1 Introduction

Many countries have undertaken large reforms to their public pension systems over the past two decades, and more seem likely to follow suit in the near future. These reforms are perhaps the most substantial reforms to social insurance policy in the developed world over the last 20 years. Public discussion of pension reforms largely focused on restoring fiscal sustainability in light of ageing populations, and a common theme of the reforms taken in most countries has been to induce workers to retire later (see e.g. OECD [2019], Barr and Diamond [2009]). That is, in addition to reducing the generosity of public pensions generally, reforms in many countries – Austria, Belgium, Canada, Denmark, France, Germany, Spain, Sweden, the UK, and possibly others – have introduced or strengthened incentives favoring longer working lives.[1] Such incentives have desirable fiscal effects – workers who retire later pay more tax – but the welfare cost of incentives for later retirement are less well understood.

This paper proposes a framework to analyze the welfare effects of pension reforms that incentivize later retirement, holding the overall spending on public pensions fixed. We thereby separate conceptually thorny questions about the overall generosity of pensions and whether they are funded or pay-as-you-go, about which much has been written, from the question of how pension benefits should vary with the timing of retirement, about which comparatively little has been written. The policy question we study therefore essentially concerns the optimal steepness of the pension benefits profile as a function of the retirement age. That is, how rapidly should pension benefits rise for workers who retire later in life?

We begin by developing a theoretical framework to assess the welfare effects of reforms that alter the steepness of the pension benefit profile over the retirement age. This framework accommodates the complex environment that comprises real-world pension policy, and it could be applied to characterize the welfare effects of virtually any change in pension benefits. We apply the framework to characterize the welfare effects of budget-neutral changes to the steepness of the pension benefits profile over the retirement age. We find that the optimal steepness trades off consumption smoothing

[1] The precise manner in which countries changed their pension benefits schedules to incentivize later retirement varies. The most common characteristic of reforms is to tighten the link between lifetime earnings and benefit amounts, as in the change from a defined benefit to defined contribution pension scheme. We describe the components of the Swedish reform along these lines that incentivizes later retirement below. In countries where, unlike Sweden, pension claiming and job exit are closely linked, reforms sometimes incentivize later retirement by rewarding delays in claiming public pension benefits. Another common feature of recent reforms is to increase the minimum age at which one can claim public pension benefits, which typically reduces the net present value of pension benefits for workers retiring before the new minimum age, thus incentivizing work at at these ages. A final feature of recent reforms that has ambiguous effects on incentives to work, but may nevertheless induce later retirement, concerns changes to statutory retirement ages like the "Normal Retirement Age" (see Seibold [2021]). For further details, see OECD [2015], OECD [2017] and OECD [2019].

and redistributive costs with incentive benefits from fiscal externalities, as in other theory on social insurance (Baily [1978], Chetty [2006]). A steeper profile incentivizes later retirement, creating a positive fiscal externality. However, a steeper profile also takes resources away from early retirees to the benefit of late retirees, which among other things reduces the insurance provided by the pension system against work longevity risk (Diamond and Mirrlees [1978]). The foregone consumption smoothing reduces welfare, provided early retirees have higher (social-welfare-weighted) marginal utilities of consumption. We show that one can identify these consumption smoothing costs and fiscal gains in terms of empirically implementable sufficient statistics.

We use administrative data from Sweden, including most importantly measures of household consumption (see Kolsrud et al. [2020]), to inform this trade-off between consumption smoothing and incentives. Our empirical analysis mainly focuses on quantifying the consumption smoothing costs of steeper profiles. That is, do early retirees actually have higher social marginal utilities of consumption than late retirees, and if so, just how much higher? We use our theoretical framework to guide the empirical analysis, building on prior literature relating patterns in consumption to the value of social insurance (Gruber [1997], Hendren [2017], Landais and Spinnewijn [forthcoming]). We take three distinct approaches to quantifying the costs of steeper profiles. First, we simply examine how overall consumption after retirement varies with workers' age at retirement, holding household composition and earnings history fixed. This implementation relies on the assumption that consumption essentially determines the social marginal utility of consumption, and it implicitly combines the insurance value of a flatter profile with the value of redistribution across retirees of different ages. Our second approach examines how the drop in consumption at retirement varies across workers retiring at different ages. The drop in consumption at retirement has been widely studied and debated (e.g., Bernheim et al. [2001], Aguiar and Hurst [2005a], Battistin et al. [2009], Stephens and Toohey [2018]), but without considering how this drop varies by the retirement age. This second approach relies on weaker assumptions about the relationship between retirement age and marginal utility, and it isolates the insurance value of a flatter profile for workers facing work longevity risk. Our third approach considers variation in the Marginal Propensity to Consume (MPC) out of a wealth shock by workers of varying retirement ages, as in Landais and Spinnewijn [forthcoming]. This approach does not require information on the curvature in consumption preferences and can be seen as considering the liquidity value of a flatter pension profile.

Our main empirical finding is that increasing the steepness of the pension benefits profile entails substantial and potentially pivotal consumption smoothing costs. The overall gradient of consumption with respect to the retirement age is steep, with those retiring after 65 enjoying about 20% higher consumption than those retiring before age 60, evaluated at the same age. The steepness of our estimated gradient of consumption by retirement age is robust to a number of measurement concerns. Importantly, we also reach similar conclusions about the consumption smoothing cost of steeper profiles from our second and third approaches to measuring the differential social marginal utility between early and late retirees. We estimate that both the consumption drop at retirement and the marginal propensity to consume out of a wealth shock are generally larger for early retirees than later retirees, consistent with a substantial difference in the marginal value of pension benefits to early versus later retirees. In fact, the analysis of consumption drops suggests that the difference in post-retirement consumption levels between early and late retirees from our first approach is largely explained by the larger drop in consumption around retirement for early retirees relative to late retirees; consequently these two approaches yield quantitatively comparable estimates for welfare.

While the overall consumption gradient between retirees at ages 55 to 70 is clear, we also document a striking non-monotonicity between the early and normal retirement age (resp. 61 and 65). The gradient is much flatter in this range and, in some specifications, negative. That is, individuals retiring between those ages have similar or higher consumption on average compared to individuals retiring at the normal retirement age. We conduct some supplementary analysis of consumption by retirement age using data from the US Health and Retirement Study (HRS) and the Survey of Health, Aging and Retirement in Europe (SHARE). The patterns in measures of consumption we estimate with these data are strikingly similar to our findings based on the Swedish population register data, including the non-monotonicity for individuals retiring in the years just before the normal retirement age.

In order to evaluate the assumptions that allow us to map these empirical moments in consumption to welfare effects, we also take a close look at patterns of selection into early retirement and observable dynamics around retirement. This analysis generally reinforces or strengthens our finding that a steeper pension benefit profile entails a substantial welfare cost. We document that health and life expectancy are generally lower for earlier retirees, suggesting that the difference in the marginal social value of transfers between early and late retirees is, if anything, larger than would be suggested from consumption differences alone. We also study the evolution of health around retirement for those retiring at different ages. Here, we find that health shocks in the years just before retirement are more prevalent for workers retiring earlier. This finding is consistent with work longevity risk as an important driver of observed differences in consumption between early and late retirees. Finally, we also shed light on the drivers underlying the non-monotonicity in consumption. Those retiring between ages 61 and 63, where the non-monotonicity appears, tend to be in households where another member of the household earns significant income, they have higher household assets, and they are more likely to be female and/or cohabiting. The non-monotone pattern is also reduced when controlling for household composition. Altogether, these results suggest that many of these retirees are members of relatively well-off households that time their retirement to coincide with an older spouse who is the primary earner. Hence, within this set of ages, incentivizing later retirement is arguably less costly than at other ages.

Our theoretical framework suggests that the optimal steepness of the pension benefits profile trades off the consumption smoothing costs of steeper pension benefits profiles against the fiscal benefits of incentivizing later retirement. Having established that the former are significant, we finally turn to the question of how the two compare. We compare our estimated costs from various approaches to a reasonable benchmark for the fiscal externality, based on our analysis of the size of the relevant fiscal incentives in Sweden and prior estimates of the response of Swedes' retirement timing to those incentives (Laun [2017]). Our findings suggests incentivizing later retirement may in fact be suboptimal despite its fiscal benefits. Specifically, we find that incentivizing later retirement is suboptimal for premature retirees - those retiring before age 60 - and for late retirees - those retiring after 65. Due to the non-monotonicity described above, we find that a somewhat steeper profile for ages 60 to 65 specifically is desirable. The results therefore suggest that the optimal pension benefits profile is likely S-shaped: flat below age 60 and above 65 and steep between these ages. Naturally, some caution is warranted here: our analysis is local, the results may depend on other aspects of the tax and transfer system, and we mainly study the trade-off in the Swedish context.

Our work contributes to a sizable recent literature using the calculus of variations to characterize the welfare effects of reforms in terms of reduced-form sufficient statistics. This approach has proven useful for the analysis of other social insurance programs, especially unemployment insurance (Baily [1978], Chetty [2006]). We build on recent work incorporating heterogeneity and dynamic considerations (Kolsrud et al. [2018]), which proves particular useful in the context of retirement because of the dynamics of aging, the selection into retirement, and the dynamics of consumption around retirement. A large literature has studied consumption smoothing over the life-cycle and into retirement in particular (see De Nardi et al. [2016], Jappelli and Pistaferri [2010] for reviews) and several papers have aimed to uncover the importance of different determinants of retirement (see Blundell et al. [2016], French and Jones [2017] for reviews). Our conceptual framework allows to connect virtually any feature of public pension policy to consumption moments and patterns of dynamic selection to be able to evaluate its value. In particular, we have identified the retirement-age gradient of estimable consumption moments as a key input for evaluating a central component of pension reform - the slope of the pension benefits profile.

Our work also contributes to a small but recently expanding literature on the tradeoff between incentives and insurance in pension design specifically. The theoretical foundations of this approach were laid by Diamond and Mirrlees [1978], Diamond and Mirrlees [1982] and Diamond and Mirrlees [1986]. Some recent papers have reexamined this basic tradeoff using both theory and empirical analysis. O'Dea [2018] takes a structural approach to this tradeoff. He contrasts the value of lifetime-earnings-based pensions with policies like minimum pensions that provide an income floor; his results also suggest that current policy under-values the insurance benefits of pension provision. In contrast, we use our sufficient statistics framework to characterize the welfare effect of a change in the steepness of the pension benefits profile over retirement ages specifically. Ndiaye [2020]'s approach to this tradeoff is in the spirit of the macro public finance, characterizing the optimal retirement wedge and how this wedge changes with the age of retirement. In his model it is the fixed cost of work and how it correlates with productivity that determines whether inducing later retirement generates positive redistributive value. While our paper does not attempt to provide a full characterization of the optimal policy, we show how the welfare impact of pension reforms can be connected for a large class of models to moments that are directly estimable in the data.

Most complementary to our work is Haller [2019], who takes a similar sufficient-statistics approach as in our paper, but focuses on the fiscal externality component of the tradeoff. His work relates to a large empirical literature studying incentives and retirement behavior (e.g., Staubli and Zweimüler [2013], Manoli and Weber [2016], Manoli and Weber [2018], Seibold [2021]) and exploits Austrian pension reforms in the benefit generosity and early entitlement age to compare the corresponding average fiscal externalities. In contrast, our main empirical contribution is to estimate the consumption smoothing effects of pension reforms. Moreover, our evaluation of the slope of the benefit profile also requires us to unpack the retirement dynamics beyond looking at the average fiscal impact.

The rest of the paper proceeds as follows. Section 2 presents a conceptual framework that guides the empirical analysis in Section 4 to 6, studying subsequently the differences in consumption levels, differences in consumption dynamics and differences in MPCs across retirement ages. The empirical analysis is preceded by the presentation of the the institutional setting and data in Section 3 and followed by a welfare analysis that puts all empirical estimates together to evaluate the steepening of pension profiles in Section 7. The final section concludes.

2 Conceptual Framework

In this section we present a conceptual framework to evaluate pension design. We characterize the welfare effect of changes in the steepness of the pension benefits profile. Figure 1 illustrates such reforms for the recent Swedish pension reform (Panel A, which we explain further in Section 3.1) and a more stylized reform that matches our theoretical analysis here (Panel B). Our characterization of the welfare effects of these reforms motivates our empirical analysis and underlies our welfare calculations based on the empirical results. In Appendix F, we discuss further details regarding the setup and provide the full derivation of all equations and approximations.

Setup At any point in time t, individual i has a history captured by the state variable $\pi_{i,t} \in \Pi_t$, which encompasses all aspects of i's history relevant for determining her utility and choices at that time.[2] In particular the individual's history may include her past earnings, shocks to her health, shocks to human capital, shocks to financial capital, etc. Without loss of generality, we assume that all individual heterogeneity is captured through realizations of the state variable over the life-time, including the starting values $\pi_{i,0}$. The individual chooses $c(\pi_{i,t})$ and $\zeta(\pi_{i,t})$ determining her flow utility $u(c(\pi_{i,t}), \zeta(\pi_{i,t}))$ at time t given history $\pi_{i,t}$. Our model can encompass the rich heterogeneity and non-separabilities in standard retirement models (e.g., French [2005], French and Jones [2011]). The key innovation here is to capture all individual characteristics and choices that affect utility, other than consumption c, by the reduced-form variable ζ. As we will show, what matters for the value of public pensions is how other factors embedded in ζ may change the marginal utility of consumption, regardless of whether these factors are exogenous or endogenous. Individual expected utility is the present discounted value of expected flow utility from some initial period 0 until a final period T, integrating over possible future states:[3]

$$\mathcal{U}_i(c, \zeta, \pi) = \sum_{t=0}^{T} \beta^t \int u(c(\pi_{i,t}), \zeta(\pi_{i,t}))\, dF(\pi_{i,t}). \tag{1}$$

We denote whether an agent chooses to stay in the labor force or retire by $s(\pi_{i,t}) \in \{1, 0\}$, which is included in $\zeta(\pi_{i,t})$. Obviously the marginal utility of consumption may be different under employment ($s = 1$) versus retirement ($s = 0$), in accordance

[2]Implicitly our analysis here considers a single cohort, so that age and time are the same. Inter-cohort/inter-generational concerns may affect optimal benefit levels, but they are immaterial for the main question of interest here, which concerns the within-cohort distribution of pension benefits.

[3]Despite our use of a deterministic final period T, we can capture life expectancy concerns affecting the marginal utility of consumption through the reduced-form ζ parameter. Individuals' expected utility can incorporate preferences over bequests as well. We provide further detail in Appendix F.

with a large literature on non-separabilities in consumption-leisure (see Jappelli and Pistaferri [2017]). We capture such dependencies by allowing ζ, which includes s, to depend flexibly on the history $\pi_{i,t}$. If $s(\pi_{i,t}) = 0$ (retirement), the individual receives pension benefits $b(\pi_{i,t})$. Pension benefits can depend on the individual's employment history in $\pi_{i,t}$ in a general way. If $s(\pi_{i,t}) = 1$ (employment), the individual earns wages $w(\pi_{i,t})$ and pays taxes $\tau(\pi_{i,t})$. Both depend generally on the history $\pi_{i,t}$ as well. In principle, $w(\pi_{i,t})$ can be endogenous and subject to shocks. After-tax income in either case in year t is denoted by $y(\pi_{i,t})$. Assets $a_{i,t+1}(\pi_{i,t})$ evolve in the usual fashion, based on previously accumulated assets and saving in year t, with a gross rate of return $R(\pi_{i,t})$.

The individual's optimization problem is therefore to maximize $\mathcal{U}_i$ subject to the following constraints in each period t:

$$a_{i,t+1}(\pi_{i,t}) = R(\pi_{i,t})\left[a_{i,t}(\pi_{i,t-1}) + y(\pi_{i,t}) - c(\pi_{i,t})\right], \tag{2}$$

$$y(\pi_{i,t}) = \begin{cases} w(\pi_{i,t}) - \tau(\pi_{i,t}) \text{ if } s(\pi_{i,t}) = 1 \\ b(\pi_{i,t}) \text{ if } s(\pi_{i,t}) = 0. \end{cases} \tag{3}$$

Pension Policy The government's problem is to maximize a generalized utilitarian social welfare function with welfare weights ω_i, as in Saez and Stantcheva [2016], subject to a government budget constraint. The government budget constraint requires that the net present value of taxes collected while working equals the net present value of pensions paid out while retired, plus a constant for non-pension public expenditure (G_0). As noted, pension benefits $b(\pi_{i,t})$ can depend in a flexible way on a worker's employment history, including the number of years worked and the corresponding earnings. However, to focus on the key question here, about how to adjust pension benefits based on the timing of retirement, we consider only the retirement-age dimension of the pension profile. We assume for simplicity that each individual works and pays taxes until they retire, and retires only once. We denote the average pension benefit for individuals retiring at age r received at age t by $b_{r,t} \equiv E(b(\pi_{i,t})|r_i = r)$ and the corresponding net present value of pension benefits received over the life-time by NPV_r. We can then express the government budget constraint using the fraction of individuals working as of age r, i.e., the survival rate $S(r) = \Pr[s(\pi_{ir}) = 1]$, the average tax they pay, i.e., τ_r, and the net present value of pension benefits received by the $S(r-1) - S(r)$ workers retiring at age r. In Appendix F, we discuss this further. The governments problem becomes:

$$\max\ \mathcal{W}(b,\tau) = \int_i \omega_i U_i(b,\tau) + \lambda GBC(b,\tau)\, di \tag{4}$$

$$GBC\left(b,\tau\right)=\Sigma_{r}\left[S\left(r\right)\frac{\tau_{r}}{R^{r}}+\left[S\left(r-1\right)-S\left(r\right)\right]NPV_{r}\right]-G_{0}. \tag{5}$$

We can now consider the welfare effect of a small change in the pension benefits. Given our focus on how benefits change with the retirement age, we consider the welfare effect of a change in pension benefits for all individuals retiring at age r. We make two further assumptions to keep the characterization tractable: we set $\beta = R = 1$, and we assume that to a reasonable approximation the behavioral response to a change in $b_{r,t}$ is entirely captured by the effect on the timing of retirement, i.e., an extensive margin labor supply response.[4] Under these assumptions, we find that the following first-order condition characterizes the optimal $b_{r,t}$ for retirement age r and year t:

$$\underbrace{E\left(\omega_{i}\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}\middle| r_{i}=r\right)}_{\equiv SMU_{r,t}}=\lambda\{1+\underbrace{\Sigma_{r'}\left[\tau_{r'}-\left(NPV_{r'+1}-NPV_{r'}\right)\right]\frac{\partial(1-S\left(r'\right))}{\partial b_{r,t}}\frac{1}{S\left(r\right)}}_{\equiv FE_{r,t}}\} \tag{6}$$

The first term captures the average social marginal utility of transferring a dollar to individuals at age t, having retired at age r, which we denote going forward by $SMU_{r,t}$. This welfare effect only depends on the social marginal utility of consumption for the beneficiaries of the increased pension benefits. Changes in labor supply or other behavioral responses only have a second-order effect on agents' welfare, due to the envelope theorem.[5] However, the changes in labor supply imply that the fiscal cost of increasing expected pension expenditures by one dollar differs from one dollar. The fiscal cost – including this fiscal externality $FE_{r,t}$ – is the second term in equation (6). To unpack the fiscal externality, we note that $\frac{\partial(1-S(r'))}{\partial b_{r,t}}$ captures the behavioral response in the survival probabilities at various potential retirement ages r' to a change in benefits when retiring at the particular age r. This behavioral response affects government revenues in proportion to the total tax on earnings at those ages, $\tau_{r'} - (NPV_{r'+1} - NPV_{r'})$. The total tax captures both income and payroll taxes on earnings and the implicit tax on earnings embedded in the pension benefits formula. While prior work (e.g. Gruber and Wise [1999]) has focused on calculating the latter - that is, whether accounting for the changes in pension benefits received and payroll taxes paid when working an additional year the pension system imposes an extra tax on earnings – the fiscal

[4]This second assumption is not strictly necessary to motivate a welfarist interpretation of the consumption patterns we study in the next section, but we rely on it in Section 7 to characterize the fiscal externality from the behavioral response to the policy changes.

[5]Behavioral biases may affect individuals' consumption and retirement behavior and thus the consumption smoothing value from pension reforms, which is captured by the SMU's. For example, biases that lead to under-saving could tend to increase the SMU of pension benefits. However, the presence of behavioral biases may also imply that changes in behavior in response to pension reforms have a first-order effect on welfare beyond the fiscal externality, which our characterization does not account for (see Spinnewijn [2015], Reck and Seibold [2021]).

externality from inducing individuals to work longer is in general dominated by the income tax paid on labor earnings and thus positive. Finally, we value the fiscal effect of this transfer for social welfare by scaling it by the marginal value of public funds λ.

Pension Profile Reform The framework allows for a simple characterization of the effect of increasing benefit *levels* for individuals retiring at a given age r, as demonstrated in equation (6). Our focus, however, is on changes to the *slope* of the pension benefits profile. That is, how do pension benefits change with the age at which one retires. A key determinant of the welfare effect of a change in the slope of the pension benefits profile is the social marginal utility of consumption for individuals retiring early vs. individuals retiring late. Conceptually, we can compare the effect a marginal change in benefits for individuals who retired at age r, $b_{r,t}$, relative to a marginal change in benefits for individuals who retired at some other age r', $b_{r',t}$. A steeper pension profile reduces benefits for individuals retiring before a certain age and increases benefits for individuals retiring after that age, as illustrated in Figure 1. For the pension profile to be optimal, we need based on equation (6) that

$$\frac{SMU_{r,t}}{SMU_{r',t}} = \frac{1 + FE_{r,t}}{1 + FE_{r',t}}. \tag{7}$$

Otherwise, we can find a *budget neutral* reform of the profile that increases welfare.[6]

Equation (7) resembles the classic insurance-incentives tradeoff often studied for other social insurance policies (Baily [1978], Chetty [2006]). The left-hand side of the equation reflects the consumption-smoothing value of re-allocating transfers across retirement ages, accounting for potential differences in welfare weights and the marginal utility of consumption. The right-hand side reflects the relative fiscal externality caused by the changing incentives to retire at those ages. We note that a number of concerns affecting the optimal level of benefits, such as fiscal sustainability or inter-generational redistribution, are immaterial for the evaluation of a budget neutral reform such as this. Formally, this is captured by the fact that we can characterize the welfare effect of such a reform without reference to the marginal value of public funds, λ. Our focus in our empirical analysis is on the left-hand side of equation (7); we further characterize the fiscal externality term in Section 7.

[6] This relates to the marginal value of public funds (MVPF) of spending on specific pension beneficiaries (Hendren and Sprung-Keyser [2020]). When the social value per dollar spent, accounting for the fiscal externality, is larger for retirement age r than for retirement age r',

$$\frac{SMU_{r,t}}{1 + FE_{r,t}} > \frac{SMU_{r',t}}{1 + FE_{r,t}}$$

we can increase welfare from spending that extra dollar on pension benefits for the former and spending a dollar less on the latter.

Differences in Consumption How can we shed empirical light on the difference in social marginal utilities between pension beneficiaries, and in particular, when evaluating a steeper pension profile, between individuals retiring at different ages? As is standard in the social insurance literature (e.g. Chetty and Finkelstein [2013]), we can use a Taylor series approximation to describe how differences in consumption map into differences in marginal utilities:

$$\frac{\partial u\left(c_{i,t},\zeta_{it}\right)}{\partial c} \cong \frac{\partial u\left(c_0,\zeta_{i,t}\right)}{\partial c}\left[1-\frac{-\frac{\partial^2 u\left(c_0,\zeta_{i,t}\right)}{\partial c^2}c_0}{\frac{\partial u\left(c_0,\zeta_{i,t}\right)}{\partial c}}\frac{c_{i,t}-c_0}{c_0}.\right] \tag{8}$$

We use this approximation to compare the SMU for retirees at age r relative to the SMU of those retiring at r' (i.e. setting $c_0 = c_{r',t}$). Assuming that the relevant heterogeneity occurs across individuals retiring at different ages, we find:[7]

Implementation 1 (Δ *Consumption Levels*)**.** *Assuming* $c\left(\pi_{i,t}\right) = c_{r,t}$, $\zeta\left(\pi_{i,t}\right) = \zeta_{r,t}$ *and* $\omega_i = \omega_r$ *when* $r\left(\pi_{i,t}\right) = r$ *for any* i, r,

$$\frac{SMU_{r,t}}{SMU_{r',t}} \cong \frac{\omega_r \frac{\partial u\left(c_{r',t},\zeta_{r,t}\right)}{\partial c}}{\omega_{r'}\frac{\partial u\left(c_{r',t},\zeta_{r',t}\right)}{\partial c}} \times \left[1+\gamma\frac{c_{r',t}-c_{r,t}}{c_{r',t}}\right], \tag{9}$$

for γ *the relative risk aversion in consumption preferences.*

If the social marginal utility of consumption for individuals retiring at different ages (r) is the same *conditional on consumption* (i.e., $\omega_{r,t}\frac{\partial u\left(c_{r',t},\zeta_{r,t}\right)}{\partial c} = \omega_{r',t}\frac{\partial u\left(c_{r',t},\zeta_{r',t}\right)}{\partial c}$), then the estimation of the relative SMU's only requires estimates of the relative difference in consumption levels at a fixed age (t) along with the curvature of the utility function over consumption (γ). Holding welfare weights (ω_r) and non-consumption determinants of marginal utility $(\zeta_{r,t})$ fixed, we observe that the lower is the consumption by individuals retiring early relative to individuals retiring late, the higher is the cost of making the pension profile steeper.

Selection on Observables The main focus of our empirical analysis is to study differences in consumption by retirement age. However, to gauge potential differences in social marginal utility, *conditional on consumption*, we complement this with a detailed analysis of selection into retirement on other observable characteristics. A natural factor why the welfare weights may differ across retirement ages are differences in health outcomes or life expectancy. For example, early retirees having worse health or

[7] When there is significant heterogeneity across individuals retiring at the same age, the aggregation needs to account for the covariance between preferences and consumption for those individuals (see Andrews and Miller [2013]).

shorter life expectancies than later retirees could justify larger social welfare weights ω for them. When we estimate welfare effects in Section 7, we also illustrate how accounting for selection patterns can affect the conclusions from an implementation of equation 7, but we will see that our qualitative conclusions are generally strengthened by accounting for these factors.

The marginal utility of consumption itself, conditional on consumption, may be different too for early and late retirees. One reason is that the observed consumption expenditures do not translate one-for-one into consumption itself (e.g., due to home production). Another reason is that actual preferences over consumption are different (e.g., due to complementarities with leisure). It is important to note here that we compare the consumption of individuals when retired, so the common concerns raised in relation to the so-called retirement consumption puzzle – drawing inference from differences in consumption when employed vs. retired – do not apply here. The main concerns here are questions which, to our knowledge, have not been studied empirically, like whether early retirees value consumption less relative to leisure than later retirees. In any case, potential differences in preferences are difficult to capture entirely through an analysis of observable factors, so we follow recent work in the social insurance literature (e.g., Hendren [2017], Landais and Spinnewijn [forthcoming]) by studying other consumption moments too.

Alternative Consumption Moments. In the classic social insurance framework, individuals are "ex ante identical" by assumption and any differential marginal utility reflects the consumption smoothing value of insurance. Conceptually, however, the relative SMU's in equation (7) could also capture welfare effects from redistribution between individuals who are not ex ante identical, i.e., individuals with different histories. We can use an alternative Taylor expansion of the ratios of social marginal utilities and separate out the change in consumption arising around retirement.

Implementation 2 (Δ *Consumption Drops*). *Assuming* $c(\pi_{i,t}) = c_{r,t}$, $\zeta(\pi_{i,t}) = \zeta_{r,t}$ *and* $\omega_i = \omega_r$ *when* $r(\pi_{i,t}) = r$ *for any* i, r, *we can approximate*

$$\frac{SMU_{r,t}}{SMU_{r',t}} \cong \frac{\omega_r \frac{\partial u\left(c_{r,pre},\zeta_{r,t}\right)}{\partial c}}{\omega_{r'} \frac{\partial u\left(c_{r',pre},\zeta_{r',t}\right)}{\partial c}} \times \frac{1+\gamma_r \frac{c_{r,pre}-c_{r,t}}{c_{r,pre}}}{1+\gamma_{r'} \frac{c_{r',pre}-c_{r',t}}{c_{r',pre}}}, \tag{10}$$

where γ *denotes the relative risk aversion in consumption preferences and* t *refers to an age or time period after retirement, while "pre" refers to an age or time before retirement.*

The higher is the drop in consumption around retirement for individuals retiring early relative to individuals retiring late, the higher is the cost of making the pension profile steeper. This implementation again assumes that the only relevant heterogeneity occurs across individuals retiring at different ages.[8] The value of this alternative implementation is twofold. First, other policy tools may be available for redistribution and insurance of earnings differences during an individual's working life (progressive income taxes, unemployment and disability insurance, etc.). Hence, planners might wish instead to evaluate welfare conditional on the differences that arise before they reach pension ages (i.e., $\omega_r \frac{\partial u\left(c_{r,pre}, \zeta_{r,t}\right)}{\partial c} = \omega_{r'} \frac{\partial u\left(c_{r',pre}, \zeta_{r',t}\right)}{\partial c}$). This welfare perspective relates to Diamond and Mirrlees [1978], where the social planner uses public pensions to provide insurance against work longevity risk, coming from for health or disability shocks later in life. Under this more narrow perspective of social insurance, the differential consumption *drops* around retirement for retirees at different ages are more informative than the differential consumption *levels* across these retirees. Second, by relying on differences in *within-individual changes* in consumption across individuals (rather than differences in post-retirement *consumption levels*), we do not need to be concerned about permanent differences in non-consumption determinants of marginal utilities ζ_r – e.g., a smaller value of consumption relative to leisure – driving selection into retirement. Such differences would confound the translation from the difference in consumption levels to SMU in the first implementation, but they would not confound the within individual differences in the second implementation.

In a similar spirit, we can learn about the consumption smoothing value of pension benefits by comparing the marginal propensity to consume of different beneficiaries. Following the approach proposed in Landais and Spinnewijn [forthcoming], we can approximate the ratio of marginal utilities relying on the difference in marginal propensities to consume when retired.

Implementation 3 (Δ *MPC's*)**.** *Assuming $c(\pi_{i,t}) = c_{r,t}$, $\zeta(\pi_{i,t}) = \zeta_{r,t}$ and $\omega_i = \omega_r$ when $r(\pi_{i,t}) = r$ for any i, r, and, in addition, the relative curvature in preferences over c and ζ and $\frac{\partial u(c_{r,t}, \zeta_{r,t})}{\partial \zeta_{r,t}}$ to be similar across retirement ages, we can approximate*

$$\frac{SMU_{r,t}}{SMU_{r',t}} \cong \frac{\omega_r}{\omega_{r'}} \times \frac{\frac{mpc_{r,t}}{1-mpc_{r,t}}}{\frac{mpc_{r',t}}{1-mpc_{r',t}}}, \tag{11}$$

where $mpc_{r,t} = \frac{dc_{r,t}}{dy_{r,t}}$.

[8] To compare this implementation to the first one based on differences in post-retirement consumption, we could separate out the difference in marginal utility due to pre-retirement consumption differences too. Applying another Taylor expansion for the pre-retirement consumption levels gives

$$\frac{SMU_{r,t}}{SMU_{r',t}} \cong \frac{\omega_r}{\omega_{r'}} \frac{\frac{\partial u\left(c_{r',pre}, \zeta_{r,t}\right)}{\partial c}}{\frac{\partial u\left(c_{r',pre}, \zeta_{r',t}\right)}{\partial c}} \times \left[1 + \gamma_{r'} \frac{c_{r',pre} - c_{r,pre}}{c_{r',pre}}\right] \times \frac{1 + \gamma_r \frac{c_{r,pre} - c_{r,t}}{c_{r,pre}}}{1 + \gamma_{r'} \frac{c_{r',pre} - c_{r',t}}{c_{r',pre}}}.$$

The higher is the marginal propensity to consume for individuals retiring early relative to individuals retiring late, the higher is the cost of making the pension profile steeper. This approximation relies on the assumption that the relative curvature of utility over consumption and the resources used to smooth consumption at the margin (e.g., future consumption, household earnings) are constant across retirement ages. The value of this alternative implementation is again twofold. First, differences in the marginal propensity to consume reflect differences in the shadow price of consumption: the higher this price, the higher the propensity to consume out of an exogenous increase in income. By considering the MPCs, we thus narrow our welfare focus further on the liquidity value that pensions provide.[9] Second, by using yet an alternative consumption moment we again rely on different implementation assumptions. The main advantage of this MPC approach is that it doesn't require knowledge about the curvature in consumption preferences γ itself, but only on how preference curvatures differ across beneficiaries. The preference parameter γ is crucial for translating consumption differences into differences in marginal utilities in the first two implementations, but generally hard to estimate empirically (e.g. Chetty [2008]).

3 Institutional Background & Data

This section provides an overview of Swedish pension institutions and the administrative data from Sweden that we use. In describing the relevant institutions, we mainly focus on the aspects of the pension system and its recent reform that affect the steepness of the pension benefits profile; a more comprehensive overview of Swedish pensions is in Appendix A.

3.1 Institutional features of the Swedish pension system

The Swedish Pension system consists of three main components: public pensions, occupational pensions, and private pensions. The first of the three, public pensions, is our main focus. We review the other two components in Appendix A. Apart from some differences mentioned below and in the Appendix, these three branches of the pension system are analogous to Social Security, 401(k) plans, and Individual Retirement Accounts in the United States.

[9] We can expect this to provide a lower bound on the consumption smoothing gains as individuals who face a higher shadow price of consumption may do so because they already need to rely more on alternative resources to smooth their retirement consumption. We provide more detail in Appendix F.

Public Pension Reform Sweden has undertaken large reforms to its public pension system in the last two decades. It is currently transitioning from the "ATP" scheme,[10] which is essentially a Defined Benefit scheme, to a Notional Defined Contribution (NDC) scheme.

In the ATP system, pension benefits are determined by the earnings over the 15 years in an individual's career where pensionable earnings were the highest and the total number of years in which an individual earns pension rights up to a maximum of 30 years.[11] Pension rights can be earned between ages 16 and 64 - earnings at age 65 or beyond have no effect on pension rights. Annual earnings are converted to pension rights by dividing earnings in a year by a *base amount* (BA) for that year, which produces the *ATP points* used to calculate pension benefits. The BA serves to index pension rights and benefits to prices, with some discretion by the government. Annual ATP points are capped at 6.5 BAs, which corresponds empirically to the median of the earnings distribution for 55 year olds in 2000; earnings in a given year beyond this level do not increase pension rights. For individuals with short careers and low life-time labor earnings there is a basic pension which serves as a floor for pension benefits. The basic pension is a function of the BA and the number of years the individual has resided in Sweden. Our data shows that a quarter of all 66 year olds received the basic pension in 2007.

From a worker's perspective, the new NDC system resembles a DC system, where the contributions are payroll taxes and a given worker's benefits are an annuity closely linked to that worker's lifetime contributions. Unlike a typical private DC scheme, however, the system retains its Pay-As-You-Go structure, as pension points are only notional. Benefits are paid for by contemporaneous taxes and evolve deterministically as a matter of policy. Therefore, the system is called a *Notional* Defined Contribution system. More specifically, pension benefits in the NDC system are calculated from the sum of wage-indexed lifetime pensionable earnings, and the sum is divided by life expectancy. Unlike with the ATP, there is no upper age limit for accumulation of pension rights: as long as an individual works, pensionable earnings grow. The BA is replaced by an "income base amount" which is indexed to average wage growth instead of prices.[12] Pensionable earnings are capped at a higher level (at 7.5 income

[10] ATP stands for *Allmän tilläggspension* in Swedish, which means "General supplementary pension." The word "supplementary" in the title refers to the fact that there is also a basic old-age pension benefit whose amount does not depend on a person's earnings history. Here and elsewhere, we refer to combined public old-age pension benefits system prior to the reform as the ATP system, which is common terminology.

[11] Pensionable earnings are labor income and income from social insurance benefits that in turn are based on labor income, such as unemployment insurance, sickness insurance, parental leave benefits, workers' compensation and disability insurance. Capital income is not considered to be pensionable earnings nor are transfers that are not based on previous labor earnings, like social aid or housing aid.

[12] The government still has some discretion over the income base amount, just like the BA.

base amounts) than the ATP system. Just as in the ATP system there is a minimum pension for individuals with short careers and low accumulated pensionable earnings, which is now called the *guaranteed pension*. The new minimum benefit is about 40% higher than the benefit under the ATP system. About 30% of all individuals receiving pension benefits are expected to receive basic pensions in 2040 when the NDC system is fully phased in.

The reform was passed the Parliament in 1994 and phased in gradually across cohorts. Cohorts born before 1938 receive their pension benefits from the ATP system. Those born between 1938 and 1953 receive a weighted mixture of ATP and NDC benefits, with increasing weight on the NDC benefits over time.[13] The cohorts at or near retirement age during the period spanned by our consumption data are those for whom the ATP system was the main determinant of benefits and the NDC was just beginning to be phased in. Pension benefits in both the ATP system and the NDC system are financed by payroll taxes.

Slope of Pension Profile As in the transition from a DB to a DC system, an explicit goal of the reform was to tighten the link between lifetime earnings and pension benefits and to incentivize later retirement, primarily because of the fiscal benefits of doing so. We quantify the effects of the reform on the average steepness of the pension benefits profile in Figure 1 Panel A. To do this, we develop a simulation tool based on a pension calculator provided by the Swedish Pension Authority. We simulate lifetime income and pension benefits for a representative set of workers born in 1941 and calculate the net present value at age 55 of all income and of pension benefits as a function of the age at which the individual exits the labor market.[14]

Figure 1A illustrates how, on average, retiring at different ages affects lifetime pension benefits for workers in the ATP and NDC system, abstracting away from the effect of the reform on the overall level of pension benefits. We discuss the level effects further in Appendix A, especially Figure A-12. To promote fiscal sustainability, the NDC reform enacted a reduction in pension benefits for most workers.

[13]Individuals born in 1938 receive 80% of their pension benefits from the ATP system and 20% from the NDC system. Each subsequent cohort gets another 5 percentage points of weight on the NDC scheme. For example, individuals born in 1939 get 25% of their pension benefits from the NDC system while the 1953 cohort gets 95% of their pension benefits from the NDC system. From the 1954 birth cohort onward, the NDC scheme alone determines pension benefits.

[14]To account for how the reform affected workers differently depending on their position in the lifetime income distribution, we consider 20 hypothetical earnings histories, calibrated based on vigintiles of the distribution of accrued ATP points at age 55, median earnings and years worked at 55 for workers in each vigintile, and historical earnings growth. Further analysis in Appendix A suggests that this approach provides a reasonably accurate account of how pension benefits change as a function of the retirement age through the distribution of lifetime earnings. Averaging the NPV of pension benefits in the NDC and ATP system across the 20 hypothetical workers, each of whom roughly represents 5% of the lifetime earnings distribution, we arrive at Figure 1 Panel A.

More importantly for our analysis, we observe in Figure 1A a marked increase in steepness of the profile in the NDC system, compared to the ATP. Additional incentives to work derive mainly from three components of the reform. First, after age 65, ATP benefits are fixed because individuals cannot earn additional pension rights by working longer, but the NDC system has no such property. Second, before 65, working longer earns additional ATP pension rights by increasing the top-15-years average earnings, but the NDC benefits schedule is even steeper because the 30-year contribution cap is removed. Third, the maximum pension benefit increased by roughly 25% in the NDC system, which provides an additional incentive to work and earn pension rights for some high-income workers. The higher minimum pension, however, reduced incentives to work for some low-income workers.[15] Appendix Figure A-9 shows how the reform affected the participation tax rate on retiring one year earlier/later on average, accounting for changes to pension benefits as well as income and payroll taxes. Consistent with the above, we observe that the reform decreased participation tax rates, especially after age 65, which incentivizes later retirement.

Retirement vs. Claiming We focus on incentives created by the pension benefits schedule to work or retire at various ages and largely ignore claiming incentives. Pensions can be claimed from age 61, which we refer to as the early retirement age. Unlike many other countries, Sweden has no earnings test whereby pension benefits are reduced for those continuing to work after claiming the pension benefits. In the ATP system, claiming before age 65 resulted in a nearly actuarially fair reduction in benefits, while benefits are adjusted slightly more for those claiming after age 65. In the NDC system, the adjustments are on average actuarially fair by design. Claiming pensions earlier means that the sum of pensionable earnings is divided by the longer life expectancy. Consistent with the idea that retirement and claiming are de-coupled in Sweden, we observe much more variation in retirement ages compared to claiming ages, as illustrated in Appendix Figure A-3. In the cohorts we study, 69% of workers claim their pension at age 65, but only about 22% retire at age 65, with far more workers retiring before 65 than claiming before 65. Of individuals retiring between 60 and 63, 76% claim their pension at age 65, and only 13% claim at job exit or one year later. Of individuals retiring between 55 and 59, 52% claim their pension at age 65, and only 4% claim at age 61, the earliest age possible. In quantifying the effects of the reform on incentives above we focused for simplicity on the case where the individual claims at 65, which empirically is the most relevant case; we discuss some further details on

[15] Due to the changes in the minimum and maximum pensions that accompanied the change from the ATP to NDC system, the change in steepness due to the reform does vary through the distribution, especially at the top and bottom of the lifetime income distribution. See Appendix Figure A-8 and the surrounding discussion for details. We discuss how this type of heterogeneity matters for welfare analysis in Section 7.

this point in Appendix A.

Other Social Insurance Motivated by our conceptual framework, we focus on retirement defined as the moment individuals stop working and permanently exit the labor force. On top of pension benefits, other components of the social insurance system in Sweden, such as disability insurance or unemployment insurance, provide transfers to cushion the shock of dropping out of the labor force for the elderly. Although these are not explicitly called "pension" benefits, such benefits received by workers at the moment they stop working do affect the profile of their labor supply incentives in old age. Non-pension social insurance benefits also contribute to "pensionable earnings" in determining a workers pension benefits, in both the ATP and NDC system. Because of all this, we integrate themse benefits as part of the overall pension system when computing the NPVs of benefits related to stopping to work at different ages. We provide details on these computations in Appendix A, and explore the robustness of our findings to alternative treatments of UI and DI benefits.[16]

We finally note that with two exceptions, the pension system, like most of the Swedish tax and transfer system, is entirely individualized. The first exception is that the minimum pension benefit in both systems is about 10% lower for married individuals than for singles. The second is that there is a survivor's benefit that is paid out for a year after one's spouse has passed, see Appendix A for details.

3.2 Data

We rely on uniquely rich data on consumption, pension and health. The data comes from several Swedish registries covering the universe of the population, as well as additional surveys, which can all be linked together using a unique personal identifier (*personnummer*).

Labor Market History and Pensions Our first source of information on labor supply history in old age is LISA, a panel containing the universe of individuals residing in Sweden aged 16 years or above, between 1990 and 2017. LISA includes socio-demographic variables such as age, education, marital status, household composition and place of residence. It also contains information on labor market status, labor earn-

[16]In Appendix A, we show that although it is especially common for low-income workers retiring early to claim social insurance after exiting the labor force, accounting for insurance benefits and their induced additional pension rights has a very small effect on the average NPV of benefits from pensions and other social insurance combined (see Figure A-7). As a result, this has a small effect on the fiscal externality from incentivizing individuals to work longer (see Figure A-9).

ings, various types of transfers such as sickness benefits, disability benefits and unemployment benefits.

From LISA, we construct a registry-data measure of retirement, defined as the moment individuals stop working and permanently exit the labor force. To do this we follow Karlstrom et al. [2004] and categorize an individual as retired when her labor earnings permanently fall below one Base Amount − about 18% of median labor earnings.[17]

Our second main registry data source is data on pension contributions in both the old ATP system and the new NDC system. Data from the ATP system contains contributions from 1960 onwards for all individuals born 1938 and later. The NDC contributions are available from the late 1990s when the NDC system was initiated. In addition, the data also contains information on all pension benefits that individuals accrue and receive: old age state pension benefits, occupational pension and private pension savings.

Consumption To measure consumption, we use the registry-based measure of annual household consumption expenditures for the universe of Swedish households created for all years 2000 to 2007 by Kolsrud et al. [2020]. The construction of this measure relies on the identity coming from the household's budget constraint between consumption expenditures and income net of changes in assets. The quality of our consumption expenditure measure owes to the comprehensiveness of income and asset data in Sweden. First, LISA contains exhaustive disaggregated information on all earnings, all taxes and transfers and capital income on an annual basis. Second, we have precise data on wealth coming from the wealth tax register (Förmögenhetsregistret), which covers the asset portfolios for the universe of Swedish individuals with detailed information on the stock of all financial assets (including debt) and real assets as of December of each year. We complement the information from the wealth tax register with data on financial asset transactions (KURU), and data on real estate transactions from the housing registries (*Fastighetsprisregistret*), which enable us to disentangle the contribution of savings from that of price changes in the evolution of asset balances. The KURU register also allows us to construct measures of wealth shocks using random variation in asset prices that we exploit in section 6.

We aggregate consumption at the household level using administrative identifiers of household structure created by Statistics Sweden. We refer the reader to Appendix B and to Kolsrud et al. [2020] for further details on the construction of our consumption

[17] The one base amount (BA) threshold is widely used to define labor force participation in the administrative data. One BA also corresponds to the minimum earnings threshold allowing individuals to earn pension rights in the ATP system. See further details in Section 3.1. Note that we define the year in which the event of retirement takes place as the last year in which the individual earns more than one BA.

measure, and for a thorough assessment of its robustness and consistency compared to survey measures of expenditures. We note that our imputed measure of consumption is capturing, like most survey measures, expenditures rather than consumption. We discuss at length how this affects the mapping between consumption and welfare when we present our empirical results below.

Health Data We complement our data with the death register, as well as with two large surveys containing detailed information on health and health expenditures. The first is the living condition survey (ULF) which contains various health measures for a representative sample of approximately seven thousand households, every year from 1997 to 2011. These measures include both subjective, such as self-reported illnesses, pain or reduced work capacity, as well as objective outcomes (number of visits to a physician in the last 12 months, body mass index, etc).[18] The second survey is the household finance survey (HEK), which samples an average of 30k individuals every year, and is also available from 1997 to 2011. The survey contains very precise information on health-related expenditures (number of visits to a doctor, to a physiotherapist, expenditures on pharmaceuticals, on outpatient care, etc).[19]

Both surveys are repeated cross-sections, but can be matched at the individual level with the administrative registers. In practice, this means that we observe for each individual surveyed in ULF and HEK their full (i.e. past and future) labor market and pension histories, consumption, etc. This allows us to investigate health dynamics around retirement using pseudo-panel techniques.

The literature on the impact of health on retirement has long recognized the potential measurement issues, leading to attenuation bias, in using only a specific subset of objective measures of health, as they may only partially capture the overall health status of an individual (Bound [1991], Stern [1989]). And while subjective measures may address these measurement issues, they can also be prone to justification bias (Butler et al. [1987]). To deal with these concerns, we follow Blundell et al. [2021]. We build, for each survey, a composite index of health by extracting the principal component of all objective and subjective measures available in the survey.[20]

Sample Selection & Descriptive Statistics Our main sample focuses on all individuals from cohorts 1938 to 1943. Figure 2 displays the distribution of age at retirement among individuals belonging to these cohorts. It shows that the vast majority of individuals retire between 55 and 70, with a big mass exiting the labor force at 65. Based

[18] This study is similar to the SILC survey conducted within the European Union.

[19] Importantly, the survey does not only report out-of-pocket expenditures, but also all expenditures that are directly taken care of by private and public health insurance.

[20] Further details on the health data and on the PCA extraction are given in Appendix B.

on this empirical distribution, we define four retirement age groups. Premature retirement is defined as individuals retiring between age 56 and 59; early retirement, between age 60 and 63; normal retirement, between age 64 and 65; and late retirement, between age 66 and 69. In the remainder of our analysis, we focus on these four groups, and drop from our sample the small group of individuals whom we observe retiring before 55, or after 70.

This choice of cohorts and retirement age groups is dictated by a series of reasons. First, we only observe the full ATP contribution history for cohorts born from 1938 onwards. Second, given our consumption data spans years 2000 to 2007, this sample selection allows us to observe, for each cohort, consumption during retirement, as well as before retirement, for all retirement age groups.[21] Furthermore, we restrict the sample to individuals who retire between the age of 56 and 69.

Table 1 provides summary statistics for this baseline sample, with information on retirement patterns, demographics, income, wealth and pensions. The sample comprises 419,790 unique individuals, with an average age at retirement of 62.9.

4 Retirement Consumption & the Value of Pension Benefits

4.1 Consumption Levels By Retirement Age

We start by documenting how consumption differs across individuals who retire at different ages. As shown in equation (9), such consumption differences represent a key empirical input to assess the value of reforms to the pension profile. Importantly, such differences should be measured at the same age, and in the same state, i.e. when individuals are retired.

To implement this empirically, we simply regress household consumption C_{it} of individual i at age t in year y, on a series of dummies that capture an individual's retirement age r.

$$C_{it} = \sum_j \alpha_j \cdot \mathbb{1}[\mathrm{r} = \mathrm{j}] + \gamma_y + \gamma_t + \mathbf{X}'\beta \tag{12}$$

[21] This sample selection therefore allows us to control for both age and cohort effects in consumption. Enlarging the sample to younger cohorts means that the consumption of these cohorts is never observed at the same age as older cohorts, making it hard to disentangle age and cohort effects. All our results on consumption levels, consumption drops, and MPCs are nevertheless robust to using a larger sample of cohorts going from 1938 to 1950.

In practice, we group retirement ages into four groups, as explained above: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). We systematically use normal retirees as the reference category.

We run model (12) including consumption at all ages $t > r$, that is we restrict the sample to individual X year observations for which individuals are observed as being retired. To control for business cycle fluctuations and for the lifecycle profile of consumption, we include both year fixed effects γ_y and age fixed effects γ_t. In effect, we compare consumption of individuals *from the same cohort, at the same age*, who are currently retired, but who have retired at different ages.

The vector of controls **X** comprises two sets of variables. First, we include four dummies corresponding to quartiles of ATP points accumulated at age 55. These dummies capture the fact that the pension policy incentives of working an additional year after age 55 depend on an individual's previous labor supply history, which are captured by her accumulated ATP points. Second we include a series of dummies capturing household composition. Such controls do not intend to capture differential pension incentives by family structure, as pensions are highly individualized in Sweden, as explained in section 3.1 above. Rather, they account for the fact that our left-hand side variable is total consumption at the household level which mechanically depends on household structure. We therefore want to control for any mechanical relationship between consumption and retirement age, in case the latter correlates with family composition.

Figure 3 reports the estimated coefficients α_j from specification (12) for all retirement age groups. We estimate the regression using consumption levels (rather than logs) but to facilitate interpretation, we scale the estimates α_j for all retirement age groups by $\mathbf{E}_j[\tilde{C}_{it}]$, the average predicted consumption level in retirement age group j from specification (12) when omitting the contribution of the retirement age group dummies.[22] We start, on the left hand side of the graph, with results from model (12) where only year and age fixed effects are included. The rest of figure shows the same estimated coefficients when sequentially adding controls for ATP quartiles and family composition.

Two important insights emerge. First, the estimates reveal the presence of a very strong positive gradient of consumption with retirement age. During retirement, the level of consumption of premature retirees is 5% lower than consumption of normal retirees from the same cohort, at the same age. Late retirees, to the contrary, enjoy

[22] $\mathbf{E}_j[\tilde{C}_{it}]$ therefore corresponds to the average level of consumption of individuals who retire between 64 and 65 from the same cohort, age, family composition and ATP quartile at age 55 as the average individual retiring in age group j.

a level of consumption that is 10 to 15% larger than normal retirees at the same age. Importantly, the magnitude of the overall gradient remains almost as large when controlling for ATP points at age 55 and for family structure: this suggests that the large differences in consumption between individuals who retire very early and those who retire very late is not primarily driven by differences in past labor market history or differences in household composition. The second insight is that, while the overall gradient is positive, the relationship between consumption and retirement age also exhibits a strong non-monotonicity. Indeed, consumption is actually significantly larger for early retirees compared to normal retirees. This is interesting as is suggests that in this range of the distribution of retirement ages, there is no trade-off between incentives and redistribution: steeper profiles for individuals who retire around age 60 to 65 can both provide larger incentives to retire later and redistribute away from early retirees who enjoy larger consumption levels than normal retirees.[23]

Appendix C provides additional evidence of the robustness of these consumption patterns. First, in Appendix Figure C-2, we show that these patterns hold irrespective of the age at which consumption is observed during retirement. We run regressions similar to specification (12), but separately for each age t.[24] The graph confirms the very strong positive gradient of consumption with retirement age, at all ages at which consumption is observed. The consumption of late retirees is systematically 15 to 20% larger than that of premature retirees. Furthermore, we also find that the relationship between consumption and retirement age is non-monotonic, with a decreasing range between retirement age 60 and 65: consumption is systematically smaller for normal retirees than for early retirees. In Appendix Figure C-3, we further show that the same consumption patterns emerge irrespective of household structure. We replicate specification (12), splitting the sample between single vs couples, where family structure is defined as of the year of retirement. The same consumption patterns emerge for both couples and singles: the relationship between retirement age and consumption is strongly positive overall, but exhibits a flat or declining portion, over the early to normal retirement age range. We note, though, that the non-monotonicity is more pronounced for couples than for singles, a point we come back to when discussing selection into retirement age.

[23] In Appendix Figure C-1, we also report estimates of a fully non-parametric version of specification (12) where we compare consumption levels across all retirement ages (rather than aggregating retirement ages into four groups). One additional insight that emerges is the sharp difference in consumption levels between individuals who retire before age 65 and individuals who retire just after 65.

[24] Because t is now fixed, we remove age fixed effects from the specification and control for year fixed effects γ_y. In effect, we compare consumption at age t of individuals retiring in different age groups *within the same cohort*.

4.2 Decomposition of Consumption

To further understand the differences in consumption level between retirement age groups, we decompose our measure of household expenditures into a rich set of components that shed light on the consumption means available to individuals. These components include own income, (which we break down into own labor earnings, pensions, and other transfers such as UI, or DI), consumption out of debt, consumption out of assets, consumption out of real estate, and other household income (e.g. earnings from other members of the household, etc). We run specification (12) separately for each component evaluated at age 68 on the sample of all individuals from cohorts 1938 to 1943 who are retired by age 68. Figure 4 reports the estimates $\hat{\alpha}_j$ for each component, scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, with one panel for each retirement age group.

Results reveal that the main reason why late retirees enjoy much larger consumption than other retirees is their significantly larger flow of consumption out of wealth. Late retirees benefit from larger flows of consumption out of financial assets, as well as larger flows out of their real estate wealth, the latter mainly capturing imputed rents. Together, these flows account for more than two thirds of the difference in overall consumption between late and normal retirees.

The figure also sheds important light on the drivers of the non-monotonic patterns highlighted above. Panel B shows that early retirees enjoy higher consumption despite having lower pensions, because they have both higher consumption flows from wealth, and also, significantly larger consumption flows out of the income of other household members.[25] This evidence suggests that if this group of individuals retire earlier, this is in part because they have the means to do so.

Finally, the figure shows that the lower levels of consumption of premature retirees are driven by a combination of lower flows across all available means of consumption. Premature retirees have lower pension benefits, including occupational pensions. They also have significantly lower consumption out of wealth and lower consumption out of the income of other household members. Interestingly, in Appendix Figure C-6, we replicate the same exercise at age 60, which reveals that premature retirees have a much higher incidence of unemployment insurance and disability insurance receipt. This evidence suggests that, conditional on labor market history at age 55, individuals who retire prematurely not only have limited means to smooth consumption, but may also be more likely to have experienced negative earnings shocks due to unemployment or disability in their late career.[26] We revisit this issue and provide more

[25] Note that these estimates control both for ATP points at age 55 and for household structure. Differences in the contribution of income from other household members therefore does not reflect differences in household structure, but differences in the magnitude of income flows generated by household members for a given household structure.

[26] As explained in section 3, we consider retirement as the age an individual stops working. And be-

evidence on the dynamics of consumption across retirement age groups in the next section.

4.3 Robustness & External Validity

How robust are the patterns of consumption by retirement age documented above across data sources and across contexts? Two dimensions of external validity are worth exploring in particular. First, do these results generally hold when using other measures of consumption, such as survey data on consumption expenditure rather than our registry-based measure of consumption? The main difficulty in that respect is the limited availability of data with detailed information on both consumption and retirement behavior. Second, do these results generally hold across different countries? We note of course that the consumption patterns across retirement age groups will depend on the policy environment (e.g. the steepness of the pension profile, the availability of other insurance mechanisms against consumption risk in old age, etc.) which differ across countries and over time. But many countries share similar institutions to those described in Section 3.1, with pension profiles that penalize early retirement and it is therefore important to investigate whether the broad patterns of consumption documented in Sweden hold across institutional contexts as well.

To examine these issues, we report in Appendix D results from the SHARE and HRS data which contain, for similar cohorts, information on retirement and some measures of consumption for 11 European countries and the US. Overall these results confirm that the large gradient in consumption level between individuals who retire very late vs very prematurely is a robust finding across all contexts and data sources. Second, it also confirms that the non-monotonicity in the relationship between retirement age and consumption is also quite robust across contexts and data: for most people retiring between 60 and 65, there is no gradient, or if anything a negative gradient between consumption level and retirement age. Interestingly, we find that the overall gradient found in the HRS data for the US is bigger than the one we document in Sweden. There is a 40% difference in consumption levels at the same age between the premature and late retirees in the US (compared to a 15 to 20% difference in Sweden). This could be due to the presence of a steeper pension profile in the US compared to Sweden and the fact that insurance against shocks in late career (such as UI, and DI) is generally much less generous in the US than in Sweden. These results in turn suggest that the social

cause UI and DI may provide financial support until pension claiming for premature and early retirees, we explicitly account for UI and DI when computing the incentives provided by the pension profile to stop working at different ages. In Appendix Figure C-5, we show that the consumption differences across retirement age groups are robust to using an alternative measure of retirement that accounts for the time spent in UI or DI after an individual stops working.

marginal utility cost of increasing the steepness of the pension profile is much larger in the US than in Sweden.

4.4 Selection Into Retirement Ages

Our results so far show large differences across retirement age groups in consumption levels measured at the same age, when retired. They also reveal significant heterogeneity in the profiles of individuals across these retirement age groups: individuals who retire at different ages have different means of consumption, seem to have been subject to different shocks, etc. As shown in equation (9), in our baseline welfare implementation, such heterogeneity will indeed matter, as we require not only information on consumption differences but also on potential differences in welfare weights ($\omega_{r,t}$) and the non-consumption determinants of marginal utility ($\zeta_{r,t}$) that both affect the mapping between consumption differences and social welfare.

To shed further light on such heterogeneity, we now leverage the richness of observable characteristics in the Swedish data to explore systematically selection patterns into different retirement ages. This will help us understand the main mechanisms driving such consumption differences and how these consumption differences map into welfare. We pay particular attention to heterogeneity along dimensions that may affect the marginal utility of consumption conditional on consumption (e.g. health, value of leisure vs consumption, etc), or the Pareto weights ω_r directly (e.g. life expectancy).

To characterise selection into retirement age, we start by running a multinomial logit prediction model for retiring in one of the four different age groups (premature, early, normal or late retirement). The model includes a large set of socio-demographic characteristics as well as cohort fixed effects. In Figure 5, we report for each regressor the estimated marginal effects predicted at the mean on the relative probability to select into each of the group, using normal retirees again as reference category.

The figure reveals interesting patterns of heterogeneity across retirement age groups. Late retirees are significantly more educated than all other retirees and have already accumulated significantly more ATP points at age 55, indicative of successful careers in the labor market. In line with results from Figure 4, we find that late retirement is also associated with having a larger stock of total net wealth at age 59. We also note that selecting into late retirement is more likely for men, and for individuals without a spouse or a cohabitating partner.

At the opposite end of the spectrum, premature retirees exhibit the lowest educational attainment, and the lowest levels of wealth. Like late retirees, premature retirees are more likely to be male. But interestingly, premature retirees are not characterised by having the lowest amount of ATP points at age 55. In fact, their labor supply history at age 55 appears quite similar to that of normal retirees.

The most interesting patterns of selection relate to early vs normal retirees. Figure 5 reveals that early retirees have the highest level of household wealth at age 59 among all retirees. They are also more likely to be cohabitating or married, and to be female. Their ATP points at age 55 are also significantly larger than that of normal retirees. These results confirm the evidence from Figure 4 showing that early retirees indeed have the means to retire earlier. A possible explanation for this pattern lies in complementarities in labor supply decisions around retirement: early retirees, who are more often women and more often enjoy an above-average consumption, may time their retirement with that of their older spouse.[27] This strong correlation between wealth and retirement age also hints at the presence of significant wealth effects on labor supply around retirement (Giupponi [2019], French et al. [2020]).

In panel B of Figure 5 we further explore selection on health and life expectancy. To this effect, we start by running specification (12), replacing consumption on the left-hand side by two indices for bad health: the first corresponds to the standardized principal component extracted from all health outcomes available in the HEK survey, and the second index is similarly constructed based all health variables from the ULF survey.[28] Regressions include cohort and age fixed effects (to control for the age profile of health), as well as controls for family structure and ATP points at age 55. In effect, we compare the health in retirement of individuals of the same cohort, and at the same age, who retired at different ages. On the right of panel B, we also focus on differences in "life expectancy", by now using as an outcome a dummy for having died by age 70, or by age 75.[29]

For all outcomes, we find the presence of a very steep negative gradient with retirement age. In other words, earlier retirement is strongly associated with having significantly worse health. And this effect appears particularly strong for premature retirees: their health, measured by our bad health indices, is between .5 and .75 standard deviation worse than that of late retirees. Premature retirees are also almost 14 percentage points more likely to have died by age 75 than late retirees. Interestingly, we do not

[27] The average age difference between couples in our data is 3.8 years while the difference in age of retirement is 3.3 years suggesting a joint retirement decision for couples as these two differences coincide. Gustman and Steinmeier [2000], using US data from the National Longitudinal Survey of Mature Women for the US, and Hospido and Zamarro [2014], using the European SHARE dataset, make similar findings on both the average age differences and a joint retirement decision for couples.

[28] See section 3.2 and Appendix B for details on the construction of these indices.

[29] These results rely on a specification similar to (12), although we now only have one observation per individual: as a result, we drop age fixed effects, and only include cohort fixed effects, as well as controls for family structure and ATP points at age 55.

find any significant non-monotonicity for health outcomes: early retirees do not enjoy better health status or longer life expectancy than normal retirees despite being wealthier and more likely to be female.[30]

Overall, the selection patterns documented above suggest that premature retirees have, compared to late retirees, little means to smooth consumption, significantly worse health, and much shorter life expectancies, all of this conditional on labor market history up to age 55. Such heterogeneity is therefore likely to increase the social marginal cost of steeper pension profiles, strengthening the effects of the strong gradient in consumption levels across retirement age groups.

The above conclusions on the role of selection deserve an important qualification: we have assumed, following equation (9) the absence of correlation between consumption expenditures and other determinants of marginal utility (ζ). But in practice, this assumption may seem strong: for instance, having worse health may be associated with constrained medical expenditures, driving overall consumption up. We can nevertheless easily investigate the extent of this correlation by exploring how the consumption patterns evolve when controlling for the various dimensions of heterogeneity documented above. Appendix Table C-1 shows that consumption patterns across retirement age groups are actually very robust to the inclusion in specification (12) of controls for health expenditures (health insurance). They are also robust to the inclusion of the various characteristics that correlate with selection into retirement ages, although, as expected, including wealth does reduce the overall gradient. If the inclusion of these fixed dimensions of heterogeneity have limited power to explain the differences in consumption levels across retirement age groups, this suggests that other factors such as shocks received late in the working life must play an important role.[31]

Our results so far have focused on consumption differences at retirement, and on heterogeneity observed while in retirement as well. But, as suggested by formula (10), the dynamics of consumption and heterogeneity around retirement are also informative for welfare purposes. Are the consumption differences across retirement age groups permanent? That is, are these differences in consumption similar prior to retirement? Or are they emerging around retirement? And is the health status of premature retirees permanently lower than other retirees or do these health differences happen around retirement? Could it even be reverse causality, i.e. earlier retirement caus-

[30] In Appendix Figure C-7, we report estimates separately for each available health outcomes composing our two health indices. Results confirm the existence of the same strong negative gradient for all health measures, irrespective of their subjective or objective nature.

[31] One important corollary of this finding is that even if pension benefits were made conditional on a richer set of observable characteristics such as assets or family structure, the same consumption patterns with respect to retirement age would emerge, i.e. a strong positive gradient with some non-monotonicity around normal retirement age, leading to similar conclusions on the redistributive value of the pension profile.

ing a degradation in health status? The dynamics of consumption and heterogeneity around retirement can shed light on these questions, and help understand how much of the social welfare value of pension profile is driven by insuring consumption shocks around retirement rather than persistent differences in consumption over the lifecycle. In fact, the evidence we present in the next section suggests that most of the differences in consumption and health across retirement age groups are driven by strong divergence around the time of retirement, rather than by more permanent differences arising earlier in life.

5 Consumption Dynamics Around Retirement

We now present evidence on the dynamics of consumption and heterogeneity around retirement. We focus on empirical moments which, following formula (10), offer an alternative approach to evaluate the welfare effects of variation in the steepness of the pension profile.

5.1 Consumption Dynamics Across Retirement Age Groups

To explore consumption dynamics around retirement, we start by residualizing household consumption on a set of cohort fixed effects and age fixed effects, as well as on the same set of controls for ATP points at age 55 and household structure that we used in specification (12). Figure 6 panel A then plots residualized consumption as a function of time to retirement. We do this separately for premature, early, normal and late retirees. Because of our residualization, we compare in effect the dynamics of consumption of individuals from the same cohort, and at the same age, who had similar careers up to age 55, but who retire at different ages. [32]

The figure reveals interesting heterogeneity in consumption dynamics by retirement age groups. We can decompose the analysis of these dynamic patterns into four broad periods: the pre-retirement period up to two years before retirement, the period just before retirement (the two years leading to retirement), the year of retirement itself, and the post-retirement period. We start with the pre-retirement period: up until two years before retirement, all retirement age groups seem to be experiencing relatively

[32]Note that the graph scales residual consumption of each group by its level two years prior to retirement. Because of the year and cohort coverage of our consumption and retirement pension data, the earliest we can observe consumption among all premature retirees is 3 years prior to retirement. And the latest we can observe consumption among all the late retirees is three years after retirement. This explains the differential coverage of the residualized consumption series in terms of event time in Figure 6.

similar trends in consumption. We report on the graph the yearly consumption levels of the four retirement age groups two years before retirement. It reveals that the premature, early and normal retirees not only experience similar trends, but also remarkably similar consumption *levels* at this point. This suggests that for these three retirement age groups, there are no sizeable differences in consumption patterns up to two years before retirement. Late retirees, however, clearly stand out in terms of consumption levels in the pre-retirement period - although they experience quite similar trends at this point. Their consumption level is already 15% larger than the other three groups two years before retirement. In other words, the differences in consumption level *during* retirement between late retirees and the other retirees originate in the pre-retirement period.

We focus next on the period just before retirement. The graph highlights significant divergence in consumption patterns across retirement age groups in the two years leading to retirement. First, premature retirees experience a clear decline in consumption just before retirement, compared to all other groups. This decline amounts to a drop of 2.5% in two years relative to their prior consumption level. And it represents a drop of almost 5% compared to the consumption trend of early and normal retirees, the latter two groups sharing extremely similar dynamics just before retirement. At the other extreme, the consumption of late retirees increases sharply, by about 8%, in the two years just before retirement. This finding suggests that premature retirees are hit by negative shocks just prior to retirement, while late retirees are hit by positive shocks. This is in line with the evidence, reviewed in Blundell et al. [2016], that earnings ability shocks are important determinants of labor supply decisions in old age.

While there is a clear fanning out of consumption levels across groups in the period just before retirement, the retirement event itself affects all four groups in a remarkably similar fashion. All groups experience an equivalent drop in consumption of about 5% right at retirement. A large literature has focused on this drop in consumption at retirement, trying to crack the "retirement-consumption puzzle" (Banks et al. [2016], Aguiar and Hurst [2005b], Aguiar and Hurst [2013]). Whether an individual's consumption drop is driven by lack of insurance, by myopia, by work-related expenditures, or by other complementarities between consumption expenditures and leisure, has indeed critical implications for the mapping between consumption dynamics around retirement and the insurance value of pension for this individual. But importantly for our purpose, consumption drops at retirement are almost identical across all groups. In other words, the retirement consumption puzzle is the same across all retirement age groups, and cannot account for the large differences in consumption during retirement between individuals who retire earlier vs later. This implies that the mechanism behind this puzzle is *prima facie* inconsequential to evaluate the relative insurance value of pension across retirement age groups, and ultimately, the optimal pension profile by retirement age.

Finally, after retirement, the graph indicates that consumption patterns follow very similar trends across all groups. As a consequence, the differences in consumption that emerge just prior to retirement seem to persist, more or less unaltered, throughout retirement.

In panel B of Figure 6, we summarize the evidence on consumption dynamics into two moments: the estimated consumption drop in the year of retirement (i.e. between the age of retirement r and $r + 1$), and the estimated consumption drop in a larger time window around retirement (i.e. between $r - 2$ and $r + 2$) that encompasses dynamics of consumption prior to retirement. The graph confirms that while consumption drops *at retirement* are virtually identical for all groups, consumption drops *around retirement* are significantly different across retirement age groups, and exhibit a stark overall gradient by retirement age. The percentage drop in consumption around retirement of premature retirees is 6 percentage points larger than that of late retirees. But interestingly, there is once again evidence of some non-monotonicity, similarly to what we found for consumption levels in retirement: consumption drops around retirement are weakly decreasing with retirement age for the early and normal retirement age groups.

To recap the evidence on consumption dynamics from Figure 6, a large fraction of the persistent differences in retirement consumption across retirement age groups documented in section 4 seems to emerge in the last few years prior to retirement. More than two thirds of the gap in retirement consumption between premature and normal retirees emerges in the couple of years prior to retirement. And despite late retirees already enjoying significantly more consumption than other groups in their fifties, still more than half of the gap in retirement consumption between premature and late retirees also emerges just around retirement. This suggests that a large fraction of differences in consumption during retirement across retirement age groups relates to the incidence of differential shocks to consumption ability around retirement. In turn, this implies that the redistributive value of the pension profile, inferred from consumption differences during retirement, actually captures in large part an insurance value against these late-career shocks.

5.2 Dynamic Selection Into Retirement & The Role Of Work Longevity Risk

We have shown before how individuals with different observable characteristics select into different retirement ages. We now briefly gauge whether different dynamics lead to retirement at different ages, paying particular attention to health dynamics, as a proxy for the incidence of work longevity risk. A large literature has argued that health shocks are a significant determinant of retirement. We adopt a similar methodology as in our analysis of consumption dynamics in Figure 6, and compare health dynamics and incidence of work longevity risk across retirement age groups.[33] We regress health outcomes of individual i at age t on dummies for belonging to each of the four retirement age groups interacted with dummies for being at event time $e = t - r$ relative to retirement:

$$H_{it} = \sum_j \sum_k \alpha_{jk} \cdot \mathbb{1}[\mathrm{r = j}] \cdot \mathbb{1}[\mathrm{e = k}] + \gamma_y + \gamma_t + \mathbf{X}'\beta \tag{13}$$

Due to the limited sample size of the health surveys, we group event times e by bins of 2 years, from 6 years before to 5 years after retirement and we report for each retirement age group the sequence of estimated coefficients $\hat{\alpha}_{re}$ around the event of retirement. We control in the regression for a series of cohort and age fixed effects, to account for the cohort and age profiles of health outcomes, as well on the usual vector **X** of our baseline controls (i.e. ATP points accumulated up to age 55 and household structure).

Figure 7 panel A reports the results from specification (13) where we use our bad health indices as an outcome, pooling both HEK and ULF surveys together.[34] The graph indicates the existence, in the pre-retirement period, of a significant gradient in health across retirement age groups. Premature retirees have a bad health index around .25 standard deviations higher than other retirees already five years prior to retirement. But we also see a clear fanning out of health outcomes just around retirement, driven by a significant worsening of the health of premature retirees. As a result, the post-retirement differences in health between premature retirees and the other three groups are twice as large (around .5 standard deviation in our bad health index) as their pre-retirement level. Interestingly, there is no significant variation in health around retirement for early, normal and late retirees (once controlling for the age profile of health).

Panel B confirms these dynamic patterns, using as an outcome the fraction of individuals reporting that they are experiencing pain. The graph shows that premature

[33] This further allows us to check whether the differences in health outcomes during retirement documented in Figure 5 pre-date retirement, and whether they are caused by early retirement (Kuhn et al. [2018], Fitzpatrick and Moore [2018], Bozio et al. [2021])

[34] In practice, this means that we run specification 13 on the combined ULF and HEK samples, with H_{it} being the standardized first principal component from the ULF health outcomes if individual i is observed in the ULF sample, and H_{it} being the standardized first principal component from the HEK health outcomes if individual i is observed in the HEK sample. In Appendix Figure C-8, we report the results where instead of pooling the data, we run separate regressions on the ULF and HEK samples.

retirees have a 5 percentage points higher probability of experiencing pain 5 years prior to retirement compared to other retirees. But this probability increases steadily up to retirement, at which point it is 15 percentage points larger than for the other three groups, and persists at this high level after retirement. Again, we find no significant evolution of the probability to report pain around retirement for early, normal and late retirees. Appendix Figures C-8 and C-9 show that these dynamic health patterns replicate across various health outcomes, such as the fraction experiencing reduced work capacity, or the fraction reporting retiring due to health reasons. Overall, these results provide evidence that premature retirees (and to a smaller extent early retirees) experience significant negative health shocks around retirement, with persistent effects throughout retirement. This in turn implies that a large fraction of health differences during retirement between premature (and to a lesser extent early) retirees and other retirees are due to negative health shocks experienced just around retirement. We also note that the evidence displayed here alleviates concerns about potential reverse causality in the relationship between retirement age and health during retirement. If reverse causality was at play, that is if health differences in retirement across groups were driven by the absence of work in old age being detrimental for health, we would expect to observe a (potentially gradual) decrease in health, similar for all groups, after retirement. To the contrary, we observe that the degradation of health happens entirely prior to retirement, and is highly heterogeneous across groups.

To summarize, we find that differences in retirement consumption levels across retirement age groups are primarily driven by the dynamics of consumption just around retirement. In particular, premature retirees seem to experience negative consumption shocks just around retirement, which happen to strongly correlate with proxies for the incidence of work longevity risk, like, for instance, the estimated dynamics of health. This suggests that flatter pension profiles offer particularly valuable insurance against work longevity risk for premature retirees.

Furthermore, our results suggest that health shocks affect the timing of retirement primarily for premature retirees, and not so much for the rest of the population. This confirms the results from Blundell et al. [2016b] that health dynamics explain only a limited part of the overall distribution of the timing of retirement, but with an important caveat. Indeed, if there is no significant correlation between health dynamics and the timing of retirement for most retirees (i.e. for the large fraction of the population that retires after 63), the sensitivity of labor supply to health in old age is also highly heterogeneous, and is actually particularly strong for the minority of people who stop working prematurely (Gustman and Steinmeier [2018]).

6 Marginal Propensity to Consume Around Retirement

We finally turn to the estimation of MPCs around retirement. Comparing MPCs across retirement age groups offers an alternative way to empirically capture the social marginal utility costs of variations in the pension profile. The advantage of this approach, relative to the comparison of consumption levels, or consumption drops around retirement, is that it does require much fewer assumptions on the curvature of utility. Furthermore, because MPCs implicitly reveal the shadow price attached to raising an additional unit of consumption (Landais and Spinnewijn [forthcoming]), comparing MPCs enables to identify how the value of liquidity, or equivalently the level of insurance against consumption risk in old age, varies across retirement age groups.

6.1 Empirical Strategy: Quasi-Random Wealth Shocks

The challenge in measuring heterogeneity in MPCs lies in finding a credibly exogenous source of variation in income or wealth that applies similarly across the population of retirees. We use variation in individuals' financial wealth coming from quasi-random shocks to the price of stocks that individuals hold in their portfolio (similar to what has been done in Di Maggio et al. [2020]) We start from the KURU register, which has disaggregated information over the period 1999 to 2007 on all quantities of stocks, by ISIN number, held by individuals outside of mutual funds. We then match this data with information from the financial company SIX on prices of all listed stocks at the Stockholm stock exchange for each ISIN over the entire period 1990-2015. For each individual i, we define the passive capital gains on her portfolio in year $t+1$ as:

$$\mathrm{KG}_{i,t+1} = \sum_j (p_{j,t+1} - p_{j,t}) \cdot a_{ijt} = \sum_j \Delta p_{j,t+1} \cdot a_{ijt}$$

where a_{ijt} is number of stocks of company j held by individual i on 31st of December of year t and Δp_{jt+1} is the change in the price of stock j between 31st of December of year $t+1$ and 31st of December of year t.[35] We then match this data with our baseline retirement sample. Appendix Table E-1 provides descriptive statistics on this matched sample, and evaluates its representativeness, compared to our baseline sample. First, we observe financial portfolios in the KURU data for almost half of the individuals from our baseline retirement sample. Second, the distribution of retirement ages is well balanced between the two samples: the fraction of premature, early, normal and

[35]Note that we consider passive capital gains at annual frequency, between 31st of December of each year, as this is the frequency at which we can also observe consumption. Throughout the analysis, we also exclude the top and bottom 1% of passive capital gains in the sample. We show in Appendix E that our results are robust to various other approaches to dealing with outliers.

late retirees is remarkably similar in both samples. Other observable characteristics such as cohort, gender, education, labor market history at 55, earnings prior to retirement, or pensions received, are also well balanced across the two samples. The main difference is that individuals observed in the KURU data are somewhat wealthier on average. Finally, in Appendix Figure E-2 we estimate consumption differences across retirement age groups for the matched KURU sample: reassuringly, results show patterns that are virtually identical to that of our baseline Figure 3.

With this data in hand, we now show that conditional on a rich set of portfolio characteristics, stock prices do follow a random walk. Or in other words, that innovation to prices of listed stocks, after controlling for the structure of a portfolio, are white noise. For this purpose, we examine the serial correlation of passive capital gains, by regressing leads and lags of passive capital gains on current passive capital gains. For all years $k \in \{-6, ..., 6\}$, we estimate the following specification:

$$\text{KG}_{i,t+k} = \alpha_k \text{KG}_{i,t+1} + \mathbf{X}'\beta \tag{14}$$

where $\text{KG}_{i,t+k} = \sum_j \Delta p_{j,t+k} \cdot a_{ijt}$ represents the passive capital gains that an individual would have accrued between $t+k-1$ and $t+k$, had the structure of her portfolio remained exactly the same as in year t. To account for the fact that portfolios of different value and of different risk structure face different stock price trends, the vector $\mathbf{X}$ controls non parametrically for the value of the portfolio in year t, as well as for the average returns and variance of the portfolio in the 6 years prior to year t.[36]

Appendix Figure E-3, which plots the estimated coefficients $\hat{\alpha}_k$ for all time horizons $k \in \{-6, ..., 6\}$, reveals that current passive capital gains display no correlation with either past or future passive capital gains, conditional on portfolio value and structure. In other words, residual passive capital gains on listed stocks are as good as random, which implies that they generate random, discrete and, most importantly, highly *persistent* shifts in financial wealth. To provide a visual representation of the dynamic impact of passive capital gains on the value of an individual's portfolio, we correlate leads and lags of one's portfolio value $V_{i,t} = \sum_j p_{j,t} \cdot a_{ijt}$ with passive capital gains in year $t+1$. More precisely, we regress the change in portfolio value $\Delta_{t,t+k}\text{V}_i = \text{V}_{i,t+k} - \text{V}_{i,t}$ of individual i between t and $t+k$ on her passive capital gains in $t+1$, conditioning on the same vector of portfolio characteristics as in (14):

$$\Delta_{t,t+k}\text{V}_i = \alpha_k^V \text{KG}_{i,t+1} + \mathbf{X}'\beta \ \ , \forall k \in \{-3, ..., 3\} \tag{15}$$

[36] In practice, we use 50-tiles of portfolio value interacted with vigintiles of average returns in the past six years, and 50-tiles of portfolio value interacted with vigintiles of average variance in the past six years.

Figure 8 panel A plots the estimated coefficients $\hat{\alpha}^V_{t+k}$ for all time horizons $k \in \{-3, ..., 3\}$. The graph shows that a passive capital gain of one krona is associated with a sharp, immediate, and permanent increase in portfolio value of about .6 krona.[37] These sharp dynamic patterns in portfolio values, driven by the randomness of stock price shocks, lend support to our strategy, which consists in treating passive capital gains conditional on portfolio characteristics $\mathbf{X}$, as an instrument for wealth. In Appendix Figure E-1, we show the variation in residualized capital gains that is key to our identification strategy. More than 31 percent of the passive capital gains/losses we exploit have absolute value over 10,000 SEK, which represent sizeable shocks.[38] Furthermore, the graph highlights that the distribution of our instrument is similar across retirement age groups.

6.2 MPC: Results

Our strategy relies on identifying the effect of wealth shocks on consumption by instrumenting wealth shocks by passive capital gains. We start by representing graphically the evolution of consumption around the time of a passive capital gain shock, which corresponds to the reduced-form dynamics of our IV. More precisely, we regress the change in consumption $\Delta_{t,t+k}C_i$ between year t and $t+k$ on the passive capital gains experienced in year $t+1$, conditioning on the same vector of portfolio characteristics as in (14):

$$\Delta_{t,t+k}C_i = \alpha^C_k \mathrm{KG}_{i,t+1} + \mathbf{X}'\beta \tag{16}$$

Panel B of Figure 8 plots the estimated coefficients $\hat{\alpha}^C_k$ from the above specification, for all year horizons $k \in \{-3, ..., 3\}$. The graph conveys two important insights. First, in support of our identification strategy, we observe no sign of correlation between an individual's current passive capital gains and her consumption path in previous years. The absence of pre-trend in consumption indeed lends credibility to the validity of our instrument. Second, the figure shows that, in response to a passive capital gain of

[37]Two related factors explain why $\hat{\alpha}^V_1$ is lower than 1, as one would have anticipated. First, because of the yearly frequency (between December and December) at which we observe stock price movements, and because of the presence of within-year trading, many portfolios change structure over the course of a year. For instance, an individual may have sold in January of $t+1$ all her stocks a_j she held in December of year t. If all the price appreciation $\Delta p_{j,t+1}$ of stock j between December of year t and December of year $t+1$ actually happened after January, e.g. between February and December of year $t+1$, then KG_{t+1} will overstate the true capital gains experienced in $t+1$. To the extent that intra-year trading is uncorrelated with the evolution of prices between these two dates, this will simply introduce measurement error. But, and this is the second factor, individuals may also *endogenously* realize passive capital gains, thus decreasing portfolio value V_{t+1} by the share of passive capital gains that is realized. To deal with both issues, our approach consists in treating passive capital gains KG_{t+1} as an instrument for the change in financial wealth ΔV_{t+1}.

[38]These shocks are large compared to the variation exploited in the existing literature on wealth shocks. For instance, only 9% of the lottery shocks in Cesarini et al. [2016] are larger than 10,000 SEK.

1 krona, consumption increases immediately, significantly and persistently by about .03 krona. The sharpness of these consumption patterns, which closely mimic the dynamics of portfolio value in panel A, suggests that our strategy truly captures the causal effect of the induced wealth shock on consumption.

To obtain the implied marginal propensity to consume, the increase in consumption estimated in panel B needs to be scaled by the corresponding increase in wealth estimated from the first stage. In Panel A we get that the value of financial wealth increases by about .6 krona in response to a passive capital gain of 1 krona. Therefore, the estimated increase in yearly consumption of .03 krona translates into a marginal propensity to consume of .03/.6=.05 after a year, and of .15 after three years.

In Table 2, we report 2SLS estimates of MPCs corresponding to the evidence presented in Figure 8. We focus on average yearly consumption in the three years following a wealth shock $\overline{C}_{i,t,t+3}$, and estimate the following 2SLS model:

$$\overline{C}_{i,t,t+3} - C_{i,t} = \alpha_{IV}^{C} \Delta_{t,t+1} V_i + \mathbf{X}'\beta \tag{17}$$

$$\Delta_{t,t+1} V_i = \alpha_1^{V} \mathrm{KG}_{i,t+1} + \mathbf{X}'\gamma \tag{18}$$

Note that the vector $\mathbf{X}$ conditions on the same rich set of portfolio characteristics as in (14) and also includes controls for year and cohort fixed effects, ATP points accumulated up to age 55, as well as household structure, as in our analysis of consumption level and of consumption dynamics in the previous sections. It finally includes a dummy for being retired in t. So in effect, we allow the dynamics of consumption to flexibly differ across individuals with different retirement status, previous careers, household structure or portfolio allocations. The coefficient α_{IV}^{C} identifies the average yearly marginal propensity to consume in years $t+1$ to $t+3$, out of an increase in financial wealth V_i generated by a random passive capital gains incurred between t and $t+1$. We obtain an MPC estimate *over a three years horizon*, by multiplying the coefficient α_{IV}^{C} by three. Standard errors are clustered at the individual level, and we explore the robustness of our results to alternative inference strategies in Appendix Table E-3.

Results reported in panel A confirm the graphical evidence from Figure 8. We find an average marginal propensity to consume of .17 (.01) over three years. This estimate lies at the lower end of the distribution of MPC estimates found in the literature, but can be rationalized by the fact that our population of interest is on average older and wealthier than in other similar studies. Furthermore, our results are in line with estimated MPCs in Di Maggio et al. [2020] who also rely on passive capital gains shocks as instruments for wealth shocks. We also report in the last column of Table 2 the estimates from a placebo test where we replicate specification (17) using as an outcome the change in consumption in the three years prior (rather than after) the wealth shock. The lack of any significant pre-trend is an important validation of the credibility of our identification strategy.

In panel B, we split the sample according to retirement status at the time of the passive capital gain shock to explore how MPCs differ before vs after retirement. We find that marginal propensities to consume increase significantly after retirement. The MPC of retired individuals is .30 (.04), compared to .13 (.01) for individuals who are still working. Because we are comparing retired and non-retired individuals conditional on age and cohort fixed effects, these results are not simply capturing the fact that older, retired individuals have a shorter horizon over which to smooth consumption, driving their MPCs up. Rather, it suggests that retirement is associated with an increase in the value of liquidity conditional on age.

In panel C, we then split the sample and estimate MPCs by retirement age groups, to see how the value of liquidity varies with retirement age. The results show significant heterogeneity in MPCs across retirement age groups with a strong overall negative gradient of MPCs with retirement age. MPCs for premature and early retirees are around .35 over three years, and markedly larger than for normal retirees (.09). Interestingly we find that the MPC of late retirees is small, and not significantly different from zero. In other words, while the value of additional liquidity seems to be high for individuals who retire early or prematurely, it seems negligible for late retirees. These results accord with the evidence on consumption dynamics from the previous section. In particular, it suggests that individuals who retire earlier are more likely to be subject to negative, uninsurable shocks, and as a consequence, to have a higher value of additional liquidity to smooth consumption relative to individuals who retire late.

The results from panel C of Table 2 control for age and retirement status and therefore compare MPCs of individuals who retire at different ages while in the same retirement state. Yet, the estimates may capture different LATEs across retirement age groups, as they will place more weights on the MPCs of retired people among the premature retirees, and more weights on non-retired individuals among the late retirees. Ideally, we would therefore like to compare the MPCs of the different retirement age groups *only while retired*. Having enough power to do so however, requires adding more cohorts to our original sample, in order to observe a long panel of consumption while retired for all retirement age groups. We do so in Table 3 where we enlarge our sample to include all cohorts from 1932 to 1950, and restrict the sample to individuals who are retired at the moment of experiencing a capital gain shock. Panel A reports estimates for all retirement age groups together: the estimated MPC over a three-year horizon is .28 (.04). Reassuringly, this is almost identical to the estimated MPC for retired individuals in panel B of Table 2, which focused on cohorts 1938 to 1943. In panel B, we report the estimated MPC when splitting the sample into our four retirement age groups. Although standard errors are somewhat larger, results confirm that, while in retirement, MPCs are high for premature and early retirees, and that MPCs are low and insignificant for late retirees.

Appendix E provides further sensitivity analysis. In particular, we show that, when focusing on smaller capital gains by excluding the top and bottom 5% of capital gains, the overall level of MPC increases, but the gradient with retirement age remains robustly negative.

Concluding Comments on Empirical Evidence We have documented three important facts about consumption patterns by retirement age. First, consumption levels while in retirement exhibit a strong overall gradient with retirement age. Second, within-individual consumption dynamics around retirement also differ by retirement age: premature retirees exhibit larger drops in consumption around the time of retirement. Finally, MPCs in retirement decrease with retirement age, being almost insignificant for late retirees. These three empirical moments (consumption level in retirement, consumption drops, MPC) offer three ways to capture the marginal utility of pension transfers that seem remarkably congruent, despite relying on different underlying assumptions regarding the mapping of consumption into welfare.

7 Welfare and Policy Implications

This section uses the consumption patterns documented in the previous sections to evaluate pension reforms that provide stronger incentives for later retirement. We consider two types of budget-balanced changes in the pension profile. First, we consider a simple steepening of the pension profile at a given retirement age $\tilde{r}$ by reducing pensions for individuals retiring before age $\tilde{r}$ by some small amount $db_{r\leq\tilde{r}}$, and increasing them for individuals retiring after age $\tilde{r}$ by $db_{r>\tilde{r}}$. Budget balance requires that $db_{r>\tilde{r}} = -\frac{1-S(\tilde{r})}{S(\tilde{r})}db_{r\leq\tilde{r}}$, where $1 - S(\tilde{r})$ is the share of individuals who retired before age $\tilde{r}$.[39] This type of reform is illustrated in Panel B of Figure 1 for $\tilde{r} = 65$. Second, we consider a marginal, budget-neutral tilt in the pension profile in the direction of the 1998 Swedish pension reform described in Section 3.1. We can view this change in the pension profile over the entire range of retirement ages as a combination of the first type of retirement-age specific changes.

[39] To be precise, we can implement this change in benefits for individuals at any given age t, but would need to scale by the share of individuals retiring before vs. after age $\tilde{r}$ among the individuals still alive at that age t. For brevity, we drop the age subindices.

Consumption Smoothing To calculate the consumption smoothing cost of providing steeper incentives, we first use the implementation of the relative difference in SMU's using the relative difference in consumption levels, as shown in equation (9) and estimated in regression (12). We thus scale again the differences across retirement age groups relative to the normal retirement age group. Figure 9 shows the consumption smoothing costs of steepening the profile for each retirement age $\tilde{r} \in [57, 69]$. For this baseline implementation, we assume no differences in welfare weights across retirement ages, neither in marginal utilities conditional on consumption. That is, building on equation (9),

$$\frac{SMU_{r\leq\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}} \approx \gamma \times \left[\frac{E_{r>\tilde{r}}(c)}{E_{r\in NRA}(c)} - \frac{E_{r\leq\tilde{r}}(c)}{E_{r\in NRA}(c)}\right]. \tag{19}$$

We assume a CRRA risk aversion parameter γ of 4, following Landais and Spinnewijn (2021). We discuss alternative assumptions below. For this baseline implementation, the consumption smoothing costs range between .10 and .33. Hence, per dollar(/krona) transferred from individuals retiring early to individuals retiring late, social welfare decreases by between 10 and 33 cents due to the loss of consumption smoothing. Figure 9 shows a clear non-monotonicity in the consumption smoothing costs by retirement age, reflecting the earlier non-monotonicity in the consumption levels. With a constant fiscal externality across retirement ages, this pattern implies that the net welfare return of providing steeper incentives is higher at ages between the early and normal retirement age compared to the age before the early retirement age or after the normal retirement age.

We can also obtain an estimate of the consumption smoothing cost of the change in profile due to the Swedish reform by weighting the SMU's with the change in pension benefits at each retirement age. The corresponding estimate equals .15. Because most individuals retire between 61 and 65, where we estimate the lowest costs of providing steeper incentives, this estimate for the Swedish reform is at the lower end of the range for all age-specific reforms.

Fiscal Externality Benchmark While our focus is on the consumption smoothing aspect of the welfare effects of steeper profiles, we benchmark our estimates with a back-of-the-envelope estimate of the corresponding fiscal externality.[40] Steeper incentives at retirement age $\tilde{r}$ increase the survival rate into employment at this age due to a substitution effect, depending on the Frisch labor supply elasticity at age $\tilde{r}$. We assume $\frac{\partial S(\tilde{r})}{\partial b_{r>\tilde{r}}} \cong -\frac{\partial S(\tilde{r})}{\partial b_{r\leq\tilde{r}}} \cong \varepsilon_{S(\tilde{r}),w_{\tilde{r}}} \times \frac{S(\tilde{r})}{w_{\tilde{r}}}$, where $w_{\tilde{r}}$ is the wage at age $\tilde{r}$. Furthermore,

[40] Appendix F and Appendix G provide more details on the derivation and the implementation of the fiscal externality respectively.

a reduction in pensions for those retiring before age $\tilde{r}$ increases their survival in employment due to an income effect, while an increase in pensions for those retiring after age $\tilde{r}$ reduces their survival in employment. Assuming that the fiscal externalities of the opposing income effects cancel out for a budget-balanced change, the net return to transferring a dollar from individuals retiring before $\tilde{r}$ to individuals retiring after $\tilde{r}$ can be approximated by:

$$\Delta W_{\tilde{r}} \cong \frac{\tau_{\tilde{r}} - [NPV_{\tilde{r}+1} - NPV_{\tilde{r}}]}{w_{\tilde{r}}} \times \varepsilon_{\frac{S(\tilde{r})}{1-S(\tilde{r})}, w_{\tilde{r}}} - \frac{SMU_{r\leq\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}}. \tag{20}$$

The first term in equation (20) captures the fiscal return, which depends on the elasticity of the odds ratio of the labor share at age $\tilde{r}$ and the corresponding participation tax rate.[41] We assume a labor supply elasticity of .22, as estimated in Laun (2017) using the Swedish reform. Estimates in other European countries report both somewhat higher elasticities (.25 in Manoli and Weber [2016] and .33 in French et al. [2020]), but also lower elasticities (≈ 0 in Seibold [2021]). The results from the simulations of pension benefits discussed in Section 3.1 suggest a participation tax rate of about .45 (see Appendix Figure A-9 and the surrounding discussion).[42] Together, this results in a fiscal externality from inducing later retirement of .15. This means that per dollar transferred from individuals retiring before $\tilde{r}$ to individuals retiring after $\tilde{r}$, we would gain about 15 cents.

For a fiscal externality of .15, the net impact of the steepening of the profile in the Swedish reform would have been zero. However, if the fiscal externality is the same at different retirement ages, the net welfare effect of providing steeper incentives, either below the early entitlement age or above the normal retirement age, has been negative, while it has been positive in between.[43] This suggests the optimality of making

[41]Here we have expressed the welfare effect relative to the value of a dollar given to our reference group of individuals retiring at the normal retirement age (SMU_{NRA}), which we assume to be approximately equal to marginal cost of public funds λ.

[42]We gauge the robustness of this value when accounting for non-pension social insurance benefits and changing the claiming age in the Appendix. Such benefits increase the participation tax rate by about 0.05, implying that they increase the fiscal externality by 0.02.

[43]While the participation tax rate is relatively flat across retirement ages in reality, the invariance of the fiscal externality across retirement ages also assumes that the odds ratio elasticity $\varepsilon_{\frac{S(\tilde{r})}{1-S(\tilde{r})}, w_{\tilde{r}}}$ is constant across r. A more detailed analysis of labor supply responses would allow us to relax the assumption of a constant fiscal externality across retirement ages. The key unknown is how the relevant elasticity varies between early and late retirees. As far as we can tell, this question is not studied in prior literature. The literature on retirement incentives and labor supply rightly points out that the elasticity is not a structural parameter and depends on what portion of workers are near the margin of retirement at a given age (French [2005], French and Jones [2012], Blundell et al. [2016]). However, the existing studies mostly point out how this matters for labor supply elasticities at prime working age versus around retirement, rather than at early versus late retirement ages. For our purposes, one would also wish to account for compositional effects, as later retirees are different from earlier retirees in ways that could matter for their labor supply elasticity (e.g. they are less subject to negative health shocks

the retirement incentives more S-shaped, with stronger incentives for continuing to work between early and normal retirement ages, but more muted incentives at both premature and late retirement ages.

Sensitivity and Alternative Implementations Our baseline implementation shows how the differences in consumption translate into differences in SMU's, but, as discussed in Section 2, this mapping crucially depends on the curvature in preferences and potential differences in welfare weights. Table 4 gauges the sensitivity of our estimates of the SMU's to different implementation assumptions. Column (1) repeats the baseline estimates, averaged for the age ranges that correspond to our four retirement age groups. Column (2) shows the estimates when reducing the curvature in consumption preferences to $\gamma = 2$. This reduces the consumption smoothing cost and would turn the net welfare gain into a positive value for a large range of retirement ages. However, recent work in the context of unemployment (e.g. Hendren [2017], Landais and Spinnewijn [forthcoming]) indicates that the consumption-based approach requires more curvature than in our baseline implementation ($\gamma \geq 4$). Moreover, the level of risk aversion, when uniform across retirement ages, does not change the the overall pattern in consumption smoothing gains and the non-monotonicity in particular. Column (3) shows the estimates when assigning welfare weights to retirement age groups depending on their life-expectancy. We obtain differences in life expectancy using a Gompertz extrapolation of the mortality rates estimated by retirement age group, following Chetty et al. [2016]. We then calculate compensating consumption differentials that would equalize the expected life-time utility for individuals with different retirement ages, following Becker et al. [2005], and use these compensating differentials to adjust the SMU's. Individuals who expect a shorter lifetime are assigned a higher SMU and vice versa. See Appendix G for further details. The resulting impact on the consumption smoothing costs is intuitive. Since individuals retiring earlier expect a shorter life-time, their welfare-adjusted SMU's will be higher and thus increase the consumption smoothing costs from providing steeper incentives, ranging now between .15 and .37 for different retirement ages.

In columns (4) and (5) we consider the consumption smoothing costs using the two alternative implementations of the SMU's based on the consumption drops and MPCs respectively. The estimates in column (4) follow equation (10). We use the difference in consumption drops from two years before to two years after retirement (see Figure 6), scaled by $\gamma = 4$. We now assume that the welfare weights multiplied by

and have longer life expectancy, as shown above). Note that our assumption of a constant odds ratio elasticity $\varepsilon_{\frac{S(\tilde{r})}{1-S(\tilde{r})},w_{\tilde{r}}}$ implicitly assumes that later retirees have a relatively inelastic Frisch elasticity of labor supply $\varepsilon_{S(\tilde{r}),w_{\tilde{r}}}$.

the marginal utility of consumption before retirement are the same across retirement ages. The estimated consumption smoothing costs are somewhat smaller than in the baseline estimation. For the Swedish profile reform, we obtain a cost of .11 instead of .15. The pattern is also similar across retirement ages. As shown in the empirical analysis, the differences in consumption drops around retirement capture most of the differences in consumption levels post-retirement. This suggests that the loss in consumption smoothing due to Swedish reform has been predominantly driven by the loss of insurance against retirement shocks, rather than by the reduced redistribution between individuals with different pre-retirement consumption. Column (5) reports the consumption smoothing costs based on the MPC implementation in equation (11). We use the MPC estimates when retired for the extended sample in Table 3. The estimated consumption smoothing costs are now somewhat higher when evaluating the profile change due to the Swedish reform. We obtain a cost of .21 compared to .15 in the baseline implementation. Note that this implementation no longer relies on an estimate of the curvature in consumption preferences. The pattern in retirement age-specific costs, however, is different, reflecting the (imprecisely) estimated pattern of MPC estimates for the premature and early retirees in the extended sample in Table 3. We also find a very high cost (.88) of steepening the profile for late retirees. This is driven by their near-zero MPC estimates, indicating that the value of providing extra liquidity to this retirement group is very low.

Policy Implications Overall, our estimates indicate that the consumption smoothing cost of providing steeper incentives can be substantial, and especially so for premature and late retirement ages. If the fiscal cost is similar across ages, this then suggests the optimality of an S-shaped reform of the pension profile, with stronger incentives between early and normal retirement ages, but muted incentives for premature and late retirement ages. In other words, there must be strong incentive effects to be able to rationalize higher penalties for workers leaving the labor market before the early entitlement age and higher bonuses for workers continuing to work after the normal retirement age. These penalties and bonuses, however, are central in pension reforms, including in the Swedish pension reform which increased incentives the most for individuals retiring after the normal retirement age.

Our analysis demonstrates the value of providing insurance against the risk of leaving the labor market prematurely. As discussed before, especially for the premature exits, the pathway into retirement is often through DI or UI (see Appendix Figure A-6). DI and UI thus provide complementary insurance, both through the transfers received and the accumulation of pension points while on DI/UI. Our consumption-based estimates of the marginal value of extra transfers account for all resources retirees can rely on, including these transfers received through the DI/UI system. As discussed before, this pathway also changes the fiscal externality from inducing individuals to work longer, but these effects are very modest, increasing the fiscal externality from .13 to .15 only (see Appendix Figure A-9).[44]

Finally, one could enrich the policy implications of the analysis undertaken here by accounting for additional heterogeneity, both in the reform that different subgroups have been subject to and the impact the reform has had on them. The 1998 reform has changed the incentives to continue working differently for individuals with different careers earlier in life – see Appendix Figure A-8. For individuals in the bottom decile of the distribution of pension points accumulated at 55, the pension profile in fact became flatter, mostly due to the more generous minimum pension benefit after the reform. For individuals in the top decile, the pension profile became much steeper, mostly due to the more generous maximum pension benefit. Columns (2) and (3) in Appendix Table G-4 show the consumption smoothing cost from increasing incentives for the respective groups. The consumption differences are less pronounced in the bottom decile, partly because of the flatter pension profile. Hence, making the profile steeper for this group would have been less costly, but the Swedish reform did exactly the opposite. Similarly, we found that the overall gradient in consumption is smaller and the non-monotonicity at early retirement is less pronounced for couples, presumably because they can rely on intra-household insurance. This translates into substantially lower consumption smoothing costs from steeper incentives for couples than for single households, especially between the early and normal retirement age (columns (4) and (5) of Appendix Table G-4). As discussed above, apart from the minimum pension and survivor benefits, public pension benefits in Sweden are no longer dependent on household status, unlike in some other countries (see Persson [2020]). Our results suggest that the insurance benefits of the pension system could be better targeted by conditioning on household status, with more generous insurance against the risk of early retirement for single-member households than for couples.

8 Conclusion

We find that pension reforms that incentivize later retirement by steepening the pension benefits profile have a substantially and potentially pivotal redistributive cost. We

[44]One could alternatively define retirement not as when people stop working, but as when people stop accumulating pension points. Column (6) in Appendix Table G-4 shows how with this definition change - i.e., using the consumption estimates for the alternative retirement age definition reported in Appendix Figure C-5 - the consumption smoothing cost is smaller than in the baseline case (repeated in column 1). Indeed, redistributing resources away from people who stop working early, including those who go on UI and DI, is costlier than from people who leave the labor market early, excluding those who go on UI and DI.

reach this conclusion from not only an analysis of the gradient of consumption over the retirement age, but also an analysis of drops in consumption around retirement, marginal propensities to consume, and patterns of selection into early retirement. A number of findings further suggest that work longevity risk is an important driver of the redistributive cost of steeper pension benefits profiles. However, we also find that the redistributive cost of a steeper benefits profile is largest for very early and very late retirement ages, and significantly smaller between ages 61 and 65. Altogether, these results suggest that the optimal pension profile is S-shaped, with relatively strong incentives rewarding longer working lives between 61 and 65 and more muted incentives providing greater insurance before 61, because premature retirees are especially in need and subject to shocks, and after 65, because late retirees are typically quite well off.

Our analysis could be extended in a number of directions in future work. First, pension benefits are notoriously complex, and one could evaluate reforms to other dimensions of the pension benefits schedules, such as the relationship between earlier-in-life earnings and pension benefits, in a similar fashion to our analysis here. Second, as we briefly discussed in the previous section, one could delve more deeply into heterogeneity in the steepness of the pension benefits profile across workers with different earnings histories. Doing so would be useful for evaluating, for instance, minimum and maximum pension benefits. Third, reflecting our discussion of UI and DI above, one could study the optimal design of pension and other social insurance programs jointly, accounting for the sometimes fuzzy boundaries between programs (Inderbitzin et al. [2016]). Fourth, a caveat to our finding of an optimal S-shaped pension profile is that we assume that the fiscal return to a steeper profile does not vary significantly over various retirement ages. Future work could speak to this question empirically by examining how the elasticity of retirement with respect to pension incentives varies between early and late retirees. Fifth, future research could incorporate behavioral frictions into the analysis of the optimal steepness of pension profiles. The types of behavioral frictions that are most likely to matter for the evaluation of steeper profiles are those affecting retirement decisions specifically (e.g. Seibold [2021], Reck and Seibold [2021]).

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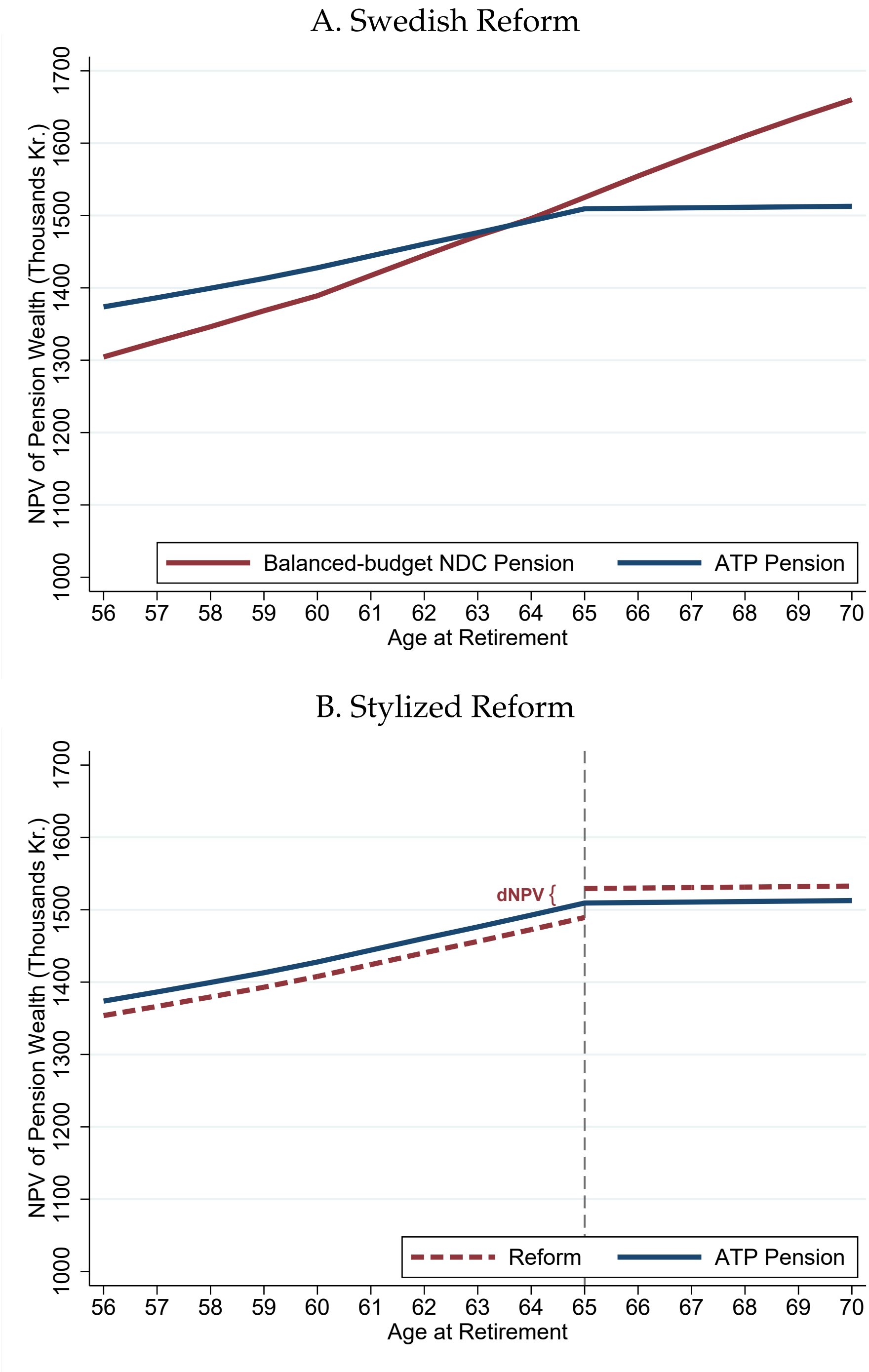
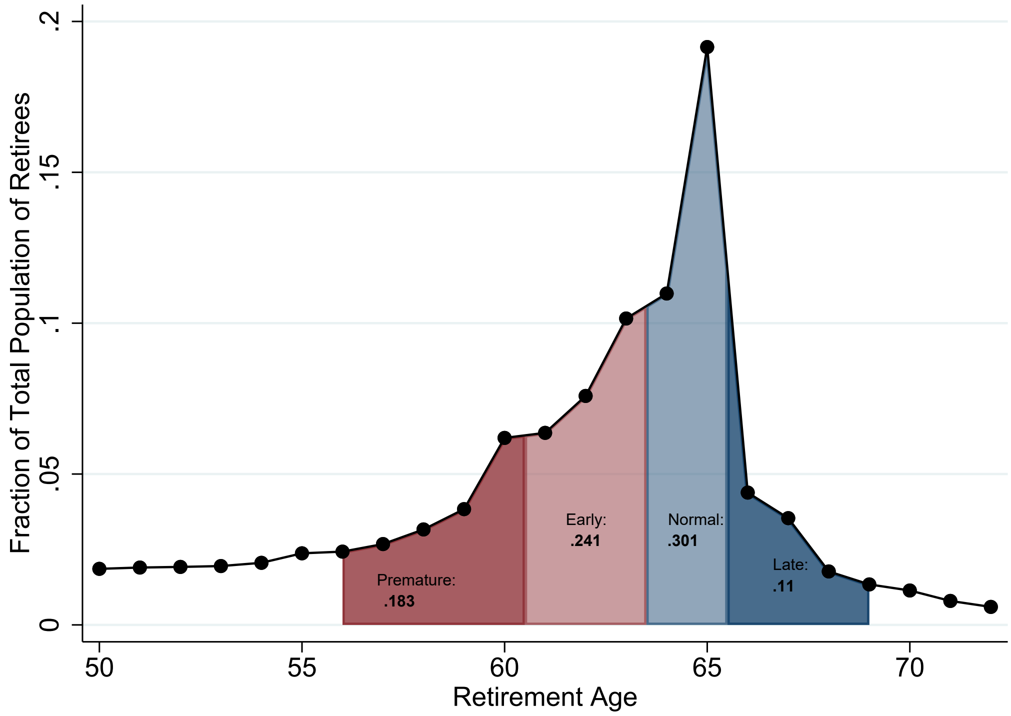
Stern, S. (1989). Measuring the effect of disability on labor force participation. *Journal of Human Resources*, 24(3):361–395.

Figure 1: NET PRESENT VALUE OF PENSION BENEFITS



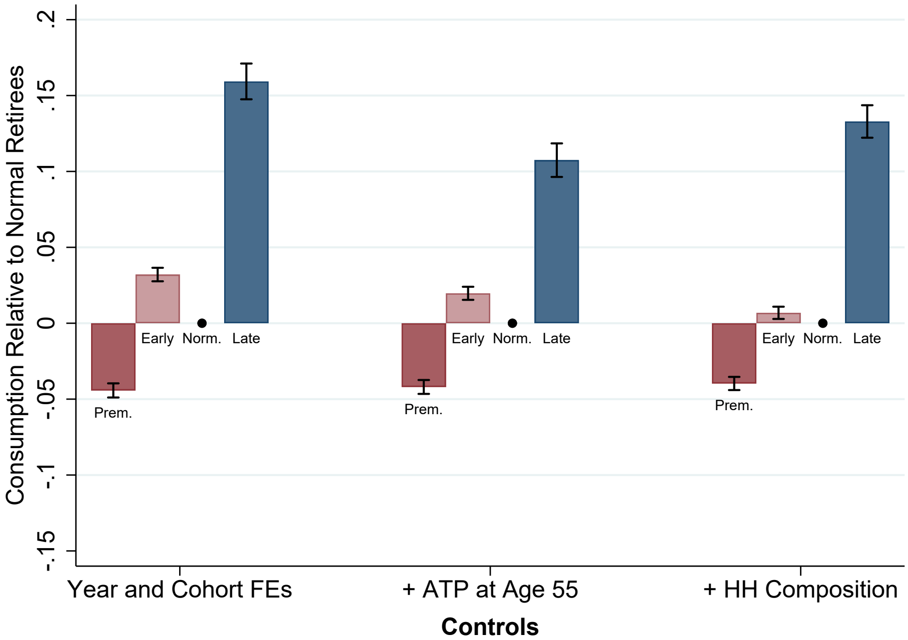
Notes: Panel A shows the effect of the Swedish pension reform on the net present value of pension wealth by age at retirement averaged across vigintiles of accrued pension rights (ATP points) at age 55. Calculations are for individuals born in 1941 with a discount factor of 0.98. To focus on the effect of the reform on the slope of the pension profile, we remove the level effect of the NDC reform on pension benefits, and call the resulting schedule "balanced budget NDC" – see also Figure A-12. Panel B illustrates a stylized balanced-budget reform in the pension profile that increases pension benefits above age 65 and decreases them below that age. Our theoretical model characterizes the welfare effects of the reform in Panel B, and a combination of age-specific reforms can be used to approximate the reform in Panel A.

Figure 2: DISTRIBUTION OF RETIREMENT AGE



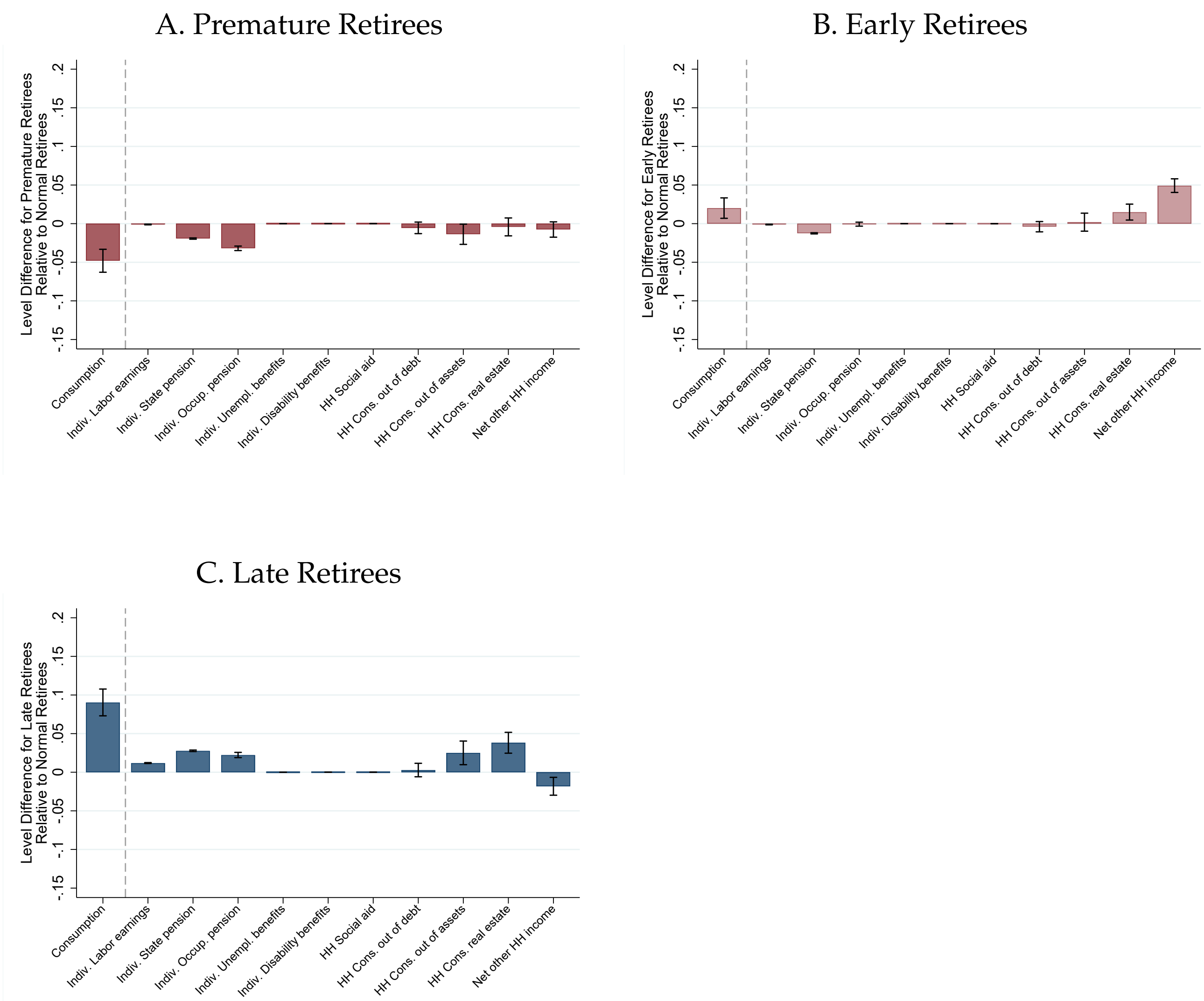
Notes: The figure reports the distribution of age at retirement among individuals from the 1938 to 1943 cohorts in Sweden. Retirement is defined as labor earnings dropping permanently below one Base Amount. In our empirical analysis, we group individuals into for categories of retirement age. Premature retirement is defined as individuals retiring between age 56 and 59; early retirement, between age 60 and 63; normal retirement, between age 64 and 65; and late retirement, between age 66 and 69. For each group, we report the total fraction of individuals retiring in that group among the 1938 to 1943 cohorts. In the rest of the analysis, we drop from our sample the small group of individuals whom we observe retiring before 55, or after 70.

Figure 3: CONSUMPTION DIFFERENCES IN RETIREMENT ACROSS RETIREMENT AGE GROUPS



Notes: The figure documents how consumption in retirement differs across individuals who retire at different ages. The sample comprises all individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed. Individuals are grouped into four retirement age categories: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). Normal retirees are the reference category. The graph reports for all retirement age groups, the estimated coefficients α_j from specification (12), scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire between 64 and 65 from the same cohort, age, family composition and ATP quartile at age 55 as the average individual retiring in age group j. We start, on the left hand side of the graph, with results from model (12) where only year and age fixed effects are included. The rest of figure shows the same estimated coefficients when sequentially adding ATP quartiles accumulated at age 55 and controls for family composition in the vector of controls $\mathbf{X}$.

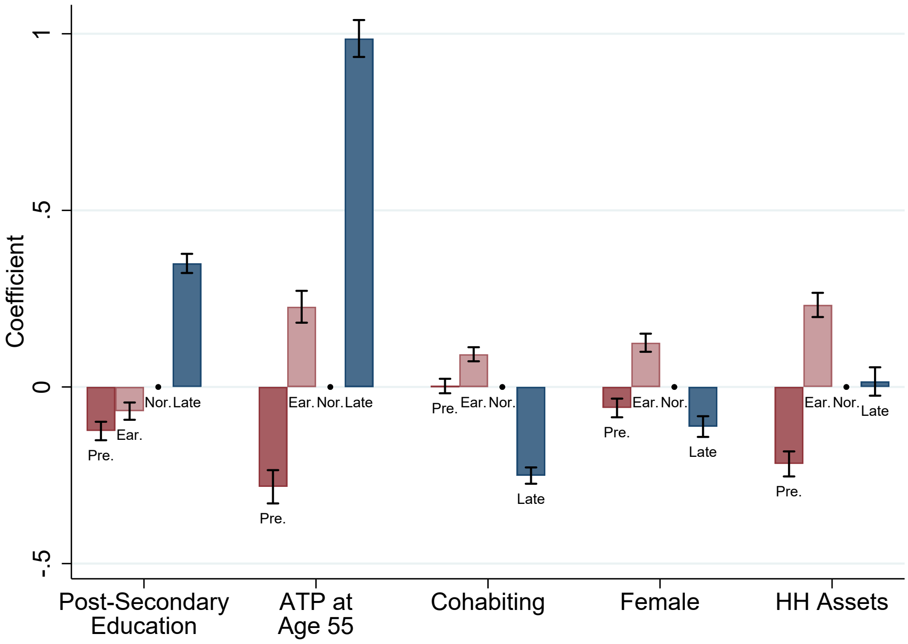
Figure 4: DECOMPOSITION OF CONSUMPTION EXPENDITURES AT AGE 68 BY RETIREMENT AGE



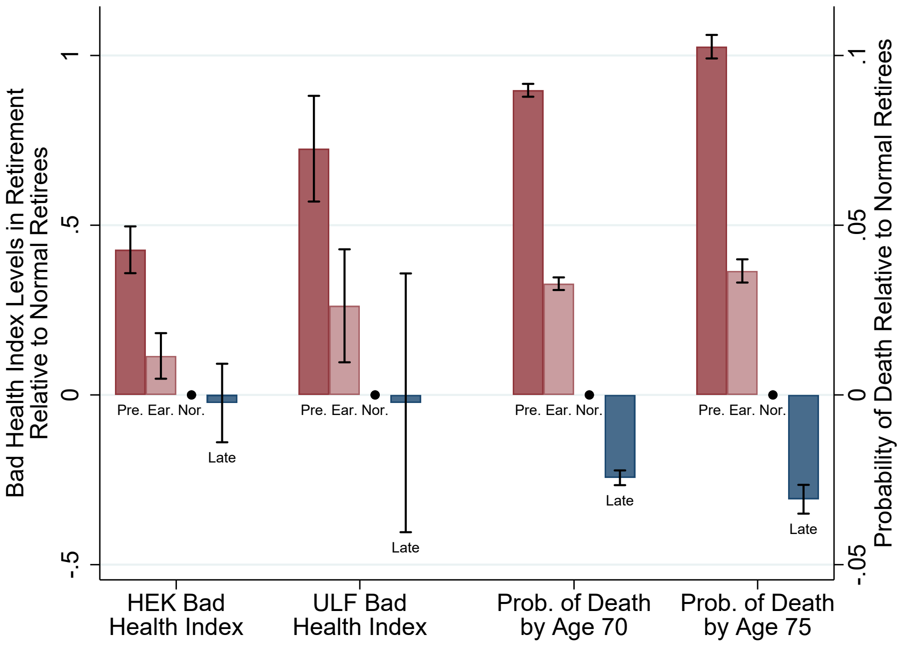
Notes: The figure decomposes consumption differences at age 68 across individuals who retire at different ages. The sample comprises all individuals from cohorts 1938 to 1943 who are retired age 68, and individuals are grouped into four retirement age categories: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). We decompose our measure of household expenditures into a set of components that shed light on the consumption means available to individuals. These components include own income, (which we break down into own earnings, pensions, and other transfers such as UI, or DI), consumption out of debt, consumption out of assets, consumption out of real estate, and other household income (e.g. earnings from other members of the household, etc). We run specification (12) separately for each component evaluated at age 68, and report for all retirement age groups, the estimated coefficients α_j, using normal retirees as the reference category. As in Figure 3, the coefficients α_j are scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire between 64 and 65 from the same cohort, age, family composition and ATP quartile at age 55 as the average individual retiring in age group j. All regressions include year and age fixed effects as well as controls for ATP quartiles accumulated at age 55 and controls for family composition.

Figure 5: HETEROGENEITY & SELECTION INTO RETIREMENT AGES

A. Socio-Demographic Characteristics

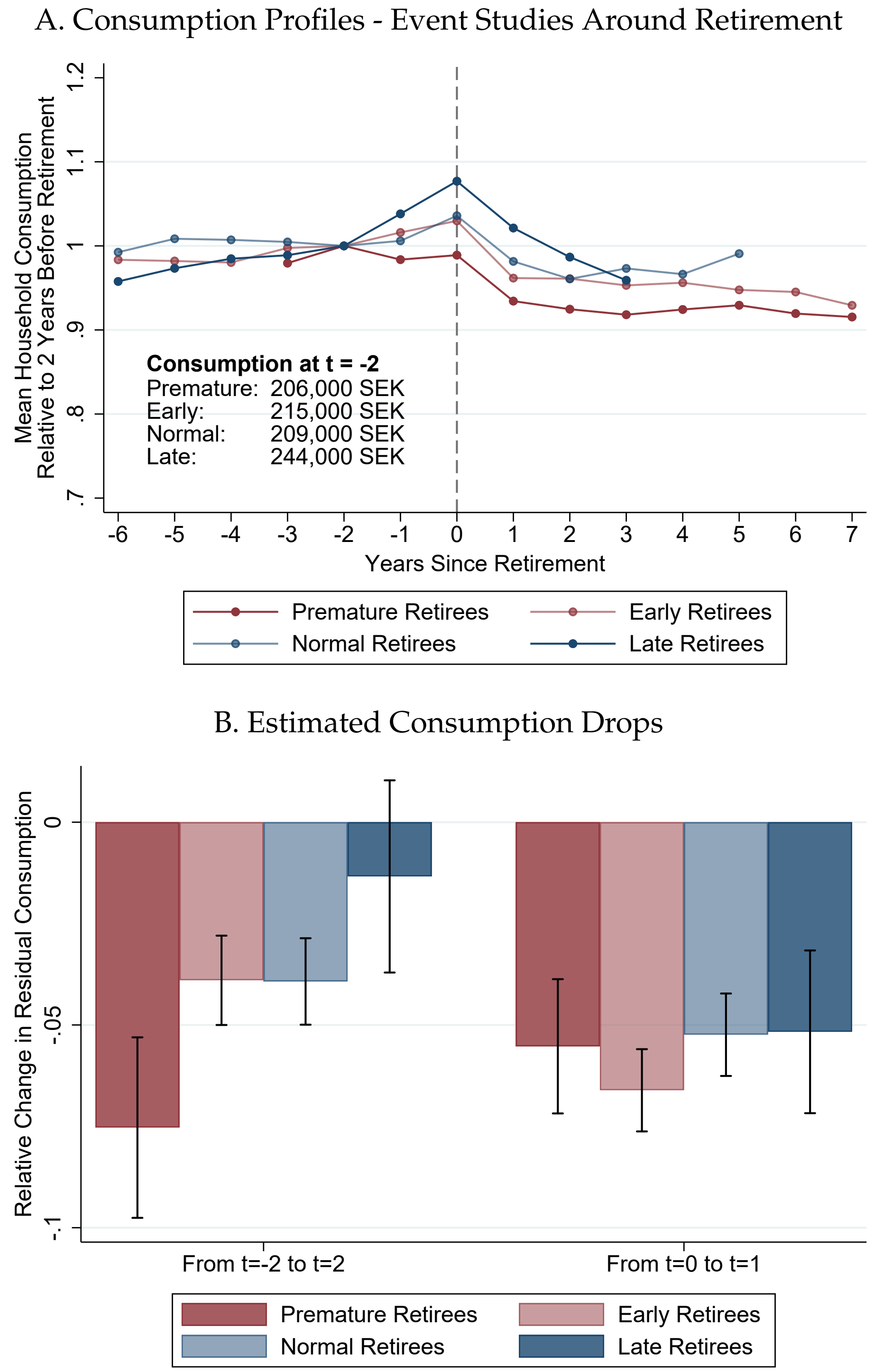


B. Health and Life Expectancy



Notes: The figure documents patterns of heterogeneity across retirement age groups. Panel A displays estimates from a multinomial logit prediction model for retiring in one of the 4 different age groups. The regression sample includes one observation for each of the 419,790 unique individuals of our baseline sample. The model includes cohort fixed effects, a dummy for having post-secondary education, the total ATP points accumulated at age 55, a dummy for being married or cohabitating, a gender dummy, and total net wealth at age 59. We report for each regressor the estimated marginal effects predicted at the mean on the relative probability to select into each of the group, using normal retirees as reference category. Panel B explores selection on health and life expectancy. The graph reports estimates from specification (12) (with cohort and age fixed effects and controls for family structure and ATP points at age 55). We replace consumption by our two indices for bad health (i.e. standardized principal components extracted from all health outcomes in the HEK and ULF surveys) and two measures of "life expectancy" (dummies for being dead by age 70, or by age 75). For the latter outcomes, we have one observation per individual and drop age fixed effects in the regression.

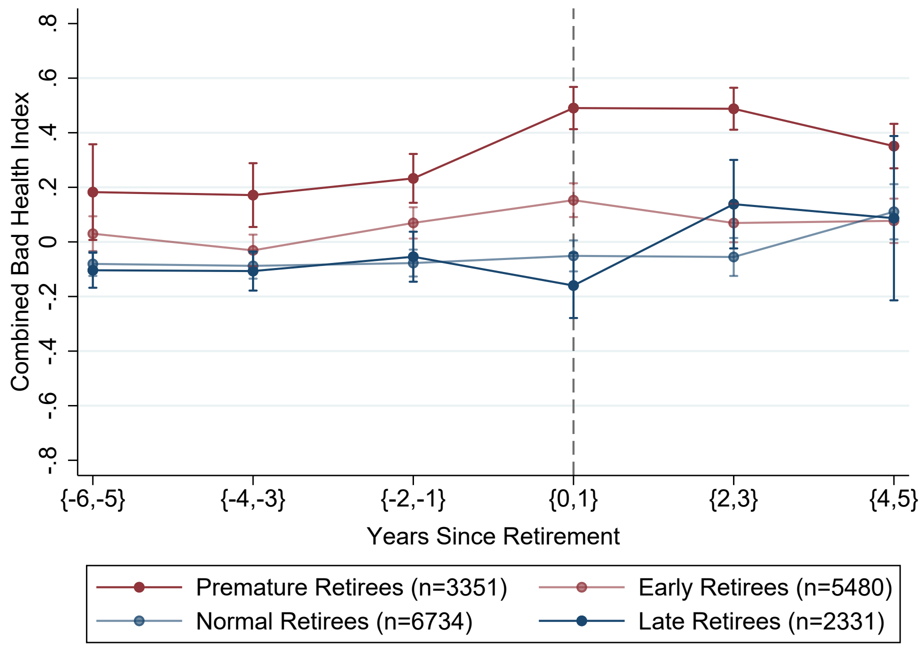
Figure 6: CONSUMPTION DYNAMICS AROUND RETIREMENT, BY RETIREMENT AGE GROUP



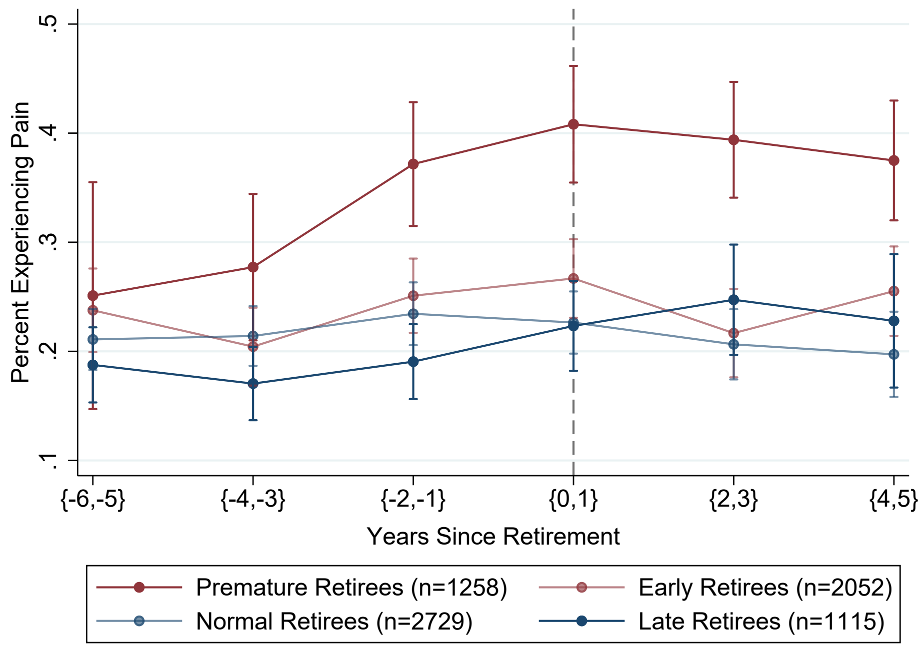
Notes: The figure documents consumption dynamics around retirement. In both panels, household consumption is first residualized on a set of cohort fixed effects and age fixed effects, ATP points at age 55 and household structure as in specification (12). Panel A plots average residualized consumption as a function of time to retirement, separately for premature, early, normal and late retirees. The graph scales residual consumption of each group by its level two years prior to retirement (this level is also reported on the graph). Because of the year and cohort coverage of our consumption and retirement pension data, the earliest we can observe consumption among all premature retirees is 3 years prior to retirement. And the latest we can observe consumption among all the late retirees is three years after retirement. This explains the differential coverage of the residualized consumption series. Panel B reports, for each retirement age group, estimates of residual consumption changes in a 5 year period around retirement (from $r-2$ to $r+2$) and just at retirement (from r to $r+1$). The latter drop has been the focus of the "retirement-consumption puzzle" literature.

Figure 7: HEALTH DYNAMICS AROUND RETIREMENT, BY RETIREMENT AGE GROUP

A. HEK & ULF Bad Health Index - Combined



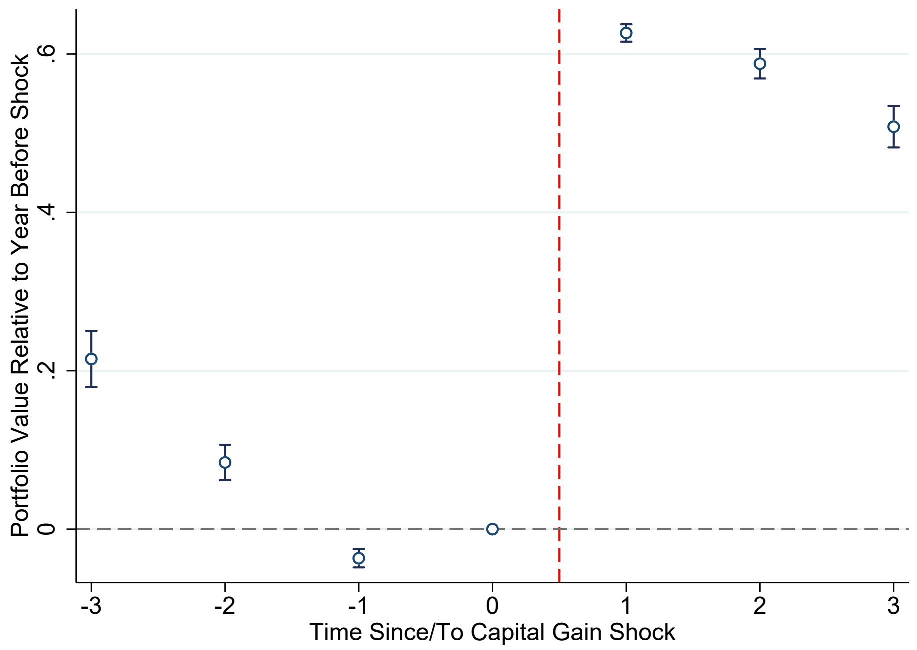
B. Fraction Experiencing Pain



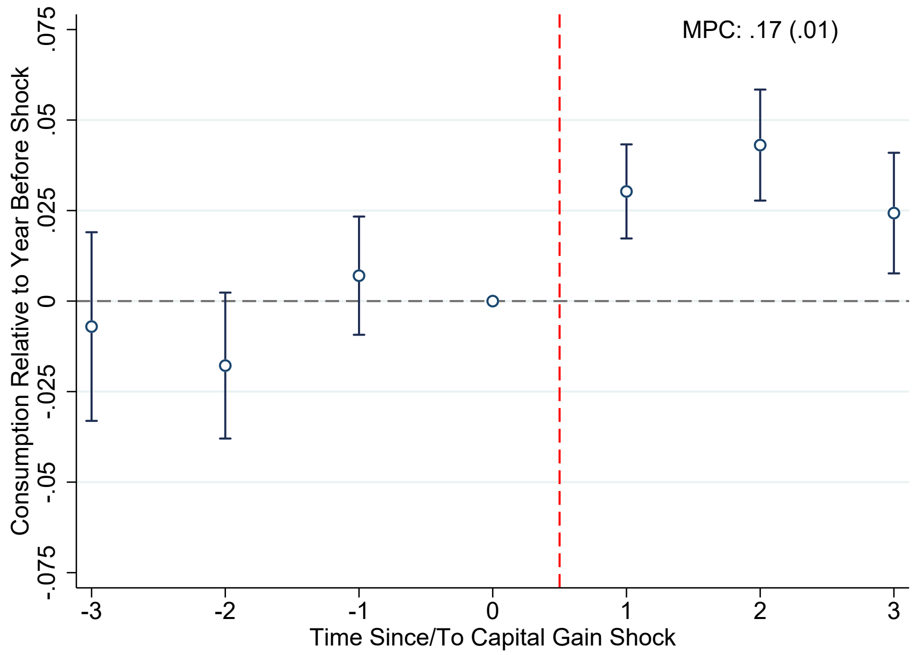
Notes: The figure documents heterogeneity in health dynamics around retirement, by retirement age group. Both panels report, for each retirement age group, the sequence of estimated coefficients $\hat{\alpha}_{re}$ from specification (13). where we control for cohort and age fixed effects and on the usual vector **X** of our baseline controls (i.e. ATP points accumulated up to age 55 and household structure). Panel A uses our bad health indices as an outcome, pooling both HEK and ULF surveys together. Panel B uses as an outcome the fraction of individuals reporting that they are experiencing pain.

Figure 8: MARGINAL PROPENSITIES TO CONSUME OUT OF WEALTH SHOCKS

A. First Stage: Portfolio Value

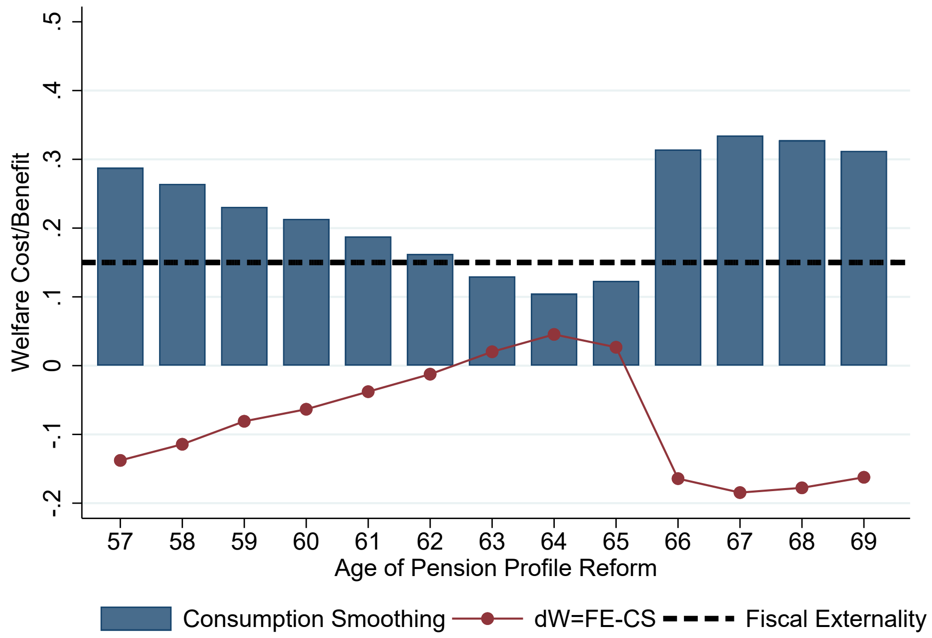


B. Reduced-Form: Consumption



Notes: Panel A reports the estimates of the first stage regression, that is the regression of the change in portfolio value between t and $t+k$ at year t on the passive capital gains at $t+1$, that is a year after the wealth shock, controlling for the value of the portfolio in year t, as well as for the average returns and variance of the portfolio in the 6 years prior to year t (see equation 15). Panel B reports the estimates of the reduced form regression, that is, for each year k, the regression of the change in consumption between t and $t+k$ on the forward passive capital gain at $t+1$, controlling for the value of the portfolio in year t, as well as for the average returns and variance of the portfolio in the 6 years prior to year t (see equation 17). It also reports the implied marginal propensity to consume, which is the ratio of the reduced form and the first stage over the three years.

Figure 9: WELFARE IMPACT OF STEEPER PENSION PROFILE BY RETIREMENT AGE



Notes: This figure reports the consumption smoothing cost of steepening the pension profile at different retirement ages (blue bars) and benchmarks them with the fiscal externality gain (dashed line), following equation 20. The difference between the two captures the net welfare impact (red line). The terms correspond to the welfare effects of transferring a dollar for individuals retiring *before* a specific age to individuals retiring *after* that age. The consumption smoothing costs follow our baseline implementation,

$$\frac{SMU_{r\leq\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}} \approx \gamma \times \left[\frac{E_{r>\tilde{r}}(c)}{E_{r\in NRA}(c)} - \frac{E_{r\leq\tilde{r}}(c)}{E_{r\in NRA}(c)} \right], \tag{21}$$

where the differences in consumption levels are based on estimates in regression 12 and γ is set at 4. Further details on the computation of the welfare terms are provided in Appendix G. The sensitivity of the estimates is explored in Table 4.

Table 1: DESCRIPTIVE STATISTICS: RETIREMENT SAMPLE

	Mean (1)	(s.d.) (2)
I. Retirement		
Fraction of Premature Retirees	16.08 %	
Fraction of Early Retirees	33.4 %	
Fraction of Normal Retirees	34.57 %	
Fraction of Late Retirees	15.95 %	
Age at Retirement	62.91	(3.1)
II. Demographics		
Age	62.8	(2.86)
Cohort	1940.67	(1.73)
Fraction Men	49.33 %	(50)
Fraction Married	67.78 %	(46.73)
Kid at Home (≥ 1)	17.67 %	(38.14)
Kid at Home Under 18 (≥ 1)	3.39 %	(18.1)
Post-Secondary Education	24.91%	(43.25)
III. Income and Wealth at 59, SEK 2003 (K)		
Total Earnings	210.5	(158.8)
Net Wealth	779.4	(2289.3)
Bank Holdings	83.4	(302.2)
Portfolio Value	249.6	(1665.6)
Consumption	200	(530)
IV. Pensions		
State Pension (K SEK)	78.2	(52.90)
Occupational Pension (K SEK)	62	(92.7)
Total ATP Pension at 55	109.51	(51.13)
N (Unique Individuals)	419,790	

Notes: The table reports descriptive statistics from our baseline sample of retirees. The sample is restricted to cohorts 1938 to 1943 who retire between age 56 and 69. The sample comprises 419,790 unique individuals. Retirement is defined as labor earnings dropping permanently below one Base Amount. Panel I reports statistics on the distribution of retirememt age. Premature retirement is defined as individuals retiring between age 56 and 59; early retirement, between age 60 and 63; normal retirement, between age 64 and 65; and late retirement, between age 66 and 69. Panel II reports various demographic information. Panel III focuses on income and wealth measured at age 59. Wealth and consumption is aggregated at the household level. Panel IV reports the average state and occupational pension benefits received. Total ATP points correspond to the total number of ATP points accumulated in the state pension system at age 55. Note that based on the average exchange rate between 2000 and 2007, 1SEK $\approx$ 0.11USD.

Table 2: 2SLS Estimates of Marginal Propensity to Consume Out of Wealth Shocks

	First Stage α_1^V	Reduced Form $3 \times \alpha_{rf}^C$	IV Result $3 \times \alpha_{IV}^C$	Placebo Test α_1^P
	A. Whole Sample			
	.66	.11	.17	.01
	(.01)	(.01)	(.01)	(.02)
N	546,836	546,836	546,836	546,836
# of Indiv. Clusters	133,133	133,133	133,133	133,133
	B. By Retirement Status			
Non Retired in t	.66	.09	.13	-.01
	(.01)	(.01)	(.01)	(.02)
Retired in t	.71	.21	.30	.07
	(.03)	(.03)	(.04)	(.05)
	C. By Retirement Age Group			
Premature Retirees	.69	.23	.34	-.01
	(.04)	(.03)	(.04)	(.07)
Early Retirees	.63	.22	.34	.03
	(.02)	(.02)	(.03)	(.03)
Normal Retirees	.68	.06	.09	.03
	(.01)	(.01)	(.02)	(.02)
Late Retirees	.70	0.01	.01	(.06)
	(.03)	(.03)	(.04)	(.05)

Notes: The table reports the 2SLS results from equations 17 and 18. Column (1) reports the estimates of the first stage, obtained by regressing the change in portfolio value of the individual between t and $t+k$ on the passive capital gains in $t+1$, controlling for the value of portfolio in year t, the average returns and variance of the portfolio in the 6 years prior to t, but also adding a dummy for the retirement status and controlling for year, cohort fixed effects, ATP points accumulated up to 55 years old and household structure. We cluster the standard errors at the individual level. Column (2) reports the estimates of the reduced form, obtained by regressing the average yearly consumption in the three years following the wealth shock on the change in the value of the portfolio in year t instrumented by the passive capital gains. We add the same controls as in the first stage. The estimates are multiplied by three in order to obtain the MPC over a three years horizon. Column (3) reports the instrumental variable results, obtained by taking the ratio of the reduced form to the first stage, over a three years horizon. Column (4) presents the results of the placebo test, which is a replication of equation 16 where the outcome is the change in yearly consumption in the three years before the shock. The results are presented for three panels. Panel A consists of the observations considered in the baseline sample from regression 12 matched with KURU data. Panel B considers this same sample split according to the retirement status at the time of the passive capital gain shock. Panel C is a split of this same sample by retirement age group. For each sample, we trim the change in portfolio value at the 1% level and the passive capital gain each year at the 1% level.

Table 3: 2SLS ESTIMATES OF MPCS: SAMPLE RESTRICTED TO INDIVIDUALS WHO ARE RETIRED AT TIME OF KG SHOCK

	First Stage α_1^V	Reduced Form $3 \text{ x } \alpha_{rf}^C$	IV Result $3 \text{ x } \alpha_{IV}^C$
	A. All Retired Individuals (Cohorts 1932-1950)		
	.70	.19	.28
	(.02)	(.02)	(.04)
# of Indiv. Clusters	59,419	59,419	59,419
	B. By Retirement Age Group (Cohorts 1932-1950)		
Premature Retirees	.77	.18	.24
	(.05)	(.05)	(.06)
# of Indiv. Clusters	9,595	9,595	9,595
Early Retirees	.69	.26	.37
	(.03)	(.04)	(.06)
# of Indiv. Clusters	21,118	21,118	21,118
Normal Retirees	.69	.25	.36
	(.03)	(.04)	(.06)
# of Indiv. Clusters	21,036	21,036	21,036
Late Retirees	.78	.05	.07
	(.05)	(.07)	(.08)
# of Indiv. Clusters	7,589	7,589	7,589

Notes: This table follows the same approach as for Table 2 where we enlarge the set of cohort to 1932 - 1950 and restrict to individuals retired at the moment of the capital gain shock.

Table 4: CONSUMPTION SMOOTHING COST OF STEEPENING THE PENSION PROFILE

	Baseline	Sensitivity		Alternative	
	Cons. levels	Risk aversion	Welfare Wgts	ΔC	MPC
	$\gamma = 4, \theta = 1$	$\gamma = 2, \theta = 1$	$\gamma = 4, \theta \sim$ Life Exp.	$\gamma = 4$	
	(1)	(2)	(3)	(4)	(5)
		A. Age-Specific Profile Change: $\frac{SMU_{r<\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}}$			
$\tilde{r} \in [57;60]$	.25	.13	.32	.17	-.39
$\tilde{r} \in [61;63]$	.16	.08	.22	.12	-.09
$\tilde{r} \in [64;65]$	.11	.06	.16	.09	.26
$\tilde{r} \in [66;69]$	.32	.16	.35	.12	.88
		B. Swedish Pension Reform: $\Sigma_r \mu_r \frac{SMU_r}{SMU_{NRA}}$			
	.15	.07	.18	.11	.21

Notes: This table presents the consumption smoothing cost of the two policy reforms described at the start of Section 7. The consumption smoothing costs are expressed per dollar transferred from early to late retirees for the respective policies, following equation 20, and can be benchmarked against a fiscal externality of .15 to evaluate the net welfare gain, as illustrated in Table 4. The first policy change consists in providing steeper incentives at each age $\tilde{r}$ in a specific interval, $\frac{SMU_{r<\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}}$, while the second one consists in evaluating the effect of the budget-neutral profile change implied by the Swedish pension reform, $\Sigma_r \mu_r \frac{SMU_r}{SMU_{NRA}}$, where the weight μ_r depends on the share of individuals retiring at that age and the corresponding change in pension benefits, $\widehat{NDC}_r - ATP_r$ (see Appendix A.2.5). Column (1) repeats the results for the baseline implementation, using the difference in consumption levels to approximate the the difference in SMU's (see equation 9). In column (2), we consider a change of the curvature in preferences while in column (3) we assign welfare weights that depend on life expectancy. Column (4) shows the results for the alternative implementation using the difference in consumption drops to approximate the difference in SMU's (see equation 10), while column (5) uses the difference in MPC's (see equation 11). Appendix G provides more details underlying the welfare calculations.

Appendix A Additional Institutional Details

Appendix A.1 Review of the Swedish Pension System

Appendix A.1.1 Details on Public pensions and pension reform

The public pension system in Sweden has undergone large reforms the last two decades and is in the process of going from a defined benefit (DB) system to a system based on notional defined contributions (NDC). The NDC system is expected to be fully phased-in around year 2040. Cohorts born before 1938 receive their pension benefits from the old ATP system, which is a DB scheme. Cohorts born between 1938 and 1953 receive their pension benefits from both the DB and the NDC schemes, with the weight on the NDC scheme increasing gradually over time.[45] Cohorts born in 1954 onwards will receive all pension benefits from the NDC scheme. The cohorts at or near retirement age during the period spanned by our consumption data are those for whom the ATP system was the main determinant of benefits and the NDC was just beginning to be phased in. Pension benefits in both the ATP system and the NDC system are financed by payroll taxes.

Here we will review both the old and the new system. We also describe the treatment of couples and how the pension system interacts with other parts of the social insurance systems, mainly disability insurance (DI) and unemployment insurance (UI).

The ATP system. The ATP system is a DB scheme. Pension benefits are based on 1) the 15 years in an individual's career where pensionable earnings were the highest,[46] 2) the total number of years in which an individual earns pension rights (with a maximum of 30 years), and 3) the claiming age.

Pension rights can be earned between ages 16 and 64 - earnings at age 65 or beyond have no effect on pension rights. Annual earnings are converted to pension rights by dividing earnings in a year by a *base amount* (BA) for that year, which produces the *ATP points* used to calculate pension benefits. The BA serves to index pension rights and benefits to prices, with some discretion by the government.[47] Annual ATP points

[45] Individuals born in 1938 receive 80% of their pension benefits from the ATP system and 20% from the NDC system. Each cohort then gets another 5-percentage point from the NDC scheme. For example, individuals born in 1939 get 25% of their pension benefits from the NDC system while the 1953 cohort gets 95% of their pension benefits from the NDC system.

[46] Pensionable earnings are labor income and income from social insurance benefits that in turn are based on labor income, such as unemployment insurance, sickness insurance, parental leave benefits, workers' compensation and disability insurance. Capital income is not considered to be pensionable earnings nor are transfers that are not based on previous labor earnings, for instance social aid.

[47] The BA is used to calculate benefits throughout the Swedish social insurance system. It is set each

are capped at 6.5 BAs, which corresponds empirically to the median of the earnings distribution for 55 year olds in 2000.

For a worker claiming their public pension at age 65, the annual ATP pension benefit received by an individual i in year t is given by the following formula:

$$b_{it} = 0.6 \cdot AP_i \cdot \min\left(\frac{N_i}{30}, 1\right) \cdot BA_t, \tag{22}$$

where 0.6 is the replacement rate for a worker with 30 years of contribution, AP_i are the average number of ATP pension points accrued by the individual during the highest earning 15 years, N_i are the number of contributing years and BA is the base amount in year t. The highest attainable pension benefit from the ATP system in year t is $0.6 \cdot 6.5 \cdot BA_t$.

The normal retirement age in the ATP system is 65, but pension benefits can be claimed from age 61. Claiming early reduces pension benefits by 0.5 percentage points for each month of early withdrawal relative to the month an individual turn 65. For example, individuals who claim pension benefits a year before turning 65 get their pension benefits reduced by $12 \cdot 0.5 = 6$ percentage points. Individuals who claim after 65 receive an extra 0.7 percentage point increase in pension benefits for every additional month that claiming is postponed. There is no earnings test whereby working while claiming reduces benefits, though the progressivity of the income tax schedule disincentivizes working while claiming to some degree.

For individuals with short careers or low life-time labor earnings there is a basic pension which serves as a floor for pension benefits. The basic pension is a function of the BA and the number of years the individual has resided in Sweden. 30 years of residence is required for full basic pension. Married individuals receive lower basic pension benefits than singles.[48] Our data shows that a quarter of all 66 year olds received basic pension in 2007.

The new NDC system In the NDC system, income-related pension benefits are calculated as the sum of wage-indexed life-time pensionable earnings and the sum is divided by life expectancy. Unlike with the ATP, there is no upper age limit for accumulation of pension rights: as long as an individual works, pensionable earnings

year by the Swedish government and tracks the CPI closely. However, the government can make discretionary decisions not to raise the BA or raise it more or less than the annual inflation rate. The BA also defines the minimum earnings governing whether the individual earns any ATP pension rights in a year, which was 1 BA. The BA for 2000 was 36.600 kronor or 18% of the median labor earnings among 55 year olds (see Appendix Figure A-1).

[48]Formally, the basic pension for singles is calculated as $1.529 \cdot \min(H_i/30, 1) \cdot BA_t$ where H is the number of residential years in Sweden. For married 1.529 is replaced by 1.349 which means that the basic pension is $1.529/1.349 - 1 \approx 12\%$ lower for married pensioners.

grow. The income base amount replaces the old base amount (BA) and is indexed to average wage growth instead of prices.[49] Pensionable earnings are capped at 7.5 income base amounts. Pensions in the NDC system can be claimed from age 61. However, retiring and claiming pensions earlier means that a smaller sum of pensionable earnings is divided by longer life expectancy. This decreases the net present value of the individual's pension and results in smaller pension benefits.

Just as in the ATP system there is a minimum pension for individuals with short careers and low accumulated pensionable earnings, which is now called the *guaranteed pension*. The guaranteed pension in the NDC system is a function of the *enhanced base amount*. This amount tracks the CPI, like the BA, but is slightly larger. Retirees with income-related pension benefits below 2.13 base amounts for singles and 1.93 enhanced base amounts for couples, receive the guaranteed pension (see Appendix Figure A-2). About 30% of all individuals receiving pension benefits are expected to receive basic pensions in 2040 when the NDC system is phased in.[50]

Treatment of singles and couples The Swedish pension system is highly individualized. Household composition is mainly used when minimum pensions are determined. As mentioned above, married individuals receive lower minimum pensions in the NDC system and in the ATP system. The minimum pension benefit in both systems is about 10% lower for married individuals, relative to singles.

The Swedish pension system also contains a survivor's benefit which is paid out for a year after the spouse has passed. However, for women who either married before 1989 and had a joint child with her husband born before December 31, 1989 or had been married since 1984, receive survivor's pension based on the passed husband's ATP pension. Widows aged below 65 and widows born before 1930 receive 40% of the husband's ATP pension while widows born 1930 and later and who are 65 years or older receive a lower survivor's pension which depends negatively on the widow's own pension and her year of birth.

Interaction with other social insurance programs Social insurance benefits that are based on previous labor income counts as pensionable income in both the ATP and the NDC system. Individuals who are unemployed, receive sickness benefits or disability insurance also collect pension rights. Individuals can receive social insurance benefits until they become 65 years old.

[49]The income base amount is determined by the Swedish government, just like the BA.
[50]Scenarios can be found in this government report: `http://www.sou.gov.se/wp-content/uploads/2013/05/d99edc83.pdf`. The number referred to in the text is taken from figure 13 and assumes future price indexation of basic pensions.

Before 2003, disability insurance (DI) was integrated with the pension system. DI benefits were calculated as ATP pension benefits but with actual earnings being replaced by an assumed earnings profile in the calculation of pension rights (Jönsson et al. [2011]). Workers who were DI claimants when they reached 65 became public pension claimants and received pension benefits at the same level as DI benefits. In 2003, DI became part of the sickness insurance system. Since then, DI benefits are 64 percent of labor income from the best three years within a five-to-eight-year period leading up to disability claiming. In the new DI system benefits are slightly higher than in the old system, but the pension rights earned from receiving DI is lower (Laun and Wallenius [2015]).

Appendix A.1.2 Other Pensions

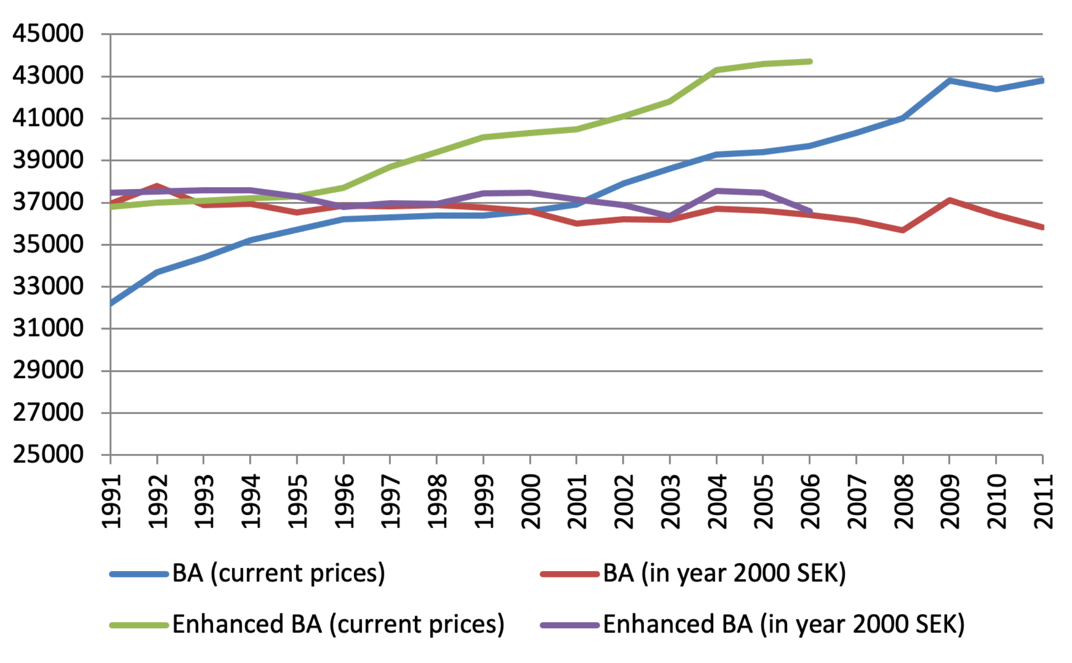
Nine out of ten workers in Sweden are covered by collective bargaining agreements negotiated between trade unions and employer organizations. The terms of *occupational pensions* are a component of these collective bargaining agreements.[51] Contributions, which are are mandatory for workers covered by collective bargaining agreements, are paid in by employers to pension funds that are jointly owned and administered by trade unions and employer organizations. Like the 401(k) pension plans in the US, contributions receive deferred income tax treatment. In most schemes, pension benefits can be claimed at age 55 but the recipient is not allowed to work after claiming them. Claiming earlier results in an actuarial downward adjustment of the pension benefits. It is also possible to claim occupational pensions without claiming public pensions.

Individuals can also contribute voluntarily to *private pensions*.[52] Like occupational pensions, private pensions can be claimed from age 55 onward without incurring penalties. For example, individuals who claim their private pension can continue to work and the income earned from private pension does not affect social insurance eligibility.

[51] There are four different occupational pension schemes: one for private sector blue collar workers, one for private sector white collar workers, one for local government employees and one for central government employees.

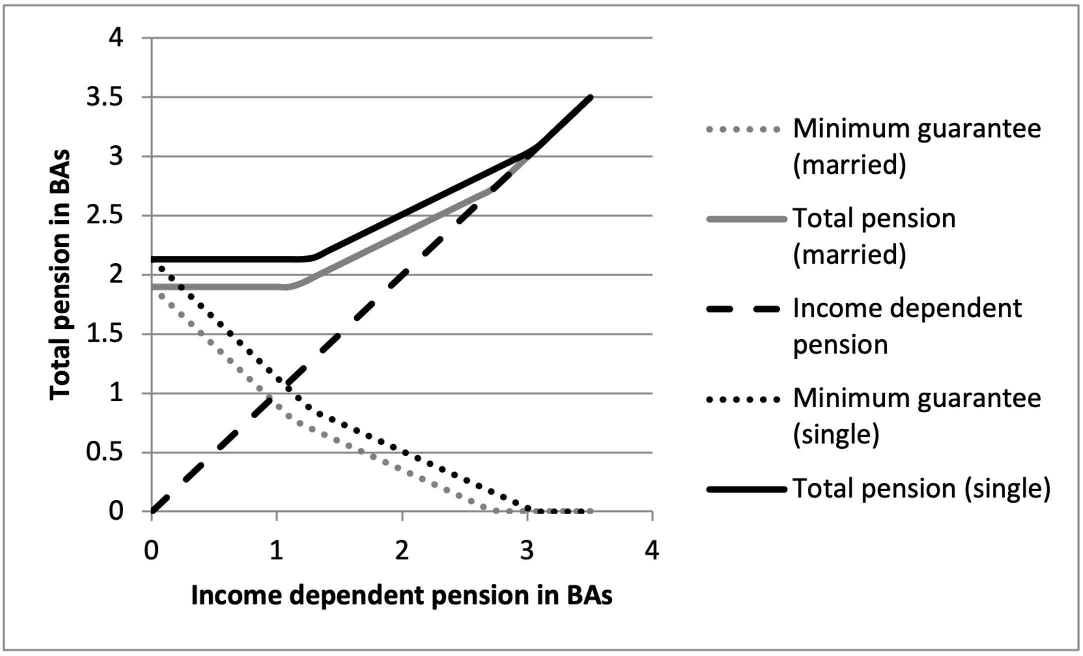
[52] In Sweden individuals can save in so called pension insurance policies. These are savings vehicles that invests in both risky assets, such as stocks, and low-risk assets like short-term bonds. While working, the individual saves money and after retirement or at a specified age, such as 55 or 60 years old, the individual receives an annuity each month from the policy for either a specified time, often 5-20 years, or for life. Hagen [2015] reports that 25-30 percent of all individuals claim their occupation pensions for a specified number of years. Surveys done by private pension providers indicate similar figures for private pension payments. The individual is typically guaranteed a certain minimum monthly payment by the issuer, hence the wording pension insurance. Until 2016 saving in private pension policies was tax deductible.

Figure A-1: THE BASE AMOUNT (BA) AND THE ENHANCED BASE AMOUNT (EBA), 1991-2011



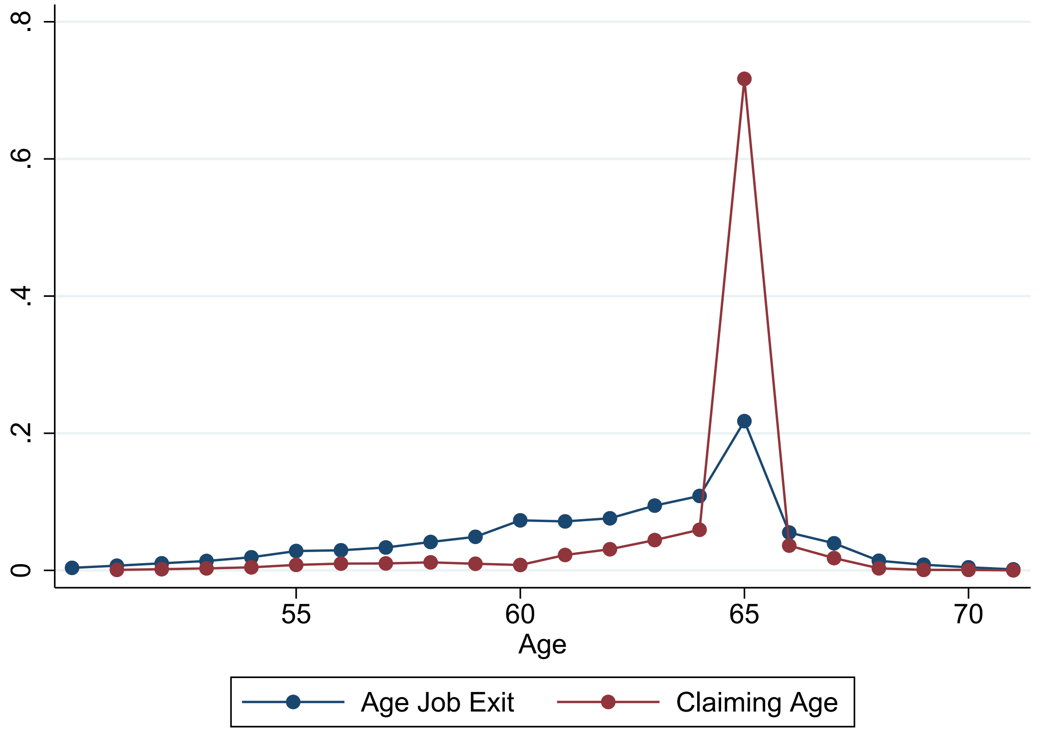
Notes: This figure shows the Base Amount (BA) and Enhanced Base Amount (EBA) over time. Both the BA and EBA are indexed against inflation.

Figure A-2: RELATIONSHIP BETWEEN INCOME DEPENDENT PENSION AND MINIMUM GUARANTEE



Notes: The income related pension is the same for singles and married. Total pension is the sum of the income dependent pension and the minimum guarantee.

Figure A-3: DISTRIBUTIONS OF JOB EXIT AND PENSION CLAIMING AGES



Notes: This figure shows the density distributions of job exit age and pension claiming age for workers born between 1938 and 1943.

Appendix A.2 Pension Simulation Details

Here we provide further details on our simulations of pension benefits. We use these simulations in the main text to characterize the effects of the Swedish pension reform on the profile of benefits over the retirement age, and to derive benchmark values for participation tax rates to quantify the fiscal externality.

Appendix A.2.1 Constructing Simulations

To guide our simulations, we imagine a hypothetical worker, aged 55, who is planning their retirement at some age between 55 and 70. The worker wishes to know the effect that retiring at different ages will have on their pension benefits and overall income. The worker characteristics that are inputs for the simulation are:[53]

- The worker's birth cohort. We assume the worker is born in 1941 throughout, which is the midpoint of the birth cohorts we study in our empirical analysis.

[53] We do not consider aspects of the pension system like survivor benefits, under which pension benefits may also depend on marital status and gender.

- The worker's lifespan. Using mortality data, we estimate the expected lifespan of an individual from the 1941 cohort who reaches age 65. Based on this, we assume the worker lives until age 84.
- The workers marital status. This only matters for the minimum pension in either system; we assume the individual is single.
- The number of years worked before age 55. We calibrate this based on empirical data, see below.
- The workers' annual (pre-tax) earnings at 55. We calibrate this based on empirical data, see below.
- Whether the individual claims non-pension social insurance benefits (UI or DI) after retiring, and the duration and generosity of social insurance benefits. We calibrate these based on empirical data, and we present results with and without non-pension social insurance benefits.
- The age at which the individual claims their pension. We mainly assume the individual claims at 65, which as discussed above is the modal case. We vary this in a sensitivity check.
- The age at which the individual retires (permanently stops working). This is the x-axis of the figures derived from this calculator. We vary this from age 55 to 70 in one-year increments for each specification of the above characteristics.

Given these inputs, we first simulate a complete earnings path for our individual. For years before the worker turns 55, the earnings history is based on empirical earnings growth rates, given the number of years worked and earnings at 55.[54] For years after age 55, we use a constant growth rate based on average earnings growth from 1996 to 2011. This ensures that idiosyncracies in earnings growth do not generate noise in our simulated NPVs and tax rates, and it is consistent with the intuition that a worker contemplating retirement knows their earnings history before age 55 but only knows their expected earnings after age 55.

Given the earnings history and other characteristics, we then calculate the workers' lifetime pension benefits in either the ATP and NDC system, as a function of the exit age, given the assumed claiming age and longevity. The worker will receive pension benefits from claiming age until death. As we did with earnings histories, for both the ATP and NDC systems we use actual, empirical basic amounts ("income base

[54] For simplicity we assume the worker worked continuously from some starting year until age 55. For example, a worker with 30 years of experience at age 55 would be assumed to start working at age 25.

amounts" in NDC) up to age 55, and after age 55 we use the average growth rate of the base amounts from 1996-2011. Once again this ensures that idiosyncracies in base amounts do not generate noise in the NPVs and participation tax rates. By design, the average growth rates of base amounts are very similar to that of the price index for ATP and the wage index for NDC. We then calculate the NPV at age 55 of lifetime pension benefits at each possible retirement age from 55 to 70. We include non-pension social insurance benefits and the pension rights they provide in this NPV, but as we shall see this does has a very small effect. We use a discount rate of 0.98 to calculate NPVs, under which the adjustments to benefits in the NDC system that should be actuarially fair are in fact actuarially fair. Thus we obtain the slope of the pension benefit profile over retirement ages for a worker with the specified characteristics.

Next, we simulate participation tax rates at each possible retirement age. For a given age a, these are defined as

$$\text{Participation Tax Rate}_a = \frac{\text{income tax}_a + \text{payroll tax}_a - [NPV_a - NPV_{a-1}]}{\text{Gross earnings}_a}, \tag{23}$$

where NPV_a is the net present value at 55 of pension benefits for a worker retiring at age a, and *both payroll tax and gross earnings include employer payroll tax contributions*.[55] Finally, conceptually it is useful to separate out the component of the participation tax rate that is directly attributable to the pension system, i.e. payroll taxes that fund pensions (a flat tax rate of 18.5% of gross earnings in both systems) and the change in the NPV of pensions. This is calculated similarly to the above, as:

$$\text{Implicit Tax Rate}_a = \frac{\text{pension payroll tax}_a - [NPV_a - NPV_{a-1}]}{\text{Gross earnings}_a}. \tag{24}$$

The difference between implicit and total participation tax rates therefore represents non-pension payroll taxes and income taxes.

Appendix A.2.2 Accounting for Heterogeneity by Lifetime Earnings

Our simulator performs all of the above for any specified set of worker characteristics. Our goal is to use these simulations to paint a reasonably complete picture of how the reform affected the slope of the pension benefit profile on average, accounting for differences across workers. The main form of heterogeneity we should account for in doing so is heterogeneity by lifetime income. We use some empirical moments to calibrate our simulations along these lines.

[55] This gross earnings concept is sometimes called "super-gross" earnings, to distinguish it from earnings gross of income and employee payroll taxes but not employer payroll taxes.

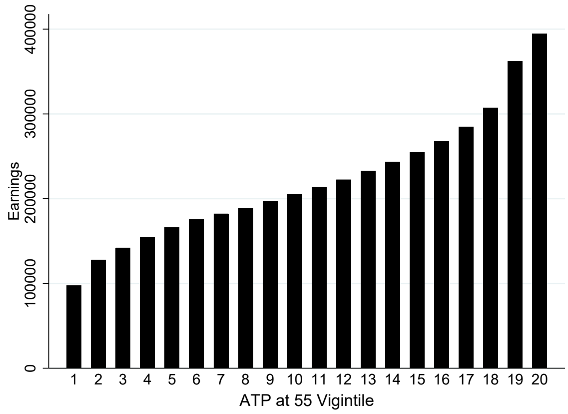
Specifically, we divide the sample of individuals born from 1988-1943 – the main cohorts of interest for our analysis – into 20 vigintiles based on individuals' accrued ATP pension rights as of age 55. Accrued pension rights are an attractive proxy for lifetime earnings; we do not observe full earnings histories, but this proxy mechanically captures the features of the earnings history that matter for pension benefits. Some complications arise from the cap on ATP pension rights: all individuals in the 20th vigintile have the maximum possible ATP pension at 55. In the 19th vigintile, 63% of individuals have the maximum possible ATP pension at 55. Individuals reaching the cap are split randomly between the 19th and 20th vigintiles.

We then think of these 20 vigintiles of accrued ATP rights at age 55 as 20 different workers, each of whom represents 5% of the full population of interest. We run the simulator described above 20 different times, where the worker characteristics are based on the characteristics of a typical worker in the given vigintile of accrued ATP rights at 55. We use one set of moments to discipline labor earnings and public pension benefits, and another to account for non-pension social insurance benefits.

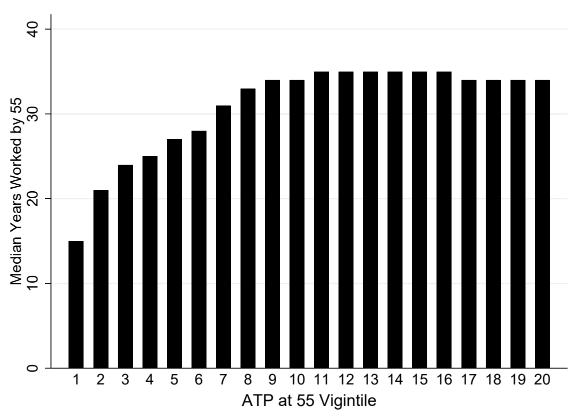
Labor Earnings and Pension Benefits We estimate the median earnings and median years worked within each vigintile, and use plug these into the simulator for each of the 20 hypothetical workers. These medians are plotted in Figure A-4 below, along with the fraction of workers who have worked beyond 30 years by age 55, which is important for the ATP system.

Figure A-4: STATISTICS BY VIGINTILE

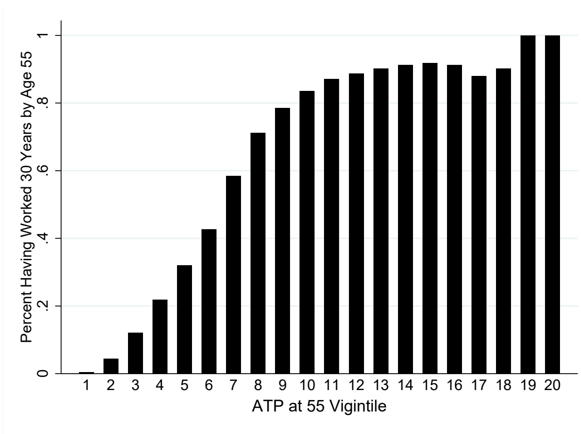
A. MEDIAN EARNINGS AT AGE 55



B. MEDIAN CAREER LENGTH BY AGE 55



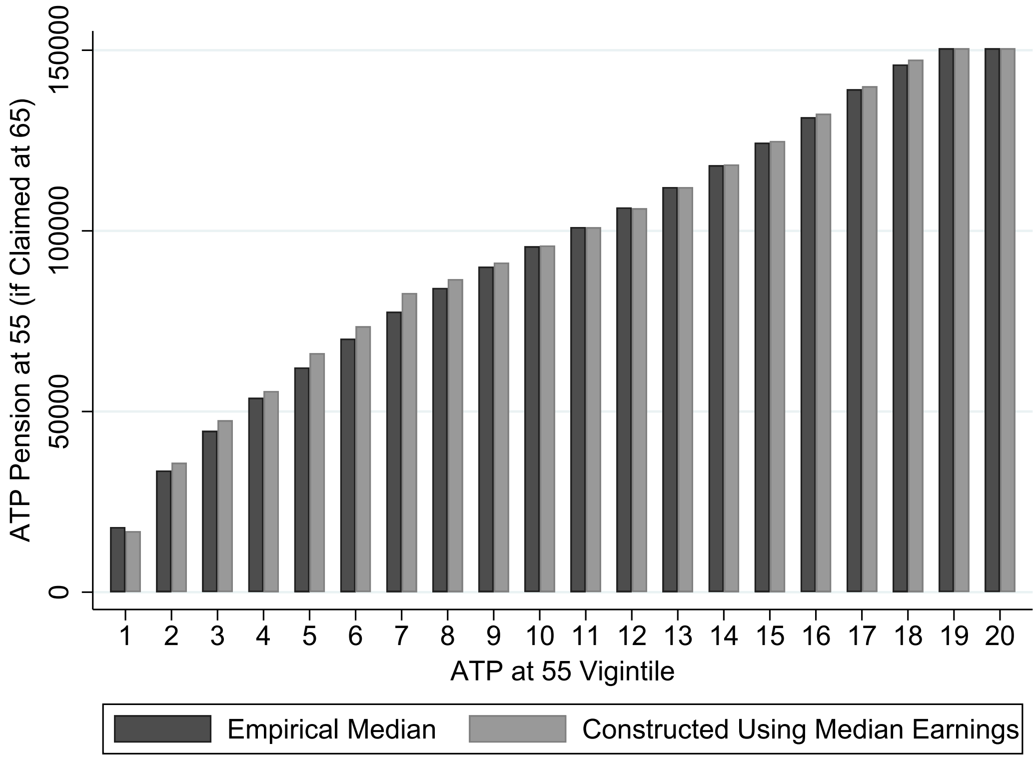
C. PERCENT OF WORKERS REACHING 30-YEAR CAREER LENGTH BY AGE 55



Notes: Panel A of this figure shows the median earnings at 55 of workers born between 1938 and 1943 for each ATP at 55 vigintile. Panel B shows the median years worked by age 55 for each vigintile. Panel C shows the percent who reach a career length of 30 years by the age of 55 for each ATP at 55 vigintile.

To validate this basic approach and the way we construct earnings histories, the most important thing to verify is that the earnings history we construct implies a reasonable level of accrued pension rights as of age 55. Although we divided individuals into vigintiles based on observed pension rights at age 55 in the data, our simulator constructs ATP pension rights at 55 based on the simulated earnings history, i.e. based on earnings at 55, career length, and average earnings growth in the full population. In Figure A-5, we verify that simulated ATP rights accrued as of age 55 closely match actual, empirical ATP rights accrued as of age 55, implying that the simulation constructs realistic earnings histories throughout the distribution, and therefore that it will provide an accurate picture of the pension benefits profile and participation tax rates through the distribution.

Figure A-5: STATISTICS BY VIGINTILE



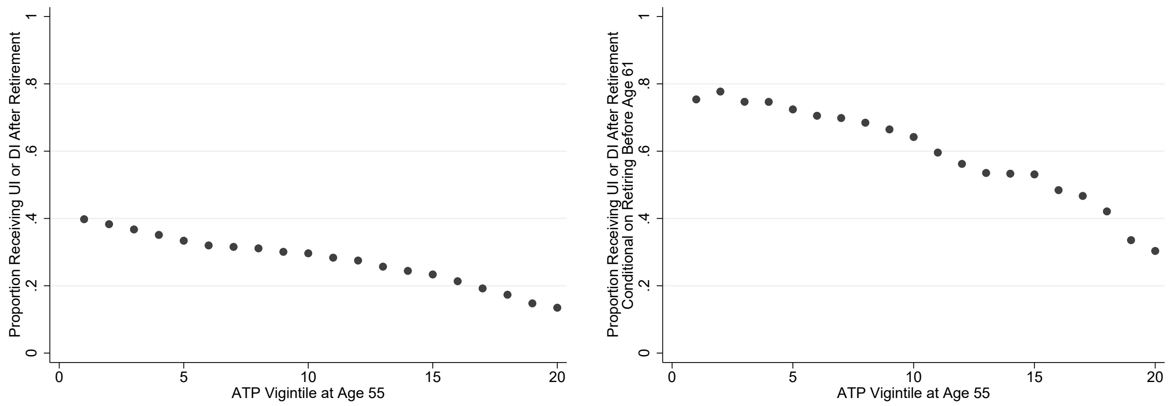
Notes: This figure shows the median ATP pension that workers born between 1938 and 1943 were eligible for at age 55 (assuming the pension is claimed at age 65) plotted alongside the simulated ATP pension. These are shown for each ATP at 55 vigintile.

Non-Pension Social Insurance We next consider how we should empirically discipline non-pension social insurance benefits received after job exit (and before pension claiming).

These programs turn out to matter little for the shape of the pension profile, but we should account for them because early retirees do claim these benefits with some regularity. Figure A-6 plots the empirical proportion of individuals receiving UI or DI after they retire by ATP vigintile at 55. Panel (b) focuses on premature retirees, those retiring before 61. We observe that low-income, premature retirees in particular are likely to claim UI or DI after exiting and before claiming, which makes sense given our other findings (e.g. on health shocks) and the fact that these workers exit the labor market before they can claim their public pension (at 61).

Figure A-6: PROPORTION OF INDIVIDUALS RECEIVING UI OR DI AFTER RETIREMENT BY ATP VIGINTILE AT 55

A. ALL (RETIREMENT AGES 56-69) B. PREMATURE RETIREES (RET. AGES 56-60)



Notes: These graphs show the proportion of individuals in each ATP at 55 vigintile who receive UI or DI after retiring. Panels B restricts to individuals retiring before age 61.

To account for the effect of these benefits on the pension profile and incentives, we suppose that our hypothetical age-55 worker knows that in the event they retire before 65 there is some probability that they will claim UI or DI afterwards, and they have some expectations of how much and how long they would receive these benefits. The worker factors these possibilities into their expected NPV of benefits (pension benefits plus other social insurance benefits claimed during these ages). We therefore estimate the following three parameters by vigintile of ATP at 55 and (exact) exit age: (1) the probability of claiming UI or DI after exit, 2) the median annual benefit amount, and 3) the median benefit duration (in years). We estimate both benefit amounts and durations conditional on claiming UI or DI after exiting. From the last of these we find that assuming the individual claims for one year if exiting at age 63 or earlier, and the individual does not claim if exiting at age 64 or later, provides a reasonable approximation to reality.

We specify the NPV of pension benefits for a given age and vigintile of ATP at 55 as the weighted mean of the NPV of pension benefits without any non-pension social insurance claims and the NPV of benefits if the individual claims non-pension social insurance benefits for one year after exiting. The weights are given by the probability of claiming from (1) above and the levels of non-pension SI benefits are the median generosity of benefits from (2) above. The NPV in the case where the individual claims non-pension SI benefits accounts for adjustments to pension benefits from social insurance receipt, and to the value of these benefits themselves.

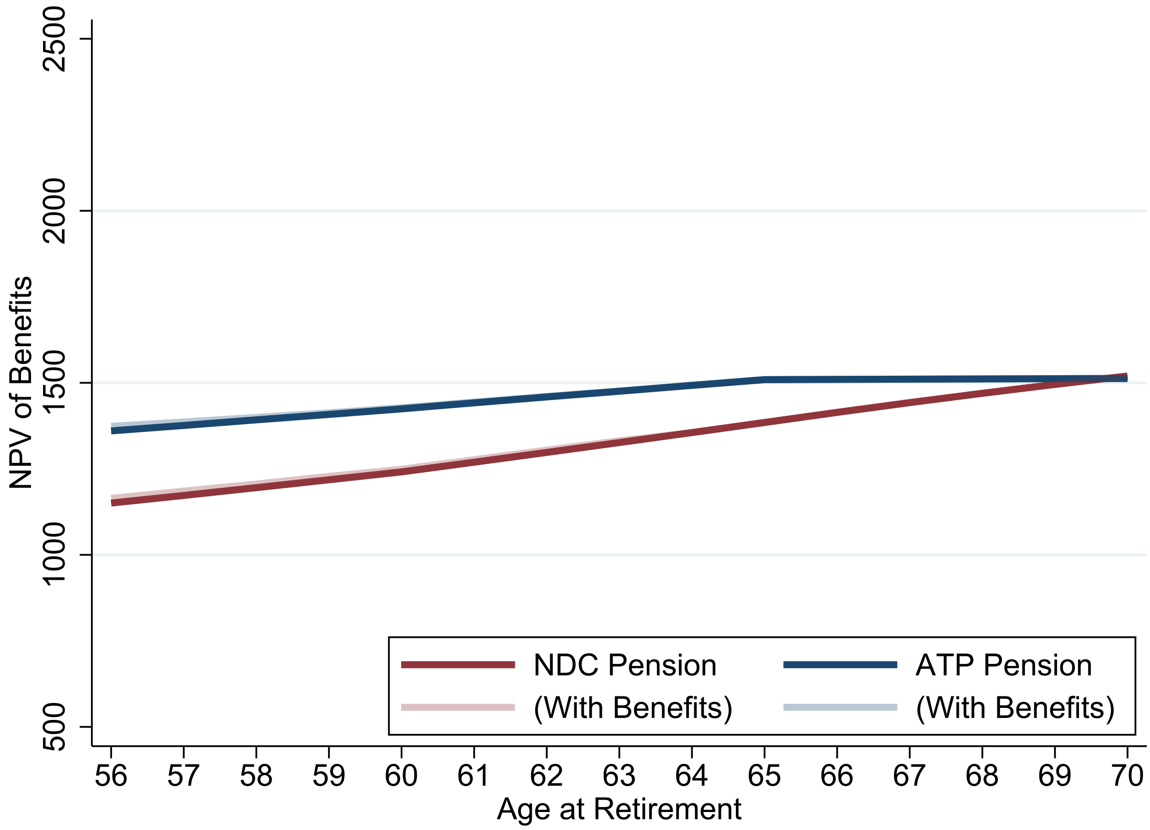
We will also present results for the simpler case where individuals do not claim any non-pension SI benefits, to show how much this matters.

Appendix A.2.3 Results

Given these calibrations, we then simulate the NPV of pension benefits and participation tax rates for each of the 20 hypothetical workers. To arrive at Panel A of Figure 1 in the main text, we average the resulting NPVs across individuals and subtract the level shift in overall benefits from the NDC system. The latter step is quite straightforward and we describe how this is done at the very end of this Appendix. Until then, in order to provide a complete and transparent characterization of the NDC reform and address some conceptual issues that are unrelated to the levels issue, we plot the NPV of benefits in the actual NDC system rather than the illustrative, budget-neutral version of NDC used in Figure 1. As a result, the NPV of benefits in the NDC system in the next few figures is lower than what we plot in Figure 1, because the NDC system decreased benefits for most workers.

Figure A-7 shows the NPV of benefits for different retirement ages compare in the ATP and NDC systems. We observe the same change in the steepness of the pension benefits profile as Figure 1, along with a level decrease in benefits in the NDC system. We also show how assuming individuals never claim non-pension SI benefits ("Without Benefits") affects our picture of the pension profile. We observe that our treatment of non-pension SI benefits matters very little, even for premature retirees. Intuitively, the main reason these benefits matter little is that the typical non-pension benefit duration is relatively short compared to the duration of receipt of public pension benefits.

Figure A-7: NPVs With and Without Post-Retirement Benefits

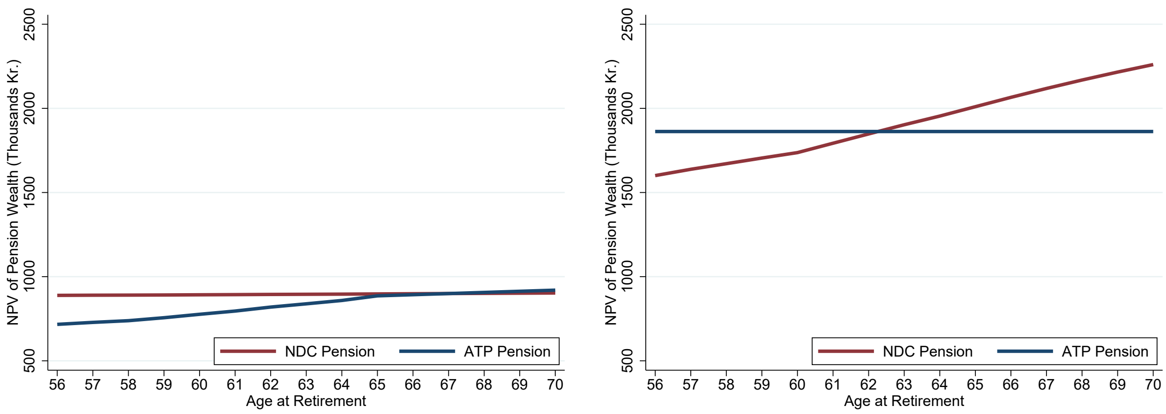


Notes: This graph shows the mean net present value (NPV) of pension benefits across the 20 ATP at 55 vigintiles for each retirement age. The opaque lines show this for an individual who does not receive post-retirement UI or DI benefits. The transparent lines show the weighted mean of the NPVs without post-retirement benefits and the NPVs with 1 year of post-retirement benefits, with the size of the benefit equal to x. x is equal to the median post-retirement benefits received for each retirement age and ATP vigintile. The weights are the probabilities of receiving post-retirement benefits for each retirement age and ATP vigintile but are set to zero for ages 64 and greater.

To get some sense of how the reform affected the steepness of the pension profile heterogeneously through the distribution of lifetime earnings, we also plot the NPVs of the ATP and NDC system in the top and bottom decile of the lifetime earnings (averaging across the top and bottom two vigintiles). These results are in Figure A-8. We observe that in the bottom decile, the higher minimum pension benefit in the NDC system resulted in a level increase in benefits for some workers, along with a flatter profile in the NDC system than in the ATP system (in contrast to most of the distribution). In the top decile, meanwhile, the cap on ATP pension benefits was binding for nearly all workers, while the higher cap on the NDC system is not. This results in a steepening of the pension profile and, at later retirement ages, higher benefits after the reform than before. For all other parts of the distribution, where the minimum and maximum on benefits are seldom binding, the qualitative effects of the reform on the pension benefits is similar to that of Figure A-7.

Figure A-8: NET PRESENT VALUE OF PENSION BENEFITS BY AGE AT RETIREMENT

A. 1ST DECILE B. 10TH DECILE

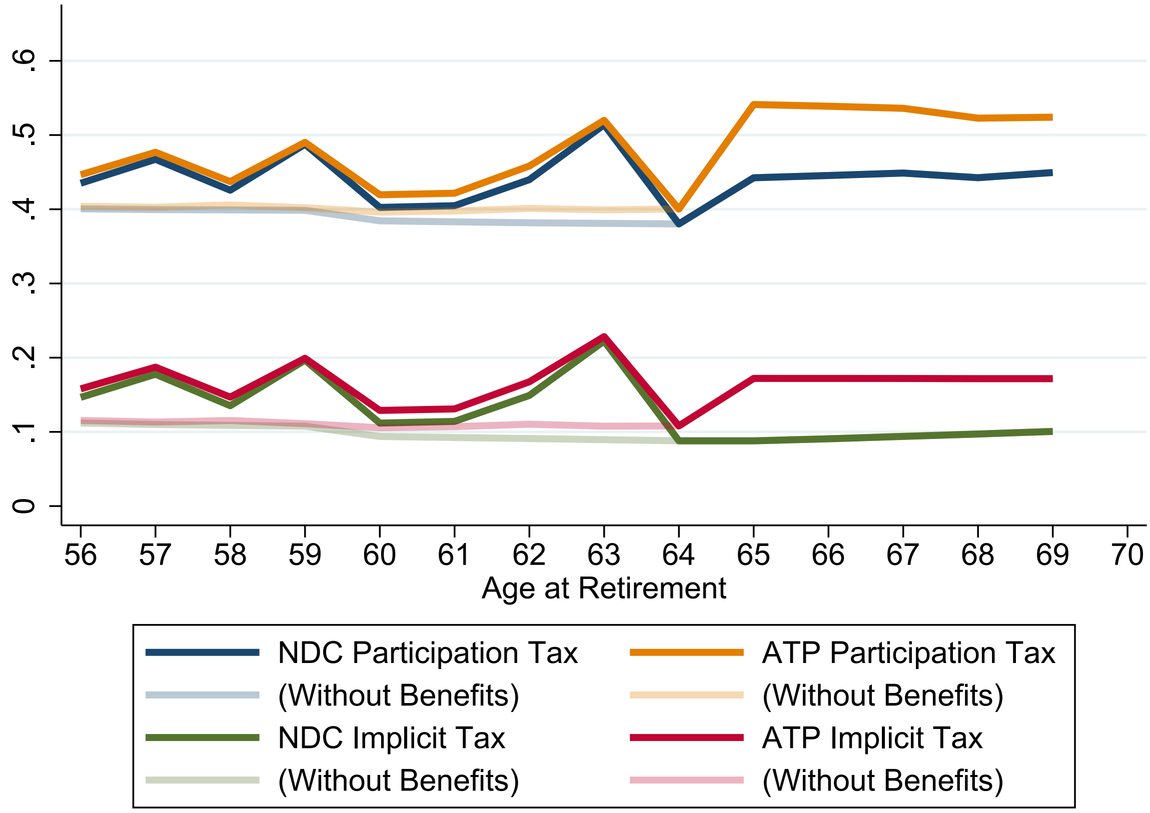


Notes: These graphs show the net present values (NPVs) of pension wealth by age at retirement for the top and bottom deciles of the distribution of ATP at age 55. The graph for each decile is created using the average NPVs of both vigintiles within that decile. Calculations are for individuals born in 1941 with a discount factor of 0.98.

We next turn to the participation and implicit tax rates, which, as discussed in Section 7, are an essential determinant of the fiscal externality from a change in steepness. Figure A-9 plots these tax rates, averaging once again over our 20 hypothetical workers. Most importantly for the welfare calculations in Section 7, we observe that a participation tax rate of 0.45 for each retirement age provides a reasonable approximation to reality in either system. The most prominent effect of the NDC reform was to decrease both the implicit and participation tax rates after age 65. This occurs because working past 65 did not accumulate pension rights in the ATP system, which acts as an implicit tax on earnings, while the NDC system allows individuals to accumulate pension rights.

We note that the tax rates in Figure A-9 vary slightly and somewhat arbitrarily across retirement ages before 65. This occurs because the empirical moments underlying our specification of non-pension social insurance benefits vary somewhat with retirement ages, which introduces some noise into the simulated tax rates. To show this and understand how these benefits contribute to the tax rates overall, we also simulate participation and implicit tax rates in both systems for a scenario in which individuals never claim non-pension SI benefits. In this case, the tax rates flatten out and are virtually constant across ages, and the participation tax rate before 65 is slightly lower at about 0.4 in both the ATP and NDC system. Using a participation tax rate of 0.4 rather than 0.45 would have a negligible impact on the benchmark fiscal externality we use in the main text, changing it from about .15 to .13.

Figure A-9: Participation and Implicit Tax Rates, With and Without Non-Pension Social Insurance Benefits



Notes: This graph shows the mean implicit and participation tax rates of pension benefits across the 20 ATP at 55 vigintiles for each retirement age. The opaque lines show this for an individual who does not receive post-retirement UI or DI benefits. The transparent lines show the participation and implicit tax rates when the NPVs are equal to the weighted mean of the NPVs without post-retirement benefits and the NPVs with 1 year of post-retirement benefits with the size of the benefit equal to x. x is equal to the median post-retirement benefits received for each retirement age and ATP vigintile. The weights are the probabilities of receiving post-retirement benefits for each retirement age and ATP vigintile but are set to zero for ages 64 and greater.

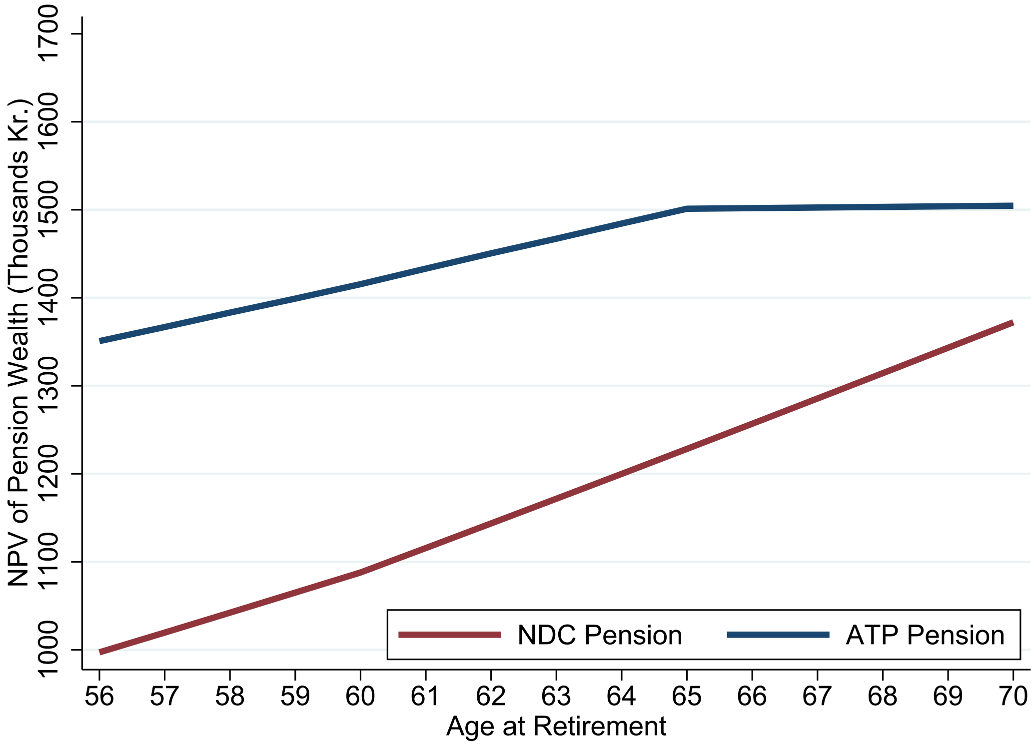
Appendix A.2.4 Alternative Claiming Age Specification

As discussed in the main text, we primarily focus on incentives to retire at other ages, setting aside the question of the claiming age. In the simulations, we held the claiming age fixed at its modal value, age 65. While justified based on the Swedish case (see Figure A-3 and the discussion in Section 3.1), this choice creates some difficulties in interpreting the incentives for retiring after age 65. Here we discuss these complications and simulate an alternative scenario for illustrative purposes.

Most importantly, the participation tax rates in Figure A-9 increase modestly after age 65 even in the NDC system. We observe that this does not derive from the implicit tax rate, which captures everything to do with the pension system, but rather the residual component of the participation tax rate. This turns out to happen because of progressive income tax rates. If an individual claims at 65 and works at some age beyond 65, the individual would face a higher average income tax rate on their labor and pension income combined than on their labor income alone. To show that this does in fact drive the increase in the participation tax rates in the NDC system, and get some idea of how a later claiming date would affect the relevant tax rates for late retirees, we plot the average pension profile and tax rates for a scenario in which individuals always claim at 70. We continue to average across 20 simulations, each representing 5% of the lifetime earnings distribution. For simplicity, we focus on the case where individuals never claim non-pension social insurance benefits after retiring, which are not material for the main point of this exercise.

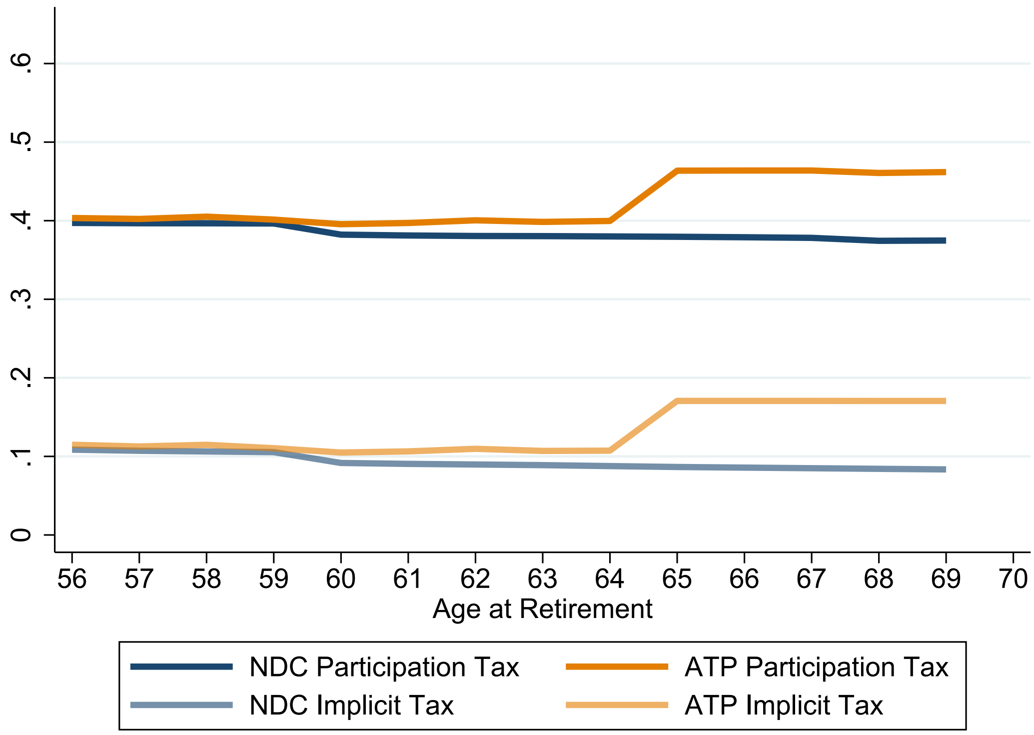
We observe that the pension profile in Figure A-10 is very similar to Figure 1/A-7. The main difference is that the level difference between ATP and NDC profiles is slightly larger, which occurs because ATP system incorporates slightly more generous adjustments for those claiming after 65. In Figure A-11, we observe that the implicit and participation tax rates before age 65 are very similar to Figure A-9 (without non-pension benefits), suggesting a flat participation tax rate of about 0.4. After age 65, NDC participation tax rate remains constant at around 0.4 or just below in the claim at 70 specification. This confirms that the increase in this tax rate at 65 in Figure A-9 is driven by the progressivity of the income tax schedule. As such, this increase in participation tax rates is spurious for the purpose of understanding the incentives faced by late retirees retiring after 65 – such workers typically also claim after 65. The most important implication of all this is that using a constant participation tax rate at different retirement ages in our benchmark for the fiscal externality provides a good approximation to reality, even after age 65.

Figure A-10: AVERAGE NET PRESENT VALUE OF PENSION BENEFITS - CLAIM AT AGE 70



Notes: This graph shows the net present value of pension wealth by age at retirement averaged across all ATP at 55 vigintiles. Calculations are for individuals born in 1941 with a discount factor of 0.98.

Figure A-11: AVERAGE IMPLICIT TAX RATE - CLAIM AT AGE 70



Notes: This figure shows the average participation tax rate and implicit tax rate across all 20 ATP at 55 vigintiles by age at retirement .

Appendix A.2.5 A Balanced-Budget NDC Reform

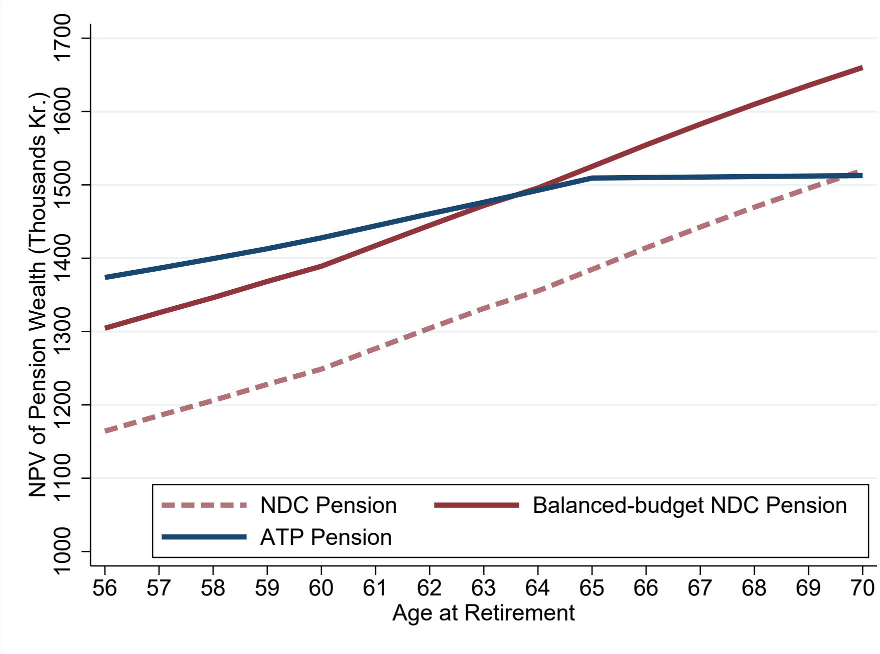
The above simulates pension benefits profiles for the actual ATP and NDC pension schemes. As one of the goals of the reform was to promote fiscal sustainability, the reform was not budget-neutral. In Figure 1 and our implementations of the sufficient statistics framework, we characterize the effects that this reform would have had if it were budget neutral. To do this, we calculate a profile that has the same budget as the ATP scheme but the same slope as the NDC scheme. We call this "budget-neutral" NDC in Figure 1.

Let $f(r)$ denote the fraction of individuals with retirement age r. Denoting the NPV of benefits at age r in the ATP and NDC schemes by ATP_r and NDC_r, respectively, our goal is to find a profile $\widehat{NDC}_r$ with the desired properties.

Keeping the budget fixed at the ATP level requires:

$$\sum_{r=56}^{69} [ATP_r f(r)] = \sum_{r=56}^{69} [\widehat{NDC}_r f(r)] \tag{25}$$

Figure A-12: NET PRESENT VALUE OF PENSION BENEFITS - ACTUAL NDC PROFILE



Notes: This figure shows the net present value (NPV) of pension wealth by age at retirement averaged across all ATP at 55 vigintiles. Calculations are for individuals born in 1941 with a discount factor of 0.98. NPVs are shown for both the actual NDC pension and the balanced-budget version of the NDC pension.

Keeping the slope of the profile the same as the NDC throughout requires that for any r,

$$\widehat{NDC}_r = \Delta + NDC_r. \tag{26}$$

Plugging this into equation (25) and solving for Δ we obtain:

$$\Delta = \frac{\sum_{r=56}^{69}[ATP_r f(r)] - \sum_{r=56}^{69}[NDC_r f(r)]}{\sum_{r=56}^{69}[f(r)]}. \tag{27}$$

Figure 1 in the main text draws on the budget-neutral version of the NDC reform, $\widehat{NDC}_r$. Figure A-12 compares the ATP profile (ATP_r), the actual NDC profile (NDC_r) and the budget-neutral NDC profile $\widehat{NDC}_r$. The implementation results that characterize the change in slope in the Swedish reform are also based on a comparison of $\widehat{NDC}_r$ and ATP_r (see Appendix G for further details on the implementation).

Appendix B Data - Additional Details

Residual Measure of Consumption Expenditures

Our third registry data source is granular data on wealth from the wealth registry. These data were collected by Statistics Sweden 1999-2007, years when Sweden was taxing wealth.[56] The data contains information on real estate, stocks, bonds, other securities, debt, and bank account holdings. With this data we construct a residual consumption measure using the budget identity:

$$Consumption = Income - Saving. \tag{28}$$

The consumption measure is one of consumption *expenditure* and records consumption on all goods paid for by taxed and recorded income. A number of recent papers have use such consumption measures, based on Scandinavian population registers with detailed information on income and assets.

All details on the data and programs used to create this measure of consumption can also be found at: `http://sticerd.lse.ac.uk/_new/research/pep/consumption/default.asp`.

To construct our consumption measure we follow the same method as Kolsrud et al. [2020]. The income measure used is disposable income which is constructed by Statistics Sweden, and is included in the LISA panel. It contains the net-of-tax value of labor earnings, capital earnings, flow value of student loans (received and amortized) and social insurance benefits. Saving is defined as the change in asset holdings and debt after we have accounted for passive capital gains. Capital income and student loans are removed from the disposable income measure to prevent double counting. For stocks and bonds we use the number of securities each person holds on December 31st each year and valuate them according to the end-of-day price on December 31st. For real estate we use data from the property register which covers real estate transactions which are then linked to buyers and sellers. When individuals have no transactions consumption from real estate is zero. Debt is the sum of all types debt; mortgages, consumer credits and student loans. We cannot separate mortgages or consumer credits from the stock of debt an individual holds.

Specifically, consumption expenditures C_{it} by household i in period t is written as

[56] The wealth tax was installed in 1947 and repealed in 2006. Data was also collected in 2007. Before 1999 only data on total wealth is available and, mostly, only for individuals or households subject to wealth tax, about 5 percent of the population.

$$C_{it} = Z_{it} - \sum_k p_{kt} \left[A_{ikt} - A_{ikt-1} \right], \tag{29}$$

where Z_{it} captures all sources of income and transfers, $\mathbf{A}_{it} = A_{i1t}, .., A_{iKt}$ denotes the portfolio of assets and $\mathbf{p}_t = p_{i1t}, .., p_{iKt}$ the corresponding vector of prices at which they are traded. With wealth data spanning 1999-2007 we can estimate consumption expenditure 2000-2007.

The wealth data are annual and financial assets are recorded on December 31st each year. This means that we cannot detect intra-year trading. Baker et al. [forthcoming] find that the error this creates is small on average though it may be important for some households. We also do not account for trading fees. However, these can be seen as a consumption expenditure; individuals purchase a service − investment counseling − which they pay for and this cost is included in the consumption expenditure measurement. See Kolsrud et al. [2020] for further detail on the consumption expenditure measure.

Health Data

Table B-1 provides descriptive statistics on the samples from the ULF and HEK surveys that we match to our administrative data. To maximize power, we focus on cohorts 1938 to 1950. The table compares individuals matched in the ULF and HEK samples, to all individuals from our baseline sample of retirees. The table shows that the distribution of age at retirement is very similar across samples, and so are demographic and pension characteristics.

The table also reports descriptive statistics for the various health proxies that we combine into two health indices, by extracting their first principal components. Measures from the HEK (which is a household finance survey) are mostly objective measures of health expenditures. We use the following variables:

BANTGYM: Number of visits to a physiotherapist in last 12 months

BANTLAK: Number of visits to a doctor in last 12 months

BFRIMED: dummy for having access to free pharmaceuticals. When expenditures on pharmaceuticals reach a certain threshold (around 2000SEK per year) individuals become eligible to free pharmaceuticals.

UMED: Pharmaceutical expenditures (under the cap).

BFRISJU: a dummy for having access to free outpatient care. Similarly, when expenditures on outpatient care reach a certain threshold (around 1200SEK per year) individuals become eligible to free outpatient care.

USJUKA: Total out-of-pocket expenditures for healthcare (excl. rehab) in last 12 months.

UFORBR: Expenditures for assistive technology (e.g. motorized wheelchair, etc.)

UHJALP: Expenditures for renting of assistive technology

In the ULF data, we have both subjective and objective measures of health. We extract the principal component from a PCA on the following variables: Number of visits to a physician in the last 12 months, a dummy for individuals reporting having a long term / chronic illness, the number of long term illnesses reported, a dummy for reporting having serious health difficulties and/or pain, a dummy for having reduced work capacity, and the body mass index.

We create two health indices corresponding to the first component extracted from a PCA on these two sets of variables, and we then standardize both indices.

Table B-1: Descriptive Statistics:
Health Information From HEK & ULF Surveys

	Retirement Sample		Retirement x HEK Sample		Retirement x ULF Sample	
	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d.)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
I. Retirement						
Premature Retiree	16.08 %		11.84%		12.52%	
Early Retiree	33.4 %		32.8%		32.1%	
Normal Retiree	34.57 %		38.15%		37.8%	
Late Retiree	15.95 %		17.21%		17.54%	
Age at Retirement	62.91	(3.1)	63.27	(2.87)	63.24	(2.94)
II. Demographics						
Cohort	1940.67	(1.73)	1944.08	(3.54)	1943.92	(3.46)
Fraction Men	49.33 %	(50)	48.8%	(49.99)	48.64%	(49.99)
Married at 59	66.78 %	(47.73)	73.68%	(44.04)	66.77%	(47.11)
Kid at Home at 59	17.69 %	(38.14)	21.54%	(41.11)	18.9%	(39.15)
And Kid < 18	3.39 %	(18.1)	4.54%	(20.83)	3.91%	(19.38)
Post-Secondary Edu.	24.91%	(43.25)	30.38%	(45.99)	28.78%	(45.28)
III. Income and Wealth at 59, SEK 2003(K)						
Total Earnings	211	(159)	240	(173)	234	(171)
Net Wealth	779	(2289)	951	(1814)	877	(1529)
Bank Holdings	83	(302)	105	(263)	95	(212)
Portfolio Value	250	(1666)	289	(1252)	256	(1057)
Consumption	200	(530)	239	(842)	226	(528)
IV. Health (HEK)						
Visited Physio.			15.95%	(36.61)		
No. Physio. Visits			1.68	(5.29)		
Visited Doctor			68.41%	(46.49)		
No. Doctor's Visits			2.9	(3.84)		

Continued on next page

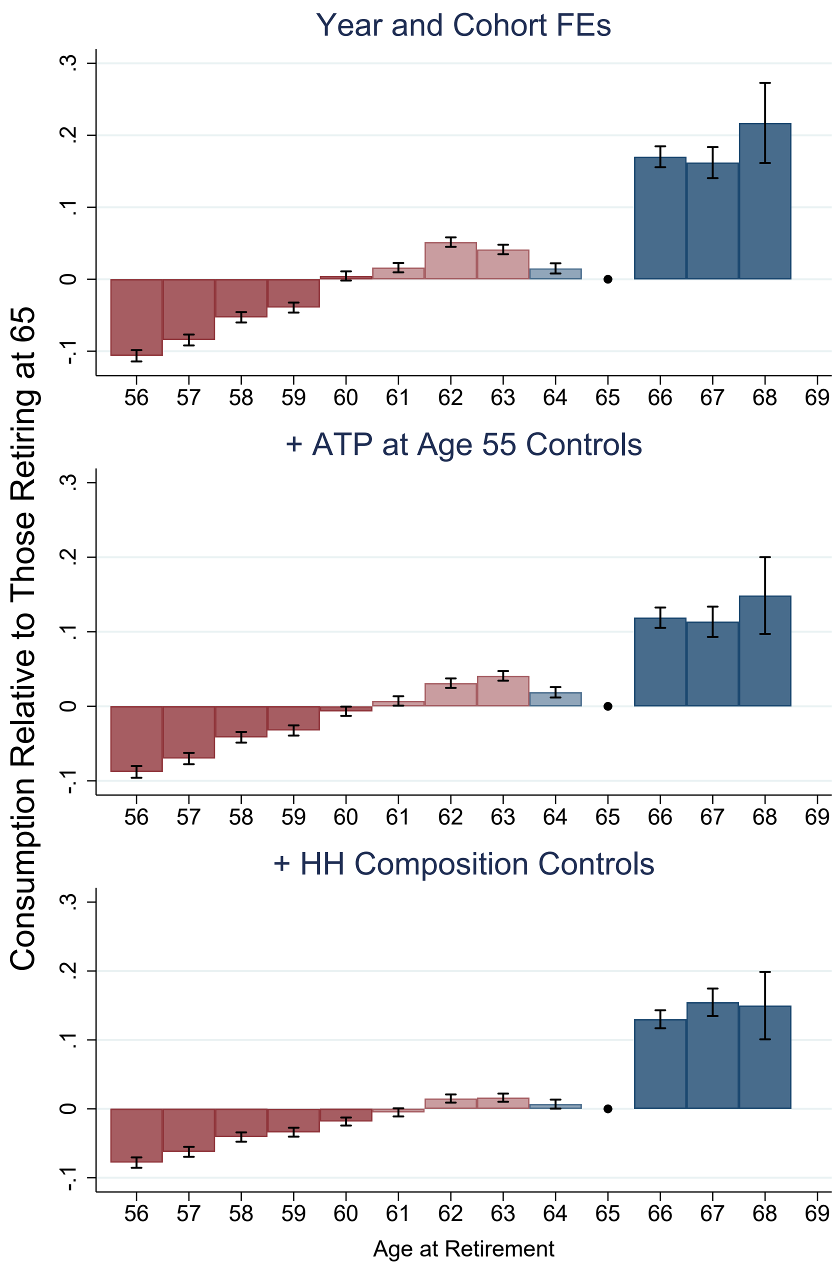
Table B-1: Descriptive Statistics:
Health Information From HEK & ULF Surveys

	Retirement Sample		**Retirement x HEK Sample**		**Retirement x ULF Sample**	
	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d.)
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Free Pharmaceuticals			25.83%	(43.77)		
Pharm. Expenses			746.1	(762.1)		
Free Outpatient Care			23.33%	(42.3)		
Healthcare Expenditure			366.8	(552.4)		
Assistive Tech. Exp.			5.5	(95.3)		
Ass. Tech. Rent Exp.			6.4	(202.7)		
V. Health (ULF)						
Visited Physician					38.68%	(48.7)
Has Long-Term Illness					54.74%	(49.78)
No. of LT Illnesses					.93	(1.13)
Difficulties/Pain					16.28%	(36.92)
Reduced Work Cap.					10.16%	(30.21)
Body Mass Index					256.87	(36.51)
N (Unique Individuals)	419,790		19,568		7,068	
Cohorts	[1938,1943]		[1938,1950]		[1938,1950]	

Appendix C Consumption Levels & Heterogeneity

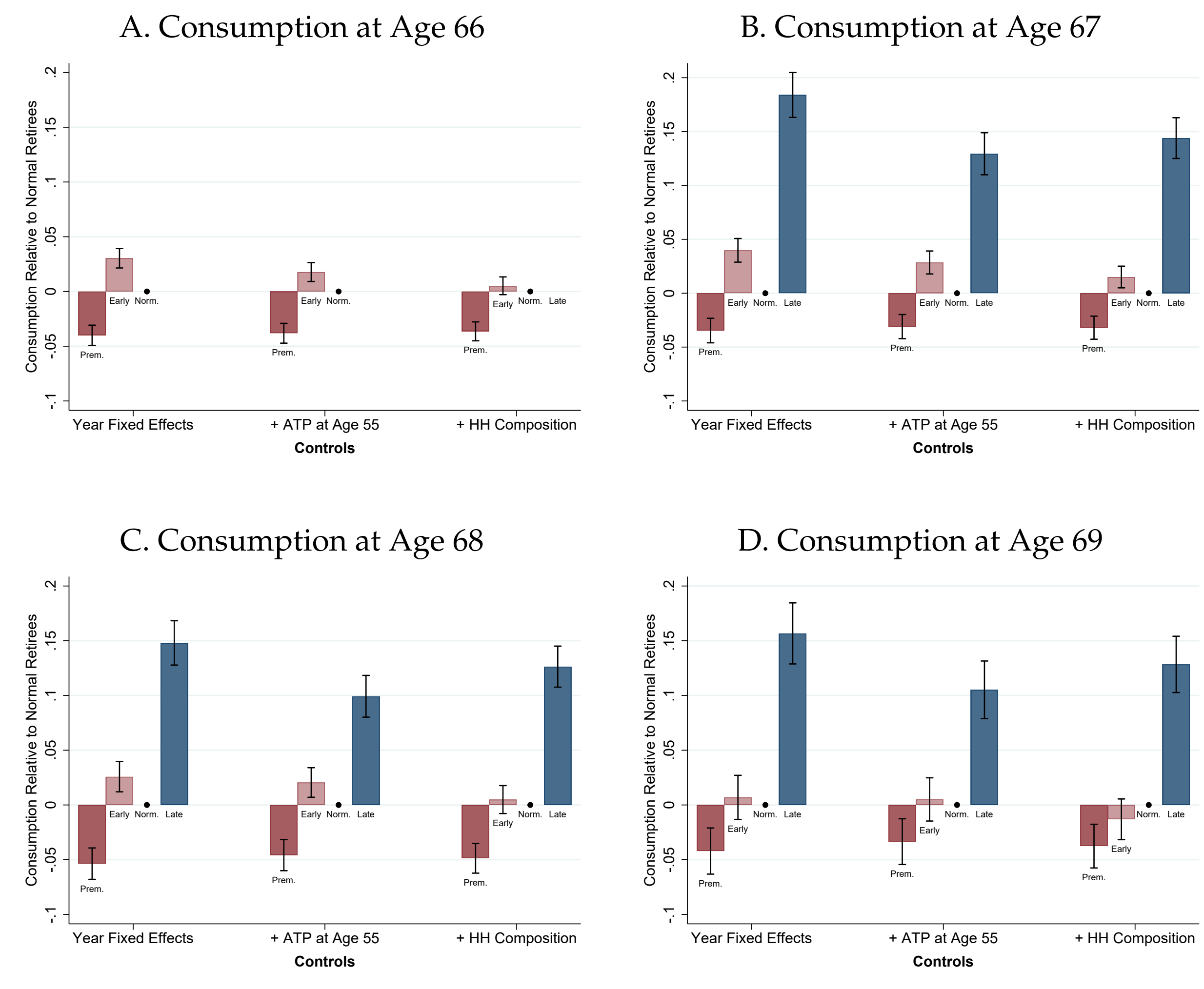
Consumption Differences By Retirement Age: Robustness

Figure C-1: CONSUMPTION DIFFERENCES BY RETIREMENT AGE



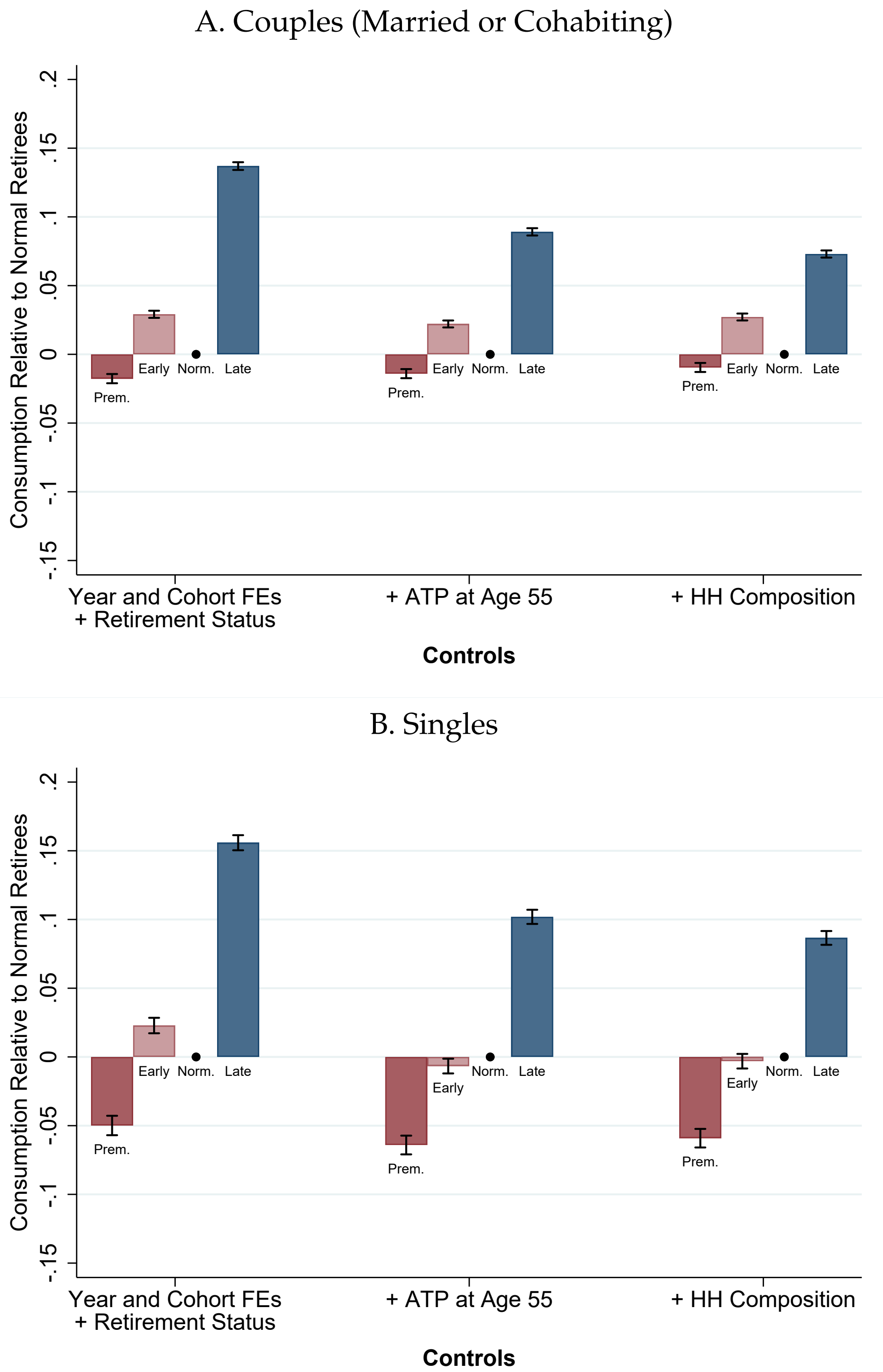
Notes: The figure report estimates of a fully non-parametric version of specification (12) where we compare consumption levels across all retirement ages (rather than aggregating retirement ages into four groups). The sample comprises all individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed. Individuals who retire at 65 are the reference category. The graph reports for all retirement age, the estimated coefficients α_j from specification (12), scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire at 65 from the same cohort, and age as the average individual retiring in age group j. The top panel starts with results from model (12) where only year and age fixed effects are included. The middle and bottom panels show the same estimated coefficients when sequentially adding ATP quartiles accumulated at age 55 and controls for family composition in the vector of controls $\mathbf{X}$.

Figure C-2: Consumption Differences by Retirement Age Groups: By Age At Which Consumption is Observed



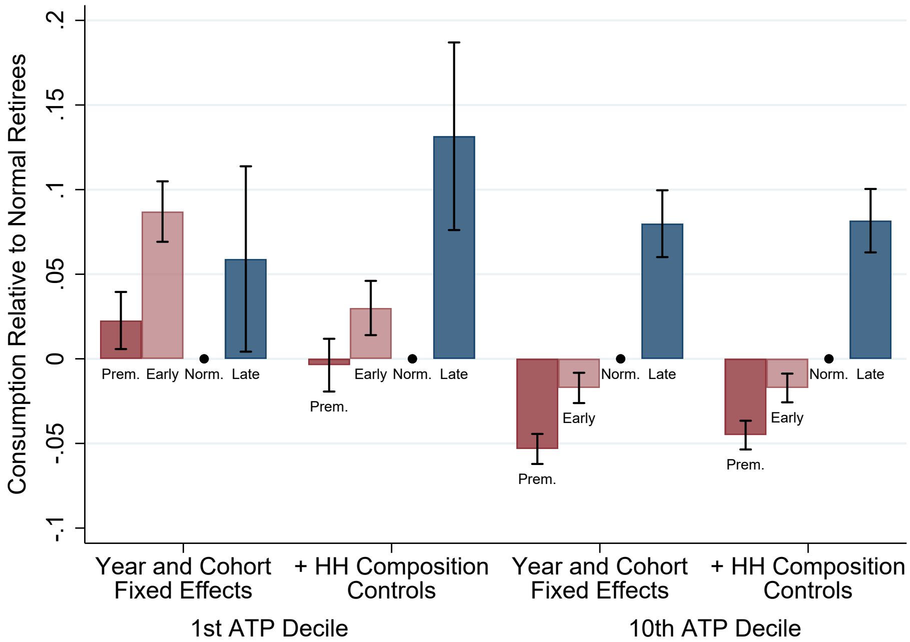
Notes: The figure shows that the consumption patterns hold irrespective of the age at which consumption is observed during retirement. We run regressions similar to specification (12), but separately for each age t. Because t is now fixed, we remove age fixed effects from the specification and control for year fixed effects γ_y. In effect, we compare consumption at age t of individuals retiring in different age groups *within the same cohort*. The graph confirms the very strong positive gradient of consumption with retirement age, at all ages at which consumption is observed.

Figure C-3: Consumption Differences by Retirement Age: Split By Household Structure



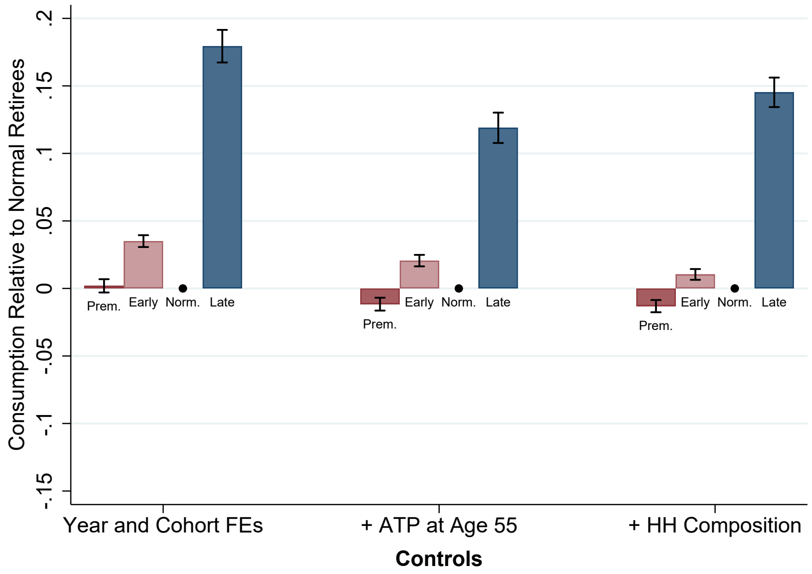
Notes: The figure reproduces estimates of consumption differences in retirement by retirement age group, similar to Figure 3 but splitting the sample between individuals who are single vs married/cohabiting at the time of retirement. The sample comprises all individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed.

Figure C-4: CONSUMPTION DIFFERENCES IN RETIREMENT ACROSS RETIREMENT AGE GROUPS



Notes: The figure reports consumption in retirement across individuals who retire at different ages relative to normal retirees. The sample comprises all individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed. Individuals are grouped into four retirement age categories: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). Results are shown for individuals in the 1st and 10th ATP at 55 deciles, with only year and age fixed effects as well as with added controls for family composition.

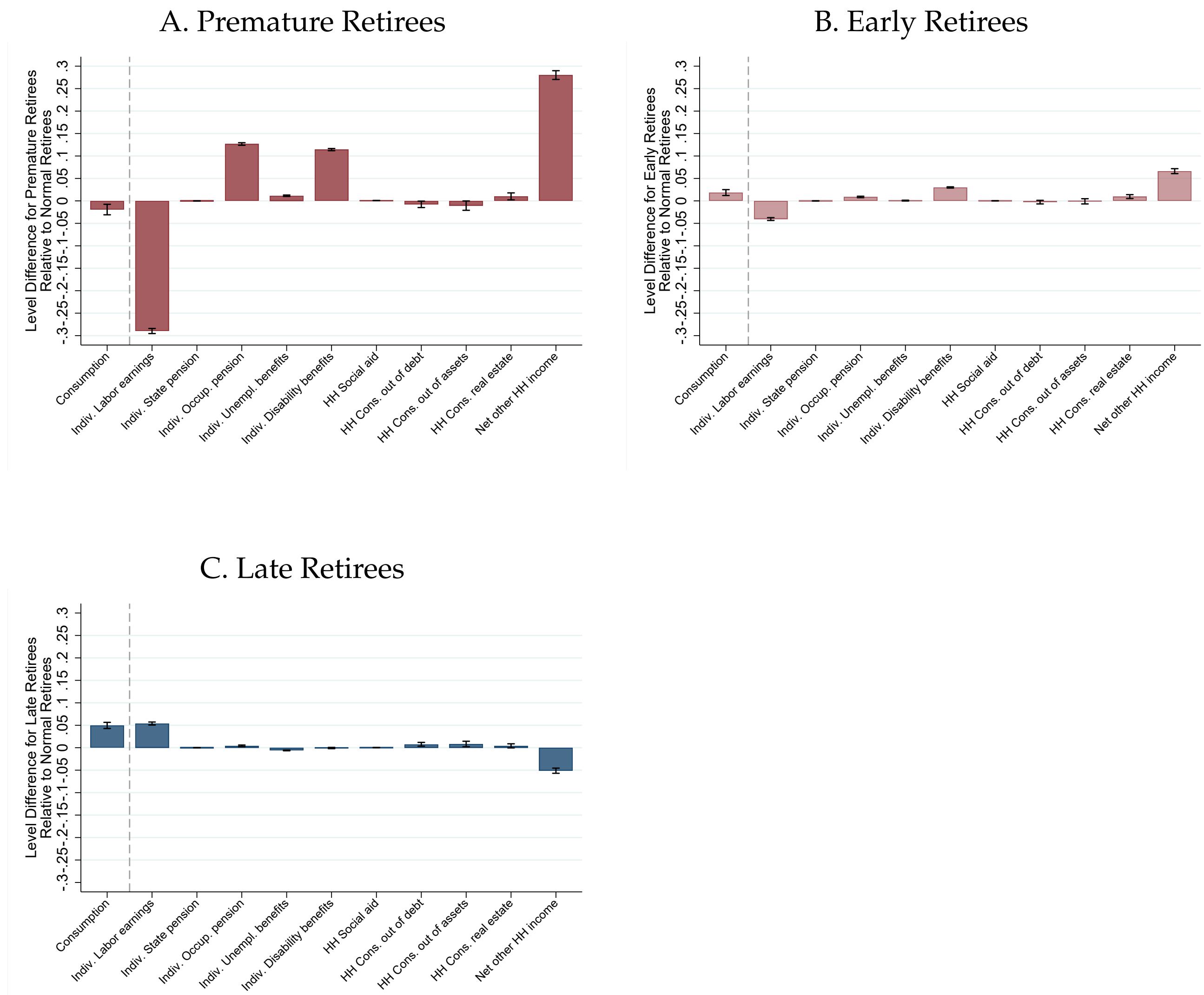
Figure C-5: CONSUMPTION DIFFERENCES BY RETIREMENT AGE: ALTERNATIVE DEFINITION OF RETIREMENT



Notes: The figure documents consumption differences across retirement age groups using an alternative measure of retirement age that accounts for the time spent in UI or DI after an individual stops working. The sample comprises all individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed. Individuals are grouped into four retirement age categories using this alternative measure of retirement age: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). Normal retirees are the reference category. The graph reports for all retirement age groups, the estimated coefficients α_j from specification (12), scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire between 64 and 65 from the same cohort, age, family composition and ATP quartile at age 55 as the average individual retiring in age group j. We start, on the left hand side of the graph, with results from model (12) where only year and age fixed effects are included. The rest of figure shows the same estimated coefficients when sequentially adding ATP quartiles accumulated at age 55 and controls for family composition in the vector of controls $\mathbf{X}$.

Decomposition of Consumption Expenditures at Age 60

Figure C-6: DECOMPOSITION OF CONSUMPTION EXPENDITURES AT AGE 60 BY RETIREMENT AGE

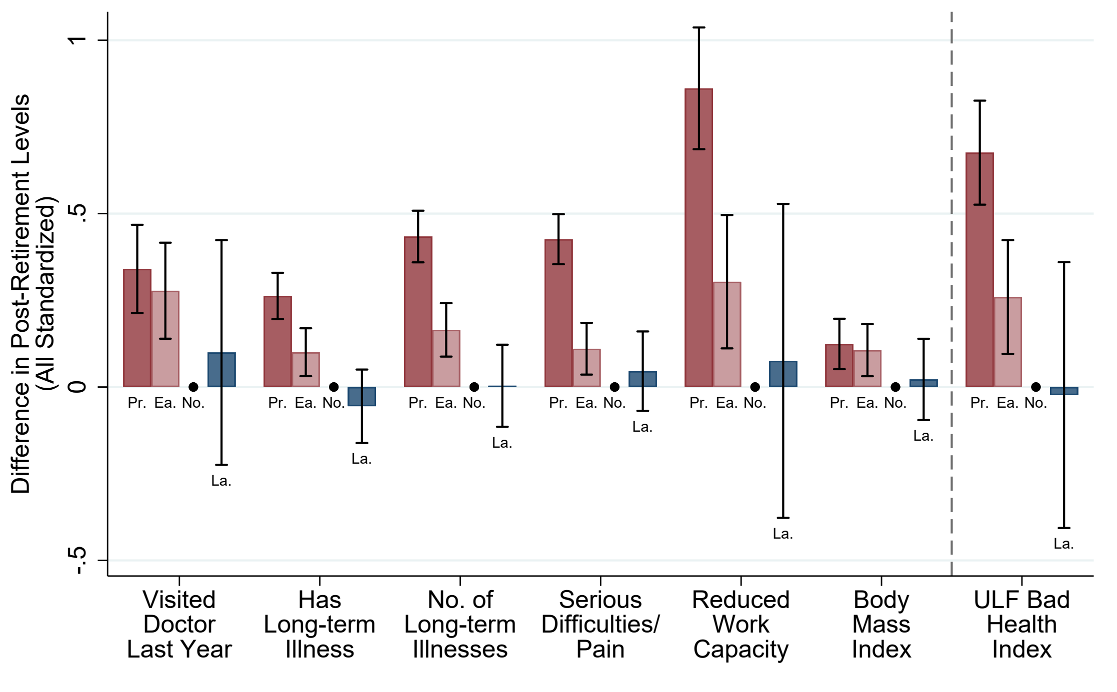


Notes: The figure decomposes consumption differences at age 60 across individuals who retire at different ages. The sample comprises all individuals from cohorts 1938 to 1943. Individuals are grouped into four retirement age categories: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). We decompose our measure of household expenditures into a set of components that shed light on the consumption means available to individuals. These components include own income, (which we break down into own earnings, pensions, and other transfers such as UI, or DI), consumption out of debt, consumption out of assets, consumption out of real estate, and other household income (e.g. earnings from other members of the household, etc). We run specification (12) separately for each component evaluated at age 60, and report for all retirement age groups, the estimated coefficients α_j, using normal retirees as the reference category. As in Figure 3, the coefficients α_j are scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire between 64 and 65 from the same cohort, age, family composition and ATP quartile at age 55 as the average individual retiring in age group j. All regressions include year and age fixed effects as well as controls for ATP quartiles accumulated at age 55 and controls for family composition.

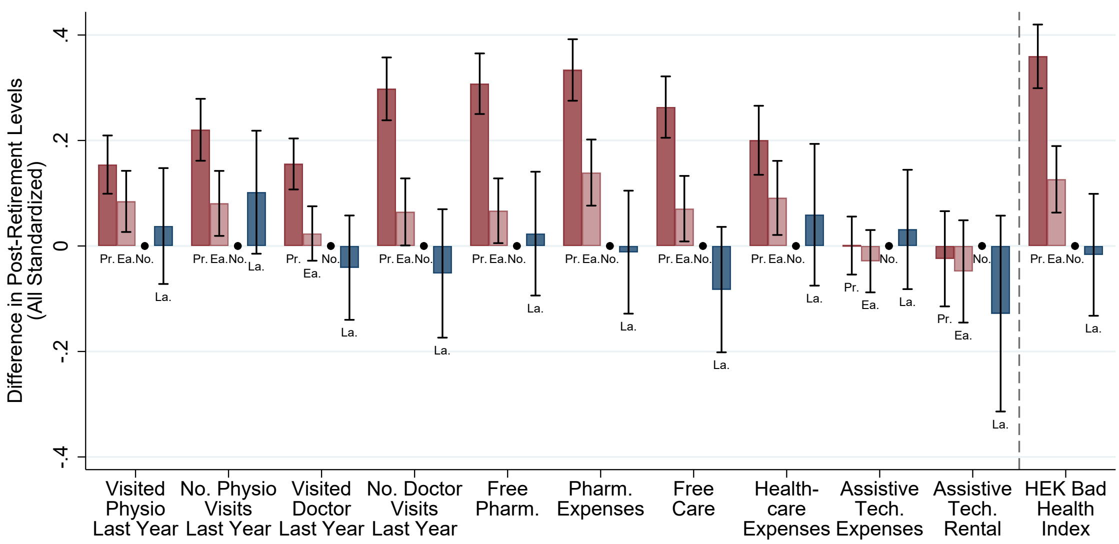
Heterogeneity in Health Outcomes

Figure C-7: Differences in Health Status by Retirement Age: Separate Estimates For Each Component of HEK and ULF Bad Health Indices

A. ULF Survey Outcomes



B. HEK Survey Outcomes



Notes: The figure documents differences in health outcomes across retirement age groups. The sample comprises all individuals from cohorts 1938 to 1943 who are observed either in the ULF or HEK surveys, and who are retired at the time of the survey. Individuals are grouped into four retirement age categories using this alternative measure of retirement age: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). Normal retirees are the reference category. The graph reports for all retirement age groups, the estimated coefficients α_j from specification (12), where we control for age and cohort fixed effects, as well as ATP quartiles accumulated at age 55 and controls for family composition in the vector of controls $\mathbf{X}$. All outcomes are standardized.

Correlation Between Consumption & Observable Heterogeneity

Table C-1: ESTIMATED DIFFERENCES IN CONSUMPTION LEVELS CONTROLLING FOR OBSERVABLE HETEROGENEITY

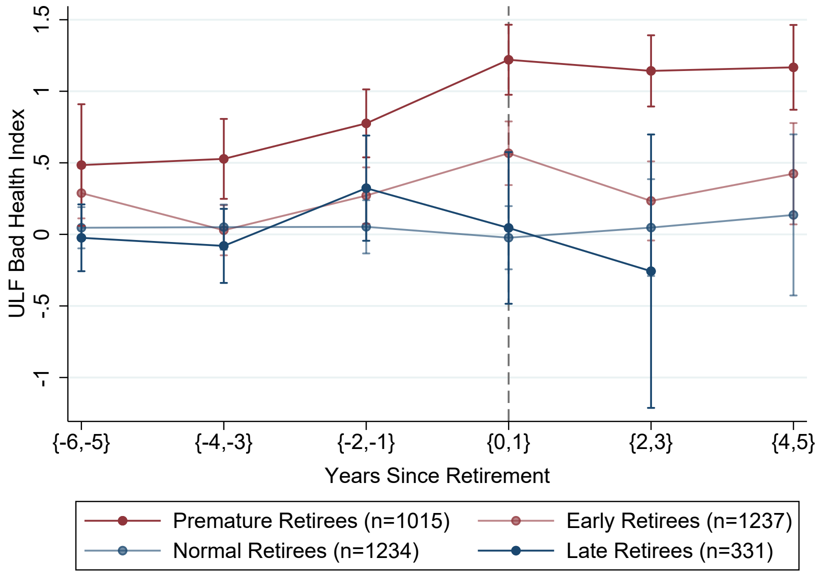
	Consumption While Retired Relative to Normal Retirees			
	(i)	(ii)	(iii)	(iv)
Panel A: Demographics				
Premature Retirees	-.04	-.04	-.04	-.03
Early Retirees	.01	-.00	-.00	.01
Normal Retirees	.	.	.	.
Late Retirees	.13	.10	.10	.09
Controls Added				
Gender		X	X	X
Education		X	X	X
Industry		X	X	X
Lifespan			X	X
Assets				X
Panel B: Health (HEK)				
Premature Retirees	-.03	-.03		
Early Retirees	.04	.04		
Normal Retirees	.	.		
Late Retirees	.05	.05		
Controls Added				
HEK Health Expenditures		X		

Notes: The table reproduces estimates of consumption differences in retirement by retirement age group, similar to Figure 3 but adding to specification 12 a series of observable characteristics that correlate with retirement age. The sample comprises all individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed. Panel A adds controls for education (12 dummies for education levels), 1-digit industry code dummies for industry at age 55, lifespan (dummies for probability to be dead at 60, 65, etc) and wealth at age 59 (deciles). Panel B focuses on the narrower HEK sample where we control for health expenditures. Note that in both panels, column (i) reproduces the baseline specification with year and age fixed effects, as well as controls for ATP points at age 55 (quartiles) and family structure.

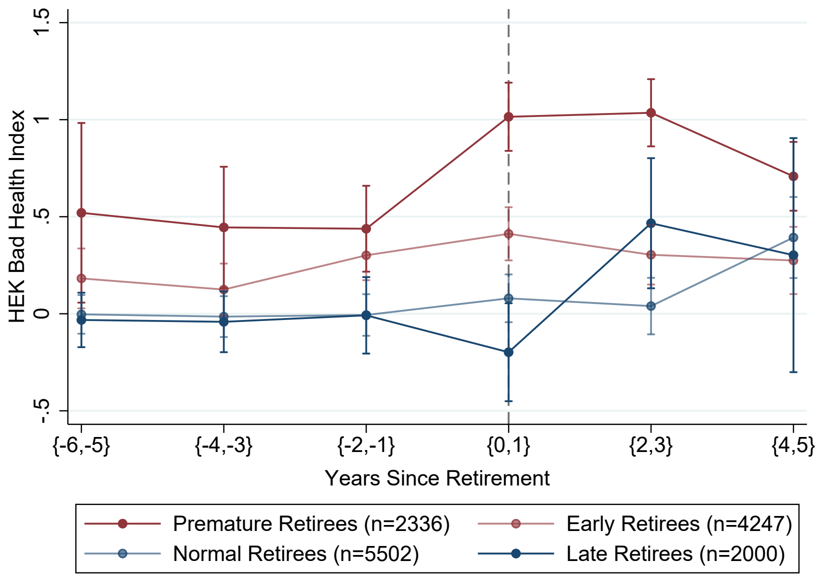
Health Dynamics

Figure C-8: Health Dynamics Around Retirement BY Retirement Age Group: HEK and ULF Bad Health Indices

A. ULF Health Index



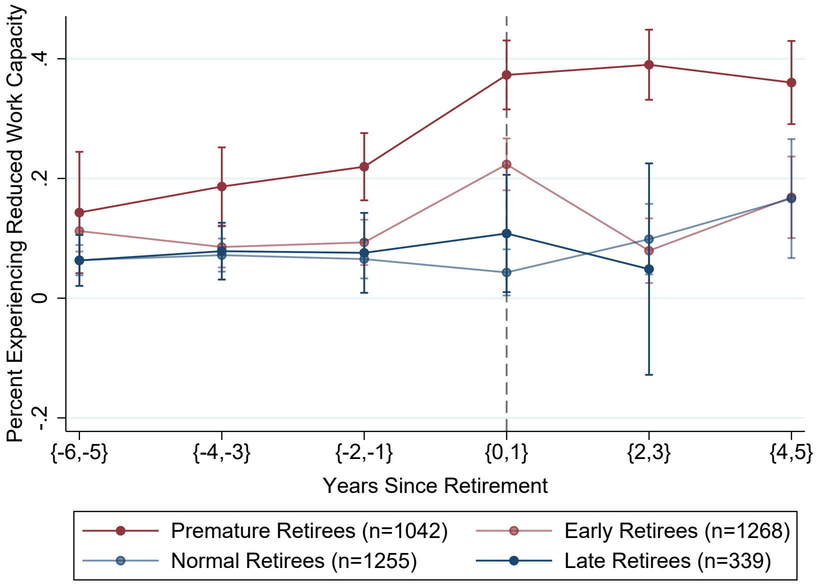
B. HEK Health Index



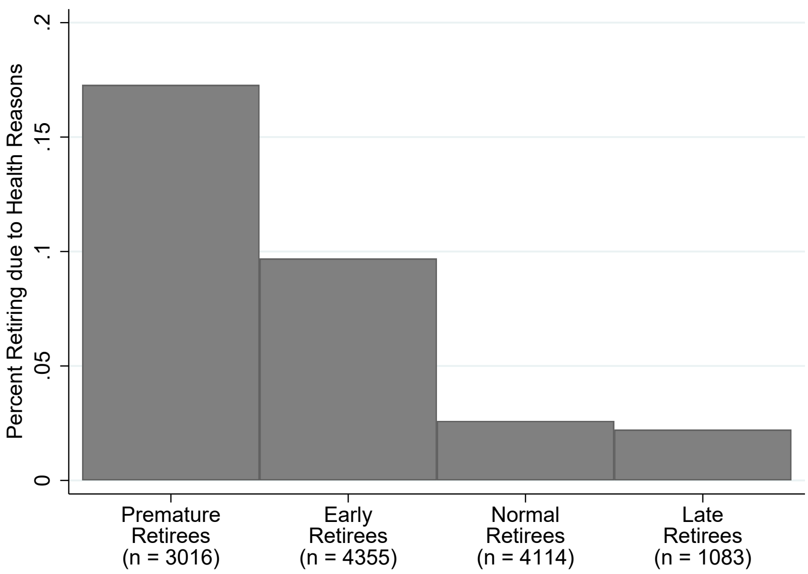
Notes: The figure documents heterogeneity in health dynamics around retirement, by retirement age group. Both panels report, for each retirement age group, the sequence of estimated coefficients $\hat{\alpha}_{re}$ from specification (13). where we control for cohort and age fixed effects and on the usual vector $\mathbf{X}$ of our baseline controls (i.e. ATP points accumulated up to age 55 and household structure). Panel A uses the ULF bad health index as an outcome. Panel B uses the HEK bad health index as an outcome.

Figure C-9: HEALTH DYNAMICS AROUND RETIREMENT BY RETIREMENT AGE GROUP: HEK AND ULF BAD HEALTH INDICES

A. Reduced Work Capacity



B. Retirement For Health Reasons



Notes: The figure documents heterogeneity in health dynamics around retirement, by retirement age group. Panel A reports, for each retirement age group, the sequence of estimated coefficients $\hat{\alpha}_{re}$ from specification (13) similar to Figure 7 where we use the fraction reporting reduced work capacity in the ULF survey as an outcome. In panel B, we report the fraction of individuals reporting that they retired due to health reasons in the ULF surevy, by retirement age groups.

Appendix D Robustness of Consumption Patterns by Retirement Age Across Contexts

In this appendix, we explore the external validity, across contexts and data sources, of the consumption patterns by retirement age we documented in Sweden. We note of course that the consumption patterns across retirement age groups will depend on the policy environment (e.g. the steepness of the pension profile, the availability of other insurance mechanisms against consumption risk in old age, etc.) which differ across countries and over time. Most countries share very similar institutions (see OECD [2015, 2017, 2019]), with pension profiles that penalize early retirement and it is therefore interesting to investigate whether the broad patterns of consumption hold in these contexts as well.

One of the difficulty is of course the limited availability of data with both detailed consumption and retirement information. We use two surveys that contain such information: SHARE available for a large set of European Countries (with information on food consumption) and HRS for the US (which contains a broader measure of consumption).

Appendix D.1 Evidence from SHARE

The Survey of Health, Ageing and Retirement in Europe (SHARE) is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and family networks of about 140,000 individuals aged 50 and older. The survey took place in 2004, 2007, 2011, 2013, 2015 and 2017, it has a small panel structure, and covers the 27 EU countries. It is harmonised with the US Health and Retirement Study (HRS). However consumption in the SHARE survey is only available for food items.

To make the analysis comparable to the analysis we conducted in Sweden, we restrict the SHARE sample to the cohorts born between 1938 and 1958, and to individuals aged between 50 and 75. We only keep for analysis countries that are repeatedly sampled since 2004, which leaves us with 11 countries: Austria, Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Spain, Sweden, Switzerland and the United States.

We define retirement as the year an individual reports having stopped working for pay. In terms of methodology, we follow a similar approach as in our baseline analysis and regress consumption of individual i at age t living in country l on a series of dummies for retirement age, and we control for country fixed effects, year fixed effects and age fixed effects:

$$C_{it}^{l} = \sum_{j} \alpha_j \cdot \mathbb{1}[\mathrm{r} = \mathrm{j}] + \gamma_y + \gamma_t + \gamma_l \quad (30)$$

In practice, we follow the same grouping of retirement age as in Sweden: we define as premature retirees individuals who retire before age 60, early retirees as individuals retiring between age 60 and 63, normal retirees as people retiring between 64 and 65, and late retirees for people who retire after 65. All results are expressed relative to the consumption level of the normal retirees.

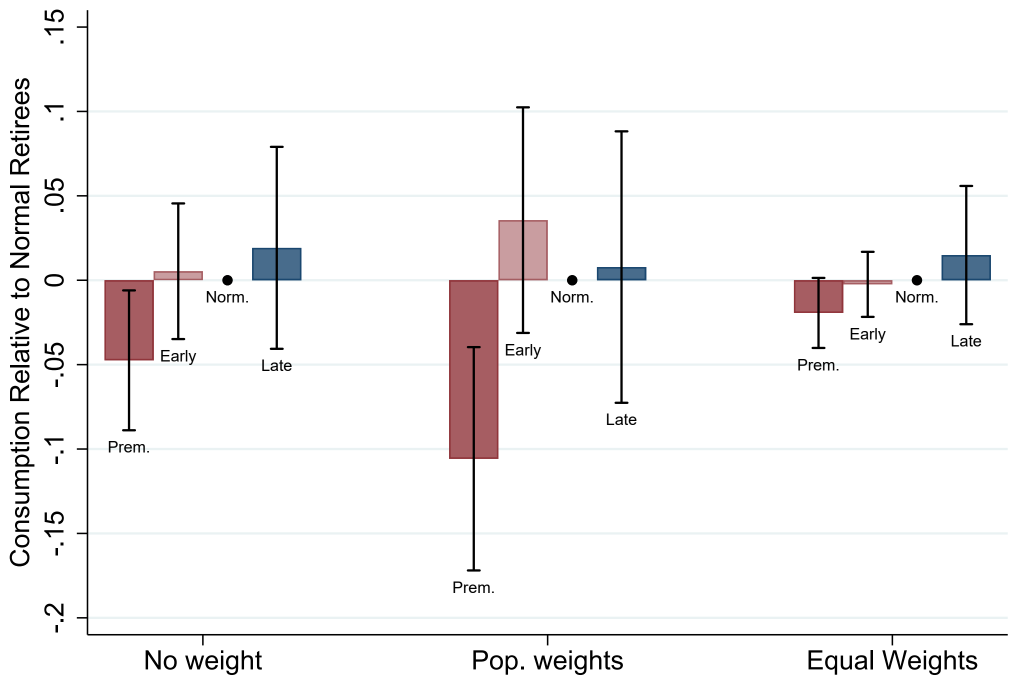
In terms of aggregating results across countries, we run all regressions at the individual level with country fixed effects and report results for 3 weighting options: (i) the no weight option in which we do not include any weight in the regression (so all individual observations in the SHARE sample are given equal weight irrespective of the country population size or sampling frame); (ii) the population weight option uses weight corresponding to the sampling frame of each country in the survey, and reweights each individual weight so that the sum of weight in each country reflects a country's relative population size; (iii) finally the equal weight option (our preferred option) uses weight corresponding to the sampling frame of each country in the survey and reweights each individual weight so that the sum of weights in each country is the same (in other words, all countries are given equal weight in the regression).

Results In Figure D-1 below, we report estimates of the α_j coefficients for each retirement age group, scaled by $\mathbf{E}_j[\tilde{C}_{it}^{l}]$, the predicted consumption level from specification 31 when omitting the contribution of the retirement age group dummies. $\mathbf{E}_j[\tilde{C}_{it}^{l}]$ corresponds to the average level of consumption of individuals who retire between 64 and 65 from the same country, cohort and age as the average individual retiring in age group j.

Results show that the overall patterns of food consumption by retirement age are very similar on average in the SHARE sample as the consumption patterns found in Sweden: there is a strong positive gradient, with the level of food consumption of premature retirees being significantly lower than that of late retirees. We also find evidence of non-monotonicity, with the level of food consumption of early retirees being slightly larger than that of normal retirees on average across the 12 countries in our sample.

We note however that the differences in consumption levels across retirement age groups are smaller overall in the SHARE survey than what we found in Sweden. We believe that this may be because the SHARE survey can only focus on food consumption, for which there is generally much less variance than for other types of expenditures. We also note that the small sample size within each country makes these estimates imprecise. And we turn for further investigations to the HRS data that has more information on consumption, and the largest sample size within the countries sampled in the SHARE/HRS data.

Figure D-1: FOOD CONSUMPTION LEVELS BY RETIREMENT AGE: SHARE DATA



Notes: The figure documents differences in food consumption across retirement age groups. The sample comprises all individuals aged 50 to 75 from cohorts 1938 to 1958 who are observed in the SHARE data from Austria, Belgium, Denmark, France, Germany, Greece, Italy, the Netherlands, Spain, Sweden, Switzerland or the United States (HRS data). Individuals are grouped into four retirement age categories using this alternative measure of retirement age: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). Normal retirees are the reference category. The graph reports for all retirement age groups, the estimated coefficients α_j from specification (30), where we control for age, year and country fixed effects.

Appendix D.2 Evidence from the US Using HRS Data

The HRS data has slightly richer information on consumption than the SHARE data, and a slightly larger sample size. This allows us to provide more detailed results for the US to investigate the external validity of the consumption patterns by retirement age found in the Swedish context.

The sample is composed of all individuals interviewed for the consumption module (CAMS) of the Health and Retirement Study (HRS). While the HRS takes place every two years since 1992, the CAMS modules happen every two years since 2001, making up 9 waves in total, and are composed of randomly selected HRS participants. In the final sample, we drop individuals for which consumption, age or the date of retirement are not observed. We are left with 13,498 observations, corresponding to 3,808 individuals and distributed across waves in the following way:

Wave	Nb of observations
2001	1,755
2003	1,524
2005	1,581
2007	1,738
2009	1,601
2011	1,534
2013	1,414
2015	1,278
2017	1,073

Consumption Measure in the HRS The HRS special modules contain rich information about consumption. The following expenditure items are available:

- Automobiles: automobile or truck purchase, payments related to car (referred to as finance charges or interest/principal), vehicule insurance, gasoline, vehicule maintenance (parts, repairs and servicing);
- Household appliances: refrigerator, washer-dryer, dishwasher, television, computer, mortgage;
- Home cost: rent, property tax, homeowner's or renter's insurance, electricity, water, heating, telephone, cable and internet, housekeeping supplies, home repairs and maintenance, gardening and yard supplies, household furnishings and equipment;
- Food: food and beverages inside the home, dining and drinking out;

- Clothing and apparel;
- Personal care products and services;
- Health: health insurance, out-of-pocket cost of prescription and non-prescription medications, out-of-pocket cost of healthcare services, out-of-pocket cost of medical supplies;
- Hobbies/holidays: trips and vacations, tickets to movies/events, hobbies
- Other: contributions (to religious, educational, charitable or political organisations), gifts.

We focus on expenditure items that are reported in every wave. Excluded categories that do not appear in every wave are usually rather small: sport equipments, personal care products and services, gardening and yard supplies, home furnishings and equipment.

Consumption variables were originally expressed in nominal terms. We use CPI data and express all consumption in 2003 USD.

Retirement Age: Definition The HRS survey allows to infer the date of retirement in several ways:

- It asks individuals to directly report the month and year in which they retire.
- In the HRS waves (every two years since 1992), respondents are asked to report their occupation, namely whether they are currently working for pay, unemployed, temporarily laid-off/sick, disabled, retired, or homemaker. Those option choices are not mutually exclusive and individuals are given the possibility to select themselves into several categories.
- In the CAMS waves (every two years since 2001), respondents are asked whether they are currently retired.

In order to be consistent with our definition of retirement in the Swedish context, we define retirement as a permanent switch to reporting one's occupation status as not working for pay. And retirement age is defined as the first year in which the individual does not report his occupation status as working for pay.

Methodology We follow a similar methodology as in the Swedish context and regress household consumption C_{it} of individual i at age t in year y

$$C_{it} = \sum_j \alpha_j \cdot \mathbb{1}[\mathrm{r} = \mathrm{j}] + \gamma_y + \gamma_t \tag{31}$$

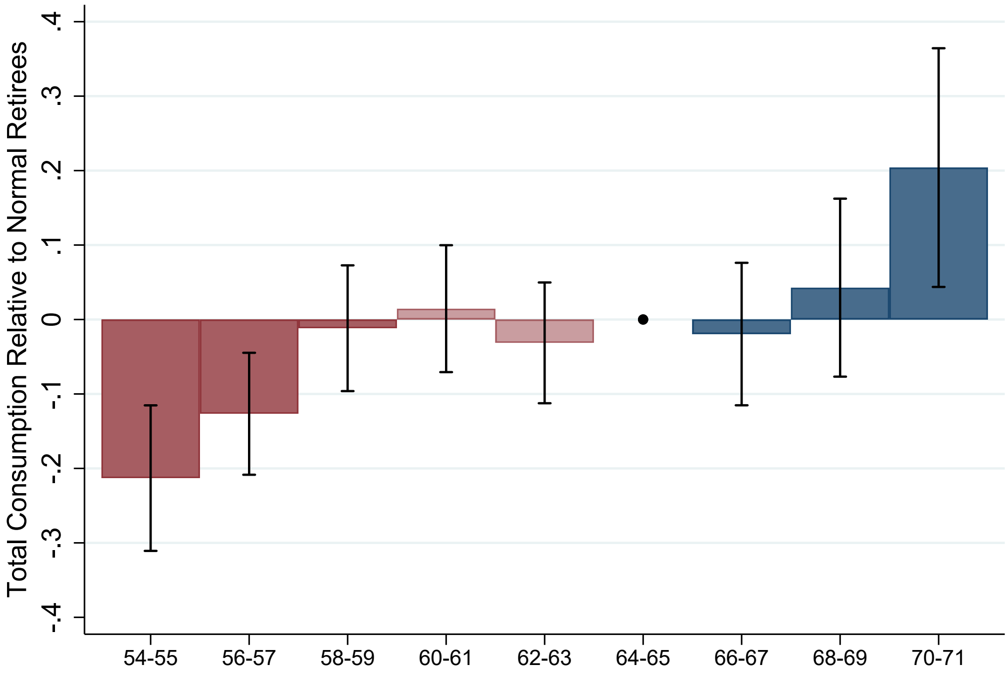
In practice, we group retirement ages into two-years bins, and use individuals retiring between 64 and 65 as the reference category. We control for year fixed effects γ_y and age fixed effects γ_t, so that in effect, we compare consumption of individuals retiring in different age groups *within the same cohort, at the same age*. Figure D-2 below reports the estimated coefficients α_j for all retirement age groups, scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the predicted consumption level from specification 31 when omitting the contribution of the retirement age group dummies. $\mathbf{E}_j[\tilde{C}^l_{it}]$ corresponds to the average level of consumption of individuals who retire between 64 and 65 from the same cohort and age as the average individual retiring in age group j.

Results The patterns of consumption by retirement age revealed in Figure D-2 are similar to those found in the Swedish context (see for instance Figure C-1). First, we see a strong overall gradient of consumption with retirement age: "Premature" retirement (i.e. before age 60) is associated with significantly lower consumption, while individuals who retire late (i.e. after 65) experience much larger levels of consumption, at the same age, than other individuals from the same cohort. Interestingly, we also detect the presence of non-monotonicity in the relationship between consumption and retirement age: this relationship is locally decreasing in the retirement age range 60 to 65.

The measure of expenditures used in the HRS is clearly not exactly perfectly comparable to the measure we use in our main analysis: it is not as comprehensive as the one we have in Sweden. But the comparison of results across these contexts and data sources is nevertheless very informative. Overall these results confirm that the large gradient in consumption level between individuals who retire very late vs very prematurely is a robust finding across all contexts and data sources. Second, it also confirms that the non-monotonicity in the relationship between retirement age and consumption is also quite robust across contexts and data: for most people retiring between 60 and 65, there is no gradient, or if anything a negative gradient between consumption level and retirement age.

We should stress that the overall gradient found in the HRS data is bigger than the one we document in Sweden. There is more than a 40% difference in consumption levels at the same age between the premature and late retirees in the US (compared to a 15 to 20% difference in Sweden). This could be due to the presence of a steeper pension profile in the US compared to Sweden and the fact that insurance against shocks in late career (such as UI, and DI) is generally much less generous in the US than in Sweden. These results in turn suggest that the social marginal utility cost of increasing the steepness of the pension profile is much larger in the US than in Sweden.

Figure D-2: CONSUMPTION LEVELS BY RETIREMENT AGE IN THE US: HRS DATA



Notes: This figure documents how consumption differs across individuals who retire at different ages. The sample is composed of all individuals born between 1938 and 1958 interviewed for the consumption module (CAMS) of the Health and Retirement Study (HRS). The CAMS modules happen every two years since 2001, making up 9 waves in total, and are composed of randomly selected HRS participants. We drop individuals for which consumption, age or the date of retirement are not observed. Individuals are grouped into nine retirement age categories from 54 to 71. Retirement ages $64-65$ are the reference category. The graph reports for all retirement age groups, the estimated coefficients α_j from specification (31), scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire between 64 and 65 from the same cohort and age as the average individual retiring in age group j.

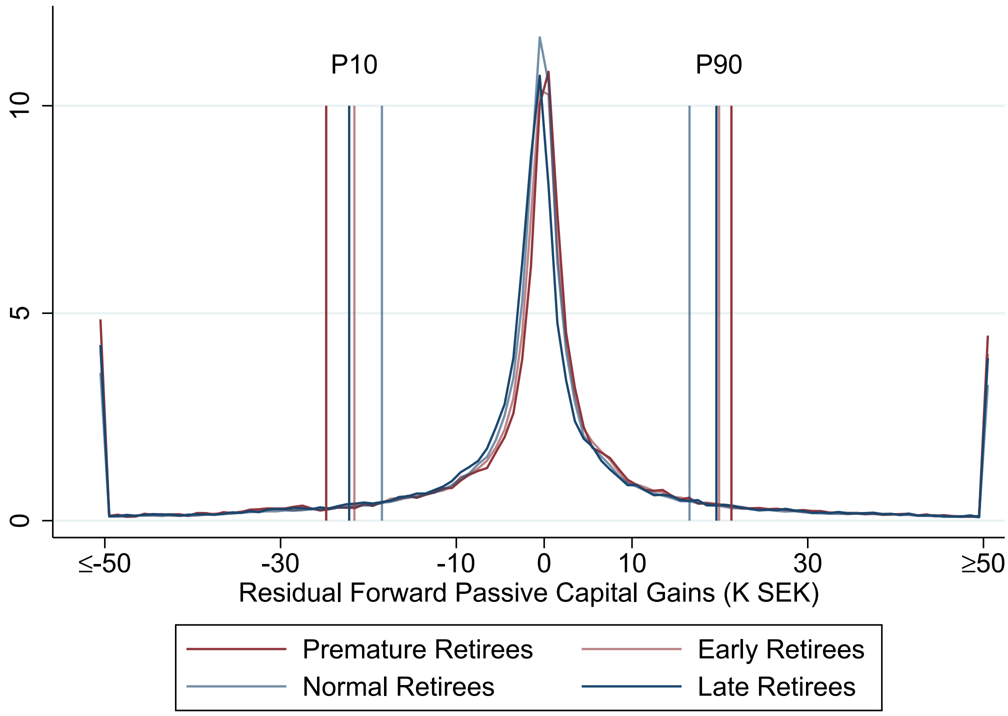
Appendix E Marginal Propensities to Consume

Table E-1: DESCRIPTIVE STATISTICS ON MPC SAMPLE (I.E. RETIREMENT SAMPLE MATCHED TO KURU DATA ON FINANCIAL PORTFOLIOS)

	Retirement Sample		**Retirement x Stock Sample**	
	Mean	(s.d.)	Mean	(s.d.)
I. Retirement				
Premature Retirement Probability	16.08 %		13.07%	
Early Retirement Probability	33.4 %		40.16%	
Normal Retirement Probability	34.57 %		35.34%	
Late Retirement Probability	15.95 %		11.42%	
Age at Retirement	62.91	(3.1)	62.8	(2.77)
II. Demographics				
Cohort	1940.67	(1.73)	1940.56	(1.68)
Fraction Men	49.33 %	(50)	52.28%	(49.95)
Fraction Married	67.78 %	(46.73)	73.13%	(44.33)
Kid at Home ($\geq$ 1)	17.67 %	(38.14)	17.68%	(38.15)
Kid at Home Under 18 ($\geq$ 1)	3.39 %	(18.1)	2.95%	(16.92)
Post-Secondary Education	24.91%	(43.25)	30.43%	(46.01)
III. Pension Information, SEK 2003				
State Pension	78.2	(52.9)	45.4	(52.1)
Occupational Pension	62	(92.7)	81.8	(119.9)
ATP Points at 55	109.51	(51.13)	119.4	(51.42)
IV. Income and Wealth at 59, SEK 2003(K)				
Total Earnings	210.5	(158.8)	234	(181.9)
Net Wealth	779.4	(2289.3)	1238.6	(2648.7)
Bank Holdings	83.4	(302.2)	121.7	(458.3)
Portfolio Value	249.6	(1665.6)	266.4	(1662.2)
Consumption	200	(530)	218	(696)
N (Unique Individuals)	419,790		183,504	
Cohorts	[1938,1943]		[1938,1943]	

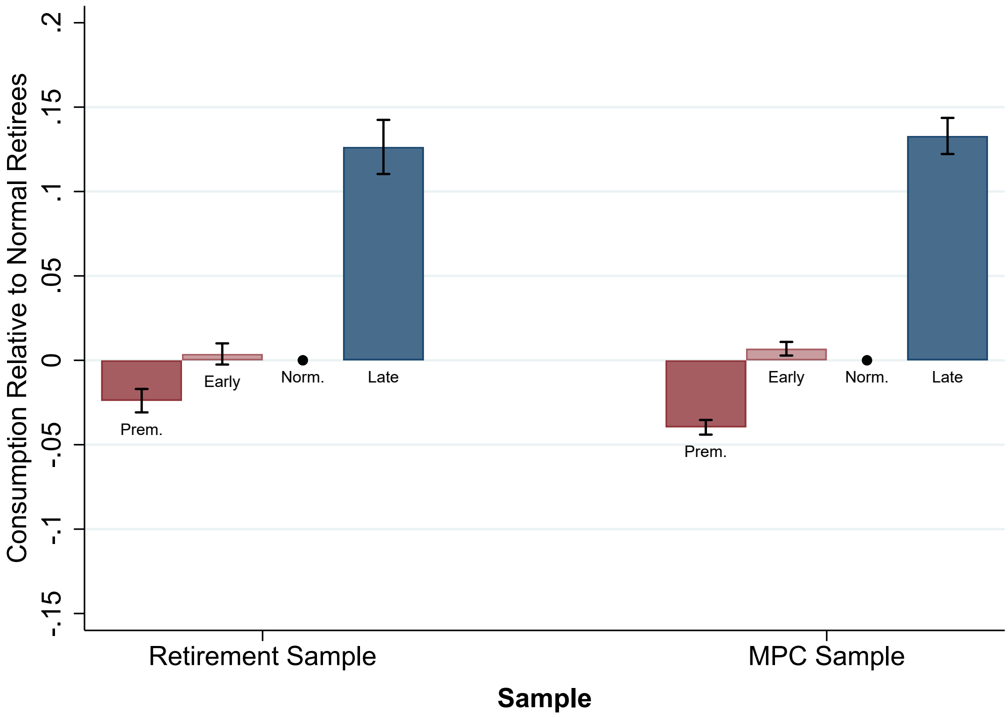
Notes: The table reports descriptive statistics from our baseline sample of retirees and for the baseline sample matched with portfolio information on stock ownership (KURU). Both samples are restricted to cohorts 1938 to 1943 who retire between age 56 and 69. The matched sample comprises 183,504 unique individuals. Retirement is defined as labor earnings dropping permanently below one Base Amount. Panel I reports statistics on the distribution of retirememt age. Premature retirement is defined as individuals retiring between age 56 and 59; early retirement, between age 60 and 63; normal retirement, between age 64 and 65; and late retirement, between age 66 and 69. Panel II reports various demographic information. Panel III reports the average state and occupational pension benefits received. Total ATP points correspond to the total number of ATP points accumulated in the state pension system at age 55. Panel IV focuses on income and wealth measured at age 59. Wealth and consumption is aggregated at the household level.Note that based on the average exchange rate between 2000 and 2007, 1SEK $\approx$ 0.11USD.

Figure E-1: DISTRIBUTION OF RESIDUALIZED PASSIVE CAPITAL GAINS BY RETIREMENT AGE GROUP



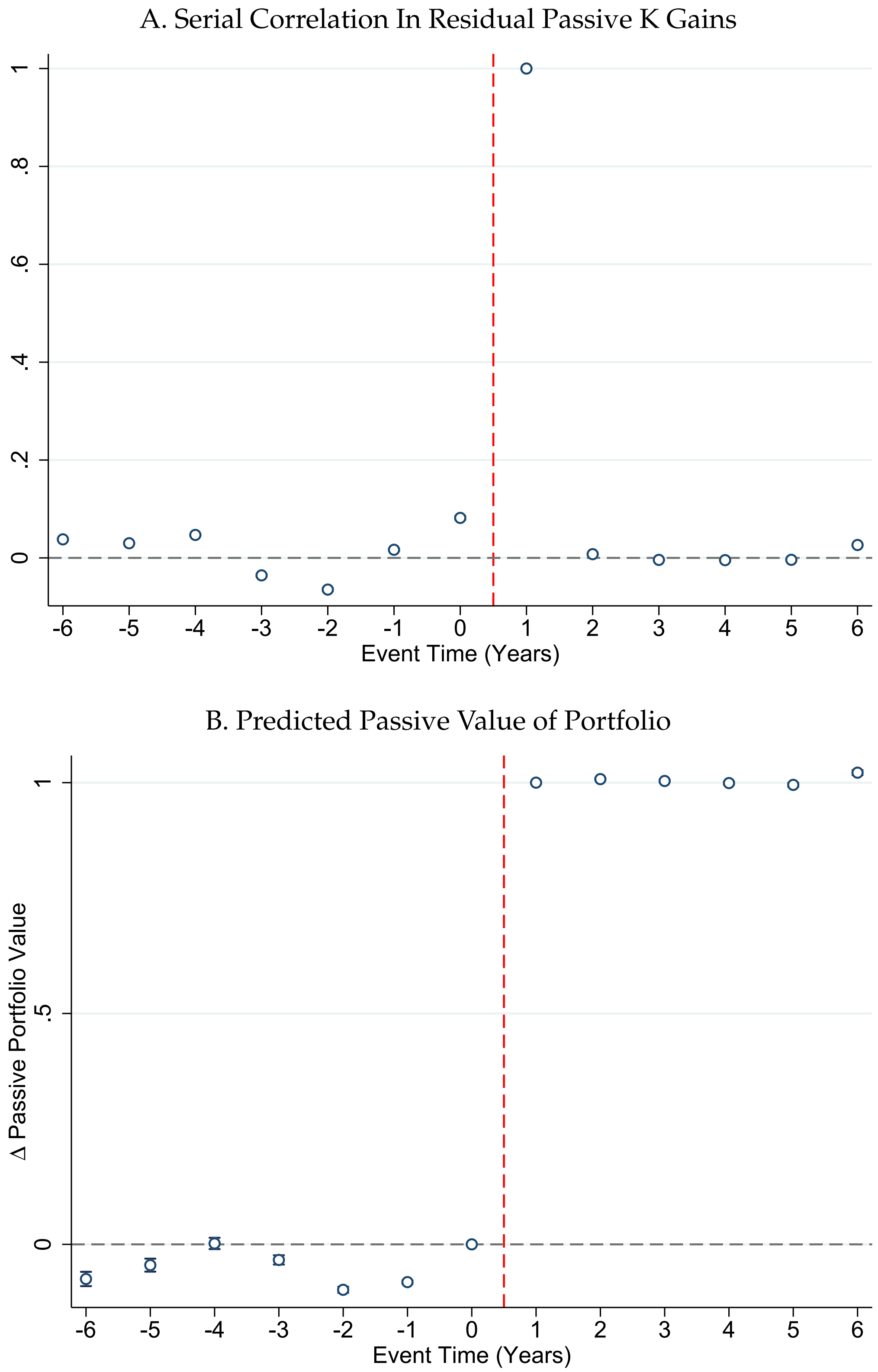
Notes: The figure plots the distribution of residualized passive capital gains. The sample is the baseline retirement sample merged with the KURU register, which has disaggregated information over the period 1999 to 2007 on all quantities of stocks, by ISIN number, held by individuals outside of mutual funds. The sample is described in Table E-1 above. For each individual i, passive capital gains on her portfolio in year $t+1$ are defined as $\text{KG}_{i,t+1} = \sum_j (p_{j,t+1} - p_{j,t}) \cdot a_{ijt} = \sum_j \Delta p_{j,t+1} \cdot a_{ijt}$ where a_{ijt} is number of stocks of company j held by individual i on 31st of December of year t and Δp_{jt+1} is the change in the price of stock j between 31st of December of year $t+1$ and 31st of December of year t. The passive KG are then residualized on a set of portfolio characteristics, capturing the value of the portfolio in year t, as well as the average returns and variance of the portfolio in the 6 years prior to year t. In practice, we use 50-tiles of portfolio value interacted with vigintiles of average returns in the past six years, and 50-tiles of portfolio value interacted with vigintiles of average variance in the past six years. In Figure E-3, we show that these residualized passive KG follow a random walk. The Figure plots the distribution of residualized $\text{KG}_{i,t+1}$, and also indicates the 10th and 90th percentile of the distribution, for each retirement age group. More than 31% percent of the residual passive capital gains/losses we exploit have absolute value over 10,000 SEK, which represent sizeable shocks. These shocks are large compared to the variation exploited in the existing literature on wealth shocks. For instance, only 9% of the lottery shocks in Cesarini et al. [2016] are larger than 10,000 SEK. Furthermore, the graph highlights that the distribution of our instrument is similar across retirement age groups.

Figure E-2: CONSUMPTION DIFFERENCES BY RETIREMENT AGE GROUP IN BASELINE SAMPLE AND MPC SAMPLE



Notes: The figure replicates in the MPC sample our baseline estimates of consumption differences in retirement from Figure 3. Both samples comprises individuals from cohorts 1938 to 1943 who are retired at the time their consumption is observed. Individuals are grouped into four retirement age categories: premature retirees ($56 \leq r \leq 59$), early retirees ($60 \leq r \leq 63$), normal retirees ($64 \leq r \leq 65$) and late retirees ($66 \leq r \leq 69$). Normal retirees are the reference category. The graph reports for all retirement age groups, the estimated coefficients α_j from specification (12), scaled by $\mathbf{E}_j[\tilde{C}_{it}]$, the average level of consumption of individuals who retire between 64 and 65 from the same cohort, age, family composition and ATP quartile at age 55 as the average individual retiring in age group j. On the left hand side of the graph, we reproduce results from Figure 3 for the model (12) with year and age fixed effects, ATP quartiles accumulated at age 55 and controls for family composition. On the right hand side of the graph, we plot the estimates obtained from the same model run on the MPC sample.

Figure E-3: Serial Correlation In Residual Passive K Gains & Passive Value of Portfolio



Notes: Panel A plots for each time horizon $k \in \{-6, ..., 6\}$ the serial correlation of the residual passive capital gain at k and the current residual passive capital gain, that is the coefficient α_k from regression 14. We control for the value of portfolio in year t, the average returns and variance of the portfolio in the 6 years prior to year t. Panel B examines the predictive effect of the residual on the change in passive portfolio value for each time horizon $k \in \{-6, ..., 6\}$. The passive portfolio value in year $t+k$ is defined as $\sum_j p_{j,t+k} \cdot a_{ijt}$ where a_{ijt} is number of stocks of company j held by individual i on 31st of December of year t and p_{jt+k} is the price of stock j in 31st of December of year $t+k$. It is therefore the value that the portfolio held in year t would be worth in year $t+k$ if the owner of the portfolio had not rebalanced it.

Table E-2: 2SLS Estimates of MPCs: Robustness to Size of KG Shocks

	First Stage α_1^V	Reduced Form $3 \times \alpha_{rf}^C$	IV Result $3 \times \alpha_{IV}^C$
	A. Without Top/Bottom 5% of KG Shocks		
All Retirees	.34	.17	.49
	(.01)	(.01)	(.04)
Premature Retirees	.29	.37	1.26
	(.02)	(.04)	(.15)
Early Retirees	.32	.26	.81
	(.01)	(.03)	(.08)
Normal Retirees	.38	.07	.2
	(.01)	(.02)	(.06)
Late Retirees	.36	.05	.14
	(.02)	(.05)	(.13)

Notes: This table shows the estimates of the 2SLS approach presented in equation 17. Column (1) reports the estimates of the first stage, column (2) the estimates of the reduced form, multiplied by three to obtain the MPC over a three years horizon. The IV result is presented in column (3). This sample is composed of the observations from the baseline analysis matched with the KURU information, trimming the value of portfolio at the 5% level. We also drop all values of passive capital gain above the 99-th percentile each year. We cluster the standard errors at the individual level.

Table E-3: 2SLS Estimates of MPCs: Robustness to Alternative Clustering

	First Stage	Reduced Form	IV Result
	α_1^V	3 x α_{rf}^C	3 x α_{IV}^C
Cluster by 50-tile of PF Value PF x 20-tile of Average PF Past Returns			
Baseline	.66	.11	.17
	(.04)	(.01)	(.01)
Number of Observations	546,836	546,836	546,836
Number of clusters	972	972	972

Notes: This table shows the results of the MPC analysis on the baseline sample, this time clustering at the cinquantile of portfolio value times vigintile of average portfolio past returns.

Appendix F Conceptual Framework

This appendix provides more detail underlying the model setup and the derivations of the welfare impact of a pension change and its different implementations.

Model Setup As stated in the main text, the individual's expected lifetime utility is given by

$$\mathcal{U}_i(c,\zeta,\pi) = \sum_{t=0}^{T} \beta^t \int u\left(c\left(\pi_{i,t}\right), \zeta\left(\pi_{i,t}\right)\right) dF\left(\pi_{i,t}\right), \tag{32}$$

where $c\left(\pi_{i,t}\right)$ is the individual's consumption choice and $\zeta\left(\pi_{i,t}\right)$ represents all other choices and characteristics, either affecting an individual's utility or the government's budget constraint. We are often using short-hand notation $c_{i,t}$ and $\zeta_{i,t}$.

The model is set up in reduced-form, but the various exogenous and endogenous factors in standard retirement models (see Blundell et al. [2016]) can be captured through ζ and how it affects the utility of consumption c. Like in all structural models of retirement, $\zeta\left(\pi_{i,t}\right)$ includes the extensive labor supply choice, which is denoted by $s\left(\pi_{i,t}\right)$ and takes value 1 if an individual is employed and value 0 if an individual is retired. We assume that an individual retires only once, denoting the retirement age choice once someone has decided to retire by $r\left(\pi_{i,t}\right)$. We thus have $s\left(\pi_{i,t}\right) = 0$ for $t \geq r\left(\pi_{i,t}\right)$ and $s\left(\pi_{i,t}\right) = 1$ otherwise. Hence, the number of individuals retiring at each r equals $S\left(r-1\right) - S\left(r\right)$, where $S\left(r\right) = \int\int s\left(\pi_{i,r}\right) dF\left(\pi_{i,r}\right) di$ is the survival rate into employment.

$\zeta\left(\pi_{i,t}\right)$ can also include exogenous factors to either capture relevant heterogeneity across workers from the start $\pi_{i,0}$ (e.g., in preferences, health or ability) or risks that individuals face (e.g., health or ability shocks) and realize over time, represented by the CDF $F\left(\pi_{i,t}\right)$ (see French and Jones [2011]). The general set up can also accommodate mortality risks and preferences over bequests as in French [2005]:

$$u\left(c\left(\pi_{i,t}\right), \zeta\left(\pi_{i,t}\right)\right) = \zeta_M\left(\pi_{i,t}\right) \tilde{u}\left(c\left(\pi_{i,t}\right), \tilde{\zeta}\left(\pi_{i,t}\right)\right) + \left(1 - \zeta_M\left(\pi_{i,t}\right)\right) \tilde{v}\left(\zeta_B\left(\pi_{i,t}\right)\right),$$

where ζ_M denotes the survival probability and ζ_B denotes any bequeathed wealth. The setup can also accommodate health shocks affecting required medical expenditures and/or the utility of consumption net of these medical expenditures:

$$u\left(c\left(\pi_{i,t}\right), \zeta\left(\pi_{i,t}\right)\right) = \zeta_{X_1}\left(\pi_{i,t}\right) \times \tilde{u}\left(c\left(\pi_{i,t}\right) - \zeta_{X_2}\left(\pi_{i,t}\right), \tilde{\zeta}\left(\pi_{i,t}\right)\right),$$

where ζ_{X_2} denotes the medical expenditures and ζ_{X_1} scales the utility of non-medical expenditures (e.g., Blundell, Borella, Commault, De Nardi, 2021 no 2020).

We denote taxes by $\tau\left(\pi_{i,t}\right)$ and pension benefits by $b(\pi_{i,t})$, which can depend in a flexible way on a worker's employment history, including the number of years worked and the corresponding earnings. We focus on workers' extensive labor supply and the age at which they retire. The government's objective is

$$\max\ \mathcal{W}\left(b,\tau\right) = \int_i \omega_i U_i\left(b,\tau\right) + \lambda GBC\left(b,\tau\right) di \tag{33}$$

where

$$GBC\left(b,\tau\right) = \Sigma_t \frac{1}{R^t} \int\int \left[s\left(\pi_{i,t}\right)\tau\left(\pi_{i,t}\right) - \left(1 - s\left(\pi_{i,t}\right)\right) b\left(\pi_{i,t}\right)\right] f\left(\pi_{i,t}\right) d\pi_{i,t} di - G_0. \tag{34}$$

We can simplify this further re-writing the budget constrains as a function of the average tax paid by workers at age r, τ_r, and the net present value of the pension benefits received for workers retiring at age r:

$$NPV_r \equiv \frac{1}{R^r}\Sigma_{t=r}^{T}\frac{1}{R^{t-r}}\int\int b\left(\pi_{i,t}\right)\frac{1[r\left(\pi_{i,t}\right)=r]}{S\left(r-1\right)-S\left(r\right)}dF\left(\pi_{i,t}\right)di.$$

The government's budget constraint becomes

$$GBC\left(b,\tau\right)=\Sigma_r\left[S\left(r\right)\frac{\tau_r}{R^r}-\left[S\left(r-1\right)-S\left(r\right)\right]NPV_r\right]-G_0, \tag{35}$$

clearly illustrating how government revenues and expenditures change with the age at which workers decide to retire. The model can in principle be extended with claiming decisions, as well as pathways to retirement through DI or UI, which then should be accounted for in the NPV_r.

Characterization The policy variation we consider is a uniform change in the benefits received by all individuals retiring at the same age. That is, $db\left(\pi_{i,t}\right)=db_{r,t}$ for $r\left(\pi_{i,t}\right)=r$. To characterize the welfare impact, we can invoke the envelope theorem, implying that the only first-order effect on workers' welfare comes from the direct effect of the benefit receipt. We write:

$$\begin{aligned} SMU_{r,t} &= E\left(\omega_i\beta^t\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}\middle| r_i=r\right) \\ &= \int\int\omega_i\beta^t\frac{\partial u\left(c\left(\pi_{i,t}\right),\zeta\left(\pi_{i,t}\right)\right)}{\partial c}\frac{1[r\left(\pi_{i,t}\right)=r]}{S\left(r-1\right)-S\left(r\right)}dF\left(\pi_{i,t}\right)di \end{aligned}$$

To compare this value to its fiscal cost, we should account for the fiscal externality of any response in $\zeta_{i,t'}$ throughout the individual's lifetime (for any t') and the implications this change in behavior has on the distribution of future states $F\left(\pi_{i,t'+k}\right)$ (for any k). In principle, individuals can change their earnings throughout their lifetime - with further consequences on the tax revenues and expected pension payments, captured through the history $\pi_{i,t}$. The change in benefits and retirement behavior can also change individuals' health and life expectancy and the labor supply of other individuals in the household with corresponding fiscal consequences (see Blundell et al. [2016]). For tractability, we consider only the behavioral response at the extensive labor supply margin by directly affected workers. The impact on the budget constraint of the pension change $db_{r,t}$ can then be written as:

$$1+FE_{r,t}\equiv\frac{1}{R^t}+\Sigma_{r'}\left\{\left[\frac{\tau_{r'}}{R^{r'}}-\left(NPV_{r'+1}-NPV_{r'}\right)\right]\frac{\frac{\partial(1-S(r'))}{\partial b_{r,t}}}{S\left(r-1\right)-S\left(r\right)}\right\}.$$

Putting the two effects together, the welfare impact per dollar spent on $b_{r,t}$ equals for $\beta R=1$:

$$SMU_{r,t}-\lambda\left[1+FE_{r,t}\right].$$

Implementation We assume that the only relevant heterogeneity occurs across workers retiring at different ages, so that $c\left(\pi_{i,t}\right)=c_{r,t}$ and $\zeta\left(\pi_{i,t}\right)=\zeta_{r,t}$ for $r\left(\pi_{i,t}\right)=r$. Implementation 1 then immediately follows from the Taylor approximation in equation (8) for $\frac{\partial u(c_{r,t},\zeta_{r,t})}{\partial c}$ around $\left(c_{r',t},\zeta_{r,t}\right)$,

$$\frac{\partial u\left(c_{r,t},\zeta_{r,t}\right)}{\partial c}\cong\frac{\partial u\left(c_{r',t},\zeta_{r,t}\right)}{\partial c}\left[1+\frac{-\frac{\partial^2 u\left(c_{r',t},\zeta_{r,t}\right)}{\partial c^2}c_{r',t}}{\frac{\partial u\left(c_{r',t},\zeta_{r,t}\right)}{\partial c}}\frac{c_{r',t}-c_{r,t}}{c_{r',t}}\right].$$

Denoting the relative risk aversion parameter by $\gamma\left(c_{r',t},\zeta_{r,t}\right)$, we have

$$\frac{E\left(\omega_i\beta^t\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}\middle| r_i=r\right)}{E\left(\omega_i\beta^t\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}\middle| r_i=r'\right)}=\frac{\omega_r\times\frac{\partial u\left(c_{r',t},\zeta_{r,t}\right)}{\partial c}}{\omega_{r'}\times\frac{\partial u\left(c_{r',t},\zeta_{r',t}\right)}{\partial c}}\left[1+\gamma\left(c_{r',t},\zeta_{r,t}\right)\frac{c_{r,t}-c_{r',t}}{c_{r',t}}\right].$$

When there is heterogeneity within a group of individuals retiring at the same age, we need to correct for the covariances between the welfare weights ω_i, marginal utility of consumption $\frac{\partial u\left(c_{r',t},\zeta_{i,t}\right)}{\partial c}$, the curvature $\gamma\left(c_{r',t},\zeta_{i,t}\right)$ and the consumption drop $\frac{c_{i,t}-c_{r',t}}{c_{r',t}}$ when expressing the average of the product of these terms as a function of the product of the average of these terms (see Andrews and Miller [2013]).

Implementation 2 follows from the Taylor approximation in equation (8) for $\frac{\partial u(c_{r,t},\zeta_{r,t})}{\partial c}$ around $\left(c_{r,pre},\zeta_{r,pre}\right)$,

$$\frac{\partial u\left(c_{r,t},\zeta_{r,t}\right)}{\partial c}\cong\frac{\partial u\left(c_{r,pre},\zeta_{r,t}\right)}{\partial c}\left[1+\frac{-\frac{\partial^2 u\left(c_{r,pre},\zeta_{r,t}\right)}{\partial c^2}c_{r,pre}}{\frac{\partial u\left(c_{r,pre},\zeta_{r,t}\right)}{\partial c}}\frac{c_{r,pre}-c_{r,t}}{c_{r,pre}}\right],$$

where we denote the relative risk aversion parameter again by $\gamma\left(c_{r,pre},\zeta_{r,t}\right)$. We again assume that the only relevant heterogeneity occurs across retirement ages. Hence, we now have

$$\frac{E\left(\omega_i\beta^t\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}\middle| r_i=r\right)}{E\left(\omega_i\beta^t\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}\middle| r_i=r'\right)}=\frac{\omega_r\times\frac{\partial u\left(c_{r,pre},\zeta_{r,t}\right)}{\partial c}\times\left[1+\gamma\left(c_{r,pre},\zeta_{r,t}\right)\frac{c_{r,pre}-c_{r,t}}{c_{r,pre}}\right]}{\omega_{r'}\times\frac{\partial u\left(c_{r',pre},\zeta_{r',t}\right)}{\partial c}\times\left[1+\gamma\left(c_{r',pre},\zeta_{r',t}\right)\frac{c_{r',pre}-c_{r',t}}{c_{r',pre}}\right]}.$$

For implementation 3, we rely on the MPC approach proposed by Landais and Spinnewijn [forthcoming]. To illustrate their approach, we denote by $\tilde{\zeta}_{i,t}(\in\zeta_{i,t})$ the resource used at the margin to increase consumption $c_{i,t}$. This could for example be future consumption or other earnings in the household. We denote by $p_{i,t}$ the rate at which $\tilde{\zeta}_{i,t}$ increases consumption. This price is state-specific and can be interpreted as the shadow price of consumption. The optimizing behavior of a worker implies

$$\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}+p_{i,t}\times\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial\tilde{\zeta}_{i,t}}=0. \tag{36}$$

From the implicit differentiation of this optimality condition, we can derive the marginal propensity of consumption smoothing with respect to state-specific income $y\left(\pi_{i,t}\right)$ for any $\pi_{i,t}$. Assuming separable preferences as in Landais and Spinnewijn [forthcoming], we can obtain:

$$\frac{\frac{dc_{i,t}}{dy_{i,t}}}{1-\frac{dc_{i,t}}{dy_{i,t}}}=p_{i,t}\times\frac{\frac{\partial^2 u\left(c_{i,t},\zeta_{i,t}\right)}{\partial\tilde{\zeta}^2}/\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial\tilde{\zeta}}}{\frac{\partial^2 u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c^2}/\frac{\partial u\left(c_{i,t},\zeta_{i,t}\right)}{\partial c}}. \tag{37}$$

We again assume that the only relevant heterogeneity occurs across retirement ages, but we need the relative curvature in preferences to be constant across individuals with different retirement ages too.

Combining equations 36 and 37, we then obtain:

$$\frac{\frac{\partial u(c_{r,t},\zeta_{r,t})}{\partial c}}{\frac{\partial u(c_{r',t},\zeta_{r',t})}{\partial c}} = \frac{\frac{\frac{dc_{r,t}}{dy_{r,t}}}{1-\frac{dc_{r,t}}{dy_{r,t}}}}{\frac{\frac{dc_{r',t}}{dy_{r',t}}}{1-\frac{dc_{r',t}}{dy_{r',t}}}} \times \frac{\frac{\partial u(c_{r,t},\zeta_{r,t})}{\partial \tilde{\zeta}_{r,t}}}{\frac{\partial u(c_{r',t},\zeta_{r',t})}{\partial \tilde{\zeta}_{r',t}}}.$$

The approximation in Implementation 3 relies on the marginal cost of using resources to increase consumption to be similar across retirement age groups, i.e., $\frac{\partial u(c_{r,t},\zeta_{r,t})}{\partial \tilde{\zeta}_{r,t}} \cong \frac{\partial u(c_{r',t},\zeta_{r',t})}{\partial \tilde{\zeta}_{r',t}}$. Landais and Spinnewijn [forthcoming] propose this MPC implementation to compare within-individual differences in marginal utility when empoyed vs. unemployed and argue that it is likely to have $\frac{\partial u(c_{u,t},\zeta_{u,t})}{\partial \tilde{\zeta}_{u,t}} > \frac{\partial u(c_{e,t},\zeta_{e,t})}{\partial \tilde{\zeta}_{e,t}}$ if $p_{u,t} > p_{e,t}$. Indeed, when hit by unemployment, an individual faces lower income and is more reliant on other resources to increase her income. Unemployment is therefore likely to increase the shadow price of consumption, but also the disutility of using more resources to smooth consumption. When comparing the MPC's across individuals instead, we also need to factor in a substitution effect, implying that individuals facing higher $p_{r,t}$ may reduce their use of this resource to smooth consumption. The approximation in Implementation 3 will thus depend on how big these potentially offsetting effects are.

Fiscal Externality of Steeper Incentives Consider a budget-balanced reform at retirement age $\tilde{r}$ with $db_{r,t} = db_{r>\tilde{r},t}$ for $r > \tilde{r}$ and $db_{r,t} = db_{r\leq\tilde{r},t}$ for $r \leq \tilde{r}$ with $db_{r>\tilde{r},t} = -\frac{1-S(\tilde{r})}{S(\tilde{r})} db_{r\leq\tilde{r},t}$. For simplicity, we drop the age subscript t. Using $T_r = \frac{\tau_{r'}}{R^{r'}} - (NPV_{r'+1} - NPV_{r'})$, we can express the impact on social welfare as:

$$\begin{aligned} dW &= (1 - S(\tilde{r}))\, SMU_{r\leq\tilde{r}} db_{r\leq\tilde{r}} + S(\tilde{r})\, SMU_{r>\tilde{r}} db_{r>\tilde{r}} \\ &\quad -\lambda (1 - S(\tilde{r})) \left[1 - \Sigma_{r'} T_{r'} \frac{\partial S(r')}{\partial b_{r\leq\tilde{r}}} \frac{1}{1 - S(\tilde{r})}\right] db_{r\leq\tilde{r}} \\ &\quad -\lambda S(\tilde{r}) \left[1 - \Sigma_{r'} T_{r'} \frac{\partial S(r')}{\partial b_{r>\tilde{r}}} \frac{1}{S(\tilde{r})}\right] db_{r>\tilde{r}} \\ &= S(\tilde{r})\, db_{r>\tilde{r}} \left[SMU_{r>\tilde{r}} - SMU_{r\leq\tilde{r}}\right] + \lambda \left[\Sigma_{r'} T_{r'} \left[\frac{\partial S(r')}{\partial b_{r\leq\tilde{r}}} db_{r\leq\tilde{r}} + \frac{\partial S(r')}{\partial b_{r>\tilde{r}}} db_{r>\tilde{r}}\right]\right]. \end{aligned}$$

The second equality uses the budget-neutrality of the reform. We now make the following assumptions regarding the response of the survival rates to changes in the benefit policy.

- *Assumption 1:* for any $\tilde{r}$, $\frac{\partial S(r)}{\partial b_{r\leq\tilde{r}}} \cong 0$ for $r > \tilde{r}$; $\frac{\partial S(r)}{\partial b_{r>\tilde{r}}}$ for $r \leq \tilde{r}$
- *Assumption 2:* for any $\tilde{r}$, $\Sigma_{r'\leq\tilde{r}} \frac{\partial S(r')}{\partial b_{r\leq\tilde{r}}} \cong \Sigma_{r'>\tilde{r}} \frac{\partial S(r')}{\partial b_{r>\tilde{r}}} \frac{1-S(\tilde{r})}{S(\tilde{r})}$ and $T_{\tilde{r}} \cong T$
- *Assumption 3:* for any $\tilde{r}$, $-\frac{\partial S(\tilde{r})}{\partial b_{r\leq\tilde{r}}} = \frac{\partial S(\tilde{r})}{\partial b_{r>\tilde{r}}} \cong \frac{\partial S(\tilde{r})}{\partial w_{\tilde{r}}}$

Assumption 1 follows from small changes in the policy for given retirement ages only affecting individuals who are at the margin of retiring at those ages. Assumption 2 is weaker than the assumption that income effects do not matter. Instead it assumes that for a budget-balanced change in the profile, the negative income effect on the retirement of early retirees is equal to the positive income effect on the retirement of late retirees. Assumption 3 relies on the fact that the change in the survival rate at $\tilde{r}$ only depends on the change in local slope of the pension profile $d\left[b_{r>\tilde{r}} - b_{r\leq\tilde{r}}\right]$ and thus that locally income effects are small relative to substitution effects.

Under assumptions 1-3, we can rewrite and re-express the welfare impact in terms of elasticities:

$$\begin{aligned}
dW &\cong S(\tilde{r})\, db_{r>\tilde{r}} \left[SMU_{r>\tilde{r}} - SMU_{r\leq\tilde{r}}\right] + \lambda T_{\tilde{r}} \frac{\partial S(\tilde{r})}{\partial w_{\tilde{r}}} \left[db_{r>\tilde{r}} - db_{r\leq\tilde{r}}\right] \\
&= S(\tilde{r})\, db_{r>\tilde{r}} \left\{ \left[SMU_{r>\tilde{r}} - SMU_{r\leq\tilde{r}}\right] + \lambda T_{\tilde{r}} \frac{\partial S(\tilde{r})}{\partial w_{\tilde{r}}} \frac{1}{S(\tilde{r})} \left[1 - \frac{db_{r\leq\tilde{r}}}{db_{r>\tilde{r}}}\right] \right\} \\
&= S(\tilde{r})\, db_{r>\tilde{r}} \left\{ \left[SMU_{r>\tilde{r}} - SMU_{r\leq\tilde{r}}\right] + \lambda \frac{T_{\tilde{r}}}{w_{\tilde{r}}} \left[\varepsilon_{S(\tilde{r}),w_{\tilde{r}}} - \varepsilon_{1-S(\tilde{r}),w_{\tilde{r}}}\right] \right\} \\
&= S(\tilde{r})\, db_{r>\tilde{r}} \left\{ \left[SMU_{r>\tilde{r}} - SMU_{r\leq\tilde{r}}\right] + \lambda \frac{T_{\tilde{r}}}{w_{\tilde{r}}} \varepsilon_{\frac{S(\tilde{r})}{1-S(\tilde{r})},w_{\tilde{r}}} \right\}
\end{aligned}$$

Normalizing with respect to the social marginal utility of individuals retiring at the normal retirement age and assuming $SMU_{NRA} \cong \lambda$, we have that the net welfare return, expressed in monetary terms, of a dollar of pension benefits taken from early retirees ($r \leq \tilde{r}$) and given to late retirees ($r > \tilde{r}$) is equal to:

$$\Delta W_{\tilde{r}} = \frac{dW / \left[S(\tilde{r})\, db_{r>\tilde{r}}\right]}{SMU_{NRA}} \cong \frac{T_{\tilde{r}}}{w_{\tilde{r}}} \times \varepsilon_{\frac{S(\tilde{r})}{1-S(\tilde{r})},w_{\tilde{r}}} - \frac{SMU_{r\leq\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}}.$$

Appendix G Welfare Implementation Details

This appendix provides further detail on the welfare implementation described in section 7 and illustrated in Figure 9 and Table 4. We estimate the consumption smoothing costs for budget-neutral reforms that steepen the pension profile. The terms correspond to the welfare effects of transferring a dollar for individuals retiring *before* a specific age to individuals retiring *after* that age. The values we obtain can then be compared with the fiscal externality to compute the net welfare effect. Below we also provide a back-of-the envelope calculation showing that a fiscal externality of .15 is a reasonable benchmark to evaluate the net welfare gain.

Appendix G.1 Consumption Smoothing Cost

We first describe in detail how we approximate the consumption smoothing cost for the age-specific policies. This reform involves a steepening of the pension profile at a given retirement age $\tilde{r}$ by reducing pensions for individuals retiring before age $\tilde{r}$ by some small amount $db_{r\leq\tilde{r}}$, and increasing them for individuals retiring after age $\tilde{r}$ by $db_{r>\tilde{r}}$. Budget balance requires that $db_{r>\tilde{r}} = -\frac{1-S(\tilde{r})}{S(\tilde{r})}db_{r\leq\tilde{r}}$, where $1 - S(\tilde{r})$ is the share of individuals who retired before age $\tilde{r}$. The consumption smoothing cost per dollar transferred then equals

$$\frac{SMU_{r\leq\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}}.$$

We can in principle implement this change in benefits for individuals at any given age t, but in our implementation we only use the consumption years we observe after retirement in our baseline sample. For brevity, we drop the age subindices.

Baseline Implementation Figure 9 and column (1) of Table 4 follow the baseline implementation using the difference in consumption levels across retirement age groups, relative to the normal-retirement age group, scaled by the relative risk aversion,

$$\frac{SMU_{r\leq\tilde{r}} - SMU_{r>\tilde{r}}}{SMU_{NRA}} \approx \gamma \times \left[\frac{E_{r>\tilde{r}}(c)}{E_{r\in NRA}(c)} - \frac{E_{r\leq\tilde{r}}(c)}{E_{r\in NRA}(c)}\right]. \tag{38}$$

We obtain the estimates of the consumption levels for people retiring at age r relative to normal retirees, using regression 12. For each age r, we approximate the consumption smoothing cost of steepening the profile at age r as the difference in the weighted average of consumption levels for people above age r and this same difference for people below age r. The weights used are the fraction of people at each retirement age. The consumption smoothing cost is obtained by multiplying the value obtained by γ, for which we set the baseline value at 4 (see Landais and Spinnewijn [forthcoming]). The grey bars in Figure 9 show these values for each age. In Table 4, we present the results for each retirement age group. These are obtained by taking the unweighted average of the consumption smoothing gain for all ages in each of the retirement age group.

Sensitivity Analysis Columns (2) and (3) of Table 4 presented results when making alternative assumptions on the curvature in consumption preferences and on the welfare weights respectively.

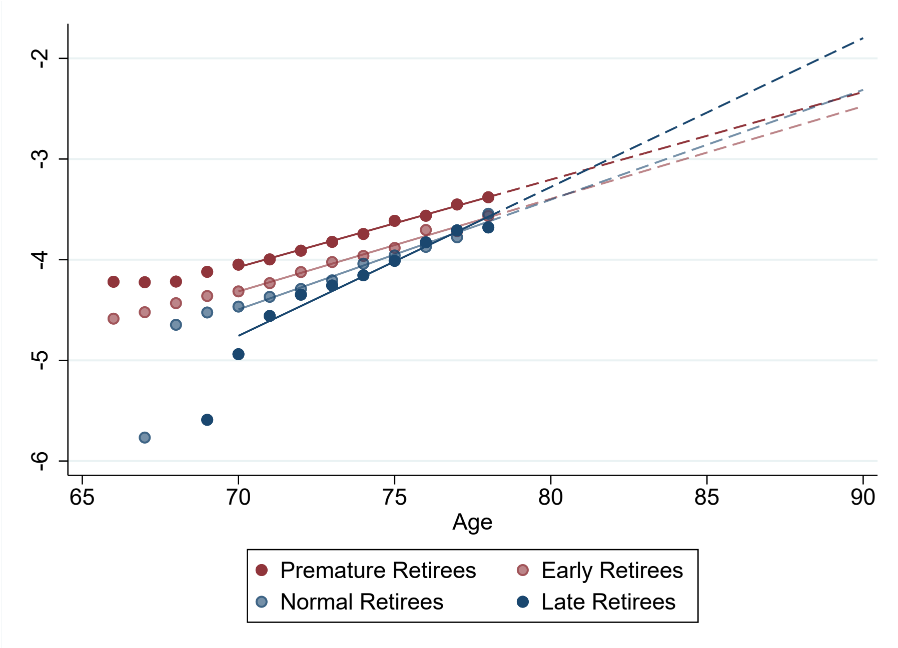
Column (2) is obtained by applying the same method as for the baseline implementation but reducing the curvature in consumption preferences to $\gamma = 2$.

Column (3) presents a sensitivity analysis when assigning welfare weights to each retirement age r that depends on life-expectancy. We follow Chetty et al. [2016] to estimate the life expectancy and Becker et al. [2005] to adjust the welfare weights.

For each retirement age group, we can compute the mortality rate at each age t, defined as the number of people who were alive at $t-1$ but died at age t divided by the number of people who are alive at age t. Since the mortality register provides death years up until 2017, we will assume that all the people who have a missing death year are alive in 2017.

For the ages [66; 78], we simply calculate the empirical mortality rates in the different retirement age groups, as illustrated in Figure G-4. To obtain mortality rates at higher ages, we implement a Gompertz extrapolation for each retirement age group. Specifically, we run the regression: $ln(mortality) = \alpha + \beta age + \epsilon$. We restrict the regression sample to the mortality values for ages [70; 78] given that up to 69 the mortality rates are mechanically different for the different retirement age groups by definition. This is shown in Figure G-4. We then compute the expected life expectancy at 65 using the true mortality rates in the range [65; 78] and the estimated ones in the range [79; 90].

Figure G-4: TRUE AND INTERPOLATED MORTALITY VALUES FOR EACH RETIREMENT AGE GROUP



Notes: This figure plots the true mortality rates (dots) and the imputed mortality rates (line) using a Gompertz extrapolation, for each retirement age group. For the extrapolation, we consider only the computed mortality rates in the range [70; 78] (solid line). The mortality rates from the dashed line are then used to compute the expected discounted lifetime by retirement age group.

As described in section 7, the goal is to compute compensating consumption differentials that would equalize the expected life-time utility for individuals with different retirement ages and use these compensating differentials to adjust the SMU's. This is done by computing Δx_j, for each retirement age group j in the formula below:

$$\sum_{k=65}^{90} S_{k,NRA} \beta^k u(\bar{c}) = \sum_{k=65}^{90} S_{k,j} \beta^k u(\bar{c} + \Delta x_j), \tag{39}$$

where $S_{k,j}$ is the survival rate at k for retirement age group j. Formally, $S_k = \prod_{i=0}^{k}(1 - m_i)$, where m_i is the mortality rate at age k we computed above. Assuming CRRA preferences, we can approximate:

$$\sum_{k=65}^{90} S_{k,NRA}\beta^k = \sum_{k=65}^{90} S_{k,j}\beta^k(1 + \gamma\Delta x_j) \tag{40}$$

which simplifies to:

$$\gamma\Delta x_j = \frac{\sum_{k=65}^{90} S_{k,NRA}\beta^k - \sum_{k=65}^{90} S_{k,j}\beta^k}{\sum_{k=65}^{90} S_{k,j}\beta^k}, \tag{41}$$

which corresponds to the relative difference in expected discounted lifetimes.

We then obtain a value for the consumption smoothing cost by applying the same method as for the baseline implementation, except that we now subtract from the consumption level the Δx_t term for each age t. Intuitively, if retirement-age group j has lower life expectancy, then Δx_j represents how much we need to increase consumption for that group to compensate them for the lower expected lifetime. We then subtract this value from their actual consumption level to obtain a corresponding increase in the SMU. The results are shown in Table 4 column (3).

Alternative Implementations Columns (4) and (5) present the results for the alternative implementations 2 and 3 described in section 2.

Column (4) shows the results applying the alternative implementation for the consumption drops in equation 21,

$$\frac{SMU_r}{SMU_{NRA}} \cong \frac{1 + \gamma\frac{c_{r,pre} - c_{r,t}}{c_{r,pre}}}{1 + \gamma\frac{c_{NRA,pre} - c_{NRA,t}}{c_{NRA,pre}}}, \tag{42}$$

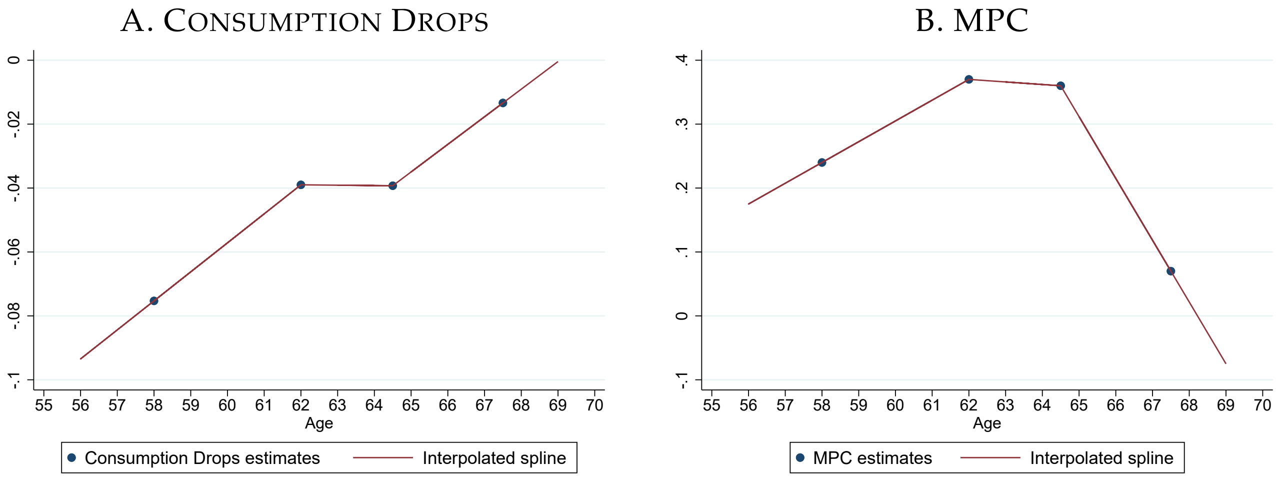
where we assumed a $\gamma = 4$ and that the welfare weights multiplied by the marginal utility of consumption before retirement are equal across retirement ages. The numbers we use for the consumption drops come from Figure 6. Since we have values for each of the four retirement age group, we can obtain age specific values by interpolating a linear spline between each point, as shown in Figure G-5 Panel A. Following the equation above, for each age r, we normalise the SMU by the value for normal retirees Then, for each age $\tilde{r}$, we obtain the consumption smoothing cost of steepening the profile at age $\tilde{r}$ by taking the difference between the weighted average of these rescaled values for each r above $\tilde{r}$, where the weights are the fraction of people in each group and this same weighted average for people below $\tilde{r}$. We assume again $\gamma = 4$. The results presented in Table 4 column (4) are obtained by taking the unweighted average in each retirement age group.

Column (5) shows the results using the MPC implementation, following equation 11,

$$\frac{SMU_r}{SMU_{NRA}} \cong \frac{\frac{mpc_r}{1 - mpc_r}}{\frac{mpc_{NRA}}{1 - mpc_{NRA}}}, \tag{43}$$

assuming now that welfare weights are similar across retirement ages. For the marginal propensities to consume, we take values from Table 3. Like for the consumption drop implementation, we can obtain age specific values by interpolating a linear spline between each of the four points, as shown in Figure G-5 Panel B. We then compute the odds ratio of the marginal propensities to consume, rescaled by the odds ratio of the normal retirees, following equation 21. Similar as above, we obtain the consumption smoothing cost of steepening the profile at age $\tilde{r}$ by taking the difference between the weighted average of these rescaled values for each t above $\tilde{r}$, where the weights are the fraction of people in each group

Figure G-5: LINEAR SPLINES FOR IMPLEMENTATIONS 2 AND 3



Notes: Panel A presents the consumption drops estimates from Figure 6 for the four retirement age groups (dots) and the interpolated linear spline between each of them. The consumption drop estimate for each retirement age group is assumed to lie at the midpoint of the interval. For instance, for the premature retirees (age range [56;60]) we assign the consumption drop to 58. We obtain age-specific values by interpolating a linear spline between each point (solid line).
Panel B replicates this same approach using the MPC values from Table 3.

and this same weighted average for people below $\bar{r}$. The results presented in Table 4 column (5) are obtained by taking the unweighted average in each retirement age group.

Swedish Pension Reform Panel B of Table 4 shows the welfare effects of the change in slope of the pension profile due to the Swedish pension reform. That is, we compute a profile that has the same slope as the NDC scheme but the same budget as the ATP scheme, denoted by $N\hat{D}C$, as described in Appendix A.2.5. The consumption smoothing cost of this reform, per dollar transferred from early to late retirees, equals:

$$\Sigma_r \mu_r \frac{SMU_r}{SMU_{NRA}},$$

where $\mu_r = \frac{f(r)\left(\widehat{NDC}_r - ATP_r\right)}{\Sigma_{r \leq \bar{r}} f(r)\left(\widehat{NDC}_r - ATP_r\right)} / S(\bar{r})$, where $\bar{r}$ is the retirement age at which the pension profiles intersect (i.e., $\widehat{NDC}_{\bar{r}} = ATP_r$). The weights are thus composed of the product of (i) the relative frequency of the retirement age group (ii) the difference between the new pension profile $N\hat{D}C$ and the ATP one. This sum is then rescaled by the total value of the pension dollars taken away from the early retirees and given to the late retirees. Note that this formulation corresponds to $\frac{SMU_{r<\bar{r}} - SMU_{r>\bar{r}}}{SMU_{NRA}}$ when using the age-specific pension reforms considered above. The age-specific estimates we take for each of the implementations in the respective columns 1-5 are the same as for Panel A. For instance, for the baseline analysis in column (1), we will take the consumption levels from regression 12.

Heterogeneity Analysis Section 7 presented a heterogeneity analysis, to account for the fact that the reform had a differential impact on different categories of people. Table G-4 presents these results, which all follow the baseline implementation using the difference in consumption levels, but using the estimates from regression 12 restricted to the relevant sample.

Column (1) reproduces our baseline results, i.e., using the baseline implementation and baseline sample. Columns (2) and (3) restricts the sample to to the bottom and top decile of ATP points at 55.For the implementation of the Swedish pension reform, we also calculate the corresponding change in pension benefits, following Appendix Figure C-4. Columns (4) and (5) consider single people and cohabiting people respectively. Lastly, column (6) uses the consumption analysis for the baseline sample, but changes the definition of retirement, as described in footnote 44.

Table G-4: HETEROGENEITY ANALYSIS: CONSUMPTION SMOOTHING COST OF STEEPER PROFILE

	Baseline	Bottom 10%	Top 10%	Couples	Singles	UI/DI
	(1)	(2)	(3)	(4)	(5)	(6)
	A. Age-Specific Profile Change: $\frac{SMU_{r\leq\tilde{r}}-SMU_{r>\tilde{r}}}{SMU_{NRA}}$					
$\tilde{r}\in[57;60]$	.25	.13	.24	.2	.38	.18
$\tilde{r}\in[61;63]$	.16	.05	.14	.11	.3	.2
$\tilde{r}\in[64;65]$	.11	.03	.14	.06	.26	.21
$\tilde{r}\in[66;69]$	.32	.32	.34	.13	.27	.46
	B. Swedish Pension Reform: $\Sigma_r \mu_r \frac{SMU_r}{SMU_{NRA}}$					
	.15	-.05	.12	.19	.09	.21

Notes: This table shows the results of the heterogeneity analysis of the baseline implementation. Column (1) replicates the estimates for the baseline analysis. Column (2) and column (3) produce the estimates for the sample restricted to the bottom decile of ATP points accrued at age 55 and top decile respectively. Column (4) and (5) present the analysis restricting to couples and singles respectively, while column (6) replicates the baseline analysis redefining retirement for those who exit the labor market through UI/DI.

Appendix G.2 Fiscal Externality Benchmark

For the implementation of the fiscal externality, we use the approximation in equation (20) and assume that both $\varepsilon_{\frac{S(\tilde{r})}{1-S(\tilde{r})},w_{\tilde{r}}}$ and $\frac{T_{\tilde{r}}}{w_{\tilde{r}}}$ are age-independent. We then use $\varepsilon_{S(\tilde{r}),w_{\tilde{r}}} = .22$, which corresponds to the extensive labor supply elasticity estimated in Laun [2017] based on the labor supply responses to the Swedish pension reform. Using $\frac{S(NRA)}{1-S(NRA)} = 0.53$, corresponding to the share of individuals retiring at 65 or later vs. before in our baseline sample, we then obtain

$$\varepsilon_{\frac{S(NRA)}{1-S(NRA)},w_{NRA}} = \varepsilon_{S(NRA),w_{NRA}}\left[1+\frac{S\left(NRA\right)}{1-S\left(NRA\right)}\right] \approx 0.35.$$

We also take $\frac{T_{\tilde{r}}}{w_{\tilde{r}}} \cong \frac{T}{w} = 0.45$. This participation tax rate relies on the pension calculator from Appendix A. See in particular Figure A-9 and the supplementary discussion around Figure A-11. Hence, putting the two terms together we obtain a fiscal externality of 0.15. That is, we would gain 15 cents per dollar transferred from individuals retiring before $\tilde{r}$ to individuals retiring after $\tilde{r}$. Without non-pension social insurance benefits, we would obtain a participation tax rate of about 0.4 rather than 0.45 (see Figure A-9). A participation tax rate of .4 would reduce the fiscal externality to .13, which is a negligible difference for our purposes.