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On the Design of a Default Pension Fund

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ABSTRACT

We investigate the effects of different equity exposures of the default fund in a defined contribution pension plan with universal coverage. Using Swedish individual-level data on financial portfolios inside and outside the pension system, we document a strong relation between default investing in the pension system and limited stock market participation outside the pension system. Motivated by this finding, we build a life-cycle portfolio choice model to investigate the effect on default investors' welfare of different designs of the default fund. We find that leverage (i.e., an equity share above 100 percent) is warranted in the sense of expected utility. The expected gain in consumption of moving from 100 to 150 percent is in the order of four percentage points during every year in retirement. The loss of a shift from 100 to 50 percent is of the same order. We also explore the implications from the introduction of a universal pension fund (i.e., abolishing individual choice of equity exposure in the pension plan). Current active investors either gain or lose from such a reform, depending on the equity exposure of the universal fund. In expectation, active investors gain more from leverage than default investors. On the contrary, if the equity exposure of the universal fund is below 100 percent, active investors do not lose as much as default investors. We attribute this effect to active investors' greater ability to use their savings outside the pension system to compensate for the equity exposure inside the pension system.

Countries debate whether, and how, their pension systems should be reformed. Reform efforts seem crucial given the predicted solvency problem of the current systems in many countries. One kind of reform to address this issue is to increase the reliance on defined contribution (DC) pension plans rather than defined benefit (DB) plans. Aside from being fiscally robust, DC plans typically allow for greater flexibility, including a multitude of fund choices. However, the flexibility and many choices associated with a DC pension plan comes with a risk, namely that many individuals are left behind in the sense that they make poor choices during working life—in terms of savings rates or in terms of portfolio allocation—that leads to unnecessary little consumption in retirement (see e.g. Benartzi and Thaler, 2007; Beshears, Choi, Laibson, Madrian, and Weller, 2008, and the references therein). Further, it seems plausible that the problem of dispersion in the replacement rate is exacerbated if the DC plan has universal coverage in the sense that every individual is assigned to it. This would be the case if, for instance, the DC plan is a component of the country's pension system. In such a context, a large fraction of individuals will lack experience from investing in stocks and mutual funds outside the pension system. Thus, it seems critical that the default fund is wisely designed.

We investigate the optimal equity exposure of a default fund within a DC plan with universal coverage. While the existing literature has focused on optimal default contribution rates (for studies on the US 401(k) system, see Madrian and Shea, 2001; Carroll, Choi, Laibson, Madrian, and Metrick, 2009; Card and Ransom, 2011) and of the dispersion in returns among individuals who opt out from the default (see e.g. Cronqvist and Thaler, 2004; Dahlquist and Martinez, 2013; Dahlquist, Martinez, and Söderlind, 2013), little attention has been given to the question how individuals with limited or no prior experience from investing can be catered the best through a careful design of the default fund. Our study is particularly warranted since the passing of the US Pension Protection Act of 2006. One intention of the act was that plan sponsors would feel more assured after its passage to offer default asset allocations that blend equity and fixed income asset classes, thus making the sponsors more confident to offer defaults with higher risk in exchange for a higher expected return.[1]

We rely on Swedish micro data on asset holdings and a structural life-cycle model of portfolio choice in our study of the effects of default fund design. Sweden provides a useful benchmark for such an investigation since it in 2000 introduced a pension system which is a self-contained entity with its own budget and with automatic adjustments of retirement benefits to avoid deficits. It has been viewed as a model for other countries. The system has two pension accounts. The first is an individual notional account with a return that adjusts according to the average wage growth in the economy. The other account is a fully funded DC account. In essence, the introduction of this second account has led to equity exposure among all Swedes in the workforce. Individuals can choose investments from a menu of hundreds of mutual funds that are also offered outside the pension system (in the retail market). Individuals who do not make an active choice are

[1] Pension Protection Act of 2006, Pub. L. 109-280 §624.

automatically assigned to a default fund. This fund is a government-operated low-cost fund with global equity exposure. In May 2010 its investment mandate was overhauled so that it now can utilise leverage with a restriction of a maximum equity exposure equal to 150 percent.

Our first contribution is that we document the relation between equity exposure in- and outside the pension system. We construct rich individual-level data to support our analysis. The data contain detailed information on the financial holdings inside and outside the pension system. To the best of our knowledge, we are the first to match a micro dataset on financial wealth outside the pension system (used in e.g. Calvet et al. 2007, 2009; and Vestman, 2012) with data on fund holdings in the DC plan inside the pension system (used in e.g. Dahlquist et al., 2013). Thus, we obtain the complete picture of an investor's financial holdings. We use our data to document how default investors differ from investors who have opted out from the default fund and find significant differences: default investors are less educated and have lower labor income and less wealth. Moreover, default investors are more reliant on their DC account than other investors since their DC account balance constitute a greater fraction of their total financial wealth. We also document a strong relation between default investing and equity exposure outside the pension system. Controlling for many observable differences such as wealth and education, we find that being a default investor in the pension system has a nine-percentage point lower likelihood of holding stocks or equity funds outside the pension system. We view this as evidence that investors who have limited experience from making investment decisions are likely to face similar problems both inside and outside the pension system.

Our second contribution is that we build a life-cycle portfolio choice model to investigate how a default pension fund can best cater its selected investors in terms of providing equity exposure. The model includes risky labor income, a consumption-savings decision, and a portfolio choice decision outside the pension system (similar to Cocco, Gomes, and Maenhout, 2005, and Gomes and Michaelides, 2005), but we also add a personal DC pension account.[2] We find that an equity share above 100 percent in the default fund (i.e., the use of leverage) is warranted in a strict expected utility sense. The expected gain in consumption from shifting the equity exposure from 100 to 150 percent is four percent during every year in retirement. Conversely, less than 100 percent equity exposure leads to fairly substantial welfare losses for default investors. The expected loss from shifting from 100 to 50 percent equity exposure equals three percent of retirement consumption.

Our third contribution is that we use our model to investigate the welfare and inequality effects if all pension investors are forced into the same universal pension fund. This investigation is motivated by the potential political tension that a universal DC pension plan can trigger. A universal DC system inevitably leads to return dispersion which ultimately increases dispersion in retirement incomes, thus possibly leading politicians to propose a pension plan with fewer or

[2]The model takes labor income as exogenous so unlike Lucas and Zeldes (2009) we cannot analyse the role of distortionary taxes.

no fund options.[3] We find that those who make active investment decisions are more able to accommodate the impact of any degree of equity exposure, should they be forced into a certain universal fund. That is, if the equity exposure of the fund is low, the active investors' expected welfare loss is smaller than the default investors' and if the equity exposure is high the active investors are expected to gain more than the default investors. The reason for this is that active investors are richer and more likely to participate in the stock market outside the pension system. This better enables them to off-set a low degree of equity exposure in the pension system.

The rest of the paper is organised as follows. Section 1 provides an overview of the Swedish pension system. Section 2 describes our data. Section 3 contains an empirical analysis of individuals' portfolio choice in- and outside the pension system and how they relate to one another. In Section 4 we build and calibrate our model. Section 5 studies the implications of different designs of the default fund. Section 6 concludes.

1 The Swedish pension system

After years of debate in the 1990's, Sweden profoundly reformed its pension system in 1999 through a broad parliamentary agreement. From the perspective of a tax payer in the labor force, it meant that (s)he was given two accounts, a notional account and a premium pension account. The balance on these two accounts, and forecasts of pension income, are reported at annual intervals through what is commonly known as "the orange envelope". For each worker, earnings during the past year determines the instalments into each account through two simple rules. The first rule is that the instalment into the notional account equals 16 percent of earnings, though the earnings that contribute to instalments are capped at 7.5 income basis amounts (in 2013 this corresponds to SEK 424,500, or approximately USD 65,000).[4] The money on this account then earns interest equal to the growth rate of aggregate earnings. For the purpose of determining the interest rate, an official "income index" has been constructed. These funds are notional in the sense that they are not reserved for the individual but are instead used to fund current pension payments as in a traditional pay-as-you-go system. The second rule is that the instalment into the premium pension account equals 2.5 percent of earnings. In contrast to the notional account, this account is a traditional defined contribution account in the sense that the funds are used to finance the future pension income of the individual. Each individual can choose to allocate these funds in up to five mutual funds from a menu of several hundreds of funds, of which most are also available outside the pension system (sometimes referred to as the retail segment). For clarity, we will henceforth refer to the premium pension account as the DC account. The small DC component of the system

[3] In Sweden, the largest labor union argued in July 2013 that the DC plan is a lottery. The union proposed that it should be abolished altogether.

[4] The income basis amount is an official statistical measure that grows from year to year at the growth rate of aggregate earnings. In 2007, it was equal to SEK 45,900.

is meant to boost pension income while at the same time maintaining the overall risk exposure at a tolerable level. At the time of retirement, the two accounts are transformed to life-long annuities that are actuarially fair. The annuity divisors are specific to each birth cohort. If the pension income is too low, the pensioner receives a substitute such that total income out of the notional account reaches a guarantied floor that in 2013 was equal to SEK 94,800 (USD 14,600) for singles.[5]

In addition to these two forms of accounts, the system in its entirety has an asset buffer which roughly equals ten percent of the aggregate liabilities. Four buffer funds were in 1999 mandated to manage these assets in such a way that they can counter demographical effects (ageing) and maintain the solvency of the system. In practice, the funds hold well-diversified portfolios of Swedish and international equities and government bonds.

Relative to most other systems around the world, and relative to the previous Swedish system, the current system has several benefits. From a political economy perspective, it is advantageous because it has been carved out as a separate entity with its own budget and balance sheet. From a pedagogical perspective, each individual can monitor his/her accounts and the forecasts for his/her retirement income. From an actuarial perspective it is advantageous because the balance sheet is at any point only a function of past events. Account balances (the liability side of the balance sheet) is a function only of past earnings. Last but not the least, the system is sustainable – up to the point of major demographical changes – since the notional accounts grow at the same rate as aggregate labor income which in turn correlates perfectly with ninety percent of the asset side of the system's balance sheet.[6]

As alluded to already in our introduction, economists have identified one major risk factor associated with the new system, namely that inequality in pension incomes may become large. The source for such dispersion – over and above the dispersion arising from income inequality during working life – is the dispersion in returns on the DC accounts.

1.1 Occupational pension

In addition to government pension, ninety percent of the Swedish work force as of today are entitled to some form of occupational pension. The agreements between labor unions and employer organisation are broad and inclusive and have over time between harmonised across educational and occupational groups. For cohorts born after 1980, the rules are pretty much homogenous and the same, regardless of educational and occupational. It works as follows. From age 27 and onwards, employers deposit 4.5 percent of total earnings into a designated individual DC account. For the part of earnings that exceeds the government ceiling of 7.5 basis amounts, the deposit rate

[5]The guaranteed pension equals 2.13 price basis amounts. In 2013 this amount is equal to SEK 44,500. In 2007 the price basis amount was SEK 40,300. For married couples the guaranteed pension is somewhat lower, namely 1.90 price basis amounts.

[6]Of course, the system is not foolproof. In fact, the relatively small buffer funds implies that the system may become insolvent before the large 1940's birth cohorts have been phased out at around 2030.

is greater. The purpose of that is to achieve a high replacement rate also for high income people. In effect, the Swedish system for occupational pension and the government-operated premium pension accounts share many features, though the occupational pension system is somewhat more complex and tailored to specific needs.

2 Data

With assistance from the Swedish Pensions Agency and Statistics Sweden we tailor a registry-based data set to our specific needs. The foundation of it is a representative panel data set called LINDA (Longitudinal INdividual DAta for Sweden) which consists of more than 300,000 households and their members. The total number of individuals in LINDA exceeds 700,000. LINDA is produced in annual waves and we use the eight waves between 2000 and 2007. This data set is compiled by Statistics Sweden and contains socioeconomic information such as age, education, household composition, civil status, etc. Further information about LINDA can be found in Appendix A. To LINDA we match on two additional data sources, one that contains detailed information about individuals' financial holdings outside of the pension system, and one that contains information about the fund holdings in the DC accounts within the government pension system.[7]

First, we match on KURU to LINDA. KURU contains detailed registry-based information on each individual's non-pension financial wealth. It is a tax-based source for information about financial security holdings outside of the pension system. Specifically, tax form 31 in KURU allows us to compute the value of the holdings of each and every bond, stock and mutual fund that an individual holds on December 31st of each year. Two exceptions to these detailed tax reporting rules are the holdings of financial assets within private pension accounts, for which we only observe additions and withdrawals, and "capital insurance accounts", for which we observe the account balance but not the detailed holdings in it.[8] The reason is that taxes on those two types of accounts depend merely on the account balances and not on the actual capital gains. There is also a tax on real estate, which allows for an accurate measurement of the value of owner-occupied single-family houses and second homes (cabins). Apartment (co-op) values are also available, though less accurately measured.

Second, we asked the Swedish Pensions Agency to deliver information to Statistics Sweden on each LINDA individual's year of entry into the pension system and information on which mutual funds the individual held on his/her DC account at the end of each year between 2000 and 2007 and the values of those. The mutual funds are identified by their ISIN. Statistics Sweden then

[7] Unfortunately, it is not possible to match on occupational pension accounts since these accounts are administered by private entities.

[8] Capital insurance accounts are savings vehicles that are not subject to the regular capital gain and dividend income taxes, but instead are taxed at a flat rate on the account balance. Hence, we do not know the exact composition of these accounts, only the year-end balance. According to Calvet, Campbell, and Sodini (2007) these accounts summed up to 16% in 2002.

matched on these data to LINDA and KURU.

In previous studies, KURU and records from the Swedish Pensions Agency have only been used by themselves. Calvet, Campbell, and Sodini (2007), Calvet, Campbell, and Sodini (2008), Vestman (2010), and Koijen, Van Nieuwerburgh, and Vestman (2013) use KURU to answer questions about investor diversification, portfolio rebalancing and consumption expenses. Dahlquist, Martinez, and Söderlind (2013) use DC account information similar to ours from the Pensions Agency to analyze how performance is related to activity. For a detailed description of either KURU or the Pensions Agency data, the reader is referred to the previous studies.

3 Empirical analysis

3.1 Sample restrictions

To simplify the analysis we impose a handful of harmless sample restrictions. We start with all individuals present in the 2007 wave of LINDA and match them onto the pension agency's records of DC account holdings. There are 430,216 individuals who are present in both data sets.[9] We then compare our records of portfolio information at the end of each year with the stated year of entry into the premium pension system according to the pension agency. We impose the restriction that we must have recorded information about the portfolio at the end of each year ever since the stated year of entry. Thus we require unbroken recording sequences. This reduces the sample to 342,974 individuals. Further, we exclude individuals with a missing recorded year of entry, which reduces the sample by another seven individuals. To be able to better match the model to data, we also exclude the richest percentile in terms of net worth, which corresponds to 7,7 million Swedish kronor in the 2005 price level. This reduces the sample size to 339,405. Finally, we exclude individuals for which we do not have educational information. Educational information is missing for less than a percent of the sample, it mainly affects recent immigrants, very old and very young individuals. Our final sample consists of 337,032 individuals.

3.2 Three types of pension investors

We classify each individual in our sample into three types based on investor behaviour in the DC pension system in order to be able to document how pension investors who show signs of active investment behaviour differ from pension investors who show signs of inertia. We base the classification on the observed sequence of fund holdings in the DC account between 2000 and 2007:

1. *Default investors.* A default investor has had its DC deposits allocated to the default fund ever since (s)he entered the pension system.

[9] The complete 2007 wave of LINDA consists of 810,222 individuals. Hence 380,006 individuals in LINDA 2007 are either too old to be part of the new pension system (only cohorts born after 1937 are members) or are not part of the pension system because they have not entered the labor force.

2. *Passive investors.* A passive investor opted out of the default fund at the time of her/his entry into the pension system but since then (s)he never made a change to her/his fund allocation.

3. *Active investors.* This type contains all other investors. An active investor is someone who have made at least one change to her/his fund allocation after the the entry into the pension system. Thus, this type consists both of individuals who have opted out of the default fund *after* entry into the pension system and individuals who have made repeated fund allocation decisions.

Apart from being appealingly simple, this classification is inspired by Dahlquist, Martinez, and Söderlind (2013). They document that over the 2000-2010 period 27% of the pension investors have been in the default fund throughout whereas 34% have initially opted out of the default fund but have since then not made any changes to their allocation. Consequently, in their sample 39% of the pension investors have made at least one fund change since the time of entry. Thus, our three-type classification will, roughly speaking, divide our sample into three equally large categories. Section 3.3 report the detailed statistics for our sample.

3.3 Summary statistics

Table I reports averages for key variables. The first column reports the values for the full sample and the second to the fourth column report the values for each investor type. For clarity, the table focuses on the 2007 wave of the panel data. Among these, default investors account for 34.6% of the full sample while passive investors and active investors account for 28.0% and 37.5% each. This means that relative to Dahlquist, Martinez, and Söderlind (2013) the fractions in our sample are somewhat different. The most marked difference is the passive category which is 6 percentage points smaller in our sample, at gain of both the default and active investor types. This difference can be due to either a slight difference in representativeness but most likely it is due to the difference in sample periods. Since activity has fallen ever since 2000, it seems plausible that the fractions of passive investors gradually increases.

As the third row shows, at an average age of 43 years, default investors are four to five years younger than the other types. The difference in labor income (row four) is however more stark. The gross labor income of investors that remain in the default fund is on average only 66% of active investors' gross labor income. This gap cannot solely be attributable to the difference in age, rather it is most likely an artefact of all kinds of differences that manifests themselves in different earnings prospects, among those educational differences (more on that below). The difference in labor income also translates into a substantial difference in financial wealth outside of the pension system. At an average value of 166 kSEK, investors in the default fund own on average only 56% of active investors financial wealth (298 kSEK). The table also reports differences in stock market

exposure outside of the pension system (i.e., exposure to the stock market among individuals' regular savings in stocks or equity funds). The stock market participation rate, defined as direct ownership of stocks or equity funds, among active pension investors is 61.7% but only 38.1% among investors in the default fund, a gap of 23.6 percentage points. Also the average equity shares differ substantially between the investor types (where non-participants' equity share is zero). Noticeably, if default investors and active investors allocated the same shares to equity conditional on stock market participation, the fraction of the two types' equity shares in the table would be equal to 61.8% (0.381/0.617) . Rather, the reported difference is 55.5% (0.141/0.254). This means that pension investors in the default fund who own stocks or equity funds outside of the pension system have a lower equity share than active pension investors who own stocks or equity funds outside of the pension system.

There are large differences also in real estate wealth. First, the home ownership rate among default investors is 50%, compared to a rate of 78% among active investors. The sum of the wealth differences - in financial wealth and in real estate - are captured in net worth which reports the value of both of those asset classes minus total liabilities. While default investors' net worth equals 487 kSEK, active investors net worth is 851 kSEK . The total wealth difference is the result of a difference in financial wealth equal to 132 kSEK and a difference in home equity equal to 374 kSEK.

Finally, there also substantial differences in education between the investor types. Though the fraction of high schoolers is quite stable at about 55% across all types, the fraction of investors with a college degree is seven percentage points smaller among default investors than among active investors (24.3% compared to 31.3%). Instead, default investors are much more likely than active investors to just have finished elementary school (20.4% compared to 12.0%).

Across the board, passive investors can be viewed as an investor type with observable characteristics in between the active investors and the default investors.

3.4 Comparisons of the investor types

To obtain a richer picture of the differences between the three investor types, this section displays histograms of labor income, age, DC account balance, and DC account balance. To be consistent with previous analysis, the histograms rely on the same sample.

Figure 1 shows average labor income by type at different stages of the life cycle. There is a strong consistency in the figure in the sense that active investors have higher average labor income than passive investors at all stages of their life cycle. Further, passive investors have higher average labor income than investors in the default fund at all stages of their life cycle. Passive investors earn on average 87% of active investors' labor income. This fraction varies little over the life cycle, from 84% for the oldest category (51 years and older) to 90% for the three younger categories (50 years and younger). The average labor income of investors in the default fund is 66% of active

investors' labor income. Neither this fraction varies much over the life-cycle, from 66% for the oldest category (51 years and older) to 73% for 31 to 50 year-old investors.

Figure 1: Labor income

The figure depicts average labor income in 2007 by investor type.

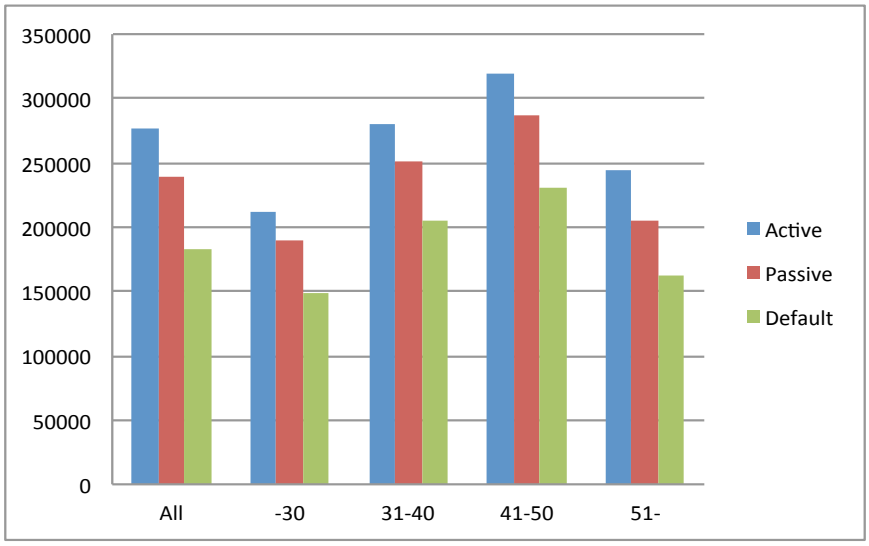


Figure 2 shows the prevalence of each investor type among different age groups (since we only rely on the 2007 wave, the age groups can also be interpreted as groups for birth cohorts). The most striking feature of the figure is the high prevalence of the default fund among investors younger than 30 years, above 70%. Across the three other age groups (31 years and older) the fractions of the three investor types is fairly stable with approximately 30 % default investors, 30% passive investors and 40% active investors.

There are two reasons why the youngest investors are much more likely to hold the default fund. First, many of them have entered the pension system after 2000 when the reform took place. Thus, their knowledge of the pension system in general, and the DC account in particular, is probably lower than among older investors. Later in this subsection we elaborate further on how inertia among entrants into the pension system has increased since 2000.

A second reason why young investors are more likely to hold the default fund is that their DC account balance is small. As Figure 3 shows, the average value among default investors younger than 30 years is just 17 kSEK, compared to 30 kSEK for young passive investors 32 kSEK for young active investors. The meagre account balance probably makes fund allocation decisions seem less important. Indeed, the share of default investors' account balance relative to active investors' account balance increases from 51% for the youngest group to between 66% and 74% for the older groups. Passive investors' share of active investors' account balance is more stable at around 90% for all age groups.

Another interesting aspect of the investor types' account balances is how important they seem

Figure 2: Age

The figure shows the prevalence of each investor type in 2007 across different age groups.

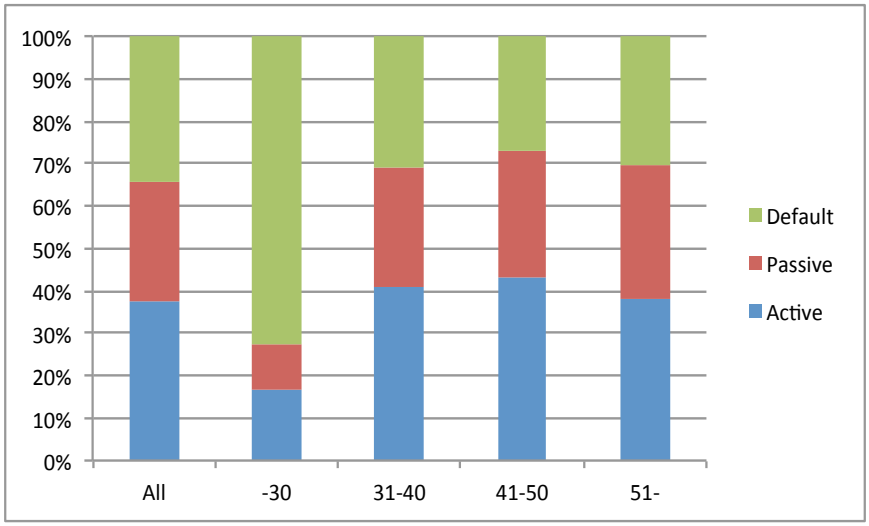
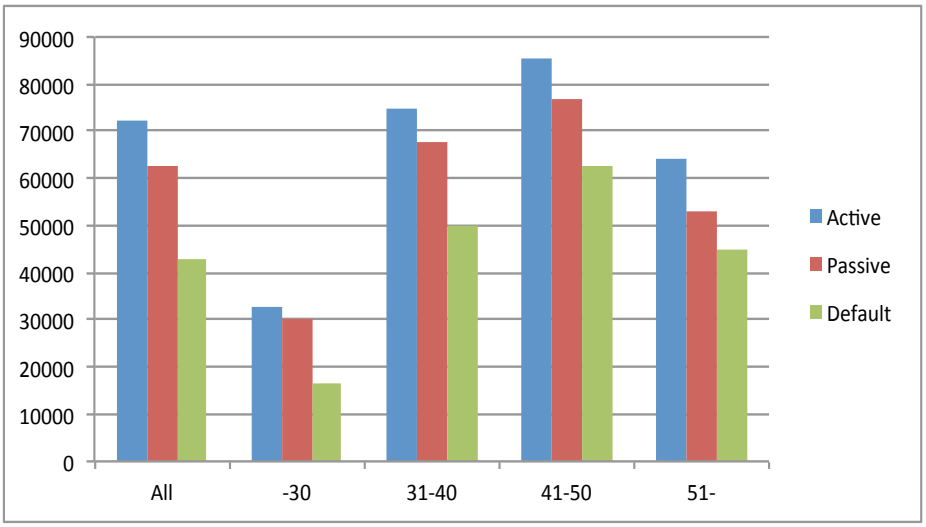


Figure 3: Balance on the DC account

The figure displays the DC account balance in 2007.

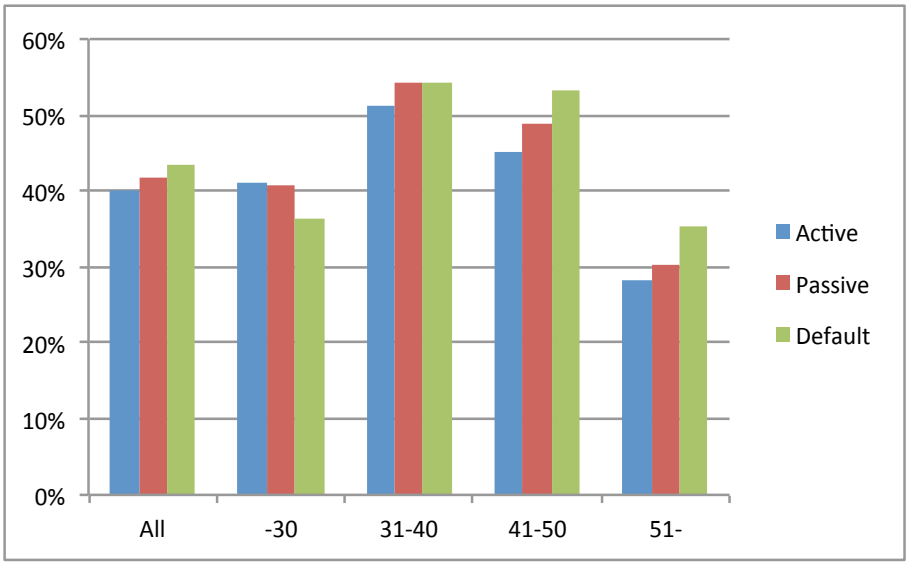


to be relative to other kinds of savings. To obtain an overview of the pension account's importance, Figure 4 displays the share of the account balance relative to (divided by) the sum of the account balance and financial wealth outside of the pension system. The figure shows that the share of the account balance is on average equal to 40% for the active investors, 42% for passive investors and 43% for default investors. Thus, passive and default investors are in fact more reliant on their pension accounts than the active investors. Among the middle-aged, the difference between default investors and active investors is particularly large. Among the 41 to 50 year-old investors,

the difference is 8 percentage points (53% compared to 45%) and among the investors who are 51 years and older the difference is 7 percentage points (35% compared to 28%). Passive investors' share of total financial wealth in the DC account is in between the share of the active and the default investor. In unreported results, we compute also compute the median shares for the three types. The difference in the medians are slightly greater than the averages. Across all age groups the difference between default and active investors is 5 percentage points (41% compared to 36%) and it peaks among the 41 to 50 year-old investors at 12 percentage points (55% compared to 43%). Overall, these findings demonstrate that although passive and default investors pay less attention to their DC accounts, they are not less reliant on them. If anything, passive and default investors are in fact more reliant on their DC pension accounts since its share out of total financial wealth, inside and outside of the pension system, is greater than for active investors.

Figure 4: Account balance relative to total financial wealth

The figure displays the DC account balance relative to total financial wealth in 2007. Total financial wealth includes the DC account plus savings outside the pension system, including bank accounts, bonds, direct stock holdings, mutual funds, capital insurance accounts, and private pension plans.



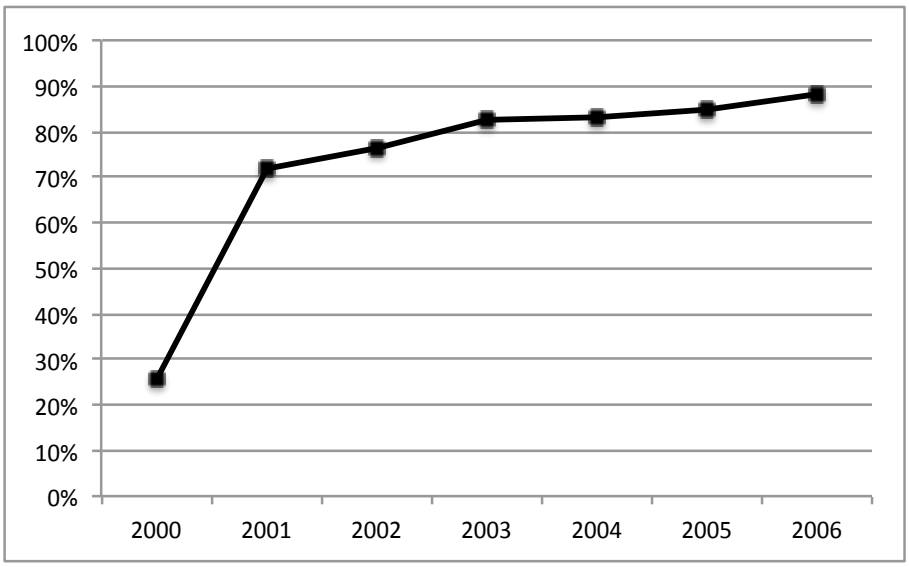
Finally, we note how activity among entrants into the pension system has fallen ever since 2000 when the system was launched. Figure 5 shows the fraction of entering investors that hold the default fund on the 31st of December in 2007.

The figure tells that among those investors who entered the system already at the time of the launch in 2000, only 26% are default investors in 2007. This fraction is quite different to the group of investors who entered in between 2001 and 2006. 72% of those who entered in 2001 held the default fund on December 31st of 2007. Gradually the prevalence of the default fund in the pool of pension investors has increased. 88% of those who entered in 2006 held the default fund on December 31st of 2007. Hence, the figure provides strong evidence that investor inertia

has increased dramatically since the time of the reform. In unreported results, we use regression analysis to separate out age effects from time effects. The results from this regression confirm that the phenomenon displayed in the figure is a result of entry year rather than age effects.[10] This means that probably the prevalence of the default fund in the investor population has not yet reached its long-run average. It also means that the long-run average most likely is closer to 60 or 70% rather than 35% as in our sample.

Figure 5: Default investors by year of entry

The figure displays the choice of the default fund by year of entry, spanning the period 2000 to 2007.



3.5 Stock market participation outside the pension system

We now turn to a more formal comparison of investment behavior outside of the pension system and investment behavior in the DC pension account.

We start by studying how passivity in the pension system relates to stock market participation outside the pension system. We do so by running OLS regressions of the following kind:

$$D(\text{Participation}_i = 1) = \alpha + \beta_1 D(\text{Default}_i = 1) + \beta_2 D(\text{Passive}_i = 1) + \gamma' X_i + \varepsilon_i \qquad (1)$$

where $D(\text{Participation}_i = 1)$ is a dummy variable that takes on value one if the individual holds stocks directly or equity funds outside of the pension system at the end of 2007, $D(\text{Default}_i = 1)$ is a dummy variable that takes value one if the individual is a default investor in the pension system (at end of 2007), $D(\text{Passive}_i = 1)$ is a dummy variable that takes value one if the individual is a

[10] Recall that entrants in 2000 encompassed all birth cohorts after 1937. Hence, the entrants in 2000 have a more dispersed age composition than entrants in later years. A standard OLS regression can control for that.

passive investor and where X_i is a set of individual characteristics, and ε_i is the error term. Since our classification of investors is static over the 2000-2007 period, we restrict ourselves to stock market participation at the end of 2007. As for the functional form for the covariates in X_i we use a simple linear specification, but we also construct piecewise linear splines for the continuous covariates that have the largest impact. The covariates included in X_i are to a large extent chosen to be consistent with a structural life-cycle model of portfolio choice, of the kind that we set up in the next section. Hence, we include age, gross labor income and financial wealth. In addition, we include educational dummies, the real estate dummy and geographical dummies. Table II reports the results from four regressions of this kind. The first column focuses on a linear specification without the variables that indicate investor type. In the second column we include the variables for investor type. In both of these columns, the dummy variable for elementary schooling has been left out in order to serve as the reference level for high school, college and PhD. The first column is meant to serve as a benchmark to the second column where the variables for investor type are included. The estimates in the second column indicates that even when controlling for observable characteristics, there is a strong relation between default investing in the pension system and lack of equity exposure outside the pension system. Being a default investor in the pension system reduces the likelihood of holding stocks or equity funds outside of the pension system by 13.5 percentage points. This effect can be compared to the effect of education. The difference between an investor who only has elementary schooling from one who has a college degree is estimated to be 13.8 percentage points. This effect can also be compared to the unconditional difference in participation rates, 23 percentage points (reported in Table I). Interestingly, the effect of education is slightly hump-shaped with a peak in conditional participation rates for college-educated investors (not investors with a PhD).

The fact that a rich set of control variables cannot close most of the gap in stock market participation rates suggests that the relation between default investing and stock market participation outside the pension system is not driven by differences in wealth, labor income, education etc., but rather driven by something unobserved such as experience from making investment decisions. In column 3 and 4 we control for observables more carefully by using splines and by including dummy variables for industry and occupation but qualitatively, this does not qualitatively alter our findings.

In an untabulated regression specification, we have also investigated the effect of stock market participation on the likelihood of belonging to either the default or the passive category. Such a regression reveals the same pattern, namely that exposure to the stock market outside of the pension system affect the probability of being either a default investor or a passive investor, rather than being active in the pension system. At an estimated marginal effect of plus seven percentage points, the effect is substantial. It is slightly greater than the marginal effect of increasing an investor's education from elementary school to college. The bottom line of our regressions is that which type of pension investor you are to a large extend can help predict whether you are exposed

to equity outside the pension system. Or, conversely, stock market exposure outside of the pension system increases the likelihood that you are active in the pension system, even when controlling for a host of covariates that correspond to the state variables of a plain vanilla life-cycle portfolio choice model. In terms of model design, this finding motivates introduction of heterogeneity in the active-passive dimension. Heterogeneity in participation costs is an important feature of our model that we specify in Section 4.

4 Model

Our model belongs to the class of life-cycle models that include risky labor income, a consumption-savings choice and a portfolio choice (see e.g. Cocco, Gomes, and Maenhout (2005), Gomes and Michaelides (2005), Gomes, Michaelides, and Polkovnichenko (2009)). Relative to those models, we revise pension system so that the individual's pension income is based on annuities from a notional and a DC account. Motivated by the regression results in section 3.5, we also allow for a simple form of heterogeneity in financial proficiency. For simplicity (but also in line with the Empirical Analysis), we merge together the default investors and the passive investors from the empirical analysis. In the model, this is called the passive type. The other type in the model is called active. It corresponds to the active type in the empirical analysis.

4.1 Demographics

We follow individuals from the start of working life, assumed to take place at age $t = 20$, until the end of their life. End of life occurs the latest at age 100, since individuals throughout the life-cycle individuals face an age-dependent unconditional survival rate Φ_t which in turn corresponds to a conditional age-specific survival rate ϕ_t. The life-cycle is split into two periods. During age 20 to 64, individuals are in the labor force and receive labor income as described below. From age 65 to death (at most 100 years) individuals are retired. We refer to the periods as working age and retirement age.

4.2 Preferences

The individual has Epstein-Zin preferences (Epstein and Zin, 1989, 1991) over a single consumption good. The future is discounted at rate β. Therefore, at age t each individual maximizes:

$$\begin{aligned} U_t &= \left(c_t^{1-\rho} + \beta \phi_t E_t \left[U_{t+1}^{1-\gamma} \right]^{\frac{1-\rho}{1-\gamma}} \right)^{\frac{1}{1-\rho}} \\ U_T &= c_T \end{aligned} \tag{2}$$

where $\frac{1}{\rho} = \psi$ is the elasticity of intertemporal substitution and γ is the coefficient of relative risk

aversion. The expectations operator $E_t[.]$ is well-defined given the description of the stochastic processes below. For notational convenience we define the operator

$$\mathcal{R}_t(U_{t+1}) \equiv E_t \left[U_{t+1}^{1-\gamma}\right]^{\frac{1}{1-\gamma}}$$

as in e.g. Hansen, Heaton, and Li (2008) and Chen, Favilukis, and Ludvigson (2012)

4.3 Labor income

During working age, the individual faces a standard individual labor income process that accounts for a life-cycle trend and persistent income shocks. The log labor income of an employed individual i at age t is:

$$y_{it} \equiv log(Y_{it}) = g_t + z_{i,t} \;\; t \leq 64 \tag{3}$$

$$z_{i,t} = z_{i,t-1} + \eta_{i,t} + \theta\varepsilon_t \;\; t \leq 64 \tag{4}$$

$$y_{it} = f\left(g_{64}, z_{i64}\right) \;\; t \geq 65 \tag{5}$$

The first component in the working age income, g_t, is a hump-shaped life-cycle trend. The second component, $z_{i,t}$, is the permanent component of labor income with innovations $\eta_{i,t}$ that are distributed $N\left(-\sigma_\eta^2/2, \sigma_\eta^2\right)$. ε_t is aggregate shock that is distributed $N\left(-\sigma_\varepsilon^2/2, \sigma_\varepsilon^2\right)$. This shock will also affect the stock return, as explained in the next section. θ is a parameter that determines the contemporaneous correlation between the (permanent component of) labor income and the stock return. The initial persistent shock is distributed $z_{i,20} \sim N\left(-\sigma_z^2/2, \sigma_z^2\right)$, thus allowing for initial heterogeneity in earnings already at age 20. Going forward, the subscript i will be suppressed unless it is necessary to avoid confusion.

During the retirement age the individual has no labor income, instead (s)he relies entirely on annuity payments from the pension accounts. The annuity from the notional and occupational pension accounts is based on an approximation that uses the individual-specific persistent component, z_{i64}, as a sufficient statistic. This approximation circumvents the need for including the account balances as state variables. We discuss the approximation in detail in appendix B.

4.4 The financial market and asset returns

To enter the stock market the household must pay a one-time entry cost, κ_t, that is proportional to the (cross-sectional) average labor income at age t. This feature is common in portfolio choice and asset pricing models. It is used in for instance Boldrin, Christiano, and Fisher (2001), Gomes and Michaelides (2005), Gomes and Michaelides (2008), Favilukis (2011), Alan (2006) and Ball (2008).

The state variable I_t keeps track of whether stock market entry has occurred between age 20

and age t. Let $\alpha_t \in [0,1]$ denote the fraction of financial wealth available outside of the pension system that is invested in the stock market. The law of motion for I_t is given by:

$$I_t = \begin{cases} 1 \text{ if } I_{t-1} = 1 \text{ or } \alpha_t > 0 \\ 0 \text{ otherwise} \end{cases} \tag{6}$$

$$I_0 = 0 \tag{7}$$

The cost is $\kappa(I_t - I_{t-1})$, i.e. either κ (upon first-time entry) or zero (otherwise). We allow the cost to take on different values for the active and the passive type (κ^A versus κ^P). The return of the equity market evolves stochastically with the following log-normal return processes:

$$R_{t+1} = \exp(\log(R_f) + \mu + \varepsilon_{t+1}) \tag{8}$$

where R_f is the return on a bond with a constant risk-free return and μ is the equity premium, $E_t[R_{t+1} - R_f] = \mu$. The shock ε_t is i.i.d. $N(-\sigma_\varepsilon^2/2, \sigma_\varepsilon^2)$. It is correlated with labor income growth because ε_t appears in equation (4) with weight θ.

4.5 Four accounts for financial wealth

An individual has four accounts for her/his financial savings, one outside the pension system and inside the pension system (s)he has a DC account, a notional account and an account for occupational pension. The funds on the account outside of the pension system are accessible at any point in time. Each individual chooses freely how much to save and withdraw from it. In contrast, the deposits into the pension accounts during working age are determined by the pension policy and the funds are only accessible in the form of annuities during retirement age.

4.5.1 Financial wealth outside the pension system

The individual starts economic life at age 20 with an initial (end of period) financial wealth $A_{i,20}$ outside the pension system. The log of this initial wealth is distributed $N\left(-\sigma_A^2/2, \sigma_A^2\right)$. In each subsequent period, the individual can freely access this account and make deposits and choose the fraction to be invested in the risk-free bond and the stock market index. The only restrictions being that (s)he cannot borrow,

$$A_{it} \geq 0 \tag{9}$$

and that the equity share (the fraction of savings outside of the pension system that is allocated to the stock market) is between zero and one,

$$\alpha_{it} \in [0,1] \tag{10}$$

Taken together, equation (9) and (10) imply that individuals cannot borrow towards the risk-free rate and they cannot short the stock market or take leveraged positions in it.

In sum, the possibility to save in the risk-free bond and the stock market outside of the pension system implies that financial wealth outside of the pension system (i.e. liquid wealth) evolves according to the following law of motion:

$$X_{t+1} = A_t \left(R_f + \alpha_t(R_{t+1} - R_f)\right) + Y_{t+1} \tag{11}$$

4.5.2 The DC account inside the pension system

Inside the pension system, each individual has a DC account with a balance equal to A_{it}^{DC}. During working age, the deposits in each year equals a fraction λ of gross labor income, Y_{it}, though there is a ceiling on the deposits equal to $\lambda\overline{Y}$ Swedish kronor (SEK). In line with the Swedish pension system, we implement the deposit as an employer tax. This means that the deposits do not show up as withdrawals from gross labor income in the individual's budget constraint.[11] Active investors freely choose the equity share in their accounts, denoted α_{it}^{DC}, with the only restriction that they cannot short the stock market or take leveraged positions:

$$\alpha_{it}^{\text{DC}} \in [0, 1] \tag{12}$$

Passive investors, on the other hand, are in the default fund and therefore have an equity exposure equal to $\alpha_t^{\text{DC-Default}}$ where the subindex t means that the default fund possibly has a life-cycle component built into it. Since the Swedish system allows leverage in the default fund we put only a lax restriction on it:

$$\alpha^{\text{DC-Default}} \geq 0 \tag{13}$$

In sum, the law of motion for the balance on the DC account for an active individual is

$$A_{it+1}^{\text{DC}} = A_{it}^{\text{DC}} \cdot \left(R_f + \alpha_{it}^{\text{DC}} \cdot (R_{t+1} - R_f)\right) + \lambda \min\{Y_{it}, \overline{Y}\} \tag{14}$$

and for a passive individual it is

$$A_{it+1}^{\text{DC}} = A_{it}^{\text{DC}} \cdot \left(R_f + \alpha_t^{\text{DC-Default}} \cdot (R_{t+1} - R_f)\right) + \lambda \min\{Y_{it}, \overline{Y}\} \tag{15}$$

with the only difference being the equity share.

[11] This is entirely consistent with our calibration of the labor income process to our micro data set, i.e. our measure of gross labor income is net of this employer tax.

4.5.3 The notional account inside the pension system

We also model the notional account. The law of motion for both the active and the passive individual's account balance is

$$A^{\mathrm{N}}_{it+1} = A^{\mathrm{N}}_{it} \cdot R_f + \lambda^N \min\{Y_{it}, \overline{Y}\} \tag{16}$$

where λ^N is the deposit rate into the notional account.

4.5.4 Occupational pension

We also model an account for occupational pension. The law of motion for both the active and the passive individual's account balance for occupational pension is

$$A^{\mathrm{O}}_{it+1} = A^{\mathrm{O}}_{it} \cdot R_f + \alpha^{\mathrm{O}}_t \cdot (R_{t+1} - R_f) + \lambda^O Y_{it} \tag{17}$$

where λ^O is the deposit rate into the notional account. Notice that unlike the deposits into the DC and notional accounts, the deposits into the account for occupational pension are not capped at $\overline{Y}$.

4.5.5 Approximation of account balances

We do not include A^N and A^O as two separate state variables. Instead, we use z_{i64} to approximate the sum of the two account balances at the time of retirement. This approximation is based on simulations of equations (3)-(5), (16), and (17) and subsequent estimation of two OLS regressions – one for each type – to obtain the best fit between z_{i64} and $A^{\mathrm{N}}_{i64} + A^{\mathrm{O}}_{i64}$. See appendix B for further details.

4.5.6 Annuitization of the pension accounts

Upon retirement at age 65, the flows into the DC and the notional accounts are converted to outflows to fund pension income in retirement age. Specifically, the DC account and notional account balances are converted to two life-long annuities using an annuitization divisor. We use the same divisor for all accounts, namely 16 years. If the total of all annuity payments fall below $\underline{Y}$ they are supplemented by the government so that total pension income never fall below that value.

4.6 The active individual's problem

Let $V_t\left(X_t, A^{DC}_t, z_t, I_t\right)$ be the value of an individual of age t, with cash-in-hand X_t, DC savings A^{DC}_t, a persistent component of income z_t and stock market participation experience I_t.

4.6.1 The Participant's Problem

An active individual who already has entered the stock market solves the following problem:

$$V_t\left(X_t, A_t^{DC}, z_t, 1\right) = \max_{A_t, \alpha_t, \alpha_t^{\mathrm{DC}}} \left\{ \left((X_t - A_t)^{1-\rho} + \beta \phi_t \mathcal{R}_t \left(V_{t+1}\left(X_{t+1}, A_{t+1}^{DC}, z_{t+1}, 1\right)\right)^{1-\rho} \right)^{\frac{1}{1-\rho}} \right\}$$
$$\text{subject to equations } (3) - (12), (14)$$

4.6.2 The entrant's problem

Further, define $V_t^+\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right)$ as the value for an active individual with no previous stock market participation experience who decides on joining at t. This problem can be written:

$$V_t^+\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right) = \max_{A_t, \alpha_t, \alpha_t^{\mathrm{DC}}} \left\{ \left(\left(X_t - A_t - \kappa^{\mathrm{A}}\right)^{1-\rho} + \beta \phi_t \mathcal{R}_t \left(V_{t+1}\left(X_{t+1}, A_{t+1}^{\mathrm{DC}}, z_{t+1}, 1\right)\right)^{1-\rho} \right)^{\frac{1}{1-\rho}} \right\}$$
$$\text{subject to equations } (3) - (12), (14)$$

4.6.3 The non-participant's problem

Finally, define $V_t^-\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right)$ as the value for an active individual with no previous stock market participation experience who decides on staying out also at t. This problem can be written:

$$V_t^-\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right) = \max_{A_t, \alpha_t^{\mathrm{DC}}} \left\{ \left((X_t - A_t)^{1-\rho} + \beta \phi_t \mathcal{R}_t \left(V_{t+1}\left(X_{t+1}, A_{t+1}^{\mathrm{DC}}, z_{t+1}, 0\right)\right)^{1-\rho} \right)^{\frac{1}{1-\rho}} \right\}$$
$$\text{subject to equations } (3) - (12), (14)$$

where the interest rate on financial savings outside of the pension system is simply R_f (formally, $\alpha_t = 0$).

4.6.4 Optimal stock market entry

Given the problems in section 4.6.2 and 4.6.3, optimal stock market entry is defined as:

$$V_t\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right) = \max\left\{V_t^+\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right), V_t^-\left(X_t, A_t^{\mathrm{DC}}, z_t, 0\right)\right\}$$

4.7 The passive individual's problem

The passive individual solves almost the same problem as the active individual. The differences are that the passive individual does not choose the equity share inside the pension system, instead $\alpha_{it}^{\mathrm{DC}} = \alpha_t^{\text{DC-Default}}$. Thus, the constraint in equation (13) replaces (12) and the law of motion in equation (15) replaces (14). Further, to be consistent the with the results of the regression analysis in section 3.5, the passive individual faces a larger barrier to stock market entry outside the pension system.

4.8 Calibration

In this section we describe our calibration strategy. To provide an overview, the values for the key parameters are reported in table III.

4.8.1 Exogenous parameters

We set most of our parameter values based on the existing literature. In terms of preferences, we choose a standard value of 0.2 for the elasticity of intertemporal substitution and a value of 8 for the coefficient of relative risk aversion. These parameter choices are in line with the literature on portfolio choice and asset pricing and facilitate a somewhat reasonable match of the equity share.

Our choice of expected returns is somewhat unusual. While the choice for the equity premium is standard at four percent ($\mu = 0.04$), we choose to set the risk-free rate of return equal to zero ($R_f = 1.00$). We argue that this is the conceptually correct choice since our model does not include economic growth whereas forecasts of future pensioners' replacement rates relative to final income is based on models with growth. Thus, we want to deflate the account returns with expected (mean) long-run growth to obtain coherent replacement rates. We elaborate further on this in Appendix B. The standard deviation of permanent labor income equals 0.10, and is modestly positively correlated with the stock market (a one-year correlation equal to 10 percent). Just as an overall volatility of the stock market equal to 18 percent, this can be viewed as standard in the literature.

We also set the deposit rates into the three pension accounts to be consistent with the current Swedish policy. The deposit rate into the DC account equals 2.5 percent of labor income. The deposit rates into the notional account is 16 percent and the deposit rate into the occupational pension account equals 4.5 percent. The maximum deposits into the first two accounts is capped (corresponding to a ceiling in labor income equal to SEK 344,000, or approximately USD 53,000).[12]

Finally, we set survival rates and expected labor income according to Swedish data. We use Statistics Sweden's statistics for the survival rates and we use our micro data set to compute mean labor income, by type, over the life-cycle.

The two top panels of Figure 6 report cross-sectional mean labor income over the life-cycle from our data for the passive and the active type. From these panels it is evident that the active individuals earn more at all stages of working life.

4.8.2 Endogenously chosen parameters and model fit

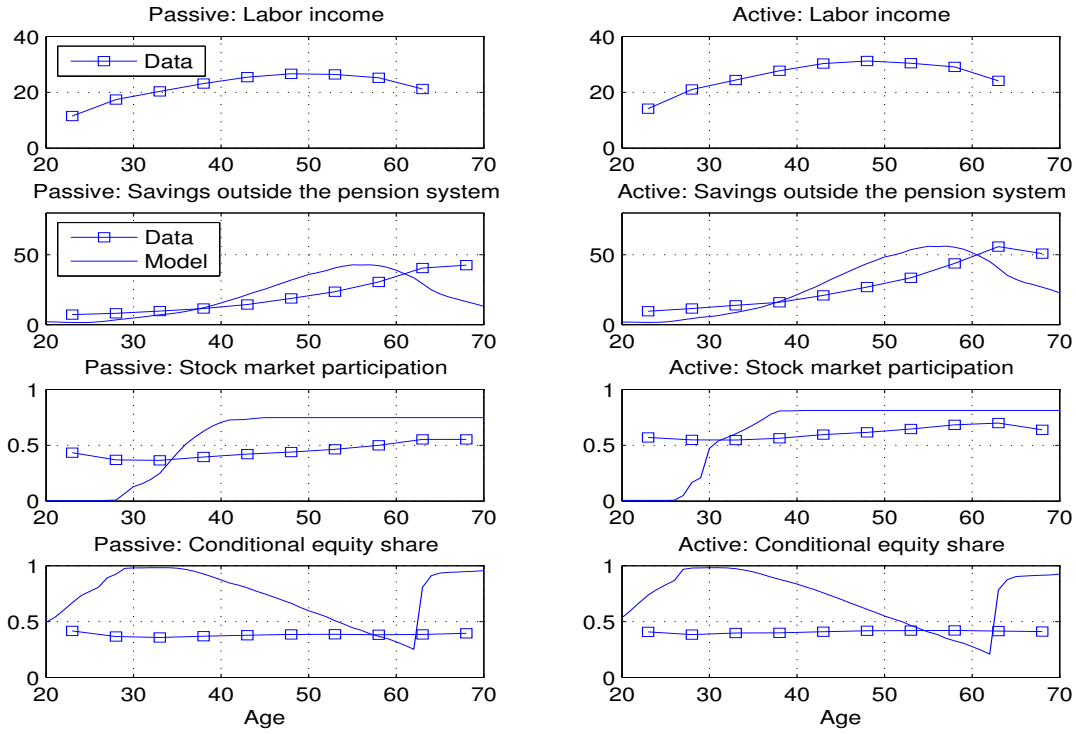
Three of the parameters are treated as endogenous in our calibration. This means that we use them to obtain a good fit between moments in the data and the model. The discount factor is calibrated to match total financial wealth outside of the pension system at age 65 and is set to

[12] Further, deposits into the occupational pension account do not begin until age 27, as is the case for cohorts born after 1979.

0.88. The participation cost is set so that we match the average stock market participation rates outside of the pension system for each type. Notice that although the stock market participation rate is lower for the passive, we can still use the same magnitude of the cost (SEK 25,000). This is because in percentage terms, relative to labor income or financial wealth, the cost is greater for the passive type. The bottom six panels of Figure 6 show financial savings, stock market participation and equity shares outside the pension system from the data and the model. The three panels to the left report statistics for passive individuals and the three panels to the right the corresponding statistics for the active individuals. We match the feature that active individuals save more outside the pension system. We also match the gap in stock market participation rates outside the pension system between the active and the passive individuals. In the data, the average gap is equal to 16 percentage points while in the model it equals 9 percentage points. Consequently, we generate a gap in the unconditional equity shares though the two investor types invest similarly if they participate in the stock market. Despite the fact that we use a coefficient of relative risk aversion as high as eight, the model overshoots in conditional equity shares. This is a manifestation of the equity premium puzzle.

Figure 6: Calibration: model fit

The figure displays the fit of the model relative to data. The four panels to the left depicts the labor income, savings, stock market participation and equity shares of the passive model type. We match this type to default and passive investors in our data. The four panels to the right depict the same variables for the active model and investor type.



5 Effects of default fund design

In this section we report the implications of different equity exposure in the default fund of the DC account. We start by studying the shift in expected pension for passive investors associated with different equity exposure. We then focus on the welfare gains and losses by focusing on consumption equivalents. We also investigate the consequences for the active investors, should they be forced into a universal pension fund. Finally, we study the implications for inequality—in pensions, wealth and consumption—of the introduction of a universal pension fund.

5.1 Simulation method

In our simulations one economy consists of 1,000 individuals (which are either passive or active) and their entire consumption sequence over the life-cycle. For each default fund design we simulate 100 such economies. Within each economy the sequence of shocks to the stock market, $\{\varepsilon_t\}_{t=20}^{T}$, is the same for each individual. Across economies, the idiosyncratic shocks to labor income, $\{\eta_{it}\}_{t=20}^{T}$, are the same, but the shocks to the stock market are different. Thus we generate the accurate cross-sectional dispersion within a single economy and by simulating 100 economies we in turn generate the accurate probability distribution of the stock market's impact . Finally, for all the designs of the default fund we are careful to re-use the same set of idiosyncratic income shocks and shocks to the stock market. This ensures that the comparisons in terms of welfare, individual by individual, are meaningful.

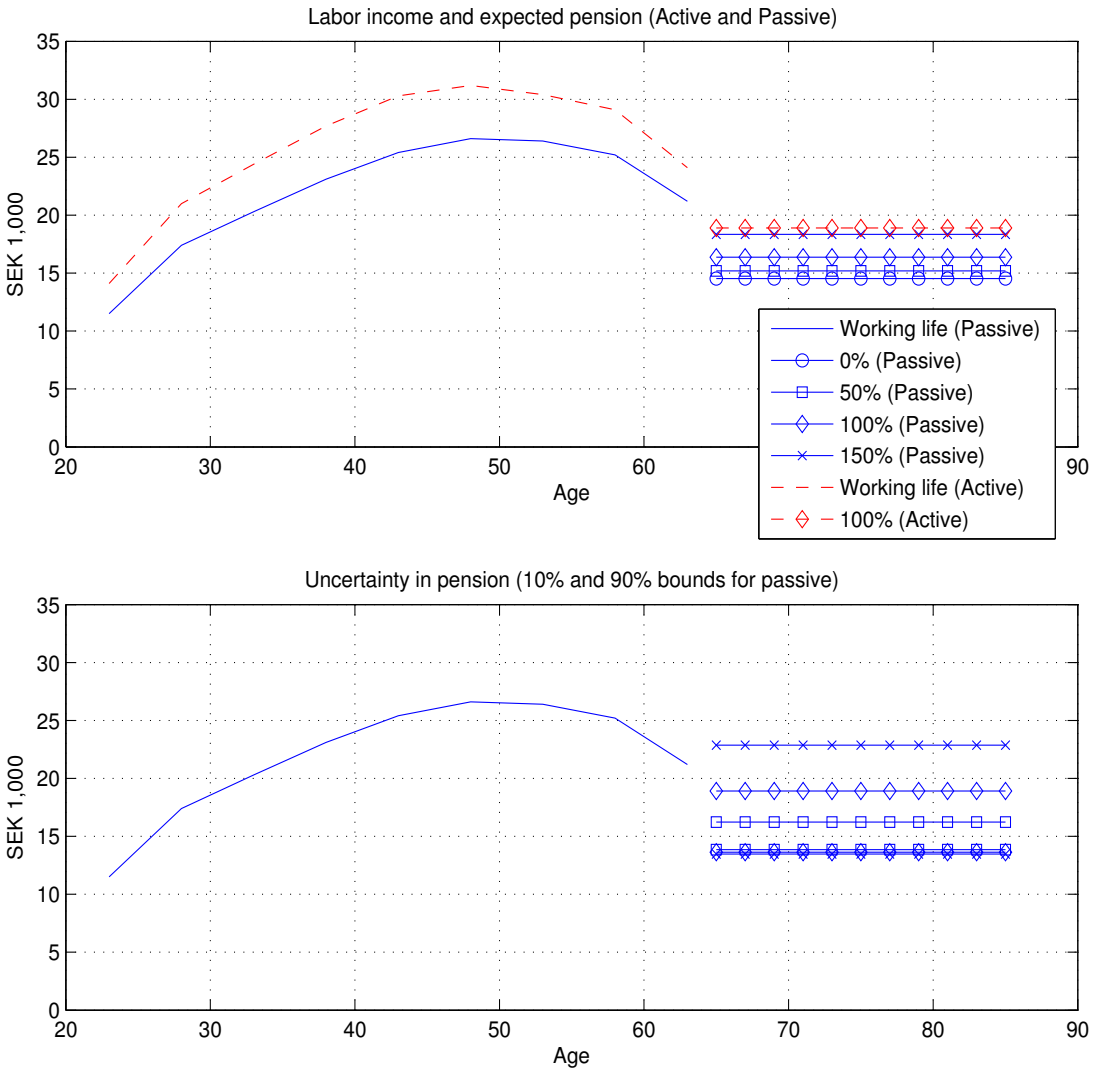
5.2 Pension and replacement rates

The top panel of Figure 7 displays passive individuals' average labor income during working life, followed by their average expected pension under different designs of the default fund. Labor income at age 64 just before retirement equals 205 kSEK. The expected pension lies in the interval 145 kSEK to 183 kSEK, corresponding to replacement rates from 70 to 89 percent. Thus, a shift from 0 to 150 percent equity exposure lifts the expected pension by an impressive 19 percentage points. An equity share of 100 percent implies a replacement rate of 80 percent. In comparison, active individuals' labor income at 64 is equal to 232 kSEK and their exposure of 100 percent leads to an expected pension equal to 189 kSEK, implying a replacement rate of 81 percent.

The bottom panel of Figure 7 displays the uncertainty on passive individuals' pension. Specifically, the figure shows the 10 percent worst outcome and the 10 percent best outcome, depending on how the stock market has evolved during working life. As can be seen, there is considerable variation even under 50 percent equity exposure in the default fund. With greater degree of exposure, the uncertainty widens additionally. Under the worst outcome, the pension corresponding to each design of the default fund almost pile up on each other, at about a pension of 135 kSEK. There is considerably more variation under the best outcomes. Under 150 equity exposure, the

Figure 7: Labor income and pension

The top panel displays average labor income during working life for active and passive individuals. For the retirement phase, the top panel shows the expected pension for passive individuals under different degrees of equity exposure and the expected pension for active individuals provided that they hold 100 percent equity in their DC account. The bottom panel shows the probability distribution of pensions under different stock market returns for the passive individuals. The plots display the 10 percent worst and the 10 best outcome under 50, 100 and 150 percent equity exposure.



probability is 16 percent that the pension exceeds labor income at age 64. To account for this uncertainty in the pension, we proceed to employ certainty equivalents in consumption.

5.3 Welfare metrics

We analyse welfare effects using consumption equivalents. We describe our welfare criteria in the following section.

5.3.1 Certainty equivalent consumption

In our welfare criteria we use the notion of certainty equivalent consumption. Since pension outcomes are uncertain, it is advisable to transform expected utility from consumption (in which poor and beneficial outcomes are weighted together) into the corresponding certainty equivalent consumption. We transform utility from a simulation of individual i's consumption sequence $\{c_{it}\}_{t=20}^{100}$ under a given default fund design to certainty equivalent consumption. The consumption equivalent c_e under any design of the default fund $\alpha^{DC} \in \{0, 50, 100, 150\}$ is given by:

$$\begin{aligned} W_T &= c_T \\ W_t &= \left(c_t^{1-\rho} + \beta\phi_t W_{t+1}^{1-\rho}\right)^{\frac{1}{1-\rho}} \ , 0 \leq t < T \\ W_{0,\alpha^{DC}} &= \left(\sum_{j=0}^{T} \Pi_{k=0}^{j} \beta\phi_k c_{k,\alpha^{DC}}^{1-\rho}\right)^{\frac{1}{1-\rho}} \\ &= c_{e,\alpha^{DC}} \left(\sum_{j=0}^{T} \Pi_{k=0}^{j} \beta\phi_k\right)^{\frac{1}{1-\rho}} \end{aligned} \tag{18}$$

where t=0 corresponds to age 20 and t=T corresponds to age 100. Notice that unlike equation (2), equation (18) does not include expectations or the coefficient for relative risk aversion. Once we have computed W_0 based on $\{c_{it}\}_{t=t_0}^{T}$ we use the same recursion to find the consumption equivalent $c_{e,\alpha^{DC}}$.

We then proceed in three steps to derive an expression for welfare gains (loss) in terms of an increase (decrease) in the consumption equivalent which is concentrated to the retirement phase, i.e. age 65 to 100. We do so in order to be able to make straightforward comparisons to the expected gains and losses in pension.[13] The first step is to note that welfare under an alternative design of the default fund of can be expressed as:

$$U_{0,\alpha^{DC}} = c_{e,\alpha^{DC}} \left(\sum_{j=0}^{T_r-1} \Pi_{k=0}^{j} \beta\phi_k + \sum_{j=T_r}^{T} \Pi_{k=0}^{j} \beta\phi_k\right)^{\frac{1}{1-\rho}} \tag{19}$$

where T_r equals the age of retirement. Second, note that if we would like to obtain the change in

[13] This can also be motived by looking at the consumption paths over different fund designs, which mainly deviate from each other during retirement.

consumption relative to the baseline, $x_{\alpha^{DC}}$, isolated to the retirement phase it corresponds to the following expression:

$$U_{0,\alpha^{DC}} = c_{e,100}\left(\sum_{j=0}^{T_r-1}\Pi_{k=0}^{j}\beta\phi_k + x_{\alpha^{DC}}^{1-\rho}\sum_{j=T_r}^{T}\Pi_{k=0}^{j}\beta\phi_k\right)^{\frac{1}{1-\rho}} \tag{20}$$

Thus $x_{\alpha^{DC}} - 1$ represents the gain and loss in consumption during the retirement phase from shifting equity exposure away from 100 percent. Third, we substitute equation (19) into equation (20) and solve for $x_{\alpha^{DC}}$:

$$x_{\alpha^{DC}} = \left(\frac{c_{e,\alpha^{DC}}^{1-\rho}\sum_{j=0}^{T}\Pi_{k=0}^{j}\beta\phi_k - c_{e,100}^{1-\rho}\sum_{j=0}^{T_r-1}\Pi_{k=0}^{j}\beta\phi_k}{c_{e,100}^{1-\rho}\sum_{j=T_r}^{T}\Pi_{k=0}^{j}\beta\phi_k}\right)^{\frac{1}{1-\rho}} \tag{21}$$

5.4 Cross-sectional effects for passive individuals

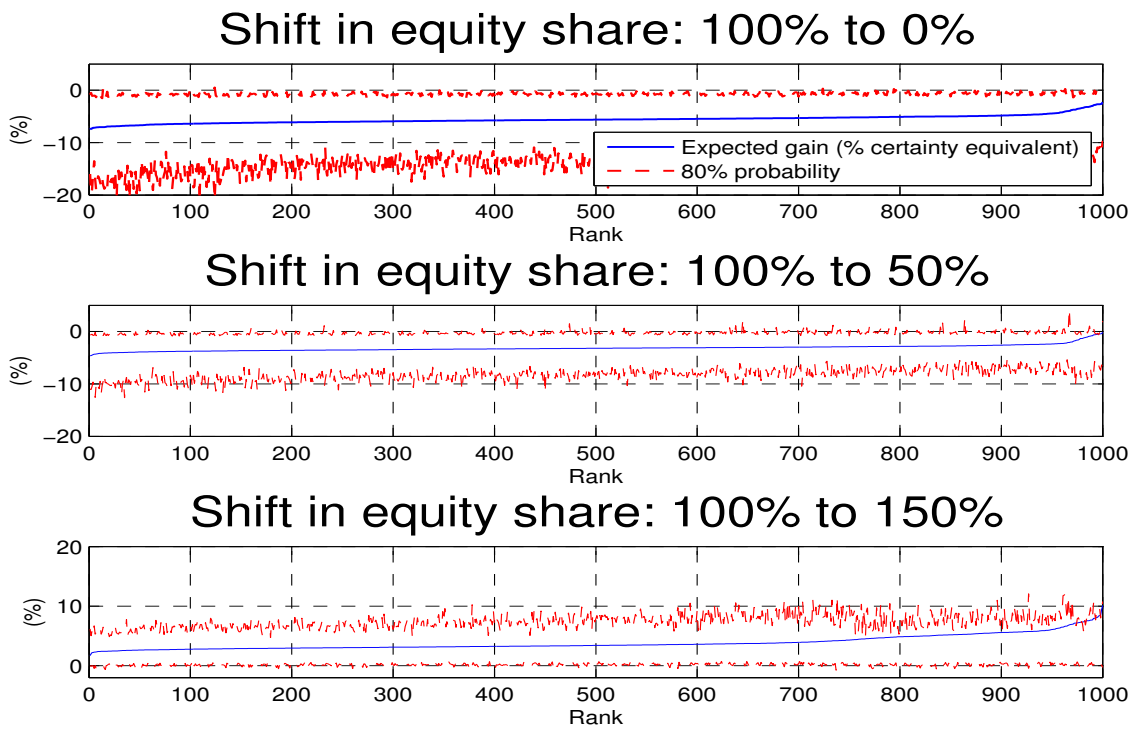
Figure 8 displays the welfare effects for 1,000 passive individuals upon a shift from an equity share of 100 percent to three alternative default funds. In each panel the individuals have been sorted based on expected effect over the 100 economies, from lowest expected gain to highest expected gain. The alternative default funds hold an equity share of 0, 50 or 150 percent instead of the baseline of 100 percent. The solid blue lines shows the expected effect (the mean across the 100 economies). As can be seen in the top and middle panel, all of the 1,000 individuals lose, in expectation, from a reduction in equity exposure. The average passive investor can expect to lose 5.6 percent of consumption, annually during retirement, following a reduction from 100 to 0 percent. The average passive investor can expect to lose 3.2 percent if the default fund reduces its equity share from 100 to 50 percent. The bottom panel shows the effect from increasing the equity share from 100 percent to 150. The average investor can expect to gain 3.8 percent annually in retirement from such a change. The effect of a 50 percent increase or decrease relative to the baseline is thus fairly linear. An important insight from the analysis is therefore that the expected gain from introducing leverage in the default fund is substantial.

Another way to analyse the effects is to investigate the magnitude of a loss or gain that occurs with a probability of 10 percent. The red dashed lines in figure 8 display the 80 percent band of the welfare effect, across the 100 economies. In other words, they report the magnitude of a loss and a gain, respectively, that occur with ten percent probability. As can be seen, those magnitudes are substantial. It is a result of the high volatility of the stock market. It is also worthwhile to note that the gains and losses for a given shift in equity share is not symmetric due to the equity premium.

Further, the heterogeneity in expected losses or gains is fairly substantial. A shift to 0 percent

Figure 8: Cross-sectional effects for passive individuals

The figure displays the expected welfare effect for 1,000 passive individuals upon a shift in the equity share away from 100 percent. The welfare effect is measured as the percent increase or loss in consumption during the retirement phase. The blue solid line depicts the expected welfare effect over 100 economies (realisations of stock market returns). The dashed red lines indicates the welfare effect in the tails, specifically the 10th worst and the 10th best effect.



equities implies that 10 percent of passive investors lose 6.4 percent or more whereas the 10 percent who lose the least only lose 4.8 percent or less. The same is true for the distribution of gains in the bottom panel. The bottom decile gains only 2.8 percent or less whereas the top decile gains 5.6 percent or more. The heterogeneity in gains upon a shift to 150 percent spans from 2.8 to 5.6 percent.

5.5 Aggregate effects for passive individuals

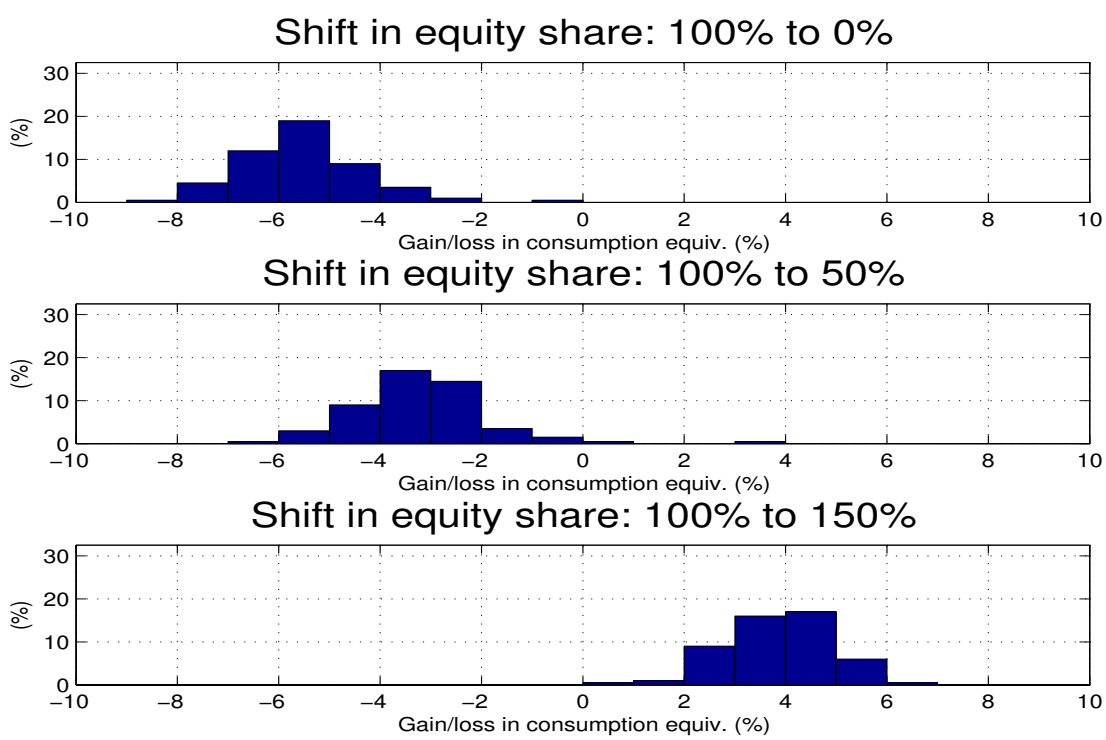
Yet another way of analysing the welfare effects is to focus on the aggregate effect in the 100 economies. First we consider the reductions in equity share, from 100 percent to either 0 or 50 percent. Since a reduction in the default fund's equity share implies that the passive investors forego the equity premium, the likelihood of a loss is quite high. A reduction in the equity share from 100 percent to 0 percent (50 percent) implies a loss with essentially certainty (with 98 probability). Similarly, an increase in the equity share from 100 percent to 150 percent produces

a gain with almost certainty.

The histograms in Figure 9 represent the probability density functions over the 100 economies. A reduction all the way down to no equity exposure implies that 34 percent of the economies suffer a loss greater than -6 percent which is a very large number (the top panel). For the case of a reduction in the equity share down to 50 percent, still as many as 25 of the 100 economies produce losses greater in magnitude than -4 percent but only one economy out of 100 produce a loss greater than -6 percent (middle panel). The positive effect of an increase in the equity share to 150 percent displays almost a symmetric distribution compared to the shift to 50 percent (bottom panel versus middle panel). The chance of a gain greater than 6 percent is just one percent.

Figure 9: Aggregate effects for passive individuals

The figure displays the probability density function of average welfare effects following a shift away from 100 percent equity share in the default fund. It is based on 100 economies of 1,000 passive individuals.



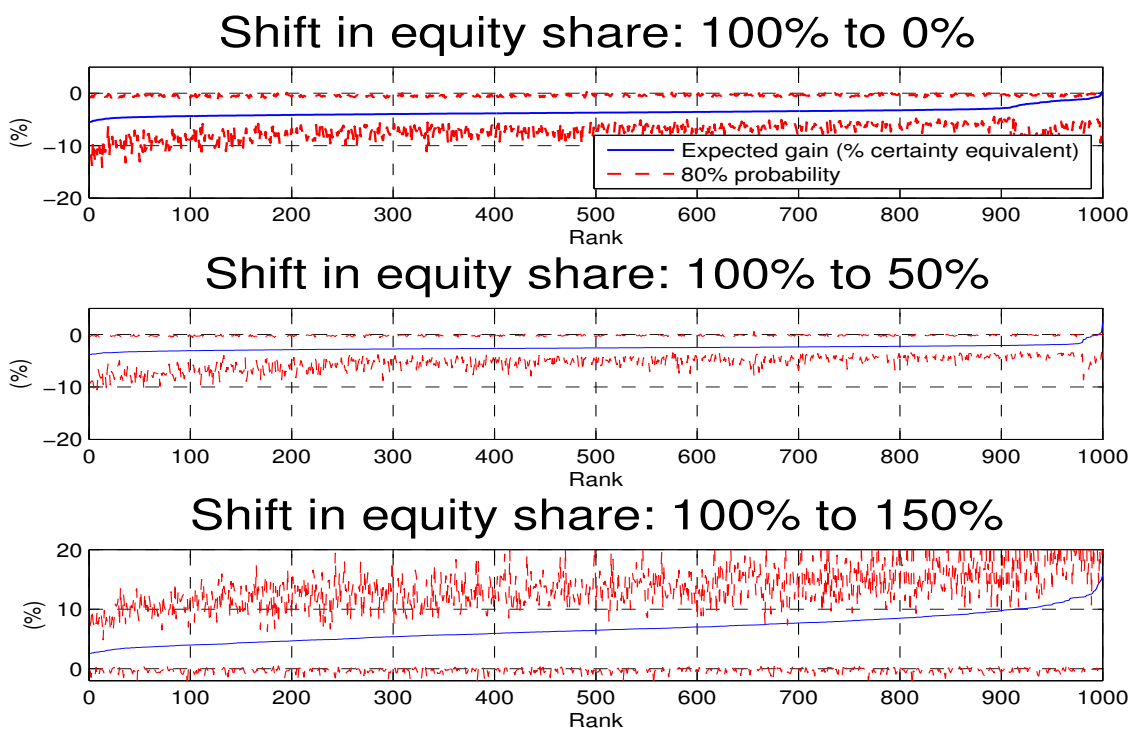
In sum, our results suggests that the welfare effect from a reduction or an increase in equity share of the default fund is fairly symmetric. The losses and gains from shifting the equity share are of about the same magnitude.

5.6 Welfare effects for active individuals

We now turn to how the active individuals are affected if a universal pension fund is introduced. For now, we assume that free choice implies an equity share of 100 percent so the meaningful designs of the universal pension fund is equity shares below or above that. Figure 10 displays the cross-sectional distribution of the welfare effects. Overall, the pattern is similar to that for the passive individuals. However, a closer inspection reveals that whereas the solid blue line of expected losses have the same slope for active and passive individuals, the slope for the gain is much greater. There is a difference in gains of 5.8 percentage points for active but only 2.8 percentage points for passive individuals. This means that there are active individuals who gain a lot more from a very high equity exposure in the universal pension fund than passive individuals.

Figure 10: Cross-sectional effects for active individuals

The figure displays the expected welfare effect for 1,000 active individuals upon a shift in the equity share away from 100 percent and into a universal pension fund with an equity share of either 0, 50 or 150 percent. The welfare effect is measured as the percent increase or loss in consumption during the retirement phase. The blue solid line depicts the expected welfare effect over 100 economies (realisations of stock market returns). The dashed red lines indicates the welfare effect in the tails, specifically the 10th worst and the 10th best effect.

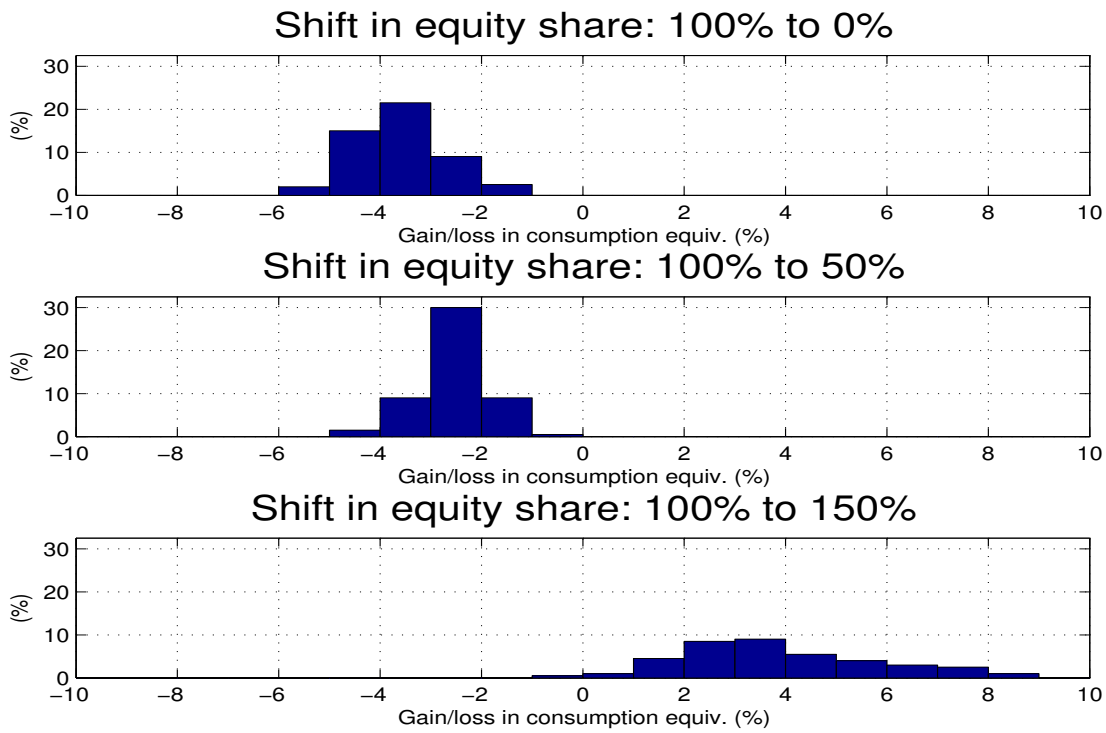


Turning to the aggregate effects among active individuals, we find quite a different pattern compared to passive individuals. First, a shift to a lower equity share in active individuals' DC accounts, implies that losses are more contained than for passive individuals. The probability

of an aggregate loss greater than 6 percent has virtually a probability of zero, compared to 34 percent for passive individuals. Similarly, a shift to 50 percent exposure yields a loss greater than 4 percent with a 25 percent probability for passive individuals but only 3 percent probability for active individuals. Second, if there is a shift from 100 to 150 percent equity exposure, the chance that passive individuals gain more than 5 percent is only 13 percent for passive individuals but as high as 42 percent for active individuals. Taken together, this means that active individuals lose less from a reduction in their equity exposure but gain more from an increase in the exposure. We analyse the forces behind these effects in the next subsection which studies responses in savings and portfolio choice.

Figure 11: Aggregate effects for active individuals

The figure displays the probability density function of average welfare effects following a shift away from 100 percent equity share into the universal pension fund with either 0, 50 or 150 percent equity share. It is based on 100 economies of 1,000 active individuals.



5.7 Responses in behaviour

In order to understand the effects on welfare, we now turn to the analysis of how behaviour—in terms of savings, consumption and stock market participation—respond as the degree of equity exposure in the pension fund shifts. Figure 12 shows how the passive and the active type adjust

their behaviour as a response to a shift in the equity share of the pension fund. All eight panels show the means for the 50, 100, and 150 percent fund. Overall, passive and active investors respond very similarly. A lower equity exposure leads to more savings outside the pension system, less consumption in retirement, a higher degree of stock market participation and a higher equity share. At a granular level, it is worthwhile to note that passive individuals respond more in terms of participation if the equity share in the pension system shifts to 50 percent. Active investors increase their participation rate by 1.5 percentage points whereas passive investors increase their participation by 3 percentage points. Thus, active and passive investors become somewhat more similar in their portfolio choice if the equity share in the pension system decreases. The response in savings outside the pension system is however very similar. Active (passive) individuals increase their savings by 7.7 percent (7.3 percent) if the equity share of the pension system is reduced to 50 percent. If the equity share shifts to 150 percent, active individuals (passive) reduce their savings by 3.5 percent (3.7 percent).

In unreported results, we further investigate the role of individuals that shift participation status and how their behaviour affects the aggregate welfare results and compare their gains and losses relative to those that remain participants or non-participants. We find that the effect across these sub-categories are not very different. The aggregate effect most likely resembles the effect among those that do not change participation status, which is the vast majority of individuals (97 percent or more).

5.8 Effects on inequality

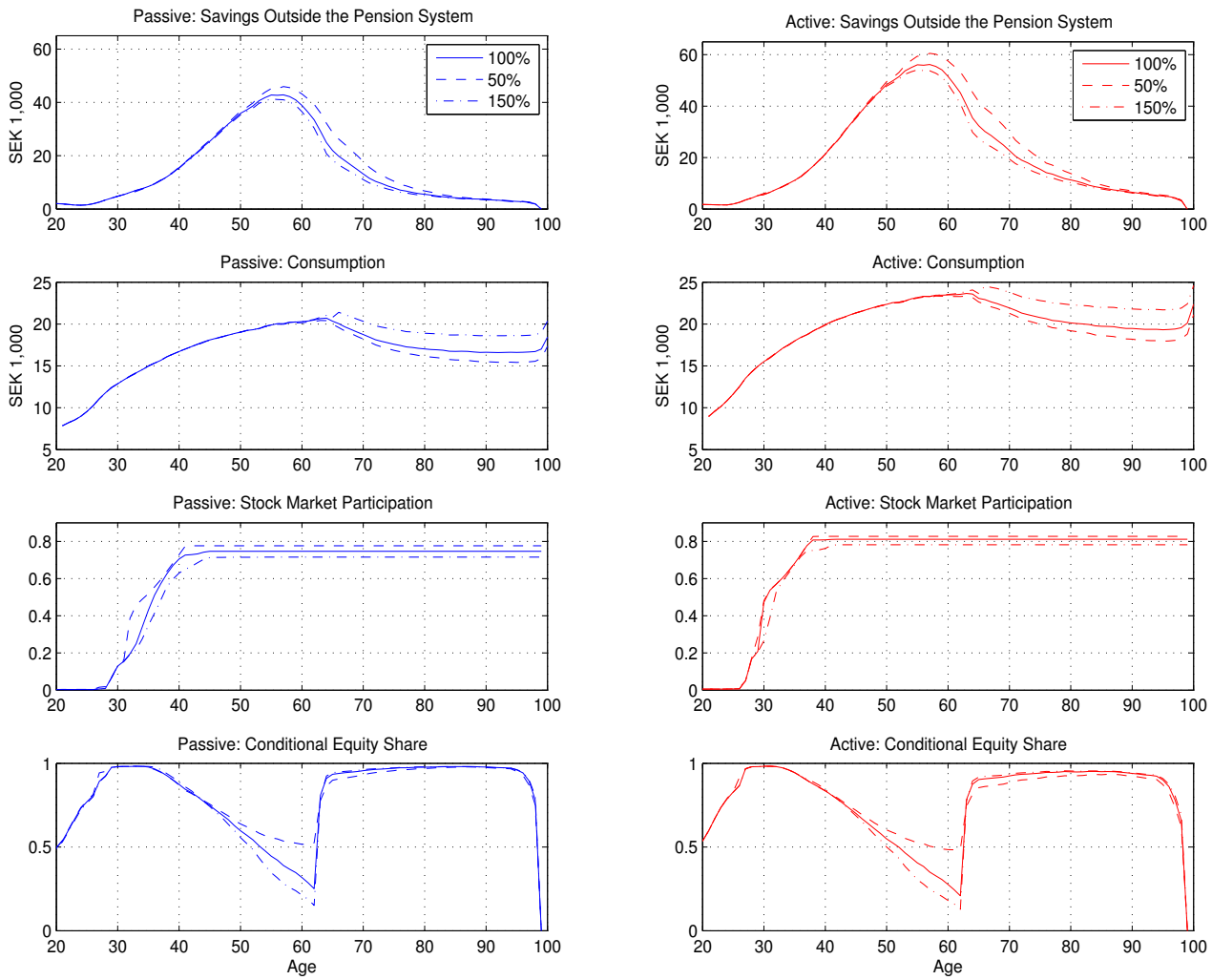
Having explored the effects on individuals' savings and portfolio choice, we now turn to the study of the cross-sectional distributions of pensions, savings outside the pension system and consumption as an effect of the introduction of a universal pension fund. Since the cross-sectional distribution is a function of the realisation of stock market returns we focus on the expected (average) effects per decile over our 100 economies. By doing so, we control for the difference between economies that arises due to differences in realised stock market returns.

5.8.1 Pension

Figure 13 displays the expected pension by decile under the different designs of the pension fund. The lower the equity share, the lower is the expected pension in all points of the distribution. Interestingly, the sensitivity with respect to equity exposure is quite different. The lowest deciles are barely affected by the equity exposure. Their pension remains in the interval from 10 to 12 kSEK (an increase of 20 percent), regardless of the degree of exposure. In contrast, the pension for the highest decile spans the interval 22 to 30 kSEK (an increase of 36 percent). This is due to the fact that the income poorest individuals have very small instalments into their DC account and to the fact that the government commits to a guaranteed minimum pension out of the notional

Figure 12: Responses in behaviour

The figure displays means of savings, consumption, stock market participation and the equity share in savings outside the pension system conditional on participation. Average across 1,000 passive and active individuals across 100 economies.



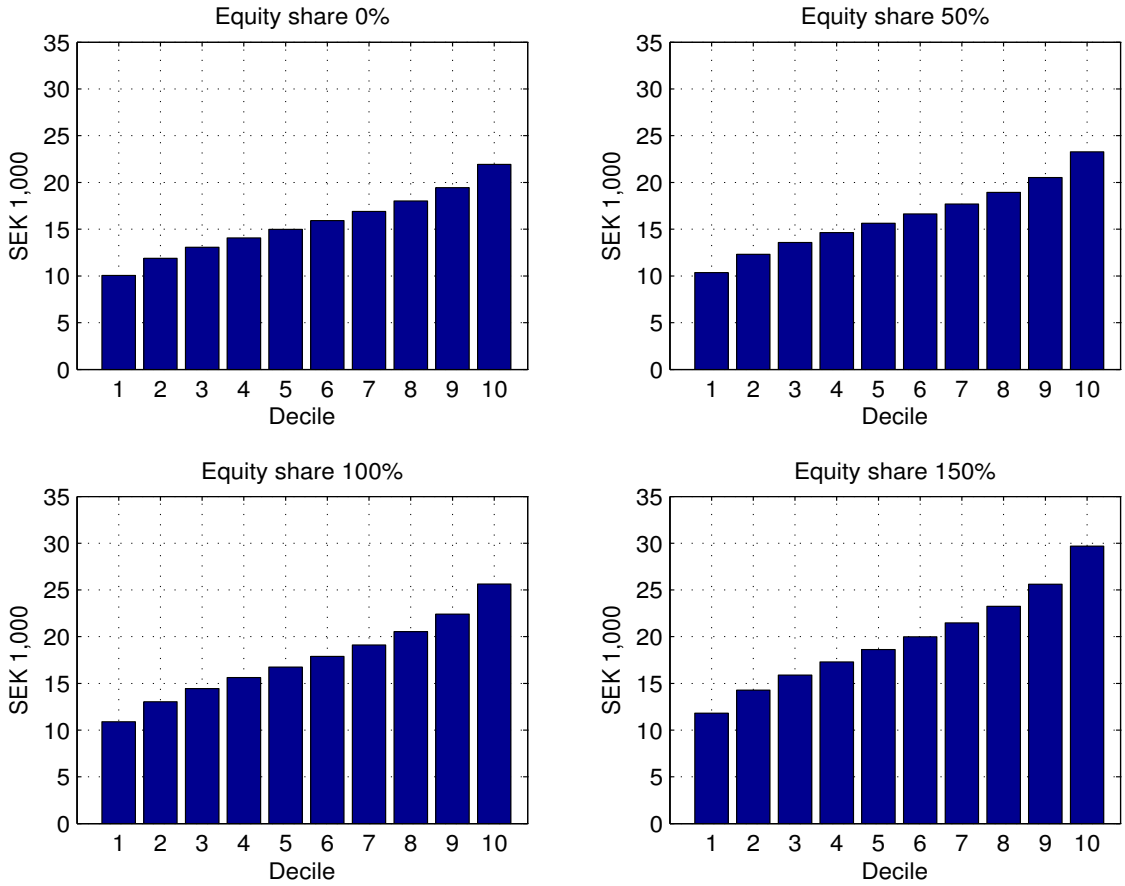
account. This differential effect across the income distribution is likely to be one reason why active individuals gain more than passive from a very high equity exposure in the pension fund.

5.8.2 Savings outside the pension system

Turning to savings outside the pension system in Figure 14 we see quite dramatic effects. The figure displays the cross-sectional distribution of savings outside the pension system at age 65. Comparing the case with 150 percent equity exposure to the case of no equity exposure we see

Figure 13: Distribution of pension

The figure displays total annuity payments out of all pension accounts by decile in the cross-sectional distribution. Average over 100 economies consisting of 1,000 passive and 1,000 active individuals.



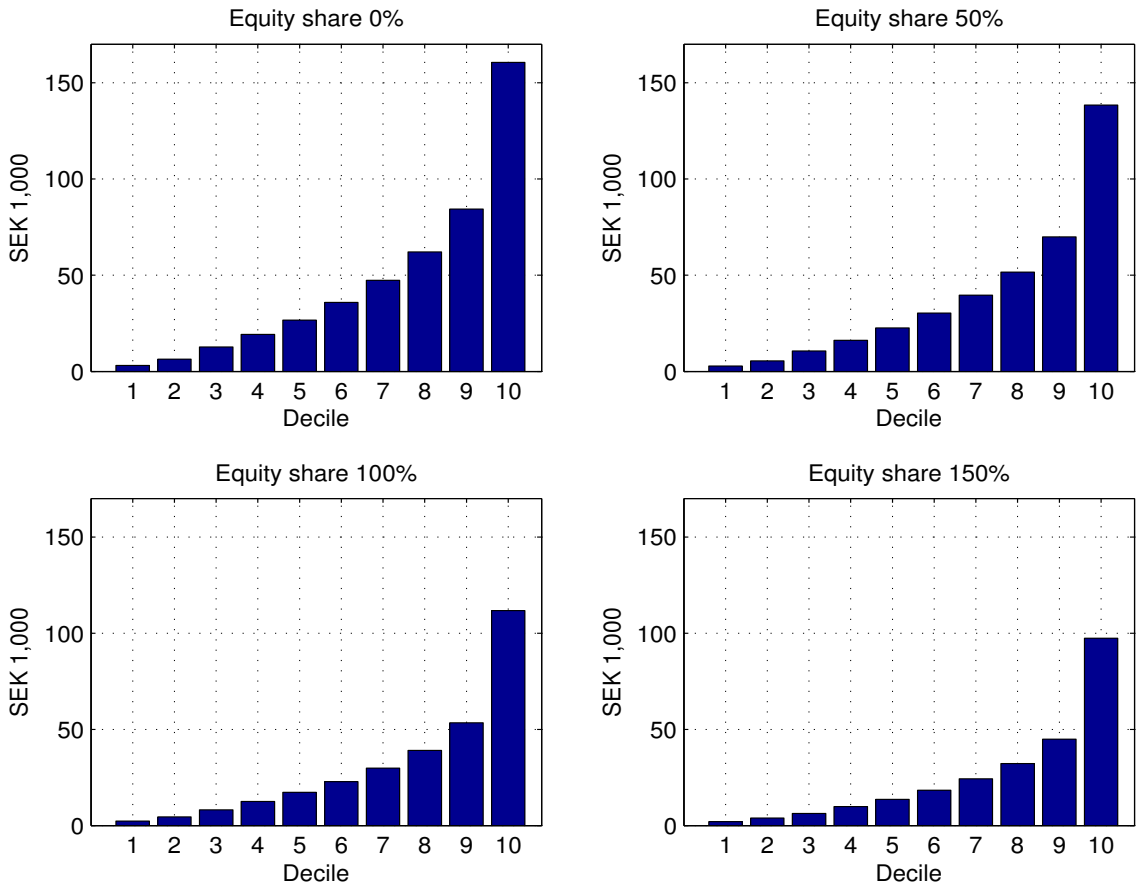
that savings outside doubles for every decile. This means that the richest decile which have savings outside the pension system of about 120 kSEK in the baseline increase their savings to 170 kSEK if the pension fund has no equity exposure.

5.8.3 Consumption in retirement

The reason for the dramatic shift in savings is the motive to save for consumption in retirement. Figure 15 displays the distribution of average consumption in retirement. The shifts in consumption in retirement are much more moderate since the shifts in savings counteract the shifts in equity exposure. Nevertheless there is a slight shift in consumption inequality. A shift from 100 to 150 percent equity exposure implies that the top decile increases consumption 11.9 percent and the increase correlates perfectly with the rank of the decile. The bottom decile gains 8.3 percent in consumption. A shift from 100 to 0 percent equity exposure implies the opposite relationship–the

Figure 14: Distribution of savings outside the pension system at age 65

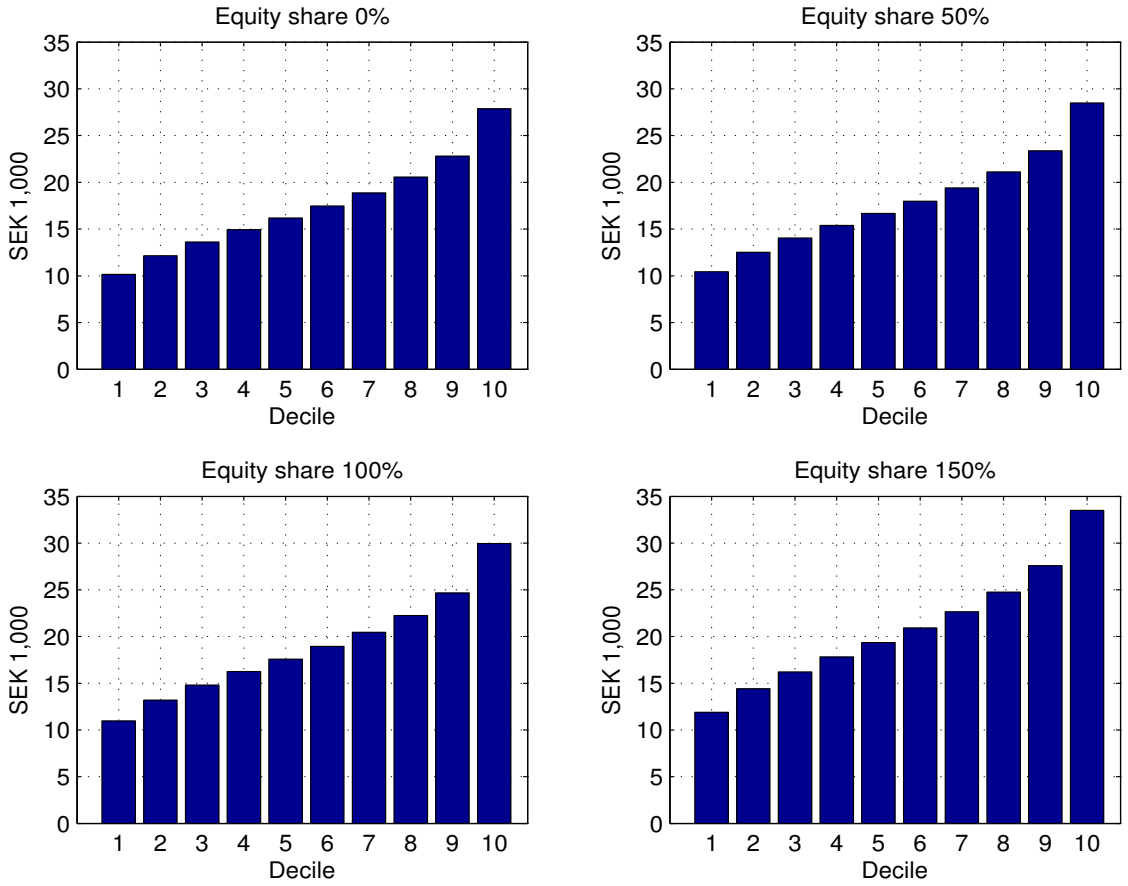
The figure displays savings at age 65 by decile in the cross-sectional distribution. Average over 100 economies consisting of 1,000 passive and 1,000 active individuals.



top decile loses 6.9 percent and the bottom decile loses 7.5 percent. Consequently, the 90/10 ratio is the lowest for a pension fund that has an equity share of 100 percent. This is also true for the 75/25 ratio and for the Gini coefficients which span 0.162 (no equity exposure), to 0.160 (100 percent equity exposure) to 0.165 (150 percent exposure). Thus the Gini coefficient displays a U-shaped pattern with the bottom value at 100 percent equity exposure.

Figure 15: Distribution of consumption in retirement

The figure displays expected consumption in retirement by decile in the cross-sectional distribution. For each individual, the average consumption during the entire retirement phase is used. Averages over 100 economies consisting of 1,000 passive and 1,000 active individuals.



6 Conclusion

We investigate how different equity exposure in the default fund of a mandatory DC pension plan affects welfare. We begin by documenting differences between default investors and investors who have opted out from the default in Sweden's DC plan with universal coverage. Our analysis is based on tailored registry-based data that include information about investors' portfolios in the DC plan as well as their portfolios outside the pension system. We find that investors who are in the default fund or who are passive — in the sense that they have not at all reallocated their savings in a period of eight years — are quite different from investors who are active. Default and passive investors are less educated, have less labor income and less financial wealth outside the pension system. They are also more reliant on their DC pension account since the fraction of their DC account balance relative to their total financial wealth is greater. We find that default and

passive investors have much less equity exposure outside the pension system compared to active investors. After controlling for a rich set of observable characteristics (such as education, labor income and financial wealth) default investors are nine percentage points less likely to hold stock or equity funds outside the pension system.

Motivated by these facts, we then ask how a default pension fund best can cater its selected group of investors. We consider a standard life-cycle portfolio choice model which we extend to incorporate the Swedish pension system. We investigate the effect on the default investors from different equity exposure of the default fund and find that an equity share above 100 percent is warranted in an expected utility sense. A shift from 100 to 150 percent equity share in the default leads to a welfare gain amounting to four percent of consumption during every year in retirement. The expected loss following a shift from 100 percent to only 50 percent equity exposure is of the same magnitude.

We also investigate the effects of abolishing free choice of equity exposure in the DC plan. This adds to the recent Swedish political debate where it has been proposed that free choice should be abolished because it produces excess inequality in pensions. We use our model to investigate the effects on welfare and inequality if active pension investors are forced into a universal pension fund. We find that active investors are less sensitive than passive to low degrees of equity exposure: if the equity share is 0 or 50 percent the active investors' expected loss is smaller than default investors'. However, if the equity exposure is 150 percent active investors gain more than default investors in expectation. Interestingly, we find that the effect of abolishing free choice on inequality among retirees is non-trivial. Though the effect on pensions is small, there is an effect on consumption inequality among retired individuals. Consumption inequality in retirement increases if the equity share of the pension fund is either lower or higher than 100 percent.

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A LINDA: Details

LINDA is a widely used data set in economic research. It is a joint endeavor between the Department of Economics at Uppsala University, The National Social Insurance Board (RFV), Statistics Sweden, and the Ministries of Finance and Labor. Edin and Fredriksson (2000) provide a detailed account of the data collection process for LINDA. More information on LINDA is also available from the web sites of the Department of Economics, Uppsala University (http://nek.uu.se/), and Statistics Sweden (http://www.scb.se/).

LINDA is a panel data set that covers slightly more than three percent of the Swedish population annually. There are approximately 300,000 core individuals of the data set. The starting point for LINDA is a representative, random sample of the Swedish population in 1994 which has been tracked back to 1968 and forward to 2007. New individuals are added to the database each year to ensure that LINDA remains representative of the cross-section of Swedish individuals. In addition, the data set contains information on all family members of the sampled individual. Thus, LINDA covers all members of approximately 300,000 households in each year. The core of LINDA are the income registers (Inkomst- och Förmögenhetsstatistiken) and population census data (Folk- och Bostadsräkningen). Each wave of LINDA contains information on taxable income and social transfers (e.g., unemployment benefits) from the Income Registers in a given year. In addition, LINDA contains information on occupation, wages, and educational attainment from separate registers held at Statistics Sweden. We also use the wealth supplement of LINDA, which is available between 1999 and 2007. The wealth supplement contains information on the market value of houses, owned apartments (co-ops), cabins, plots of land, and other forms of real estate. It also reports the value of total debt and the value of student loans.

When Statistics Sweden compiles LINDA, it lacks the information to assign two people that belong to the same household but that are unmarried and without children. Such individuals are treated as two separate households. This leads to under-sampling of this particular kind of household.

B Details on the pension accounts

As mentioned in section 4.3, carrying the balance of the notional account as a part of the individual's state is computationally demanding. To avoid this, we proceed as follows. First, we simulate many life-cycle income paths based on our calibration of the labor income process. For each path we calculate the true balance on the notional account according to the Swedish system. After that, we regress the true balance on the persistent component of labor income at the time of retirement, i.e. z_{65}. We use the coefficients from this OLS regression to approximate the account balance, with an accuracy (R-squared) of 85%. We use the approximate balance to compute the annuity that is paid out from the notional account during retirement.

We approximate the sum of the balance on the notional account and the occupational pension account for active and passive individuals at age 65 with one linear regression for each type:

$$A^N_{i65} + A^O_{i65} = \beta_0 + \sum_{j=1}^{n} \beta_j z^j_{i65} + \varepsilon_{i65}$$

where $A^N_{i65} + A^O_{i65}$ is the sum of the true account balances at age 65 for individual i and z_{i65} is the persistent component of his labor income at that age. We experiment with different orders of the polynomial in z_{i65}, from n=1 to n=5 and find that in terms of R-squared there is little difference since it is 0.661 for the active individuals and 0.697 for the passive individuals. However, higher order polynomials is better at capturing the progressive nature of the deposit rates (which includes a ceiling) so this leads us to use n=5. The top panel of Figure 16 reports the true cross-sectional distribution of the account balances at age 65 and the bottom panel the distribution that the approximation generates. Figure 17 reports the approximation error as a function of z_{i65}.

Figure 16: Distribution of Actual and Approximated Account Balances

The top panel displays the cross-sectional distribution of the actual balances on the notional and occupational pension accounts, based on a simulation of 2,000 individuals. The numeraire on the vertical axis is SEK 10,000. The bottom panel displays the corresponding distribution based on the approximation.

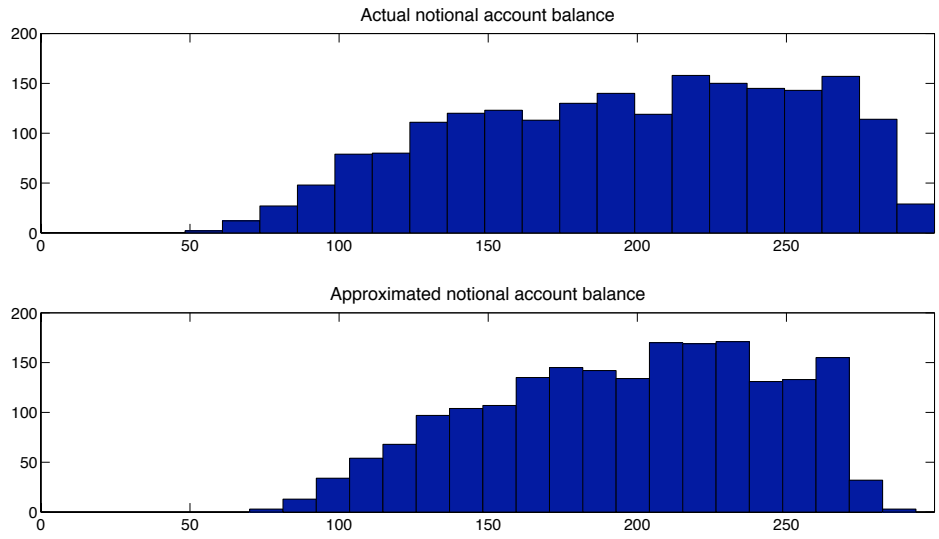

Figure 17: Approximation Error of the Account Balances

The left panel plots the approximation errors against the permanent component of income (z_{65}) based on a simulation of 2,000 individuals. The right panel displays the errors in percent.

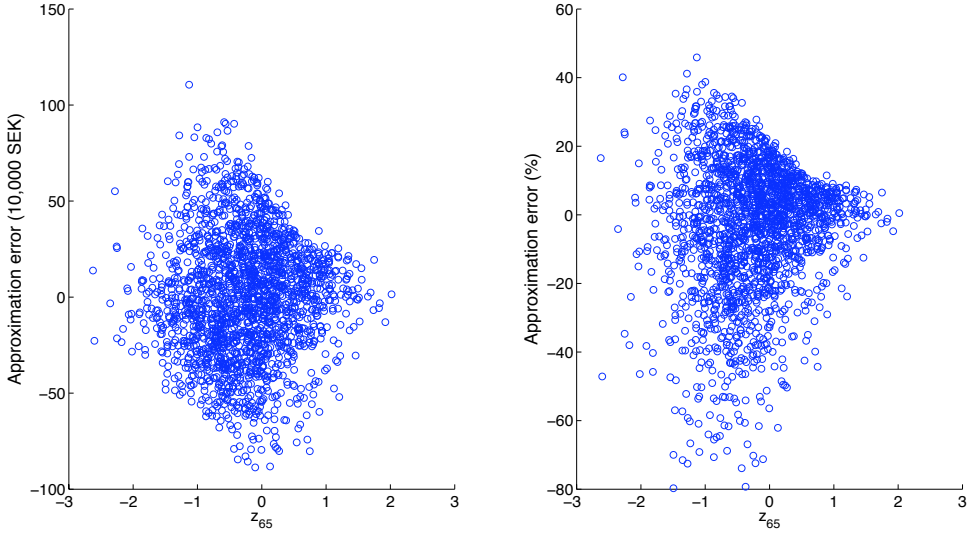

Table I: Averages of variables

	All	Default	Passive	Active
Individuals				
Number of individuals	337,032	116,476	94,273	126,283
Fraction of individuals	1.000	0.346	0.280	0.375
State variables				
Age	46.0	42.9	48.4	47.1
Labor income	233,747	182,531	239,848	276,432
Financial wealth	242,736	166,248	262,709	298,374
Stock market exposure				
Participation dummy	0.512	0.381	0.534	0.617
Equity share	0.203	0.141	0.210	0.254
Real estate ownership				
Real estate dummy	0.672	0.498	0.738	0.781
Real estate wealth	845,307	623,741	915,039	997,609
Net worth	709,632	487,356	793,697	851,891
Educational dummies				
Elementary school	0.163	0.204	0.170	0.120
High school	0.553	0.544	0.565	0.554
College	0.273	0.243	0.256	0.313
PhD	0.011	0.010	0.009	0.013

The table presents average of variables for all individuals in 2007 and for each investor category as defined in Section 3.2. Labor income refers to gross annual labor income. Financial wealth includes financial wealth outside of the pension system: bank accounts, direct bond holdings, direct stock holdings, mutual funds (equity, bond, and money market funds), as well as the balance on two savings products that are treated differently from a tax perspective (private pension accounts and capital insurances – Section 2 provides further information on those). The participation dummy is assigned a value of one if the individual holds either stocks or equity funds outside of the pension system. Equity share is the value of direct stock holdings and equity funds divided by all categories of financial wealth for which we have detailed security information (financial wealth minus private pension accounts and capital insurances). The real estate dummy is assigned a value of one if the individual owns either a house or an apartment (share in a co-op). Real estate wealth is the value of houses and apartments. Net worth is the sum of financial wealth and real estate wealth minus total debt (including mortgages, credit card debt, student loans, etc.). The educational dummies are assigned a value of one for the individual's highest obtained education.

Table II: Stock market participation outside the pension system

	I	II	III	IV
Default investor		–0.135***	–0.088***	–0.087***
		(0.002)	(0.002)	(0.003)
Passive investor		–0.055***	–0.037***	–0.038***
		(0.002)	(0.002)	(0.002)
Age	0.074***	0.017**		
	(0.007)	(0.007)		
Labor income	0.168***	0.132***		
	(0.004)	(0.004)		
Financial wealth	0.292***	0.287***		
	(0.002)	(0.002)		
Real estate	0.153***	0.130***	0.063***	0.054***
	(0.002)	(0.002)	(0.002)	(0.002)
High school	0.086***	0.074***	0.042***	0.039***
	(0.002)	(0.002)	(0.002)	(0.003)
College	0.152***	0.138***	0.072***	0.056***
	(0.003)	(0.003)	(0.002)	(0.004)
PhD	0.115***	0.113***	0.042***	0.026***
	(0.008)	(0.008)	(0.007)	(0.009)
Age/income/wealth splines	No	No	Yes	Yes
Geographical dummies	Yes	Yes	Yes	Yes
Industry & occupational dummies	No	No	No	Yes
R-squared	0.148	0.160	0.301	0.284
Number of observations	337,032	337,032	337,032	191,468

The table presents the results of regressions of a participation dummy (one if the individual participate in the stock market directly or indirectly outside of the pension system, zero otherwise) on a default dummy (one if the individual holds the default fund, zero otherwise) and a passive dummy (one if the individual is passive, zero otherwise). The other covariates are the state variables of a life-cycle portfolio choice model (age, labor income, and financial wealth) and a dummy for real estate ownership and educational dummy variables. Elementary school is the base for the educational dummy variables. Age is scaled down by 100, and labor income and financial wealth are scaled down by 1,000,000. See Section 3.3 and Table I for additional details on the covariates. Specifications III and IV replace the linear specification in age, labor income and financial wealth with piecewise linear splines. For brevity, the coefficients on these variables are not presented in the table. All specifications include geographical dummy variables. Specification IV includes industry and occupational dummy variables. The sample consists of individuals for the year 2007. Standard errors, robust to conditional heteroscedasticity, are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table III: Calibration

Description	Notation	Value
Preferences and stock market entry costs		
Discount factor*	β	0.88
Elasticity of intertemporal substitution	$1/\rho$	0.20
Relative risk aversion	γ	8
Stock market entry cost, active*	κ^A	25,000
Stock market entry cost, passive*	κ^P	25,000
Returns		
Gross risk-free rate	R_f	1.00
Equity premium	μ	0.04
Volatility (sd) of stock market return	σ_ε	0.18
Labor income		
Volatility (sd) of idiosyncratic persistent labor	σ_η	0.0995
Weight of stock market shock in labor income	θ	0.056
Ceiling for DC and notional account deposits	$\overline{Y}$	302,240
Floor for pension income	$\underline{Y}$	84,000
Defined contribution (DC) account		
Deposit rate out of gross labor income	λ	0.025
Notional account		
Deposit rate out of gross labor income	λ^N	0.16
Share of risk-free asset		100%
Occupational pension account		
Deposit rate out of gross labor income	λ^O	0.045
Share of risk-free asset		40%
Life-cycle profiles		
Labor income profile**	g_t	-
Survival rates	ϕ_t	-

The table presents the parameter values of the model. * indicates that the parameter value has been determined endogenously by simulation of the model (see section 4.8.2 for further details). ** notice that passive and active individuals have different labor income profiles, displayed in figure 6. The survival rates are computed from the unisex statistics provided by Statistics Sweden.