Medical Expenses and Saving in Retirement: The Case of U.S. and Sweden*

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Mulligan Funding

January 5, 2023

Abstract

Many U.S. households have significant wealth late in life, contrary to the predictions of a simple life-cycle model. By comparison, retirees in Sweden decumulate wealth more quickly while facing smaller out-of-pocket medical expense risks late in life. In this paper, we investigate how well the latter can account for the former, using a full life-cycle consumption-saving model. We find that medical expense level and risk account for 32-59% of the U.S.-Sweden difference in retirees' speed of wealth decumulation, depending on age. We also show that financing and coverage of health insurance affect wealth decumulation patterns in retirement.

JEL classification: D14, E21, J26, J14

Keywords: Household finance, Aging, Retirement saving, Health, Cross-country analysis.

1 Introduction

Many U.S. households have significant wealth late in life. A number of papers have addressed this so-called retirement saving puzzle (RSP). The literature attempts to disentangle which of a few key reasons are the most important in accounting for the wealth patterns we see in the data. Key reasons that are studied are bequest motives, precautionary motives, and the role of high out-of-pocket (OOP) medical expense risk. Relative importance of these and other factors can vary depending on choices of model and estimation strategy, data sample and country studied. For example, the life-cycle model that is used in this literature usually starts at

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retirement, which may impact parameter values and insights from the model. Saving behavior before retirement may matter for dissaving behavior in retirement, and may impact relative importance of various factors studied.

In this paper, we continue our and others' research on the role of medical expense risk on saving in retirement. To do this, we compare saving in retirement in two countries: the U.S. and Sweden. While in the U.S. wealth profiles in retirement are relatively flat, in Sweden (and other Northern European countries) retirees' wealth decumulation is noticeably faster. At the same time, we document that U.S. retirees face much higher average OOP medical expenses late in life, as well as higher risk of large medical expenses, than their Swedish and Northern European counterparts. We aim to shed light on possible links between these two cross-country facts, and study how much dissaving in retirement is impacted by OOP medical expense risk. In the process, we also disentangle the role of gross medical expense risk from that of health insurance coverage.

A cross-country comparison requires acknowledging that institutional differences between the two countries are not limited to healthcare risk. There are also differences in other institutions that impact lifetime saving during and, importantly, prior to retirement. To address this point, in this paper, unlike our previous single-country work, we use a full life-cycle model that captures key institutional differences between the U.S. and Sweden aside from healthcare risks. By doing this, we will be able to separately evaluate the influence of gross medical expense risk, health insurance coverage and financing schemes, and lifetime income risk on saving behavior *prior to and after* retirement. We estimate the model using U.S. data. Then we introduce observable features of the Swedish economy to the estimated model, emphasizing those that contribute to smaller gross medical expense risk and higher health insurance coverage in Sweden, to see how the wealth decumulation profile changes.

We emphasize four main findings. First, the model predicts that key institutional characteristics of the Swedish economy can account for some of the faster decumulation of wealth in retirement in that country. Specifically, we quantify that the model with salient features of the Swedish economy can account for up to 25%, 17%, and 82% of the difference in median wealth decumulation rates between the U.S. and Sweden at ages 75, 85, and 95, respectively. If we consider mean wealth instead of median, the model can account for even larger fractions of the differences at different ages.

Second, OOP medical expense risk plays an important role in determining saving behavior in retirement. A U.S. model calibrated with either Swedish gross medical expense risk profile or health insurance coverage level can account, at ages 85 and 95, for 32% and 59% respectively of the difference in median wealth decumulation rates between the two countries. This finding is consistent with the literature (e.g., De Nardi et al. (2010), Kopecky and Koreshkova (2014), and Banks et al. (2019)) which also find that medical expense risk is an important determinant of wealth decumulation and consumption profile after retirement. Relatedly, Swedish health insurance coverage can account for similar shares of the differences, since high health insurance coverage implies low OOP medical expense risk.

Third, we find that the financing structure and timing of health insurance has a significant impact on the life-cycle profile of wealth. When households pay more for health insurance after retirement, which is the case in Sweden, they bring more wealth into retirement to cover that expense. When some of the health insurance is done through means-tested programs like Medicaid, this can depress saving in retirement. We demonstrate how these two channels interact.

Fourth, using our full life-cycle model, we find that pre-retirement saving decisions, which most RSP literature abstracts from, significantly impact post-retirement saving profiles. When medical expense risk is shut down or eliminated in a version of the model that only includes the post-retirement life cycle, we find that wealth decumulation is accelerated, in agreement with the literature, because precautionary saving against medical expense risk declines. However, our benchmark *full* life-cycle model indicates that this acceleration is exaggerated, because it does not allow pre-retirement saving behavior to adjust downward in response to anticipated lower medical expense risk. In our full life-cycle model, households carry less wealth into retirement when medical expense risk is shut down, creating a less accelerated wealth decumulation profile in retirement than in the post-retirement model. Older households in a full life-cycle model still decumulate wealth faster absent medical expense risk, but at a slower rate than a model isolated to the post-retirement period.

Our work is related to several strands of literature. The first is the literature that provides explanations for the RSP using data on net worth post-retirement. De Nardi et al. (2016b) provides a recent survey. For example, Hurd (1989) studies the role of bequest motives and finds them to be small, Hubbard et al. (1995) find that government-provided social insurance should create a motive to dissave in retirement, Ameriks et al. (2011) study the relative importance of bequest motives and public care aversion for the related annuity puzzle, and Palumbo (1999) and De Nardi et al. (2010) emphasize the role of out-of-pocket medical expense risk in motivating the elderly to save. Lockwood (2012) considers the low demand for long-term care insurance as evidence of the relative importance of bequest motives versus precautionary motives. In our previous work (Nakajima and Telyukova (2017, 2020)), we found that housing plays an important role in preventing U.S. households from decumulating wealth late in life, and that options like reverse mortgages do not result in faster liquidation of housing wealth in retirement. Yogo (2016) studies portfolio allocation decisions between bonds, stocks, and housing for retirees facing health risks.

We note that the single-asset model that we use in this paper to study the entire life cycle does not allow us to account for relatively illiquid housing assets, which constitute significant portfolio shares of retirees both in the U.S. and Sweden. Based on Venti and Wise (2004), Blundell et al. (2016), and our previous work (Nakajima and Telyukova (2017, 2020)), we understand that housing plays a crucial role in accounting for slow dissaving in retirement. McGee (2019) is a related paper that studies how shocks to house value affect wealth decumulation. Thus, we acknowledge that a model without housing cannot capture all of the explanations of retiree dissaving patterns in retirement. However, for our focus on the cross-country comparison of the influence of medical and LTC expenses, a single-asset model serves the purpose well, and allows us to focus on differences in institutional features which are more important in this context.

The model in this paper is close to that of Kopecky and Koreshkova (2014). They build a full life-cycle model with income, health, and OOP medical and nursing-home expenses, calibrate the model to the U.S. economy, and use the model to quantify the size of savings attributed to OOP healthcare risk. Our paper has two key differences from their work. The first is that we bring in a cross-country perspective. The second is that our model also includes bequest motives, and we estimate the model using observed wealth decumulation profiles in the data. Relatedly, Floden and Lindé (2001) use a full life-cycle model calibrated to the U.S. and Swedish economies, but their focus is the differences in the pre-retirement earnings risk, and they do not model health or medical expense risk.

In addition, we contribute to the body of work that considers cross-country evidence on household portfolios, particularly among older households. Examples are Nakajima and Telyukova (2016), a companion paper in which we describe cross-country differences in housing in retirement across 12 countries, and Angelini et al. (2011), who characterize homeownership throughout the life cycle using the retrospective SHARELife survey. Christelis et al. (2013) characterize differences in the composition of entire household portfolios in a previous wave of the data that we use, and decompose the reasons for these differences into influences of institutional versus household characteristics. Blundell et al. (2016) compare wealth decumulation patterns of U.S. and U.K. households, while Banks et al. (2019) focus on the U.S.-U.K. differences in consumption profiles of older adults.

The rest of the paper is organized as follows. Section 2 presents data on wealth after retirement for the U.S., Sweden and other Northern European countries. Then we focus on the U.S. and Sweden, and present differences in medical expense and health risks between the two countries in Section 3. Section 4 presents our model, and Section 5 brings the model to the data. We use the model to understand the differences in wealth decumulation between the U.S. and Sweden in Section 6. Section 7 investigates interactions between two two forms of social insurance, namely consumption floor and health insurance. In Section 8, we contrast the implications of using just a post-retirement model for the question of the role of medical expense risks, as compared to our benchmark full life-cycle model. Section 9 concludes. Appendix A contains additional cross-country data. Appendix B and C provide details of how to calibrate the health transition dynamics before and after age 65, respectively. Appendix D presents results of the model with Nordic (average of five Northern European countries) health transitions. In Appendix E, we show results of an alternative model without discount factor heterogeneity. Appendix F provides context for the estimated parameters related to the bequest motive.

2 Data on Wealth after Retirement

We use two household surveys in our analysis. The first is the U.S. Health and Retirement Study (HRS), which incorporates a large sample from the Asset and Health Dynamics among the Oldest Old (AHEAD). The second survey is the Survey of Health, Aging, and Retirement in Europe (SHARE), which covers a cross section of European countries, including Sweden. Both surveys are biennial and longitudinal: the HRS was started in 1992 and SHARE in 2004. Because the panel dimension of SHARE was short at the time of analysis, we could not usefully construct life-cycle analyses of individuals or cohorts from it. Therefore, for easy comparison across countries, and unlike our previous work with the HRS in Nakajima and Telyukova (2020), we study the 2006 *cross-sectional* age profiles of the desired variables.

We use the RAND versions of the surveys. To augment RAND data, we added significant raw data from SHARE, incorporating it into a data set comparable to that of RAND HRS. A direct comparison of the data is possible across the variables of interest, upon conversion of currencies into 2000 U.S. dollars using real exchange rates and PPP adjustment. Compared to the HRS, SHARE has sparse coverage of respondents who are in nursing homes, but in the case of Sweden, this limitation is likely not crucial, because as we will show, Swedish policy provides for near-universal coverage of LTC expenses.

SHARE data has lower response rates than HRS. In Sweden, the response rates are about 54% for first-time respondents in the 2006 wave of the survey, as compared to the HRS response rate of 89% for that year. However, first-time response rates documented for Sweden are at or above average for SHARE countries in its early waves. In addition, retention rates in SHARE are high for Sweden at 71% in the early waves, and Sweden also has one of the lowest rates of missing data among responses. As an example, just 0.15% of responses are missing self-reported health data, and Sweden has among the lowest missing rates for economic variables like income (6.2%) and main residence (9.6%), as compared to double digits for most other countries. That is, Sweden has some of the best quality data in SHARE in the 2006 wave. In addition, SHARE addresses nonresponse with calibrated weights, and missing values with unfolding-bracket questions, as well as imputation, as appropriate. Finally, to address these issues further, we will present some of Sweden's data in conjunction with that from other Nordic countries. These countries have above-average response rates in the initial SHARE country pool, ranging from 58 to 64%, and similarly have missing data rates far below average for the founding SHARE countries. See Bergmann et al. (2019), HRS (2017), and Christelis (2011) for details.

Our samples in both surveys include both single and couple households, which will be mirrored in our model. We limit the sample only to those who report being mostly or fully retired, in order to remove variation in labor supply and labor income. In constructing age profiles, we stop at age 90. The reason is that unlike HRS, SHARE does not oversample the oldest old, and it has smaller country sample sizes overall. As a result, samples of the oldest retirees get too small to construct reliable moments. To smooth noise in the data for other ages, in both surveys we put households into 5-year centered age bins, so that age 65 is actually a bin of ages 63-67. Thus, each household is categorized into five different age groups, of its actual age as well as minus/plus two years. The resulting sample sizes in 2006 are 1,663 age-65 retirees in the HRS and 1,991 at age 69. This increase happens because for age bin 65, those of ages 63 and 64 are predominantly not retired and get dropped out of the data set. In SHARE's Sweden sample, there are 369 retirees in age bin 65, and the number increases to 399 at age 69. The sample sizes at age 89 are 452 for the U.S. and 59 for Sweden. Age-65 retiree samples for other countries we consider are 282 for Austria, 442 for Germany, 374 for the Netherlands, and 319 for Denmark.

Figure 1 presents age profiles of median net worth normalized by income in the U.S. and Sweden, as well as other Northern European countries, including Denmark, Germany, Austria, and the Netherlands. We normalize wealth by median income of the age-65 group, in order to control for cross-country income differences. We show additional countries here to highlight the differences between the U.S. and Sweden, while demonstrating that Sweden is not an out-

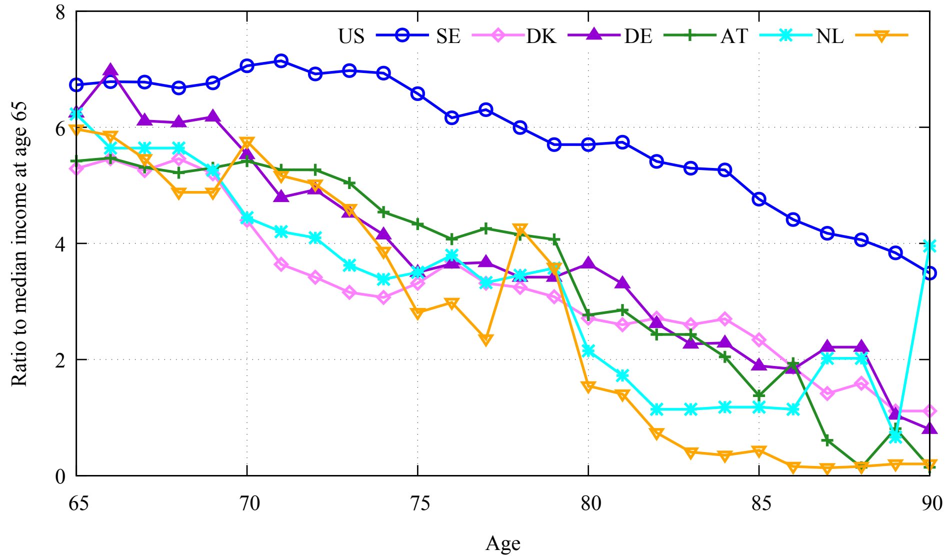


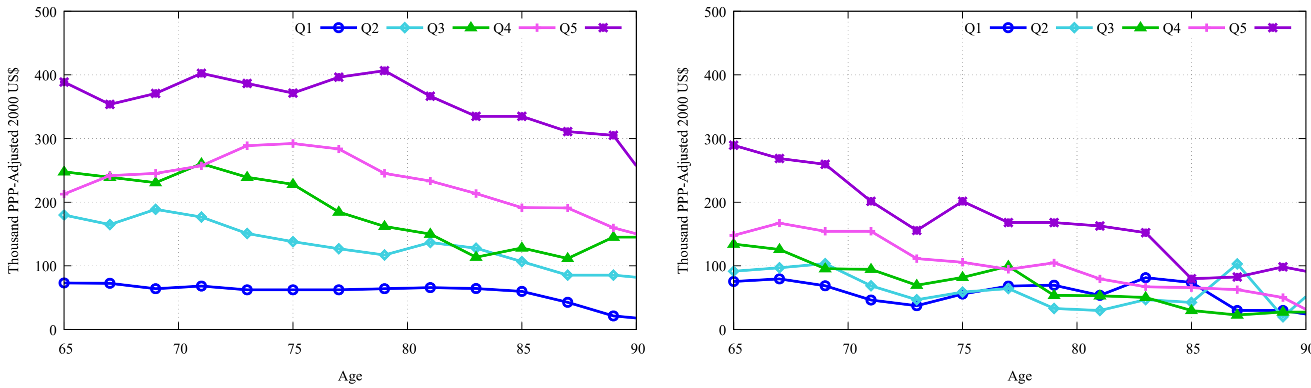
Figure 1: Median Net Worth Normalized by Median Income at 65, U.S. and Northern Europe

lier among the countries of Northern Europe in terms of these differences. We do not include Southern European countries here because they vary significantly in the amount of public provision of health and LTC services, while the Northern countries have health insurance policies comparable to Sweden, as we show in Nakajima and Telyukova (2016).

The graph clearly demonstrates that net worth decumulation among retirees is slower in the U.S. than in all the sample Northern European countries. The ratio of median net worth at age 90 to that at age 65 is 52% in the U.S., while it is 21% in Sweden, 12% in Denmark, 10% in Austria (measured at age 89, due to an outlier at age 90), 3.4% in the Netherlands, and 2.7% in Germany. This is the key motivating fact of this paper. Our goal is to understand what drives saving in retirement by studying what factors account for the differences in dissaving patterns between the U.S. and Northern Europe.

Figure 2 demonstrates that these differences in wealth decumulation patterns are present at all income levels. Specifically, the figure shows median net worth for each income quintile. While decumulation is the most dramatic for the highest-income retirees, wealth profiles are clearly flatter in the U.S. than in Sweden in all five income groups. In addition, this figure shows that wealth dispersion is higher in the U.S. than in Sweden.

As emphasized by De Nardi et al. (2010), data on wealth holding shown in this section are affected by survivor bias; if households with higher wealth tend to live longer, mean or median wealth profile is pushed up because of the change in the composition of survivors with age. As we discuss in the next section, Swedish individuals tend to live longer, which might indicate that survivor bias is weaker in the Swedish wealth profiles. Moreover, Figure 2 indicates that wealth dispersion in Sweden is smaller, which also weakens survivor bias in the Swedish data. Therefore, the stark contrast between the U.S. and Sweden shown in Figures 1 and 2 might be exaggerated. However, as in the experiments of De Nardi et al. (2010), we incorporate survivor bias into our model, and thus it is not an issue when the model outputs are compared with



(a) U.S. (b) Sweden

Figure 2: Median Net Worth Profiles by Income Quintile

the data. It is also important to note that when households tend to live longer, as with Swedes, wealth decumulation slows down, which counteracts standard survivor bias. We discuss the effects of higher longevity on wealth decumulation in Section 6.2.

3 Medical and Long-Term Care Expenses and Health

Unlike in the U.S., medical care across Europe is often insured by some combination of government-provided and mandatory private insurance (Allin et al. (2005)), with generous coverage, resulting in low OOP spending on health care for households of any age. According to Mossialos et al. (2016), Sweden's tax-based universal healthcare system is compulsory for the entire population, and it covers all expenses, with stringent mandated caps on OOP expenses. Participation in additional private insurance is voluntary. It accounts for less than 1% of all health care expenditure in the country and is associated mainly with occupational health services. In 2015, approximately 10% of Swedish working adults ages 15-74 had purchased private coverage. In contrast, in 2013 about 66% of U.S. residents received private health insurance, according to the same source. Public insurance in the U.S. is most prevalent in retirement and is provided by Medicare, with Medicaid available as a supplement for the poorest households. Medicare benefits are extensive but also rationed, and as we will show below, result in significant OOP expenses.[1]

As has been pointed out before by, for example, Brown and Finkelstein (2011), there is a lot more variation in Europe in *long-term-care* coverage. Sweden is among the countries that have the most comprehensive public coverage of LTC (OECD (2005)). Coverage is universal, i.e. not means-tested, and provides benefits for both home and institutional care. Services are provided by municipalities and regulated by federal law. According to Fukushima et al. (2010), users pay moderate monthly fees that are capped by the government. In 2007, the annual cap on LTC fees was SEK 19,344 (i.e., approximately $2,900) and this cap is further adjusted for income. For example, in 2006, 19% of home care recipients received the entire service for free. As a policy, Sweden has emphasized aging in place since the early 1990s, although providing

[1] See De Nardi et al. (2016a) for detailed information about Medicaid.

more institutional care has been in discussion in more recent years. Municipalities can choose to provide institutional and home care by purchasing from public or private providers, but by law the local authorities retain the ultimate responsibility for supplying and maintaining all the care services as well as the level of care. Less than 5% of the total cost of LTC was financed privately in 2007, with the rest financed publicly.

In contrast, U.S. long-term care is covered by Medicare and private plans, and by Medicaid for the poorest, but access to benefits leaves room for significant OOP spending for many households. For example, under Medicare, home nursing care is initially free of charge, but skilled nursing care is only covered up to 20 days; for nursing home stays or skilled nursing care between 20 and 100 days, a patient is charged $105 per day, and above 100 days, the user pays 100% of the cost. Medicaid is means-tested and requires a co-pay based on the financial status of the recipient. As one expression of differences in the system, in Sweden in 2000 about 7% of the elderly were using nursing home care, and an additional 9% employed in-home nursing care. Compare this to 4.3% of the elderly using institutional care and 2.8% using home care in the U.S. at the same point in time.

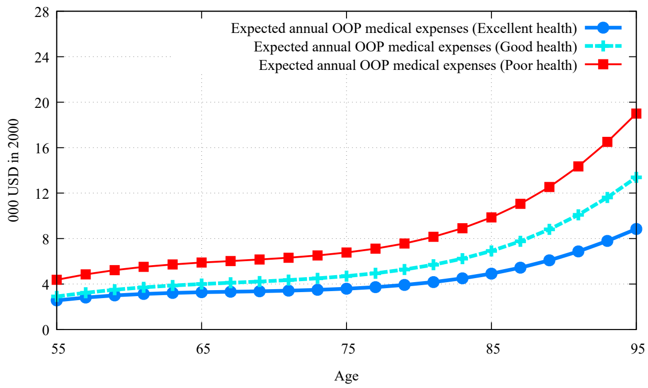
In both the HRS and SHARE, we observe OOP medical and LTC expenses directly. These include OOP expenses on prescription drugs, doctor visits, hospital stays and nursing homes. The HRS is more thorough in measuring these expenses as it has a more detailed set of questions for residents of nursing homes. While SHARE does not provide the same coverage for this population, in Sweden this is not a significant handicap, since very little of the cost of care comes out of pocket.

We first document OOP medical and LTC expenses in the U.S. and Sweden in Section 3.1. We then compare transition probabilities of health in the two countries in Section 3.2. Health status is informative, since it directly affects the distribution of OOP medical and LTC expenses. Since health is self-reported and the transition dynamics are somewhat different between the two countries, we treat the transition probabilities of health status as linked to OOP medical and LTC expense uncertainty. In other words, the main model experiment will be to change OOP medical and LTC expense risk, *including* health transition probabilities, from U.S. to Swedish calibration, and investigate how wealth decumulation patterns are affected.

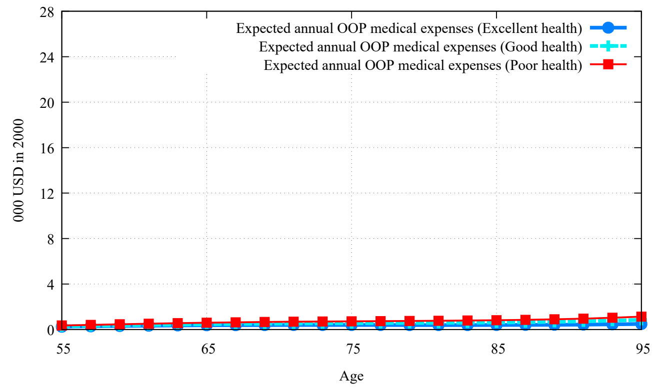
Note that age profiles of medical expenses presented here go back to age 55, unlike the wealth age profiles shown previously. The reason is that we will study the differences between the two countries from the perspective of the entire life-cycle, as discussed above. Since measurements of OOP medical expenses will be required as a calibration input of the model, and since the HRS and SHARE both begin at about age 50-55, we capture the entire available profile here.

3.1 Measuring Medical Expense Risk

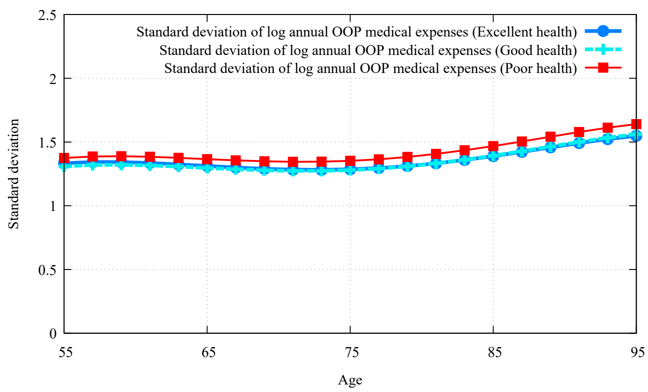
To measure OOP medical expenses and the extent of uncertainty in these expenses in the two countries, we estimate the distribution of log-OOP medical expenditures in the data by age, health, income quintile, and household size (single or couple). The mean, standard deviation, and probability of zero expenses are estimated as quintiles in age and include interaction terms between age and the other three variables. Under the assumption of log-normality, we then compute expected OOP medical expenses for different groups of retirees.



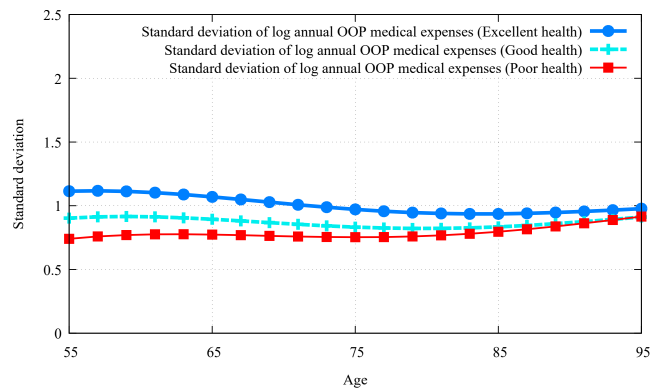
(a) Expected OOP medical expenses, U.S.



(b) Expected OOP medical expenses, Sweden



(c) Log S.D. of OOP medical expenses, U.S.



(d) Log S.D. of OOP medical expenses, Sweden

Figure 3: OOP Medical Expenses, Middle-Income Singles by Age and Health.

We show two dimensions of the data. Figure 3 shows expected OOP medical and LTC expenses and standard deviations for a single person of median income by health status in the U.S.[2] Comparing expected OOP medical expenses for the U.S. (Figure 3(a)) and Sweden (Figure 3(b)), people in both countries who are in the worst health pay the most, as we would expect. However, the orders of magnitude of these expenses are markedly different at all ages. For example, at age 90, a person of median income in poor health might expect to spend about $12,000 in the U.S. in OOP medical expenses, measured in 2000 US dollars. A similar person in Sweden would spend, on average, just over one-tenth of that.[3] Panels (c) and (d) of Figure 3 present the log-standard deviation of medical expenses for the U.S. and Sweden for single households in the middle-income quintile by health. Conditional standard deviation of medical expenses, which shows the magnitude of uncertainty that retirees face in the two

[2] Health status is self-reported, but the choices given to respondents to describe health status are harmonized between the HRS and the SHARE; more details are in Section 3.2.

[3] We cannot reliably measure expenses for persons above age 90 in Sweden because of small sample sizes, and this may raise concerns that we are underestimating expenses for the oldest old. While this is a concern, universal coverage of both health care and long-term care in Sweden is a strong form of insurance, and we rely on that information to assume that there is no hidden spike in expenses past age 90. In fact, in our data we find a *reduction* in OOP medical expenses past age 90.

countries, is lower in Sweden than in the U.S. for all health categories. In sum, these measurements imply that both average medical expenses and the medical expense risks are markedly lower in Sweden, especially in the later part of life.

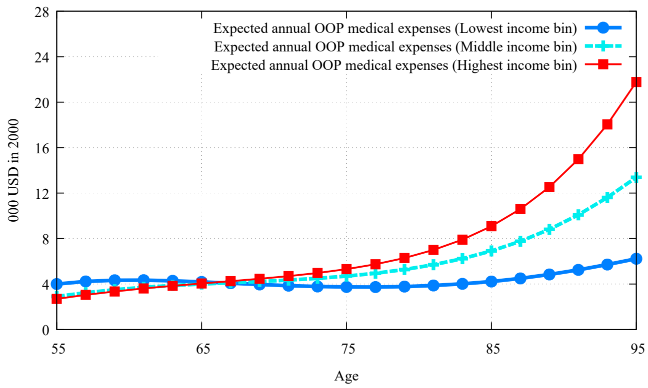
After discretizing the log-normal OOP medical expense shocks, the implications are that a single individual of age 91 in the U.S., with median income and in poor health, has a 5.4% chance of spending $109,001 and a 0.6% chance of spending $528,188 out of pocket per two years, in 2000 U.S. dollars. A similar individual at age 95 has a 5.2% chance of spending $154,224 and a 0.5% chance of spending $795,443, while a high-income 91-year-old has a 5.7% chance of spending $168,676 and a 0.6% chance of spending $1,041,535 in two years. These extreme tail risks are in line with the findings in Ameriks et al. (2011) in the U.S. data. Log-normal distribution captures the tail of medical expenses well. Compared with the significant tail risk of U.S. OOP medical expenses, Swedish tail risk is not as severe. For example, a single individual of age 91 with median income and poor health has a 5.6% chance of spending just $4,005 and a 0.6% chance of spending $9,587. An otherwise similar 95-year-old has a 5.5% chance of spending $5,158 and a 0.6% chance of spending $12,878. An age-91 individual with high income and poor health has a 5.6% chance of spending $5,299 and a 0.6% chance of spending $13,634. In sum, in Sweden OOP expenses are lower on average, while dispersion across income groups is smaller and does not go up with age nearly as much as in the U.S.

Panels (a) and (b) of Figure 4 presents expected OOP medical and LTC expenses for singles of good health by income quintile, for both countries. The conclusions are consistent with those just presented. First, the degree of inequality in medical OOP spending is markedly different in the two countries. In Sweden, with universal non-means-tested public coverage of both health care and LTC, everyone pays roughly similar amounts out of pocket, regardless of income. Even at age 90, the distribution ranges between $700 and $1,200. This is consistent with the evidence presented in Mossialos et al. (2016), who show, for example, annual OOP spending caps in Sweden of $123 for doctors' visits and $246 for prescription drugs in 2015. In the U.S., inequality in spending is much higher, with the highest quintile at age 90 spending on average about $5,000 more than the next quintile down, at about $15,000, and that difference is exacerbated later in life. Second, total mean spending in Sweden is about one-tenth of what it is in the U.S. Panels (c) and (d) compare standard deviations of log-OOP medical and LTC expenses in both countries. The level is significantly higher in the U.S. for all income groups. Standard deviation is more or less flat in age both countries, except for high-income individuals in the U.S., whose standard deviation increases as they get older.

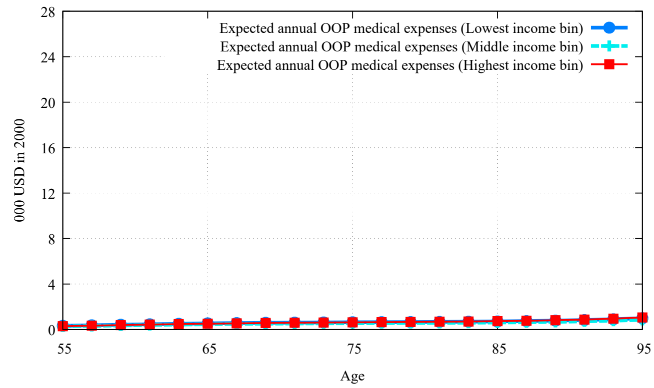
3.2 Health Status and Mortality Risk

In both the HRS and SHARE, households are asked to self-report their health status. For the post-retirement part of the model, we estimate age-dependent probabilities of health change in both countries using the HRS and SHARE. We group health into three categories: (1) excellent, (2) good/average, and (3) poor. We also add (0) death, so the resulting transition matrix incorporates both health transition and mortality probabilities. We condition health transition probabilities on income by computing them separately for each of the five income bins.[4]

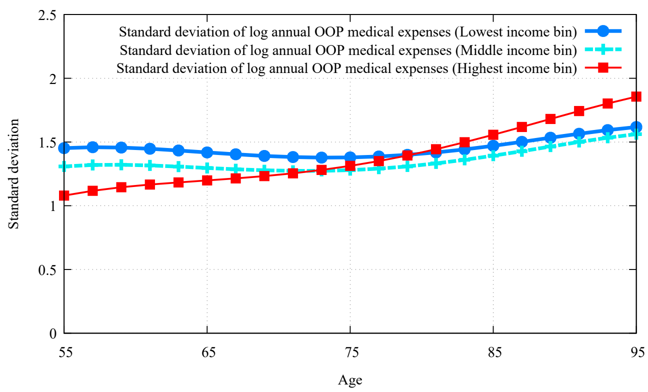
[4] Using the HRS, Pijoan-Mas and Ríos-Rull (2014) find that longevity of U.S. individuals is significantly affected by their socioeconomic background, particularly education.



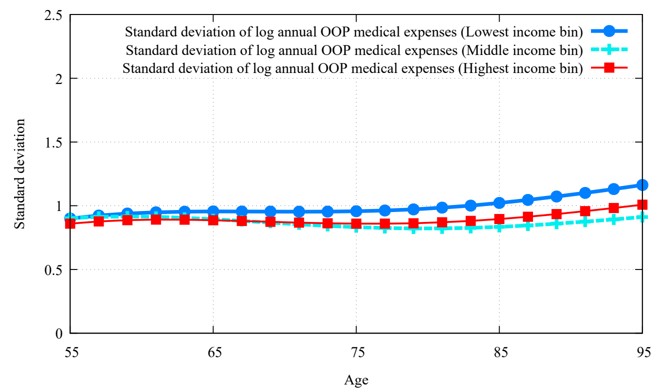
(a) Expected OOP medical expenses, U.S.



(b) Expected OOP medical expenses, Sweden



(c) Log S.D. of OOP medical expenses, U.S.



(d) Log S.D. of OOP medical expenses, Sweden

Figure 4: OOP Medical Expenses, Middle-Income Singles by Age and Income.

For the U.S. (HRS), we take any pair of consecutive survey waves (1996-1998, 1998-2000, 2000-2002, etc.) and assuming stationarity, pool them together to create two pooled consecutive waves. For Sweden (SHARE), we use 2004-2006 consecutive waves. Since the number of observations is not large for Sweden, especially when we compute health transition probabilities conditional on age, current health and income, we employ the following two procedures. First, we define wider overlapping ranges to define income groups. Second, we use a linear regression to smooth health transition probabilities with respect to age. The second procedure is useful particularly for older age groups because we have fewer observations for older individuals in the Swedish sample. Details are in Appendix C. Table 1 presents the resulting probabilities for the U.S. and Sweden for three selected age groups (65, 75, 85) of median income, as well as for age 75 of highest and lowest income bins.

Table 1 shows that health transition probabilities in both countries share logical properties. First, probability of death increases in age and is higher the worse the respondent's health. Mortality rate is generally lower for Sweden, which is consistent with the fact that Swedish individuals have a longer life expectancy. According to the latest data by OECD, life expectancy

Table 1: Health Status Transition, Selected Age and Income Groups (Percent)

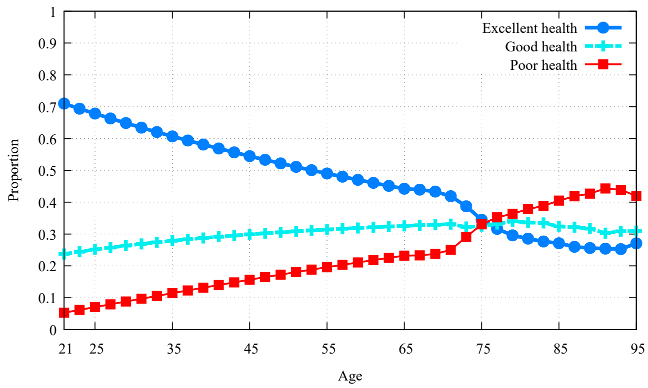
U.S.					Sweden				
Age 65, Median income					**Age 65, Median Income**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	1.1	71.4	22.3	5.2	Excellent	0.0	72.9	27.1	0.0
Good	1.7	25.5	54.2	18.6	Good	0.0	13.8	41.3	44.9
Poor	9.7	5.3	19.0	65.9	Poor	7.0	4.8	12.2	76.0
Age 75, Median Income					**Age 75, Median Income**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	3.0	60.3	25.7	11.1	Excellent	4.0	52.7	20.9	22.5
Good	7.7	23.4	41.3	27.6	Good	5.7	14.0	37.7	42.6
Poor	19.7	4.4	18.3	57.6	Poor	12.9	4.2	10.5	72.4
Age 85, Median Income					**Age 85, Median Income**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	11.0	47.8	25.9	15.3	Excellent	7.4	30.7	13.9	48.0
Good	11.6	17.3	39.1	32.0	Good	23.1	12.6	29.3	35.0
Poor	29.5	3.9	15.3	51.4	Poor	18.8	3.6	8.7	68.8
Age 75, Low Income					**Age 75, Low Income**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	3.7	58.2	27.1	11.0	Excellent	3.6	42.0	27.9	26.4
Good	6.8	21.3	46.9	25.0	Good	7.0	17.1	32.7	43.3
Poor	12.5	4.4	16.7	66.4	Poor	16.8	8.1	12.3	62.8
Age 75, High Income					**Age 75, High Income**				
	Dead	Excellent	Good	Poor		Dead	Excellent	Good	Poor
Excellent	4.4	64.7	26.7	4.2	Excellent	3.5	57.4	26.1	13.1
Good	6.3	16.6	52.3	24.8	Good	3.4	11.7	49.8	35.1
Poor	15.0	4.3	19.2	61.5	Poor	11.2	2.5	5.2	81.1

Note: Individuals are grouped into five equal income bins with low income = bin 1, median income = bin 3, and high income = bin 5. Sources: HRS 1996-2006, SHARE 2004-2006.

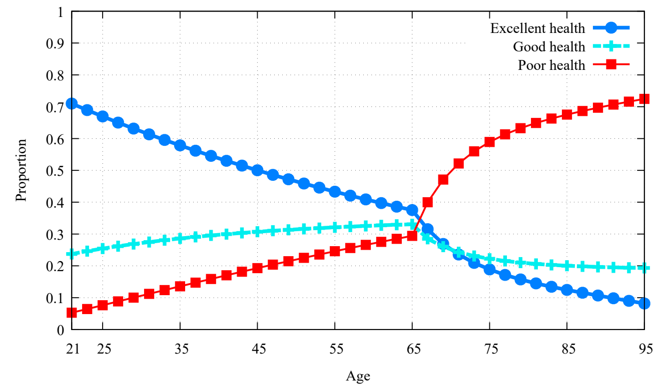
at birth is 82.6 years in Sweden and 78.7 years in the U.S.[5] Second, health deteriorates with age and is less persistent with age, owing to an increasing probability of death with age. For example, the probability that an individual with excellent health retains it 2 years after decreases from 71.4% at age 65 to 47.8% at age 85 in the U.S., and from 72.9% at age 65 to 30.7% at age 85 for Sweden. Third, higher-income individuals have lower mortality rates and are more likely to stay in good or excellent health. For example, the probability that an age-75 individual with excellent health retains it two years later is 64.7% for the high-income group, and 58.2% for the low-income group in the U.S. The respective probabilities are 54.7% and 42.0% in Sweden.

Figure 5 compares the resulting life-cycle dynamics of health distributions in the two countries. Note that while we directly estimate the post-retirement health transition matrix, we cannot do the same prior to retirement. For the pre-retirement years, we parameterize the health transition matrix and calibrate it such that the joint distribution of income and health

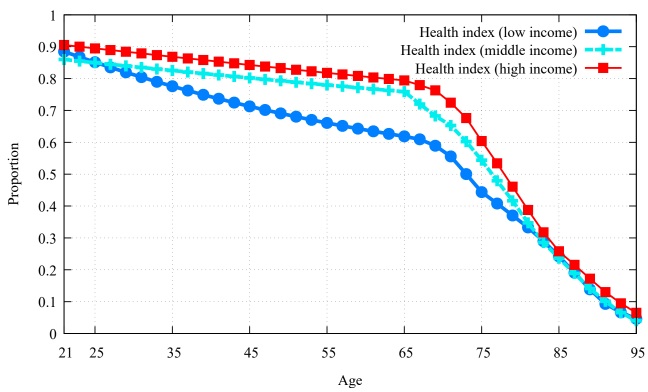
[5] `https://data.oecd.org/healthstat/life-expectancy-at-birth.htm`.



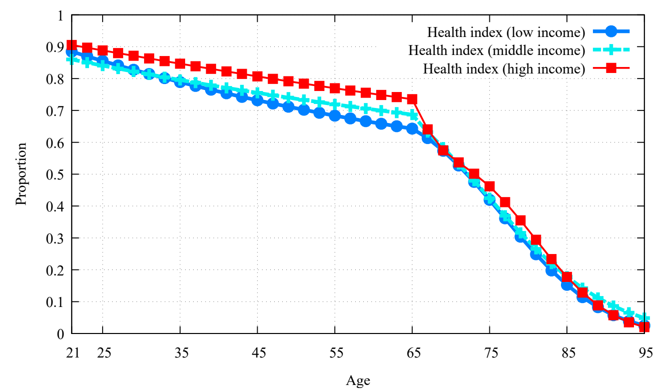
(a) Health Distribution: U.S.



(b) Health Distribution: Sweden



(c) Health Index by Income: U.S.



(d) Health Index by Income: Sweden

Figure 5: Comparison of Health Dynamics: U.S. and Sweden

matches what we observe at age 65 in the HRS (the U.S.) and SHARE (Sweden). More details are in Section 5.1 and Appendix B. In panels 5(a) and (b), the proportion of individuals with excellent, good, and poor health is shown for the U.S. and Sweden, respectively. Both figures show that distribution of health deteriorates with age, shifting towards poor health, especially after retirement. One notable difference between the two countries is that the shift to poor health for older individuals is more pronounced in Sweden. This is interesting because Sweden has longer life expectancy than the U.S. Since health status is self-reported, one interpretation is that Swedes are more pessimistic than Americans about their health. Panels 5(c) and (d) compare the "health index" for three income groups over the life cycle in both countries. The health index ranges between 0 and 1, and summarizes average health status for a given group of individuals. Specifically, we assign the value 1, 2/3, 1/3, 0, to individuals in excellent, good, and poor health and dead individuals, respectively, and compute the average value within a group. We can see that average health deteriorates with age for all income groups in both countries, and that high-income groups tend to have a higher health index over the life-cycle. A comparison between panels 5(c) and (d) indicates that dispersion of self-reported health across different income groups is smaller in Sweden compared with the U.S., since high-income individuals are more pessimistic about their health in Sweden than in the U.S.

We validate our survey-based health transition probabilities using population mortality rates for each country. For the U.S., our computed health transition probabilities imply a mortality rate of 1.7% at age 65, with the data counterpart of 1.5% based on U.S. life tables averaged between 1997 and 2006 (Anderson (1999), Arias (2010)). For other ages, the HRS-implied mortality rates and the corresponding data numbers are 2.4% (2.3% in the data) at age 70, 4.4% (3.6%) at age 75, 8.5% (5.8%) at age 80, 10.4% (9.4%) at 85, and 16.2% (14.8%) at 90. Another way to validate our health transition probabilities is to compare life expectancy. Our estimated health transition probabilities imply that the average life expectancy at age 65 is 82.5 years. According to the OECD, the average life expectancy at age 65 was 83.6 years in 2006. It is not surprising that our model implies a slightly lower life expectancy, since we use cross-sectional data to estimate health transition probabilities. For Sweden, mortality rates implied by our health transitions based on SHARE and their data counterparts are 1.2% (1.2% in the data) at age 67, 3.1% (2%) at age 72, 6.4% (3.5%) at age 77, 9.9% (6.7%) at age 82, and 13.4% (12.2%) at age 87 (Lundström (2010)). The larger discrepancy is due to the smaller sample size for Swedish data, but comparison of life expectancy at age 65 indicates that our health transition probabilities are on average consistent with the OECD data. Our Swedish health transition probabilities imply average life expectancy of 82.6 years at age 65 in 2006, which is slightly lower than the OECD estimate of 84.3 years. Note that we do not condition health transitions on gender, since we do not model gender for tractability purposes. However, since we use respondent weights in the data, our calibration reflects the appropriate gender mix of the average pools of couple and single households at each age.

4 Model

Our model combines the standard single-asset model of life after retirement (De Nardi et al. (2010)), in which health and medical expense shocks are the primary focus, with a canonical full life-cycle model (e.g., Gourinchas and Parker (2002)) where the primary pre-retirement source of uncertainty is shocks to earnings. Kopecky and Koreshkova (2014) build a model with a similar approach, for the U.S. economy. Floden and Lindé (2001) use a life-cycle model for comparison between the U.S. and Sweden, but without health and medical expense shocks after retirement.

In our model economy, there is a unit mass of households. Each household is characterized by (i, b, p, m, x, a), where i is age, b is a permanent shock to labor and pension income, p is a persistent shock to labor income, m is health status, x is a medical expense shock, and a is savings, which is the only endogenous state variable. We characterize the problem of a household recursively. Moreover, for simplicity and to reduce computational time, we assume that working households ($i < I_R$) do not face a medical expenditure shock (x) or mortality risk. Instead, medical expenses before retirement depend only on age i, permanent income shock b and health status m. On the flipside, retired households ($i \geq I_R$) are not affected by persistent income shocks p.

The problem of a working household is characterized as follows:

$$V(i,b,p,m,0,a) = \max_{a' \geq 0} \left\{ u(c/\xi_i) + \beta_b \sum_{p'} \sum_{m'} \pi^p_{p,p'} \pi^m_{i,b,m,m'} V(i+1,b,p',m',0,a') \right\} \tag{1}$$

$$\text{s.t.} \quad \tilde{c} + a' + (1-\phi^h)\overline{x}_{i,b,m} = y_i b p (1-\tau^w-\tau^h-\tau^g) + (1+r)a \tag{2}$$

$$c = \mathbb{1}_{a'=0} \max\{\xi_i \underline{c}, \tilde{c}\} + \mathbb{1}_{a'>0}\tilde{c} \tag{3}$$

Equation (1) is the Bellman equation. $u(.)$ is the period utility function. Consumption c is divided by an age-dependent consumption equivalence scale factor ξ_i to control for changes in effective household size over the life cycle. β_b is the discount factor, which depends on the permanent income shock b.[6] Equation (2) is the budget constraint. $\tilde{c}$ is period consumption expenditure, denoted by a tilde because actual consumption c might be higher than $\tilde{c}$ due to the consumption floor, as explained below. a' is savings carried over to the next period. $\overline{x}_{i,b,m}$ is gross medical expense, which depends only on age i, current income shock b and health status m.[7] ϕ^h is the health insurance coverage ratio, so $(1-\phi^h)\overline{x}_{i,b,m}$ is period OOP medical expense. y_i captures a deterministic life-cycle component of earnings, b is a permanent shock to income and p is a persistent shock. τ^w is the payroll tax rate used to finance health insurance for working households in the U.S. model. τ^h is a second payroll tax rate, used to finance health insurance for retirees. This is intended to capture U.S. Medicare tax. τ^g is the general income tax rate, applied to all households. For the U.S. model, τ^g is used to balance the budget for retiree health insurance. For the Swedish model, this is the only tax to finance health insurance for all (both working and retired) households. r is the interest rate. Equation (3) represents a consumption floor guaranteed by the government. It is available only when a household exhausts all their savings $(a'=0)$ and cannot achieve the minimum consumption level, adjusted by the effective household size $\xi_i \underline{c}$. This is meant to capture Medicaid and benefits from other social insurance programs.

After retirement $(i \geq I_R)$, there is no longer a persistent shock to income p. Instead, households face a medical expense shock x and mortality risk, which is modeled as part of the shock to health status m. Dispersion of pension income is captured by the permanent shock to income b. The optimization problem of a retired household is:

$$V(i,b,0,m,x,a) = \max_{a' \geq 0} \left\{ u(c/\xi_i) + \beta_b \sum_{m'>0} \sum_{x'} \pi^m_{i,b,m,m'} \pi^x_{i+1,b,m',x'} V(i+1,b,0,m',x',a') + \beta_b \pi^m_{i,b,m,0} v(a') \right\} \tag{4}$$

$$\text{s.t.} \quad \tilde{c} + a' + (1-\phi^h)x = y_i b(1-\tau^g) - \psi_i \chi^h + (1+r)a \tag{5}$$

and Equation (3). $v(.)$ is warm-glow bequest utility, as in De Nardi et al. (2010). x is gross medical expense for the period. As the fraction ϕ^h of medical expenses is covered by public

[6] Appendix E presents an alternative model without β heterogeneity.

[7] In the last period of working life $(i = I_R - 1)$, the household draws a medical expense shock x for the first period in retirement, but we omit it for brevity.

health insurance, $(1-\phi^h)x$ is out-of-pocket medical expense, which is observed in HRS and SHARE. y_i is average pension income at age-i. b is the permanent shock to income, which captures dispersion of pension income. τ^g is again the general income tax rate. χ^h is the health insurance premium per person (Medicare premium in the case of the U.S.). ψ_i represents the average number of adults covered by health insurance in an age-i household.

Both for the U.S. and Sweden, health insurance coverage is characterized by one parameter ϕ^h. We assume ϕ^h is the same for all households, working and retired, but is different between the U.S. and Sweden. Financing of health insurance is modeled differently for the U.S. and Sweden. For the U.S., we assume that health insurance for workers is different from that for retirees. Health insurance for retirees is intended to mimic Medicare, while for workers we assume a parsimonious health insurance scheme. Specifically, the following two government budget constraints have to hold in the U.S. model:

$$\int \mathbb{1}_{i<I_R} y_i b p \tau^w d\mu = \int \mathbb{1}_{i<I_R} \phi^h \overline{x}_{i,b,m} d\mu \tag{6}$$

$$\int \mathbb{1}_{i<I_R} y_i b p (\tau^h + \tau^g) d\mu + \int \mathbb{1}_{i\geq I_R} (y_i b \tau^g + \psi_i \chi^h) d\mu = \int \mathbb{1}_{i\geq I_R} \phi^h x d\mu \tag{7}$$

where Equation (6) is the budget constraint for the health insurance program for working households, and Equation (7) is the parallel for retirees. $\mathbb{1}$ is an indicator function and μ is the type distribution of households. In Equation (6), the left-hand side captures income from the payroll tax (tax rate of τ^w) levied on working households ($i < I_R$), while the right-hand side captures health insurance coverage (coverage ratio of ϕ^h) for working households. In estimation, ϕ^h will be taken from data, and τ^w will be adjusted to balance the budget. In Equation (7), the first term captures working households paying both the Medicare tax (at rate τ^h) and the general income tax (τ^g), while the second term captures retirees contributing through the general income tax (τ^g) and a Medicare premium (χ^h per adult). The right-hand side captures health insurance coverage for retirees. General income tax rate τ^g adjusts to balance the budget.

For Sweden, the following single government budget constraint captures universal health insurance, which covers both working and retired households:

$$\int \mathbb{1}_{i<I_R} y_i b p \tau^g d\mu + \int \mathbb{1}_{i\geq I_R} y_i b \tau^g d\mu = \int \mathbb{1}_{i<I_R} \phi^h \overline{x}_{i,b,m} d\mu + \int \mathbb{1}_{i\geq I_R} \phi^h x d\mu \tag{8}$$

The two terms on the left-hand side capture the general income tax (at rate τ^g) levied on working and retired households, respectively, while the two terms on the right hand side capture health insurance coverage for workers and retirees, respectively. General income tax rate τ^g adjusts to satisfy the budget balance.

5 Taking the Model to Data

Our calibration proceeds in two stages, as in Gourinchas and Parker (2002) and De Nardi et al. (2010): in the first stage (Section 5.1), we calibrate the parameters that are directly observable in the data; this includes medical expense shocks and health transition matrices that we described above. In the second stage (Section 5.2), we estimate the remaining parameters to match the empirical profiles of wealth and Medicaid take-up in the U.S., using simulated method of moments (SMM). All dollar amounts are normalized to 2000 dollars.

Table 2: Full Life-Cycle Model Calibration[1]

	U.S.	Sweden	Description
$\overline{\beta}$	0.9672	Same	Jointly estimated using the U.S. data.
σ_β	0.0140	Same	Jointly estimated using the U.S. data.
σ	3.8505	Same	Jointly estimated using the U.S. data.
ξ_i	Fig 6(d)	Same	Constructed using CPS (U.S.).
γ	5.1554	Same	Jointly estimated using the U.S. data.
ζ	8,844	Same	Jointly estimated using the U.S. data.
b	Tab 3	Tab 3	Computed from HRS (U.S.) and SHARE (Sweden).
ψ_i	Fig 6(b)	Fig 6(b)	Calculated using HRS (U.S.) and SHARE (Sweden).
y_i	Fig 6(a)	Fig 6(a)	U.S.: Gourinchas and Parker (2002). Sweden: Domeij and Klein (2002).
ρ_p	0.9280	0.9280	Domeij and Klein (2002).
σ_p^2	0.0651	0.0498	Domeij and Klein (2002) and Floden and Lindé (2001).
r	0.0200	0.0200	Annual interest rate.
$\underline{c}$	5,650	Same	Jointly estimated using the U.S. data.
π^m	Text	Text	Estimated using HRS (U.S.) and SHARE (Sweden).
π^x	Text	Text	Estimated using HRS (U.S.) and SHARE (Sweden).
ϕ^h	0.7256	0.9351	U.S.: Backed up from gross medical expenses of Medicare.
τ^h	0.0290	–	U.S.: Medicare tax rate. Sweden: Zero.
τ^w	0.0758	–	U.S.: Used to finance health insurance for workers. Sweden: Zero.
τ^g	0.0160	0.0837	Balances budget for health insurance program.
χ^h	2,280	–	U.S.: Medicare premium per individual. Sweden: Zero.

[1] All parameters are annualized.

Table 3: Calibration: Pension Income Bins

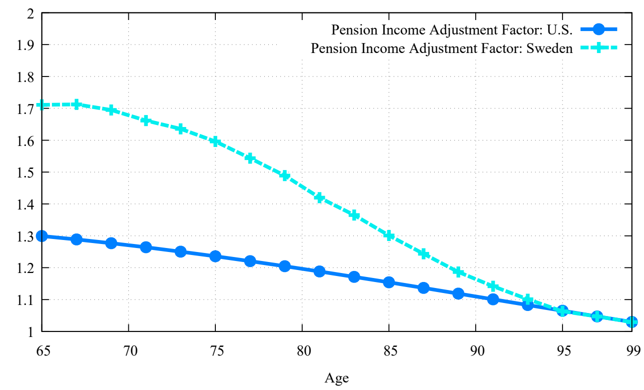
	1	2	3	4	5
U.S.	7,699	13,854	20,102	29,622	50,838
Sweden	7,397	10,504	12,427	16,257	26,018

Note: Annualized after-tax income. 2000 PPP-adjusted U.S. dollars.
Sources: HRS 2006 and SHARE 2006.

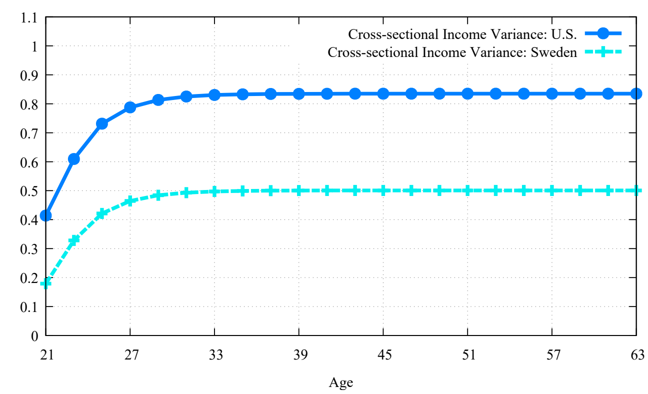
5.1 First Stage

Since both HRS and SHARE are biennial surveys, most variables are measured at that frequency, so we choose the model period to be 2 years. Households are born at age 21, start their retirement period at age 65, and live stochastically up to age 99; if they survive up to age 99, they die with certainty after the end of the period.

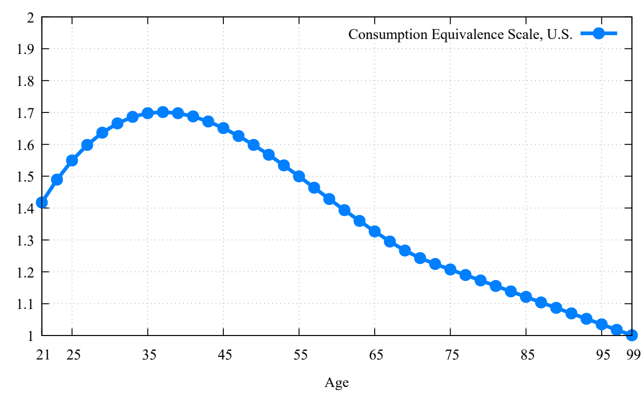
(a) Mean Age-Income Profile



(b) Pension Income Adjustment Factor



(c) Cross-sectional Income Variance



(d) Consumption Equivalence Scale (U.S.)

Figure 6: Full Life-Cycle Model: Model Inputs

5.1.1 Income

There are three components that characterize income: life-cycle income profile y_i, permanent shock to income b, and persistent shock to income p. For y_i before retirement, we take the life-cycle profile of income from Gourinchas and Parker (2002) for the U.S. and from Domeij and Klein (2002) for Sweden. The mean income profiles for the U.S. and Sweden are shown in Figure 6(a).

y_i after retirement is composed of two elements: average per-adult pension income y_R, and average number of age-i adults ψ_i. y_R is obtained using net pension replacement rates for each country.[8] According to OECD, net pension replacement rate is 51% in the U.S. and slightly more generous at 56% in Sweden.[9] The levels of y_R for both countries are shown in Figure 6(a)

[8] Net pension replacement rate is defined as individual net mandatory public and private pension entitlement divided by net pre-retirement earnings.

[9] These replacement rates imply that Swedish households receive a higher amount of pension income than U.S. households in retirement. Since households carry less wealth into retirement when they receive a higher amount of pension income, this difference partially contributes to the U.S.-Swedish differences in wealth decumulation pattern. Since our focus is on differences in medical expense risks and health insurance schemes

as well. We also adjust pension income for different ages using ψ_i, which is constructed similarly to ξ_i. In the HRS, we measure that pension income of two-adult households is on average 1.48 times higher than that of one-adult households in the U.S. Therefore, we compute ψ_i as a weighted average of 1 for one-adult household and 1.48 for two-adult household using distribution of 1-adult and 2-adult households for each age i as the age-dependent weights. Figure 6(b) shows the resulting ψ_i profiles for the U.S and for Sweden. ψ_i for Sweden is higher because pension income of two-adult households in Sweden is 2.42 times single income, according to SHARE.

In regard to income shocks, we assume that the dispersion of pension income that we observe in HRS and SHARE for the two countries represents permanent differences b, while p only matters for working households. To calibrate permanent differences in pension income, we follow De Nardi et al. (2010) and assume five permanent income groups with equal measures for retirees at age 65, which creates a five-point distribution of b at that age. The values of b (before normalization) for the U.S. and Sweden, based on HRS and SHARE, are in Table 3, which shows that the dispersion of pension income is smaller in Sweden.

Labor income shocks prior to retirement p are constructed by discretizing an AR(1) process with persistence ρ_p and variance of innovations σ_p^2. For Sweden, we use the estimates of Domeij and Klein (2002) and set $\rho_p = 0.928$ and $\sigma_p^2 = 0.0498$. In order to capture higher earnings risk in the U.S. relative to Sweden, we use relative variances of earnings shocks reported by Floden and Lindé (2001). Specifically, they estimate that variances of innovations to an AR(1) process in hourly wages in the U.S is about 30% higher than in Sweden.[10] Considering that the persistence parameter is typically estimated between 0.9 and 1.0 for the U.S., we assume that ρ_p is the same for the U.S. and Sweden, and set $\sigma_p^2 = 0.0651$, which is 30% higher than the value for Sweden. Figure 6(c) shows the implied cross-sectional variance of income over the life cycle for the U.S. and Sweden. This cross-sectional variance consists of both permanent income differences b and persistent income shocks p. We assume $p = 1$ for all households at birth.

In order to construct the age-dependent consumption equivalence scale ξ_i, we first compute average household size for each age i using CPS (Current Population Survey) in 2006 for the U.S.[11] Then we convert the average household size profile into a family-equivalent scale, using the numbers reported by Fernández-Villaverde and Krueger (2007).[12] Figure 6(d) shows the resulting ξ_i. It exhibits a hump shape as there are more single households among the young, people get married and/or have children in middle age, and household size declines among the old as children move out and/or spouses die. We set the saving interest rate r at 2% per year, based on the real risk-free interest rate in the U.S. in recent years.[13]

between the two countries, we do not explore further the implications of differences in the pension system.

[10] They estimate, using hourly wage data, that $\rho_p = 0.9136$ and $\sigma_p^2 = 0.0426$ for the U.S. and $\rho_p = 0.8139$ and $\sigma_p^2 = 0.0326$ for Sweden.

[11] Since the data are available for 5-year age groups, we use third-order polynomials to smooth out the profile.

[12] According the Fernández-Villaverde and Krueger (2007), family-equivalence scale is 1, 1.34, 1.65, and 1.97, for household size of 1 (normalization), 2, 3, and 4.

[13] We also assume that the interest rate is the same in the U.S. and Sweden. According to Jordà et al. (2019), Table XI, the real return of safe assets after 1980 is similar between the two countries.

Table 4: Joint Distribution of Income And Health at Age 65

	U.S., Data	U.S., Model	Sweden, Data	Sweden, Model
Overall				
1 (excellent)	0.442	0.442	0.375	0.375
2 (good)	0.326	0.326	0.331	0.331
3 (poor)	0.232	0.232	0.294	0.294
Income Bin 1 (Bottom)				
1 (excellent)	0.262	0.262	0.313	0.313
2 (good)	0.332	0.326	0.302	0.302
3 (poor)	0.406	0.406	0.385	0.385
Income Bin 3 (Middle)				
1 (excellent)	0.463	0.463	0.349	0.349
2 (good)	0.351	0.351	0.363	0.363
3 (poor)	0.186	0.186	0.288	0.288
Income Bin 5 (Top)				
1 (excellent)	0.532	0.532	0.503	0.503
2 (good)	0.319	0.319	0.199	0.199
3 (poor)	0.150	0.150	0.298	0.298

Sources: Data are from HRS 2006 (U.S.) and SHARE 2006 (Sweden). Numbers for the model are based on the simulations by the authors.

5.1.2 Health

Health transition probabilities for age 65 and above $\pi^m_{i,b,m,m'}$ are estimated using various waves of HRS for the U.S. and SHARE for Sweden. For the U.S., we use transition probabilities that we estimated in our previous work (Nakajima and Telyukova (2020)). For Sweden, we apply a similar procedure, but make additional adjustments to deal with the issue of having only one two-year longitudinal dimension and having smaller samples. The resulting health transition probabilities for age 65 and above are shown in Table 1 in section 3.2. In order to check robustness of our obtained health transition probabilities for Sweden, we also construct health transition probabilities of four similar countries (see Nakajima and Telyukova (2016)), including Austria, Germany, Norway, and the Netherlands, and construct the average (four countries plus Sweden) health transition probabilities, which we call the Nordic health shock. This will be useful to demonstrate that the calibration and results are not impacted by the relatively small sample sizes in SHARE for Sweden. Further details on $\pi^m_{i,b,m,m'}$ and the Nordic health shock are found in Appendices C and D, respectively.

For health transition probabilities between ages 21 and 65, we pose parsimonious parametric assumptions, and estimate the parameters so that the resulting joint distributions of income and health at age 65 generated by the model are close to what we observe in HRS and SHARE. As emphasized by De Nardi et al. (2010) and Nakajima and Telyukova (2020), there is a strong correlation in the joint distribution between income and health status at age 65. In a model of retirement that starts from age 65, as is typical in the retirement saving literature, this correlation is readily incorporated since the initial type distribution can be directly taken from data. However, given that we model the entire life cycle, the joint distribution of income and health at age 65 becomes endogenous, and the calibration of health transition probabilities before age 65 must result in the correct distribution at retirement.

Table 4 compares the joint distributions generated by the model and in the data for the U.S. and Sweden. The upper panel compares the overall distribution of health at age 65, while the lower panel shows the distribution of health among the highest, middle, and lowest income quintiles, to highlight the correlation between income and health at age 65. First, note that the model perfectly replicates the distribution of health in the data at age 65, for both the U.S. and Sweden. This is because we have two parameters characterizing health transition probabilities for each income group to match the health distribution of the same income group at age 65, which is characterized by two numbers.[14] Second, comparison across different income groups reveals that individuals in higher income groups are healthier in both the U.S. and Sweden. Third, the correlation between income and health is stronger in the U.S. than Sweden. The details of our procedure as well as more detailed comparison between the model outputs and the data are found in Appendix B.

5.1.3 Medical Expense Risk

The distribution of OOP medical and long-term care (LTC) expense risk $\pi^x_{i,b,m,x}$ for age 65 and above is constructed using various waves of HRS and SHARE, as described in Section 3.1. In order to calibrate medical expenditures $\overline{x}_{i,b,m}$ prior to age 65, we first use HRS and SHARE data for ages 51-63, since both surveys begin at about age 50 and contain significant samples for the earlier ages. For ages 21-49, we use the numbers computed for age 51. Since medical expenses increase with age in general, this overestimates medical expenses before age 51, but since the level of medical expenses at age 51 is low compared with older individuals, and we assume no risk to medical expenses before age 65, we believe this to be a reasonable approximation.

5.1.4 Health Insurance

In order to parameterize U.S. health insurance, we first need to back up *gross* medical expenses from the *OOP* medical expenses, only the latter of which are observed in HRS. We compute the implied health insurance coverage ratio as the ratio of average OOP medical expenses to average gross medical expense per Medicare participant. We estimate the denominator at \$10,558 in 2000.[15] The average OOP medical expenditure implied by the calibrated medical expenditure shocks is \$2,898 per year. This gives the average health insurance coverage ratio of 72.6%. We assume that the same coverage ratio is applied to all individuals, which means $\phi^h = 0.726$, and back up the gross medical expenses from the OOP medical expenses.

Now we are ready to pin down the parameters for the financing side of U.S. health insurance.

[14] There are four health statuses — excellent, good, poor, and dead — but we assume that mortality rate is zero before age 65. Since probabilities sum up to one, we only need two probabilities to characterize the distribution of health status.

[15] According to the Center for Medicare and Medicaid Services (CMS), the average gross medical expenditures for Medicare participants was \$7,146 per year in 2000. We multiply this number by the average household size (1.48).

For retirees in the U.S., τ^h is set at 2.9%, which is the Medicare tax rate. χ^h is computed based on the average Medicare premium, which is $95 per month ($2,280 per two years).[16] With the calibrated expenditure side of health insurance for retirees, we use the government budget constraint (7) to pin down $\tau^g = 1.60\%$. Similarly, for working households, Equation (6) implies $\tau^w = 7.58\%$.

Calibration of the financing side of Swedish health insurance is different, since Sweden offers universal health insurance, which is represented by Equation (8). First, we calibrate the coverage ratio and gross medical expenses. According to the WHO, gross health expenditures per capita in the U.S. are about 1.8 times that in Sweden in 2006.[17] Dividing gross medical expenditures per Medicare-participating household in the U.S. by the ratio of the medical expenditures per capita of the two countries, we derive gross medical expenditure per Swedish retired individual, which is $3,966 per year. With the average household size of 1.39 in Sweden, average gross medical expenses per Swedish household per year are thus $5,512. The average OOP medical expense implied by the distribution we constructed in SHARE is $358. The two numbers together imply that Sweden's average coverage ratio is 93.5%, significantly higher than the U.S. (72.6%). This coverage ratio is corroborated by literature sources.[18] This coverage ratio is used to set $\phi^h = 0.935$, and to back up gross medical expenses for each household in Sweden. Finally, Equation (8) yields τ^g = 8.37%.

5.2 Second Stage

We set the utility function to a standard CRRA form with risk aversion parameter σ. Following De Nardi et al. (2010), a household gains utility from leaving warm-glow bequests: when a household dies with wealth a, its utility function takes the following form:

$$v(a) = \gamma \frac{(a+\zeta)^{1-\sigma}}{1-\sigma}. \tag{9}$$

Conditional on other parameter values being fixed, parameter γ affects the strength of the bequest motive, and ζ affects the marginal utility of bequests, i.e. the threshold of wealth at which a household finds it valuable to leave a bequest.[19] In effect, ζ determines whether bequests are a luxury good. As in De Nardi et al. (2010), we assume that the curvature of the bequest and period utility functions is the same. We do not explicitly model estate taxation, since the exemption limit has been raised frequently, which is hard to model. Instead, since we estimate parameters related to bequest motive using the distribution of realized bequests, these parameters account directly for estate taxation.

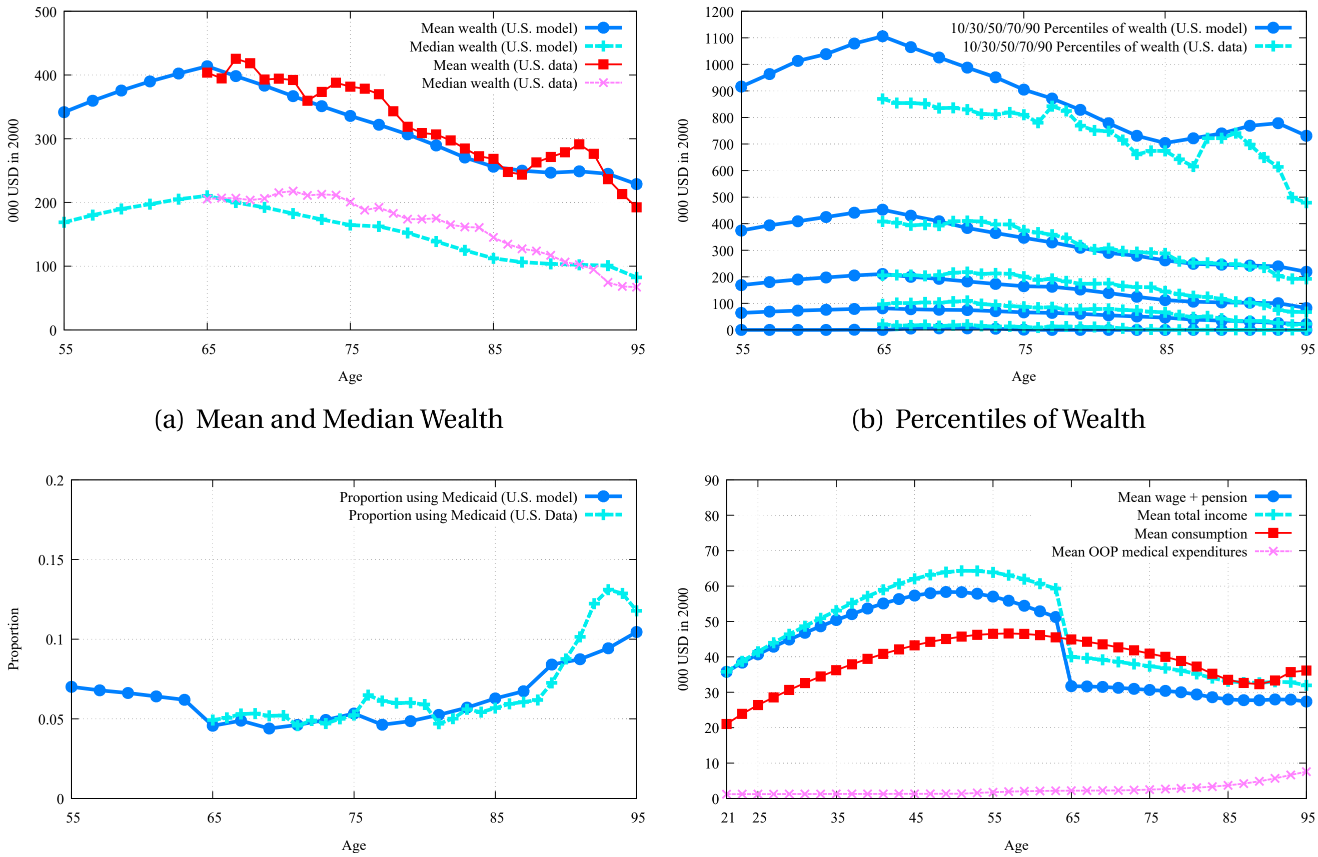
Other parameters estimated at this stage include $\underline{c}$, the government-provided consumption

[16] The average monthly premium for Medicare Part B is $88.5 in 2006 ($75.6 in 2000), and the average monthly premium for Medicare Part D is $22.7 in 2006 ($19.4 in 2000). 99% of Medicare participants do not pay a premium for Medicare Part A. Medicare Part C is an alternative and an upgrade to standard Medicare. Part C entails additional costs, but since its take-up was below 15% in 2006, we abstract from it.

[17] The data are available at Global Health Observatory Repository at the WHO website.

[18] For example, Anell et al. (2012) report that Swedish OOP expenses in 2005 were about 4.04% of total costs (coverage ratio of 95.96%) for primary care, 64.32% (35.68%) for outpatient dental care, and 24.69% (75.31%) for prescription drugs, respectively.

[19] See Appendix F as to how γ and ζ affect the bequest decision in a simplified setup.



(a) Mean and Median Wealth

(b) Percentiles of Wealth

(c) Proportion with Medicaid

(d) Income and Consumption

Figure 7: Estimated U.S. Model vs. Data

floor per adult, and the discount factor β_b, which we assume to be heterogeneous. Following Gourinchas and Parker (2002), who estimate a higher discount factor for households with higher education attainment and thus higher income, we assume that discount factor heterogeneity is perfectly correlated with permanent income b.[20] In particular, we assume that the discount factor for the five permanent income groups are $\overline{\beta} + 2\sigma_\beta$, $\overline{\beta} + \sigma_\beta$, $\overline{\beta}$, $\overline{\beta} - \sigma_\beta$, $\overline{\beta} - 2\sigma_\beta$, respectively. Thus $\overline{\beta}$ is the time discount factor for the median income household, while σ_β captures the dispersion of the discount factor. Since discount factor heterogeneity is not used in retirement literature, such as De Nardi et al. (2010) and Nakajima and Telyukova (2020), in Appendix E we present some results of an alternative model without discount factor heterogeneity, which is separately estimated. The takeaway from this alternative model is that discount factor heterogeneity is not crucial for our main results regarding relative importance of Swedish features in accounting for the differences in wealth decumulation patterns.

In total, there are six parameters to be estimated: $\overline{\beta}$, σ_β, σ, γ, ζ, and $\underline{c}$. We estimate these parameters to match (1) the mean and median wealth-age profiles, (2) 10th, 30th, 70th, and 90th

[20] Gourinchas and Parker (2002) assume that consumers with different education attainment are heterogeneous in average labor income and discount factor. They also assume consumers with different education level differ in risk aversion, and (implicitly) parameters controlling bequest motive.

Table 5: Distribution of Bequests

Statistics	U.S. Data[1]	Model
Mean bequest	262,709	265,271
Amount of bequest: 10th percentile	0	0
Amount of bequest: 30th percentile	50,279	43,008
Amount of bequest: 50th percentile	156,368	116,859
Amount of bequest: 70th percentile	301,675	265,274
Amount of bequest: 90th percentile	502,792	740,120
Amount of bequest: 95th percentile	754,188	1,133,722
Amount of bequest: 98th percentile	1,508,377	1,549,946

[1] In 2000 U.S. dollars. Based on the numbers provided by Hurd and Smith (2003), and adjusted for the observed increase in wealth, following Ameriks et al. (2011).

percentiles of wealth, (3) Medicaid take-up rates by age, and (4) all the distributional statistics of bequests presented in Table 5. The estimation procedure minimizes the weighted sum of squared distance between these targets generated by the model and the data. Figures 7(a)-(c) visualize estimation results, comparing the estimated U.S. model with U.S. data with respect to (1)-(3) above, while Figure 7(d) shows mean income and consumption expenditures in the estimated model. Figures 7(a)-(c) indicate that the model replicates targets (1)-(3) quite well. The model slightly overestimates the 90 percentile of wealth, but that is because the procedure weights median and mean wealth more highly than the tails.[21] Table 5 compares distributional statistics of bequests between the model and data, which are matched well, especially in the mean and the 98th percentile of bequests. The resulting parameter values are in Table 2.

It is worth discussing parameter identification in this model. The use of the full life-cycle model allows cleaner identification of some of the estimated parameters relative to a post-retirement model. In a post-retirement model, the initial distribution of wealth is set in stage-1 calibration to match exactly the distribution in the data at age 65. In the case of a full life-cycle model, the median discount factor $\overline{\beta}$ is identified by matching age-65 wealth levels (Figure 7(a)), thereby giving it an estimation target that is absent otherwise. σ_β, the dispersion parameter of the discount factor, is identified to match the dispersion of wealth profiles, shown in Figure 7(b). $\underline{c}$ is closely related to Medicaid take-up (Figure 7(c)). The two parameters related to the bequest motive, γ and ζ, are identified by the distribution of bequests (Table 5), i.e. the proportion of retirees who leave bequests as well as by the wealth distribution late in life. Finally, σ, which determines the strength of the precautionary savings motive, is identified through the speed of wealth decumulation, as well as the dispersion of wealth profiles.

The value of σ obtained in our estimation (3.85) is close to the estimated value of De Nardi et al. (2010) (3.84), who use a post-retirement model. $\overline{\beta}$ =0.967 is in the middle of the range typically

[21] It is also partly due to our assumption that discount factor heterogeneity is captured by one dispersion parameter, σ_b, and possibly due to our abstraction from the rate of return heterogeneity. It is likely that the wealthiest households enjoy a higher rate of return of wealth.

estimated or calibrated in the literature. σ_β is estimated to be 0.014. The dispersion of discount factor implied by the estimated σ_β is larger than what Gourinchas and Parker (2002) obtain. For example, their estimated β for households with graduate degree (highest β) is 0.962, while β for those with some high school (lowest β) is 0.944, implying the difference of 0.018. This smaller dispersion of β is probably due to the fact that they use cross-sectional dispersion in *consumption*, which is smaller than dispersion of *wealth* that we use as a target. Our estimated value of consumption floor ($5,650 per year per person in 2000) is also in the range of available estimates. For comparison, Hubbard et al. (1995) estimate the value of consumption floor per household to be $7,000 in 1984, which is $11,602 in 2000 dollars. If we use the average household size adjustment factor to convert our consumption floor to per-household terms, we get the value of $8,288 in 2000 dollars. On the other hand, De Nardi et al. (2010) estimate the consumption floor value to be $2,815 in 2000 dollars. Since they model single households only, their estimate is directly comparable to our estimated consumption floor of $5,650.

Interpretation of parameter values associated with bequest utility is not straightforward, so we convert parameter estimates into threshold values of wealth for leaving bequests and marginal propensity of bequests, and compare with those implied by parameter estimates of De Nardi et al. (2010). The details are found in Appendix F. Our parameter estimates imply a lower threshold wealth ($5,797) and a lower marginal propensity (0.60) than what De Nardi et al. (2010) obtain ($36,225 and 0.88). It is most likely due to the fact that we include couples in our study, who tend to hold more wealth and are more likely to leave bequests. We also include statistics of bequest distribution in our calibration targets, while De Nardi et al. (2010) do not.

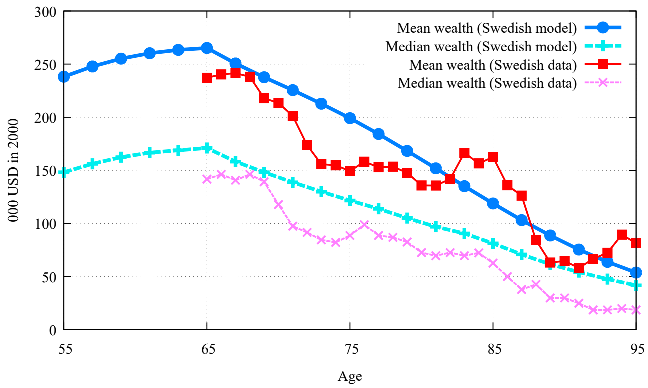
6 Understanding U.S.-Sweden Differences in Dissaving in Retirement

This section presents the main results. We start with the model estimated using the U.S. data (U.S. model). We then introduce all the observed Swedish features into the model (Swedish model) and investigate how much these Swedish elements can account for the differences in wealth decumulation patterns between the two countries (Section 6.1). In Section 6.2, we carefully look into the role of the Swedish health transition dynamics and the Swedish gross medical expense risks. Then we study the role of the Swedish health insurance in Section 6.3. In Section 6.4, we quantify the importance of all the Swedish elements. Finally, in Section 6.5, we discuss the role of bequest motive, which is recognized to be one of the most important determinants of wealth decumulation dynamics in retirement.

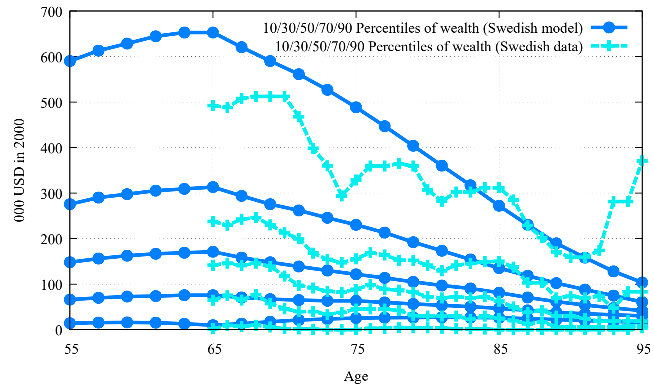
6.1 The Swedish Model

Figure 8 shows results of the Swedish model. This model retains the estimated parameters of the U.S. model, except for ζ and $\underline{c}$, which are adjusted to account for the difference in average incomes between the U.S. and Sweden.[22] In addition, institutional features of this model are replaced with Swedish calibration. These include life-cycle income profiles and income

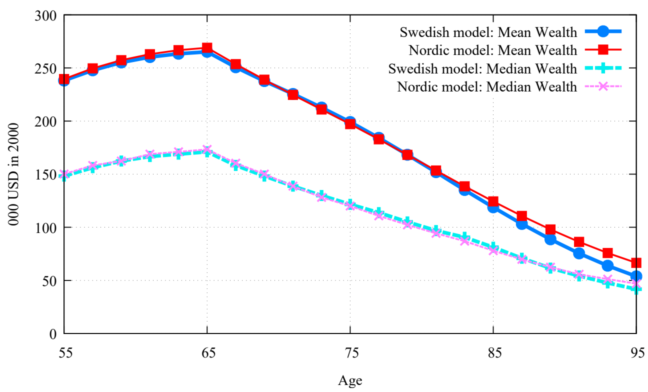
[22] We adjust ζ and $\underline{c}$, because average income is $33,100 in the U.S. and $21,600 in Sweden. If we keep the same value of $\underline{c}$ as estimated for the U.S. model, the consumption floor artificially becomes relatively more generous in Sweden. In the Swedish calibration, we multiply $\underline{c}$ estimated for the U.S. model by (21.6/33.1) to take the income level difference into account. We make the same adjustment to ζ. In testing, we found the effect of adjusting ζ and $\underline{c}$ to be minimal.



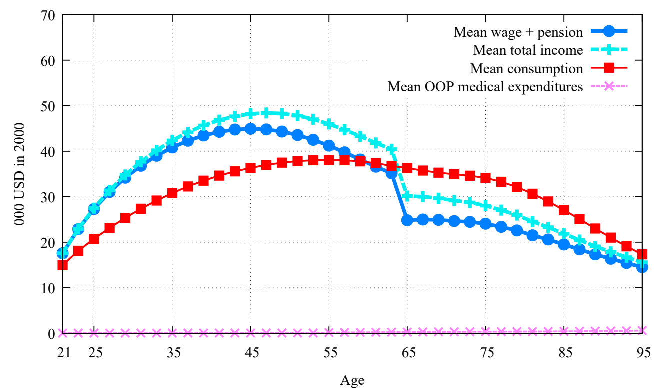
(a) Mean and Median Wealth



(b) Percentiles of Wealth



(c) Mean and Median Wealth: Sweden and Northern Europe according to the Model

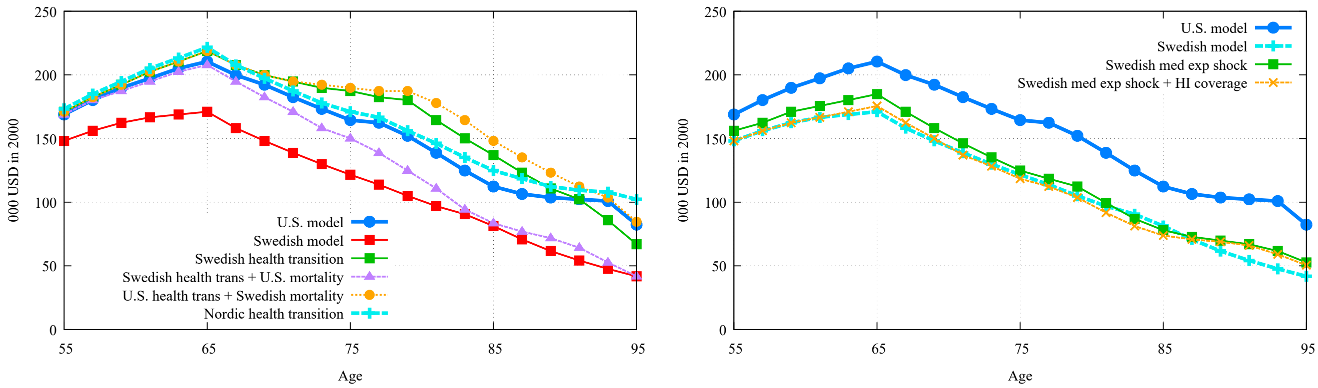


(d) Income and Consumption

Figure 8: Swedish Model vs. Data

shocks, health transitions, health insurance coverage and financing, and the level and risk of OOP medical expenses. Panel (a) compares Swedish model and data in terms of mean and median wealth. Panel (b) compares the model and the data in terms of percentiles of wealth. We do not show the proportion of households who use the consumption floor, because we do not have corresponding data for Sweden.

Figure 8(a) shows that the Swedish model fits the mean and median data wealth profiles well. In particular, the model captures the fact that Swedish households decumulate wealth faster than U.S. households. As one measure that quantifies the speed of wealth decumulation, the ratio of median wealth at age 95 relative to that at age 65 is 0.33 in U.S. data and 0.13 in Swedish data. In the model, the ratios are is 0.39 and 0.24, respectively. The data ratios of *mean* wealth at age 65 relative to that at age 65 are 0.48 in U.S. and 0.34 in Sweden. In the model, these ratios are 0.55 and 0.20, respectively. The difference in the speed of wealth decumulation between the U.S. and Sweden is smaller in the model than in the data for median wealth, but larger in the case of mean wealth. Figure 8(b) shows that the Swedish model slightly overestimates the higher percentiles of wealth, but captures lower percentiles of wealth better.



(a) U.S. Model + Swedish Health Shock (b) U.S. Model + Swedish Medical Expense Shock

Figure 9: Role of Health and Medical Expense Shocks: Median Wealth

Figure 8(c) shows the mean and median wealth of the Swedish model and the "Nordic model," which is the same as the Swedish model except for the transition probabilities of health status, which are calibrated to include the extra countries of Austria, Germany, Norway and the Netherlands as previously discussed. This is a robustness check to address small data samples sizes for Sweden later in life. The figure shows that the Swedish model and the Nordic model exhibit virtually identical median wealth decumulation profiles, while the speed of mean wealth decumulation for older households is slightly slower in the Nordic model. The key takeaway from Figure 8(c) is that the model is robust to using either Swedish or pooled health transition dynamics of the five Northern European countries.

Finally, Figure 8(d) shows average life-cycle profiles of income, consumption and medical expenses in the Swedish model. This is a counterpart of Figure 7(d) for the U.S. model. Although mean OOP medical expenses are significantly smaller in Sweden than in the U.S., mean consumption profile is similarly hump-shaped in both countries.

Notice that elements that are not directly observable, such as preferences, are assumed to be the same between the U.S. and Sweden. If this assumption is relaxed, our Swedish model would fit the Swedish data even more closely. Relatedly, since estate taxation is indirectly captured in bequest parameters, we do not explicitly model differences in estate taxation. While this is an abstraction, the exemption level for estate taxation in the U.S. is quite high ($1.5 million in 2005), while the inheritance tax was abolished in Sweden in 2004, although prior to that, the top statutory inheritance tax rate was 30%.

6.2 Role of Health and Medical Expense Shocks

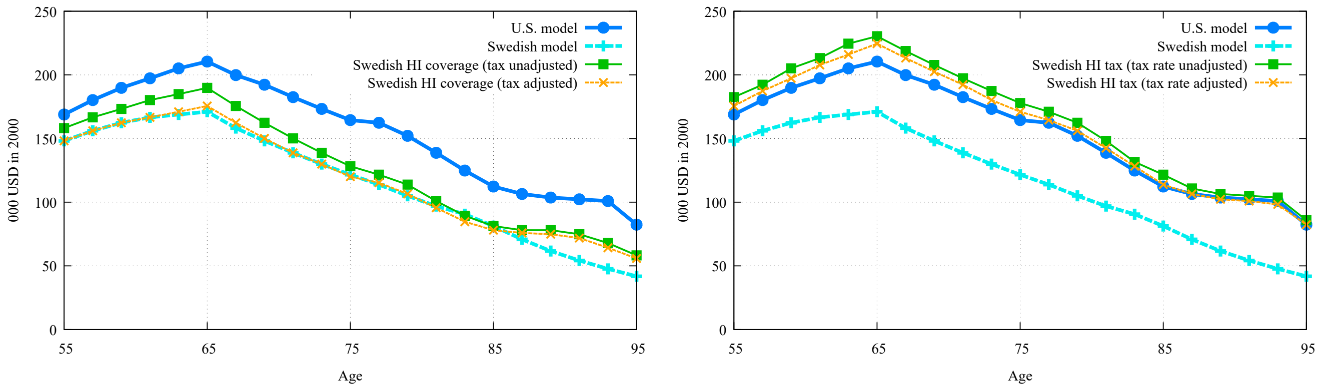
Starting with this section, we look at the key question of the paper. Specifically, we address individual elements that may account for the observed differences between Swedish and U.S. wealth profiles in retirement, one at a time. Figure 9(a) shows the model in which only the health shock is changed from U.S. to Swedish (or Nordic) calibration, keeping all other elements of the U.S. model intact. Panel (b) shows the model in which only medical expense shocks are switched from U.S. to Swedish ones.

Do these changes lead to faster decumulation of wealth in retirement? Starting with the health shock, somewhat surprisingly, when Swedish health transition probabilities are introduced, the pace of wealth decumulation slows, until after age 90 (green line in panel (a)). The reason is the relative longevity of Swedes. As discussed in Section 3.2, Swedish individuals live longer, and thus need to keep more savings as they age. The Swedish health transition also implies that medical expenses are higher when U.S. medical expenses are kept in the model, since Swedish households report being in worse health. This means that households would spend more on medical expenses, which should make wealth decumulation faster. Figure 9(a) shows a decomposition of the two elements of the Swedish health transition. In one experiment, the Swedish health transition is modified such that U.S. mortality rates are kept, but Swedish health transition probabilities conditional on survival are introduced (purple line). In that case, wealth decumulation becomes significantly faster compared with the U.S. model, caused by larger medical expenses because of Swedes' worse health. Moreover, U.S. mortality rates in this experiment imply that households do not need to save much for later years. However, this effect is more than canceled out because Swedish individuals have higher longevity and thus have to keep savings later in life. This can be seen as the difference between the purple line and the green line, which is significant. Figure 9(a) contains another experiment (orange line), in which Swedish mortality rates are introduced, but conditional on survival, U.S. health transition is kept intact. In this case, both the higher longevity of the Swedes and the relatively smaller medical expenses because of households' better health make wealth decumulation even less steep than the counterfactual with the Swedish health transition.

Figure 9(a) also contains the case in which the Nordic health shock is introduced into the U.S. model (cyan line). The Nordic health shock also creates faster health deterioration than the U.S. benchmark, but it is not as fast as in the Swedish case. Therefore, wealth decumulation in this experiment is slower than the baseline U.S. model, but the slowdown is smaller than in the model with the Swedish health shock profile. Figure D.2 in Appendix D provides more counterfactual experiments with the Nordic health transition.

Figure 9(b) shows wealth decumulation profiles in the model with the Swedish medical expense shock, keeping all other U.S. elements intact. This figure clearly shows that differences in gross medical expense shocks between the U.S. and Sweden are a key factor that creates the differences in wealth decumulation between the two countries (green line). Wealth decumulation becomes faster in the model with Swedish gross medical expense shocks because the risk of a large medical bill later in life becomes smaller, which weakens the precautionary saving motive. In addition, households arrive at retirement with less wealth, due to the same diminished precautionary motive.

Notice that we can distinguish gross medical expense risk from OOP medical expense risk here because we account for health insurance coverage in this model. If we introduce Swedish OOP medical expense shock, which is achieved by introducing both Swedish medical expense shock and Swedish high health insurance coverage ratio (orange line), wealth at retirement falls slightly further and the wealth decumulation profile becomes very close to the one of the full Swedish model. This implies that medical expense risk accounts for a large part of the observed differences in wealth decumulation between the U.S. and Sweden. De Nardi et al. (2010) find that the risk of living long and requiring expensive OOP medical care is a key driver



(a) U.S. Model + Swedish Health Insurance Coverage (b) U.S. Model + Swedish Health Insurance Financing

Figure 10: Role of Health Insurance: Median Wealth

of saving, especially for high-income retirees, in the U.S. Kopecky and Koreshkova (2014) find that 13.5% of aggregate wealth in the U.S. can be accounted for by saving for old-age OOP medical expenses. Banks et al. (2019) document that nondurable consumption expenditures decline significantly faster at older ages among U.K. households compared with the U.S., and find that differences in age profiles of medical expenses and medical expense risk between the two countries can account for the differences in the consumption profiles.

6.3 Role of Health Insurance

In this section, we explore how differences in health insurance between the U.S. and Sweden affect wealth decumulation dynamics. The general takeaway from this section is that the design of health insurance — the coverage ratio and financing scheme — significantly affects the life-cycle profile of wealth accumulation and decumulation. Health insurance coverage ratio, unsurprisingly, changes OOP medical expense risks that retired households are facing, and thus changing the coverage ratio has similar consequences to changing gross medical expense risk. How health insurance for retirees is financed also affects wealth accumulation and decumulation patterns, since households adjust saving behavior according to whether they pay for retirement health insurance prior to retirement or only after retirement.

As described in Sections 4 and 5, health insurance for retirees in the two countries is different both on the coverage side and on the financing side. Swedish health insurance covers a substantially higher fraction of gross medical expenses (93.5% as opposed to 72.6% in the U.S.) This lower coverage, as well as higher gross medical expenses overall, mean that OOP medical expenses in the U.S. are significantly higher. In terms of financing, in the U.S. health insurance for retirees, Medicare, is separate from health insurance for workers, many of whom obtain health insurance from their employers. In contrast, in Sweden, there is universal health insurance which covers both working and retired households. Secondly, U.S. Medicare is financed both by Medicare premium paid by its beneficiaries and by Medicare tax paid by working households. In other words, U.S. workers pay for part of their retirement health insurance in advance. In contrast, all Swedish households contribute to single universal health insurance scheme. Although working households tend to earn more and contribute more to the health insurance budget than retired households, there is no extra tax for working households to support health insurance for retirees as in the case of Medicare.

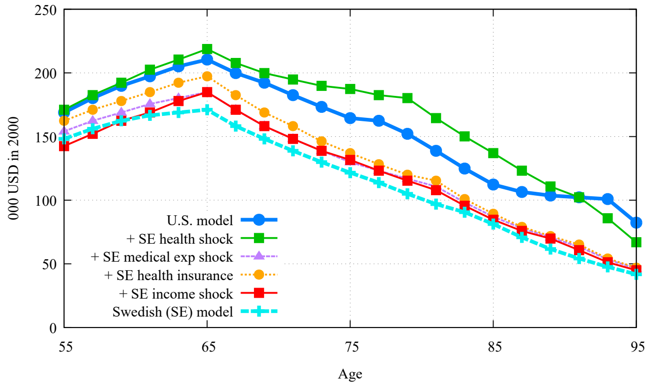
In Figure 10(a), we change the U.S. health insurance coverage ratio ϕ^h from 72.6% to 93.5%, and investigate the implications for the wealth profile. We show two cases: one with the tax rate τ^g fixed at the baseline rate (green line), and the other with the rate re-adjusted to balance the budget as in Equation (7) (orange line). When the health insurance coverage ratio is raised to the Swedish level, the tax rate must be raised to balance the budget. In the current case, the general income tax rate is raised from 1.60% to 3.05%. If health insurance coverage ratio is raised, but tax rate is not adjusted, the decumulation profile shifts down and gets closer to the wealth decumulation profile of the full Swedish model. This wealth decumulation profile is also close to the case in which Swedish medical expense shocks are introduced to the U.S. model (Figure 9(b)). This is because having U.S. medical expense shocks that are covered by Swedish high health insurance coverage rate greatly diminishes the pass-through of these shocks to households, bringing them close to the small Swedish medical expense shocks. When OOP medical expenses are expected to be small, either because the gross medical expenses are small or because health insurance coverage ratio is high, households carry less wealth into retirement and decumulate faster, since they do not need as much wealth for precautionary purposes. Further, if the general income tax rate is also raised, average life-time income goes down, so households carry even less wealth into retirement. The resulting wealth decumulation profile is virtually identical to the one in the full Swedish model between age 65 and 85.

In Figure 10(b), we keep the U.S. health insurance coverage ratio, but change the way health insurance is financed. In particular, Swedish universal health insurance as in Equation (8) is introduced. When we keep the baseline Swedish tax rate, wealth carried into age 65 goes up from the U.S. model. This is because under the Swedish financing scheme, retirees pay more and workers pay less for health insurance, compared with the U.S. Households carry more wealth into retirement to pay for the health insurance tax. In retirement, the speed of decumulation is faster since average wealth at age 95 is the same as in the U.S. model. When the tax rate (τ^g) is adjusted to satisfy Equation (8), the income tax rate has to go up from 8.37% to 11.09%, so the whole life-cycle wealth profile shifts down.

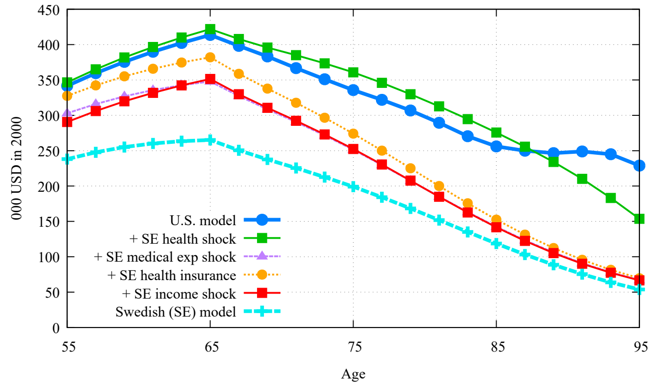
6.4 Quantifying the Swedish Experiment

This section quantifies the contribution of each of the Swedish elements in accounting for U.S.-Swedish differences in wealth decumulation. Figure 11 illustrates how wealth profiles change as we start from the U.S. model and introduce all the Swedish elements one at a time, getting closer to the Swedish model. Panel (a) shows median wealth profiles of different models, some of which we covered in the previous sections, while panel (b) shows mean profiles. Then we quantify the contributions in Table 6.

As we discussed in Section 6.2, when the Swedish health transition probabilities are introduced (green line) into the U.S. model (blue line), holding all other elements the same, the median wealth profile shifts up, since health deteriorates with age more significantly among Swedish



(a) Median Wealth



(b) Mean Wealth

Figure 11: Decomposing U.S.-Swedish Differences in Wealth Decumulation

households, and they have to carry more wealth to pay for higher OOP medical expenses. However, when Swedish gross medical expense shocks conditional on health status are added to the model (purple line), median wealth profile shifts down significantly, and gets close to the full Swedish model (cyan line), as households do not need to keep as much wealth to pay for OOP medical expenses. If the Swedish health insurance with a high coverage ratio and same tax for all households is introduced (orange line), this high coverage does not have a strong effect since gross medical expenses in Sweden are already low. However, Swedish health insurance financing scheme pushes the median wealth profile up, since retirees pay more for their health insurance under the Swedish scheme compared to the U.S. When the Swedish labor income shock is added (red line), households carry less wealth into retirement, since Swedish income risk is lower than in the U.S., and thus diminishes the precautionary saving motive during working years. Finally, when Swedish average income profile is introduced, bringing the model to the full Swedish one (cyan line), median wealth profile further shifts down as income levels are generally lower in Sweden.

Mean wealth profiles, shown in Figure 11(b), exhibit the same order and qualitative characteristics as median wealth profiles. Quantitatively, there are two relatively large differences. First, the impact of the Swedish medical expense shock (shown as the shift from the green to the purple lines) is larger for older ages. Since higher-income households do not rely on the consumption floor (i.e., Medicaid), and their medical expense risk in later years is higher, they have a larger drop in precautionary saving against medical expense shocks when Swedish shocks are introduced. Second, the effect of switching to the Swedish average income profile (shift from the red to the cyan lines) is larger for younger ages. This is because Swedish income dispersion is smaller than in the U.S. (Figure 6(c)), so high-income households hold significantly less wealth, which affects the mean wealth profile more than the median wealth profile.

In Table 6, we quantify individual contributions of Swedish institutional features to wealth decumulation patterns. The top panel of the table shows these contributions measured with median wealth, while the bottom panel is for mean wealth. The first column shows $W_{65}/W_{65}^{US} \times 100$, where W_{65} is age-65 wealth for the given row (either Swedish data or one of the models),

Table 6: Quantifying the Contribution of Swedish Elements

Percent	W_{65}/W_{65}^{US}[1]	Contribution to Faster Decumulation[2]		
		Age 75	Age 85	Age 95
Median wealth				
Swedish data	68.4	100.0	100.0	100.0
Swedish model	81.6	24.5	16.8	81.9
Swedish health transition	104.4	–25.9	–26.5	47.3
Swedish gross medical expense risk	88.2	36.9	32.1	59.1
Swedish OOP medical expense risk	83.7	37.1	32.4	57.7
Swedish health insurance coverage	90.5	36.7	30.2	47.0
Swedish health insurance financing	107.1	6.8	7.6	13.6
Mean wealth				
Swedish data	55.9	100.0	100.0	100.0
Swedish model	62.5	54.8	94.1	163.8
Swedish health transition	99.5	–39.2	–18.7	88.3
Swedish gross medical expense risk	81.7	104.9	117.7	141.3
Swedish OOP medical expense risk	79.9	108.2	119.2	140.1
Swedish health insurance coverage	86.5	86.7	94.8	96.9
Swedish health insurance financing	102.8	6.1	9.4	14.5

[1] W_{65}, which is wealth at age 65 of the given row, divided by W_{65}^{US}, which is wealth at age 65 of either the U.S. data (for Swedish data) or the U.S. model (for models).

[2] Percentage of empirical U.S.-Swedish differences in wealth decumulation that can be explained by the model. See the main text for more details.

and W_{65}^{US} is the age-65 wealth in U.S. data. Columns 2-4 show the percentage of the empirical difference between wealth decumulation profiles in the two countries that can be explained by a given feature. Specifically, the percentage explained at age-i, p_i, is computed as follows:

$$p_i = \frac{W_{\text{mod},i}^{US}/W_{\text{mod},65}^{US} - W_{\text{mod},i}/W_{\text{mod},65}}{W_{\text{dat},i}^{US}/W_{\text{dat},65}^{US} - W_{\text{dat},i}^{SE}/W_{\text{dat},65}^{SE}} \times 100 \tag{10}$$

where $W_{\text{mod},i}^{US}$ and $W_{\text{dat},i}^{US}$ are wealth level at age-i in the U.S. model and in the U.S. data, respectively, and $W_{\text{dat},i}^{SE}$ are the same for Sweden.[23] $W_{\text{mod},i}$ is the wealth level of the given row (either Swedish data or one of the models). For example, consider the number $p_i = 24.5\%$ for the Swedish model at age $i = 75$. In the U.S. data, median wealth at 65 and 75 are $W_{\text{dat},65}^{US} = 210K$ and $W_{\text{dat},75}^{US} = 198K$, the ratio of which is 0.946. For the Swedish data, the ratio is 0.657, based on median wealth at age 65 ($W_{\text{dat},65}^{SE} = 143K$) and 75 ($W_{\text{dat},75}^{US} = 94K$). The difference of the ratios, which represents how fast median wealth declines in Sweden, is 0.289. This is the denominator of equation (10) above. In the U.S. model, median wealth at age 65 and 75 are $W_{\text{mod},65}^{US} = 210K$ and $W_{\text{mod},75}^{US} = 165K$. In the Swedish model, median wealth at age 65 and 75 are $W_{\text{mod},65} = 171K$ and $W_{\text{mod},75} = 122K$. The difference in the decumulation ratio of the U.S. model (0.771) and

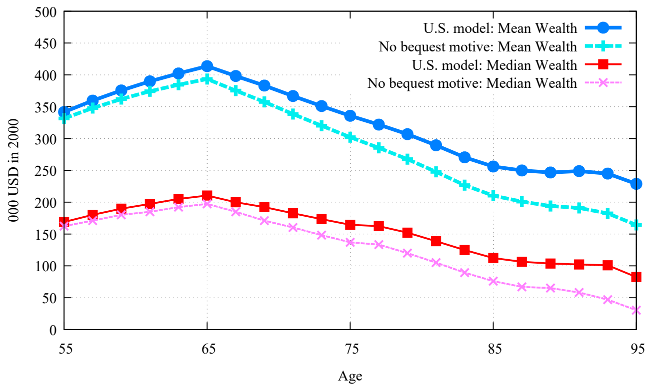
[23] U.S. and Swedish data are smoothed using a quadratic function with respect to age; using raw profiles with 5-year age binning gives similar results.

of the Swedish model (0.711) is 0.071. In the model, Swedish retirees decumulate wealth faster than the U.S. retirees, but the difference in the speed of decumulation (0.071) is not as large as in the data (0.289). How large is the difference between the model and the data? That's what $p_i = 24.5\%$ represents, as p_i is the ratio between 0.071 and 0.289.

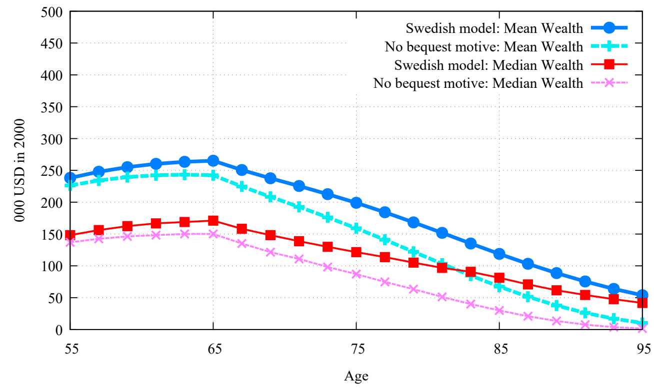
U.S. and Swedish models can account for 25%, 17%, and 82% of the observed differences in median wealth decumulation rates between the two countries at ages 75, 85, and 95, respectively. As previously discussed, introducing Swedish health transitions makes wealth decumulation slower in the model. Specifically, the model with Swedish health shocks contributes negative 26% and 27% in explaining faster wealth decumulation of Sweden relative to the U.S. at age 75 and 85, before contributing positive 47% at age 95. As we have shown, either introducing Swedish gross medical expense shocks or introducing Swedish health insurance coverage accelerates wealth decumulation in the model, and thus the model with either feature can account for a large proportion of the observed faster wealth decumulation in Sweden. Specifically, Swedish gross medical expense shocks account for 36%, 32% and 59% of the observed faster wealth decumulation in the Swedish data, at ages 75, 85 and 95. Swedish health insurance coverage accounts for 37%, 30%, and 47% for ages 75, 85 and 95, respectively. Both features together, equivalent to introducing Swedish OOP medical expense risk, account for 37%, 32% and 58%.

In addition, these two Swedish features also bring the wealth level at age 65 closer to Swedish data, as shown in the first column. For example, if Swedish OOP medical expense risk is introduced, median wealth at age 65 becomes 16% lower than the U.S. model, compared with the observed 32% difference. On the other hand, introducing Swedish health insurance financing induces households to increase saving carried into retirement, increasing the median wealth level at age 65 by 7%. Since households pay more for health insurance in retirement, wealth decumulation in the model with Swedish health insurance financing is faster, by 7%, 9%, and 14%, at ages 75, 85, and 95, respectively.

The bottom panel of Table 6 shows that results based on mean wealth are qualitatively similar, but as discussed, the percentage of wealth decumulation rate differences that each Swedish feature of the model can explain is larger, since wealthy households are less likely to rely on the consumption floor and are more sensitive to changes related to their medical expense risks. This result is consistent with graphical illustration shown in Figure 11. Specifically, the model with all the Swedish institutional features can account for 55%, 94%, and 164% of the observed faster mean wealth decumulation in the Swedish data, and also for much of the difference in wealth at age 65. Like in the case of median wealth, introducing Swedish health shocks makes wealth decumulation slower, while Swedish gross medical expense risk or health insurance coverage can account for all or almost all of the observed faster mean wealth decumulation in the Swedish data. Introducing Swedish health insurance financing makes the wealth carried into retirement higher, since retirees have to pay more for their health insurance under the Swedish scheme.



(a) U.S. Model without Bequest Motive



(b) Swedish Model without Bequest Motive

Figure 12: Models with and without Bequest Motive: Mean and Median Wealth

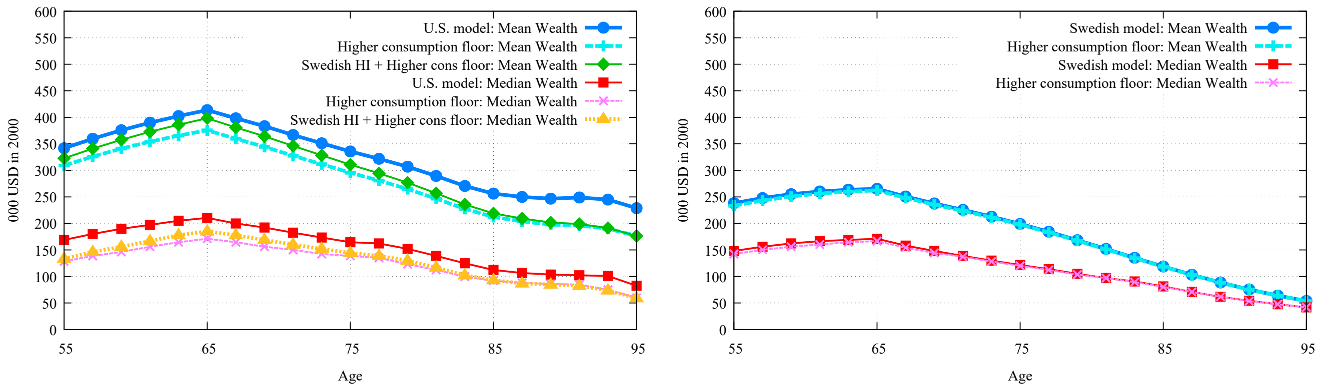
6.5 Interactions with Bequest Motive

This section briefly discusses the role of bequest motives in shaping wealth profiles in retirement, since bequests are often pointed out in the literature as one of the main driving forces behind wealth decumulation dynamics of older households. Figure 12 compares scenarios with and without bequest motives in the U.S. model (panel (a)) and the Swedish model (panel (b)). In both countries, if we shut off the bequest motive (by setting $\gamma = 0$), wealth decumulation becomes faster. In Sweden, both mean and median wealth go down to almost zero by age 95, which is consistent with predictions of a simple life-cycle model. However, among U.S. households, mean and median wealth decrease but remain positive at age 95. This is due to the large medical expense risks, especially for the oldest old. This contrast of wealth decumulation pattern between the U.S. and Swedish households is consistent with previous literature.

7 Health Insurance and Consumption Floor

This section focuses on interactions between the two forms of social insurance policy, namely unconditional health insurance and means-tested health insurance represented by the consumption floor in the model. In the U.S., Medicare is the former, while Medicaid is the latter. Since the coverage ratio for health insurance is higher in Sweden than in the U.S., Sweden can be described as relying more on the former, and the U.S. on the latter. The results of the relevant experiments are shown in Figure 13. Panel (a) shows how mean and median wealth profiles in the U.S. model change when we double the size of the consumption floor $\underline{c}$, capturing a theoretical increase in Medicaid benefits. We also show the case in which more generous Swedish unconditional health insurance is introduced in addition. Panel (b) shows the same for the Swedish model.

Starting with the Swedish model, Panel (b) shows that doubling the consumption floor does not change wealth decumulation profiles noticeably. Since gross medical expenses are relatively small and health insurance coverage is already high in Sweden, there is no strong need for means-tested health insurance in addition. In other words, unconditional health insur-



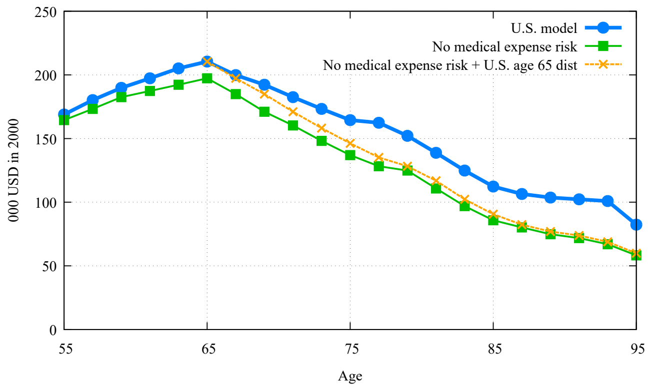
(a) U.S. Model with Higher $\underline{c}$ (b) Swedish Model with Higher $\underline{c}$

Figure 13: Interactions between Health Insurance and Consumption Floor: Mean and Median Wealth

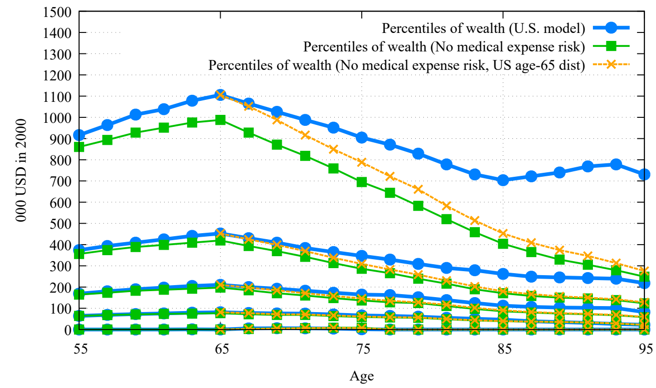
ance and means-tested health insurance policies are substitutes. It is reasonable to think that the consumption floor is different (possibly higher) in Sweden than the U.S., but we do not recalibrate $\underline{c}$ for Sweden because we do not have the necessary data, and wealth decumulation profiles are not sensitive to the consumption floor in Sweden.

The U.S. is a different story. Since gross medical expense uncertainty is significant, while unconditional health insurance coverage is lower, households rely more on the means-tested health insurance $\underline{c}$. Therefore, if the consumption floor is doubled, households across all ages save less, for two reasons. First, the worst outcome, i.e. being hit by a large medical expense shock and thus having to rely on the consumption floor, is not as bad with $\underline{c}$ twice as high. Precautionary saving motive weakens, making the third form of insurance, which is self-insurance through wealth accumulation, less important. Second, since access to the consumption floor is means tested, a household has to exhaust savings to qualify for it. With $\underline{c}$ twice as high, the motivation to do this rises. These two channels are emphasized by Hubbard et al. (1995).

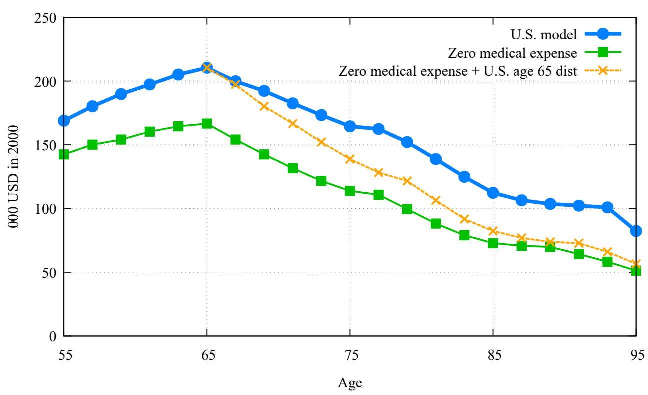
The novelty of our analysis is that while Hubbard et al. (1995) study the interactions between two forms of insurance, namely means-tested consumption floor and self-insurance, our analysis includes unconditional health insurance as the third form of insurance. Panel (a) also shows that if Swedish health insurance with the high coverage ratio is introduced on top of doubling the consumption floor, the effect of the generous consumption floor on wealth accumulation is mitigated, but only for a subset of households. The mitigating effect is stronger for younger and higher-income households, whose saving profile increases toward the initial U.S. baseline. This again can be understood as the substitutability between the two forms of social insurance. When unconditional health insurance is more generous, younger and higher-income households with more wealth rely less on means-tested social insurance, so absent the need to exhaust those savings, they increase wealth holding. In contrast, older and lower-income households rely more on means-tested social insurance $\underline{c}$ already. Their dissaving behavior is less affected by the generosity of universal health insurance.



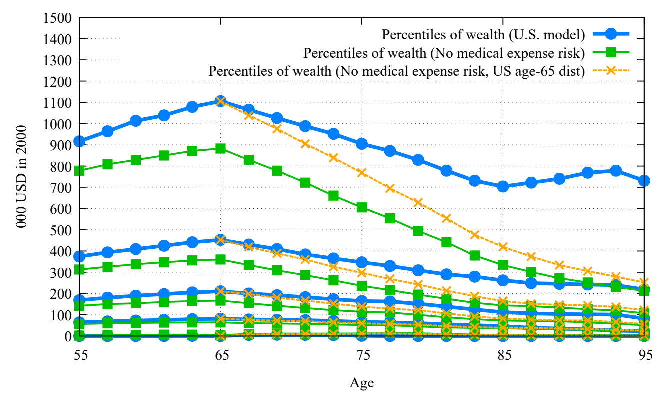
(a) No Medical Expense Risk: Median Wealth



(b) No Medical Expense Risk: Percentiles of Wealth



(c) Zero Medical Expense: Median Wealth



(d) Zero Medical Expense: Percentiles of Wealth

Figure 14: Experiments: Medical Expense Risk in Post-Retirement Model

8 Medical Expenses and Wealth Decumulation: Full vs. Partial Life-Cycle Model

In this section, we demonstrate the impact of using a full life-cycle model like ours to study saving after retirement, as compared to the partial life-cycle model typically used in the literature. Specifically, we measure the impact of medical expenses on wealth decumulation in retirement both in our full life-cycle model, and in the partial life-cycle model developed in, e.g., De Nardi et al. (2010) and Nakajima and Telyukova (2020). In the literature studying wealth decumulation after retirement, including our own past papers, it is common to assume that (1) life starts after retirement (e.g. age 65), with an exogenous distribution of agents to parallel the empirical one, and (2) there is no general equilibrium. We refer to this model as the *post-retirement model*. To capture the essence of the post-retirement model in our framework, we fix the type distribution of households at age 65 to the one in the baseline life-cycle model, and we do not allow it to change as a result of our experiments.

The use of the post-retirement model allows for parsimony in the face of complex questions (e.g., the presence of a second asset like housing), but when the model is used to study implications of a permanent and large change in the economic environment, and the change is expected to affect saving decisions of households prior to retirement, abstracting from pre-retirement decisions and from general equilibrium could change the implications of the model significantly. Our experiments presented here (see Figure 14) provide one such example. Specifically, we show that (1) pre-retirement saving decisions matter when a permanent and large policy change affects the saving motive after retirement, and (2) when there is a permanent and large change in taxes which affects the life-cycle profile of tax payments of households, the life-cycle profile of saving is also affected.

In Figures 14(a) and (b), we turn off OOP medical expense risk, by replacing OOP medical expense shocks by the expected mean of medical expenses conditional on age, income, and health. While tax rates can adjust in the model, they stay the same, since the law of large numbers implies that total expenditures of health insurance programs remain unchanged. Panel (a) shows the median, while Panel (b) shows the 10/30/50/70/90 percentiles of wealth. Since there are still shocks to health which affect expected value of medical expenses, some medical expense risk is retained, but it is small. The blue line shows the baseline full life-cycle U.S. model, while the green line shows the experiment where we solve the full life-cycle model after we shut down medical expense risk. The yellow line shows the scenario where we shut down medical expense risk, but keep the distribution of agents at age 65 the same as the baseline model, representing the common approach in the literature using a post-retirement model.

Comparing the blue and yellow lines, we see that medical expense risk causes significantly slower wealth decumulation in retirement. However, part of the effect is created by the fact that the age-65 wealth level is held unchanged. If households are allowed to change saving behavior before age 65, they carry less wealth into retirement when OOP medical expense risk is shut down, as shown by the green line, since precautionary saving motive is weakened. The rate of wealth decumulation is still faster in this model, but the difference is less dramatic than in the post-retirement model. Panel (b) shows that the same happens for all percentiles of wealth, though it is more pronounced for the higher percentiles where the ability to save for retirement is higher. The response of the lower income groups is weaker because they rely more on Medicaid when they are hit by a large OOP medical expense shock, and therefore save less for precautionary reasons. In addition to this distributional effect, panel (b) also demonstrates how the precautionary saving parameter σ is identified through the wealth distribution.

When we set OOP medical expenses to be *zero*, as shown in Figures 14(c) and (d), the implications of modeling the full life cycle are even more pronounced. Panels (c) and (d) again show median wealth and percentiles of wealth of the three models. Comparison between the blue and yellow lines in Panel (c) indicates that when OOP medical expenses are set to zero in the post-retirement model, wealth decumulation becomes even faster than the first experiment presented above. As in the first experiment, the green line indicates that the seemingly faster decumulation is in large part due to the inability to adjust savings before age 65, so retirees in the post-retirement model dissave the excess wealth more quickly. When households can adjust saving before age 65, they carry significantly less wealth into retirement for two reasons. First, precautionary saving motive is weaker, as in the first experiment above. Second, households “pre-pay” more of retirement-age medical expenses before age 65 in the form of taxation. When OOP medical expenses are set to zero, the general tax rate goes up to balance the government budget constraint. This higher tax rate is equivalent to paying for a larger part of post-retirement medical expenses in advance, which yields lower savings carried into retirement. Panel (d) again shows that the same exaggeration of faster decumulation of wealth in the post-retirement model can be seen in much of the wealth distribution, particularly in the upper percentiles of wealth. Therefore, the impact of medical expenses on (dis)saving behavior in retirement may be overstated in a post-retirement model, where faster decumulation partly replaces the true effect of lower saving prior to retirement.

9 Conclusion

In this paper, we bring in a cross-country perspective and a full life cycle to an important question of what contributes to slow decumulation of wealth among older households in the U.S. We first document that older households in Northern European countries decumulate wealth faster than U.S. households. Since gross medical expenses are lower and universal health insurance with higher coverage is available in Sweden and other European countries, we study whether the smaller gross medical expense risk and a higher health insurance coverage in these countries contributes to faster decumulation of wealth. We build a model with income, mortality, health, and medical expense shocks and health insurance program, estimate the model using U.S. data, and measure the contribution of salient Swedish features related to health and medical expense risk and insurance. The model with all the Swedish features can account for 82% of the U.S.-Swedish differences in median wealth decumulation at age 95. We find that smaller gross medical expense risk contributes to faster wealth decumulation. We also find, in a novel contribution to the literature, that the structure,timing and financing of health insurance has significant effects on the pace and dynamics of wealth decumulation in retirement. When higher health insurance coverage is available, households carry less wealth into retirement, and decumulate wealth faster, matching observed patterns in Sweden and other Nordic countries. When households pay more for health insurance after retirement, as in Sweden, they bring in more wealth into retirement to pay for health insurance.

We present a full life-cycle model, while most of the studies in the retirement saving puzzle literature, including our previous work, use models that abstract from pre-retirement saving decisions. A novel contribution of this paper is that our model sheds light on the role of these pre-retirement decisions in shaping the wealth decumulation profile after retirement. When medical expense risk is shut down, we find that wealth decumulation is accelerated in a post-retirement model relative to a full life-cycle model, because households are unable to adjust their pre-retirement wealth in response to lower risk. Therefore, a model that abstracts from the full life cycle may overstate the quantitative impact of medical expenses on wealth decumulation late in life.

There are two important questions to be answered in future research. First is the role of housing. In this paper, we focus on total wealth and do not distinguish between housing and non-housing financial assets. However, we document in our prior work that housing constitutes a large part of wealth for average households in many countries, including the U.S. and Sweden, and Swedish households decumulate financial assets faster than U.S. households, while housing assets are flat in retirement in both countries. As emphasized in our previous work (Nakajima and Telyukova (2020)), the presence of illiquid housing wealth in household portfolios can impact conclusions regarding what drives dissaving in retirement. By extending our model here by introducing housing and financial assets explicitly, we could understand U.S.-Swedish differences in wealth decumulation further. Second, the model developed in this paper can be used to understand optimal design of health insurance in retirement. How should health insurance be financed? What is the optimal combination of health insurance coverage and consumption floor? Our model provides a natural laboratory to answer these important questions.

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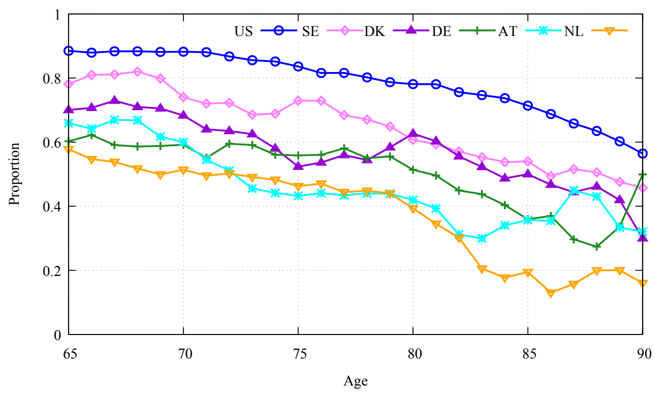
Appendix

A Additional Facts for the U.S., Sweden, and Other European Countries

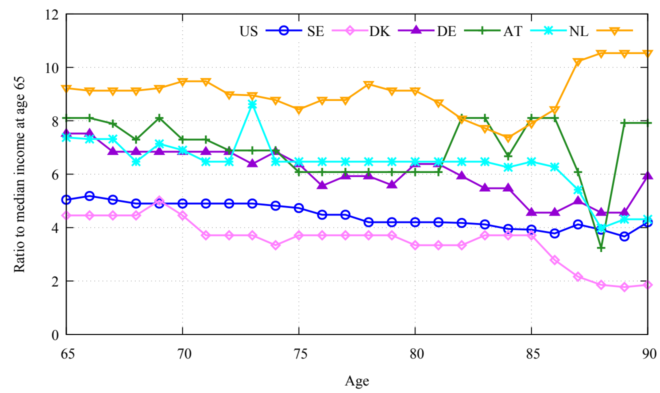
This appendix contains figures of the U.S., Swedish, and other Northern European data that are not in the main text. Figure A.1 contains (a) homeownership rate, (b) median conditional housing assets normalized by age-65 median income, and (c) median financial assets normalized by age-65 median income, for the U.S., Sweden, and four Northern European countries. This figure corresponds to Figure 1, which shows total asset profiles for these countries. For all countries, conditional housing profile seems flat, while the homeownership profile is downward sloping but not as steep as financial asset profiles, suggesting that housing is a contributing factor for generally slow decumulation of wealth, which we argue in Nakajima and Telyukova (2020). Figure A.1(c) shows that the U.S. households decumulate financial assets more slowly than European countries, which suggests that the observed slower decumulation of wealth in the U.S. is mainly due to slower decumulation of financial assets among U.S¿ households.

Focusing on just the U.S. and Sweden, in Figure A.2 shows homeownership rate (top row), median conditional housing assets (middle row), and median financial assets (bottom row) for five income quintiles for the U.S¿ (left panels) and Sweden (right panels). The panels show what we argue using the median, namely, decumulation of housing assets is slow in both the U.S. and Sweden, and the decumulation of housing assets is mostly done by extensive margin (selling the house) instead of by intensive margin (downsizing the house). On the other hand, the observed faster decumulation of wealth among the U.S. households is mainly due to faster decumulation of financial assets among the U.S. households compared with the Swedish ones. These are true for all income groups.

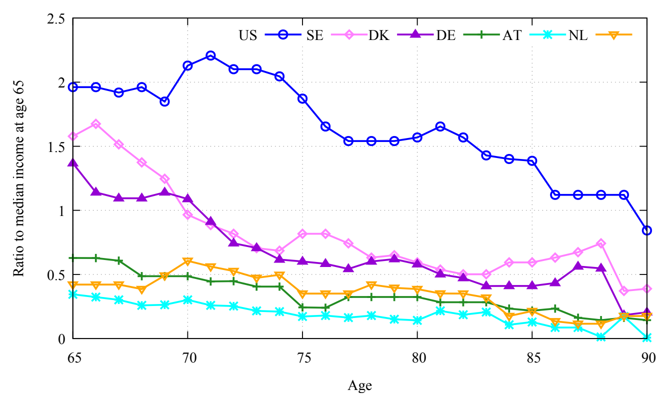
Finally, Figure A.3 shows that there is no significant differences between the U.S. and Sweden in terms of life-cycle profiles regarding debt. Panel (a) compares the overall proportion of households with a net negative financial asset position (net financial debt) for the U.S. and Sweden. They are remarkably similar, steadily declining from 20-25% at age 65 to less than 10% at around age 90. Panel (b) compares median net financial debt among debtors for the two countries. The U.S. median debt is decreasing in age, while the Swedish profile seems slightly flatter than the U.S. profile, but the difference is not large. Panels (c) and (d) compare the median debt profiles for five income quintiles, for the U.S. and Sweden. For the U.S. (Panel (c)), the median debt is generally decreasing in age for each income quintile. For Sweden (Panel (d)), it is hard to see a general tendency partly because of the small sample number of households if each income quintile is separately observed, but it seems like there is no obvious downward sloping profiles like for the U.S. profiles. Panels (e) and (f) show the proportion of households in negative financial asset position for each income quintile, for the U.S. and Sweden. For both countries, the profiles are steadily decreasing in age, as we have seen in Panel (a) which shows the overall proportion in debt. Panels (g) and (h) show that the declining profile of debt is not due to the definition of debt we use, by showing the proportion of households with gross secured debt (panel (g)) and with gross unsecured debt (panel (h)) in the U.S. and Sweden. In both countries, the proportion with gross secured debt and that with unsecured debt are decreasing in age.



(a) Homeownership Rate

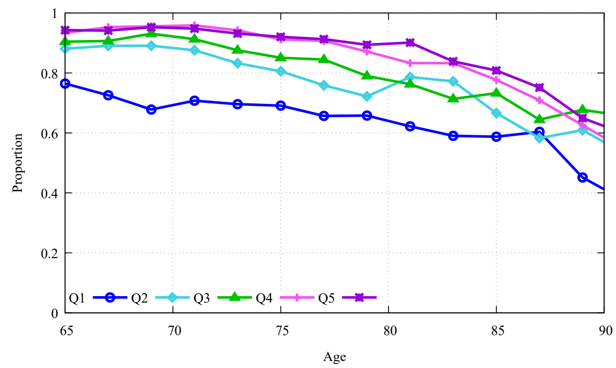


(b) Median Housing Assets /Median Inccome at 65

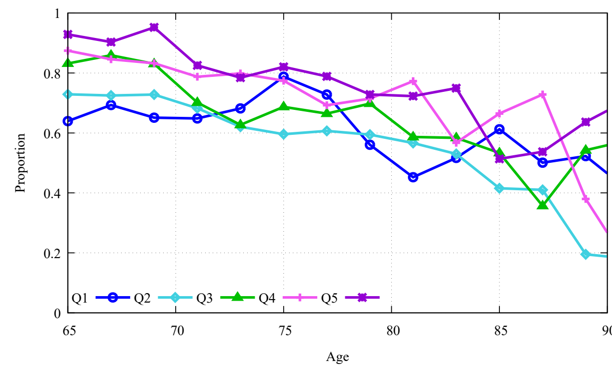


(c) Median Financial Assets / Median Income at 65

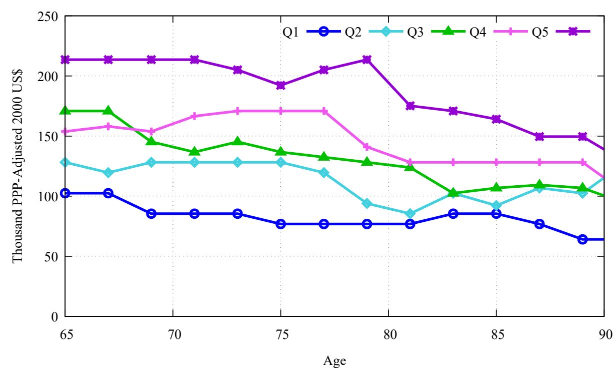
Figure A.1: Housing and Financial Asset Profiles, U.S. and Northern Europe



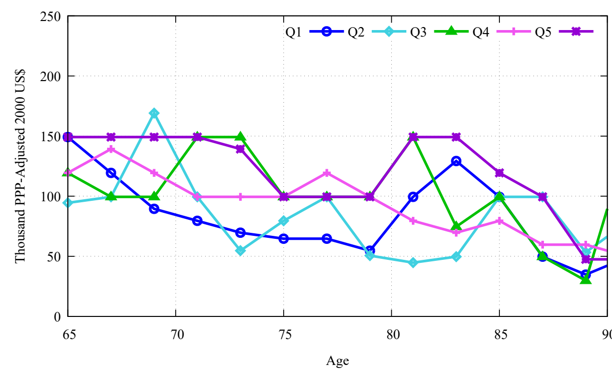
(a) U.S., Homeownership Rate



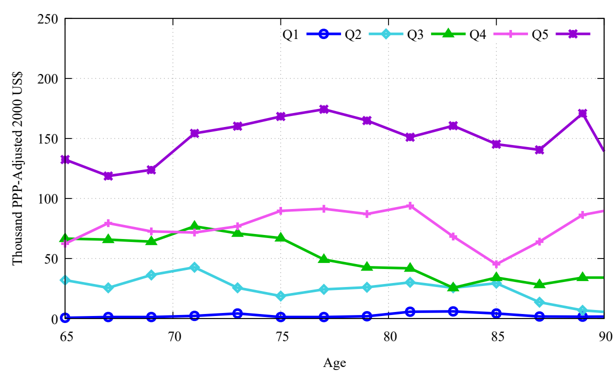
(b) Sweden, Homeownership Rate



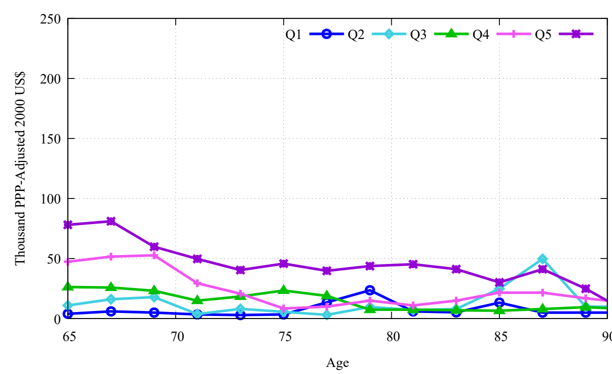
(c) U.S., Median Housing Assets



(d) Sweden, Median Housing Assets

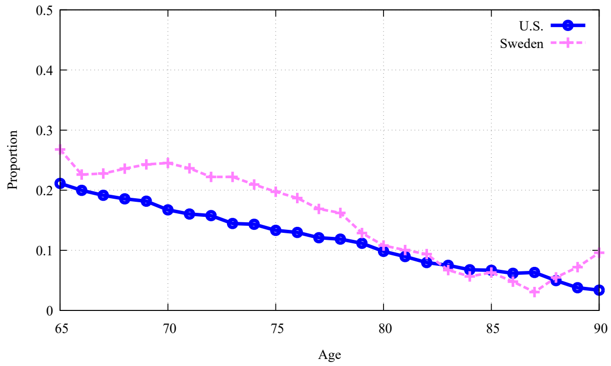


(e) U.S., Median Financial Assets

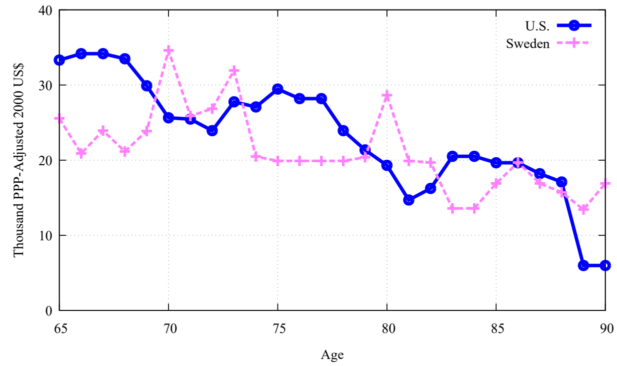


(f) Sweden, Median Financial Assets

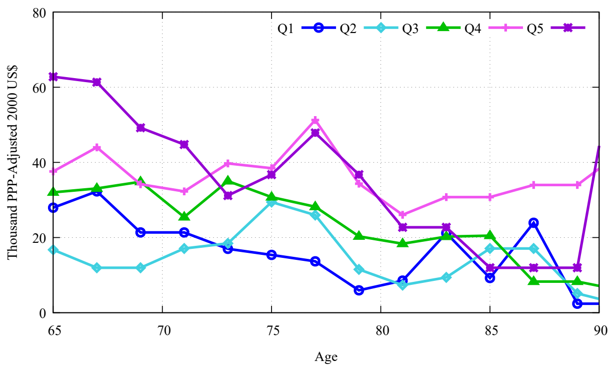
Figure A.2: Asset Profiles by Income Quintile



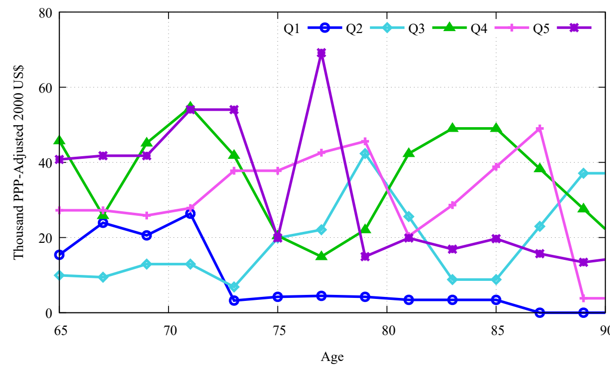
(a) Proportion in Net Debt: U.S. and Sweden



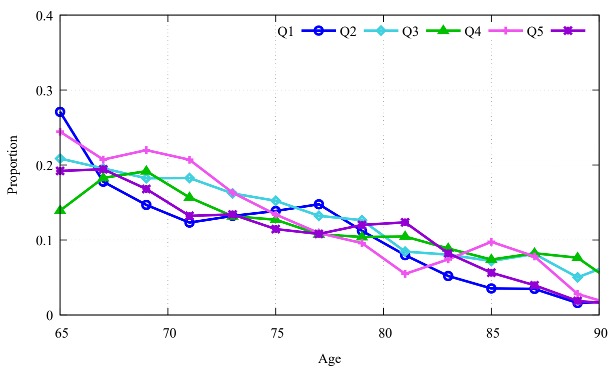
(b) Median Net Debt: U.S. vs. Sweden



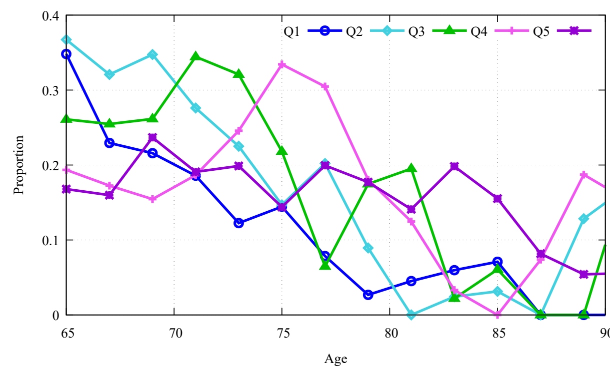
(c) Median Net Debt by Income Quintile: U.S.



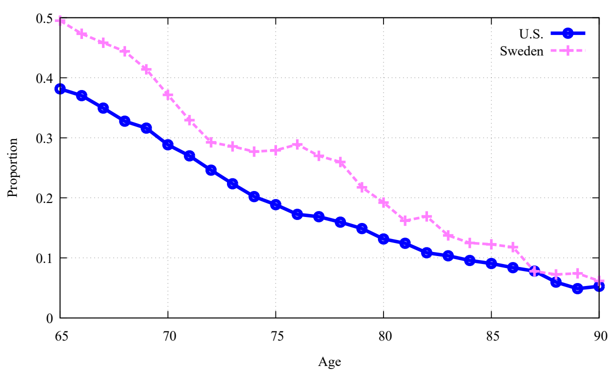
(d) Median Net Debt by Income Quintile: Sweden



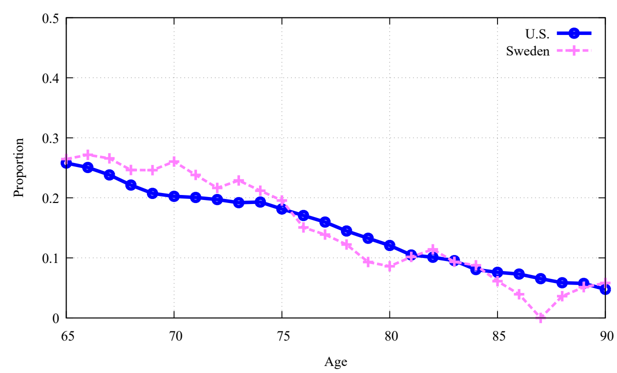
(e) Prop in Net Debt by Income Quintile: U.S.



(f) Prop in Net Debt by Income Quintile: Sweden



(g) Prop with Secured Debt: U.S. and Sweden



(h) Prop with Unsecured Debt: U.S. and Sweden

Figure A.3: Debt Profiles: U.S. and Sweden

B Health Transition Probabilities: Pre-65

Since we have a full life-cycle model, we need to construct health transition probabilities for all ages, $\pi^{m}_{i,b,m,m'}$, in the model. We divide the process of constructing health transition probabilities into pre-age-65 and post-65 stages. Prior to age 65, it is important for us to construct health transition probabilities that are consistent with the joint distribution of income and health at age 65. As emphasized by De Nardi et al. (2010) and Nakajima and Telyukova (2020), there is a strong correlation in the joint distribution between income and health status, among other household characteristics, at age 65. When a model starts at age 65, it is straightforward to incorporate the correlation since the initial type distribution can be directly taken from data, as in those two papers and many others taking the same approach. However, when we model the entire life cycle, joint distribution of income and health at age 65 becomes an endogenous object.

Unlike the post-65 health transition process, we cannot directly estimate the one prior to age 65 using longitudinal data, since HRS for the U.S. and SHARE for Europe only contain individuals of age 50 and above. For the U.S., MEPS (Medical Expenditure Panel Survey) covers individuals of all ages, and has longitudinal data. Therefore, we attempted to use MEPS to directly estimate pre-65 health transition probabilities. However, this method turned out to be unfruitful, for two reasons. First, since the distribution of health is different between HRS and MEPS, if we construct pre-65 health transition probabilities using MEPS, the resulting age-65 joint distribution of income and health is different from what we have in the HRS. Second, there is no clear way to translate income levels observed in MEPS into income shocks in the model, making the joining of the two periods of life difficult in the model.

Instead, we assumed a parsimonious parameterized form for the health transition probabilities and estimated pre-65 health transition probabilities so that the resulting age-65 joint distribution of income and health replicates the empirical age-65 distribution in the HRS as closely as possible. In estimating health transition probabilities, we make the following four assumptions. First, we assume that there is no mortality risk before age 65, i.e., $\pi^{m}_{i,b,m,0} = 0$. This is a reasonable assumption considering low mortality rates for younger individuals. Second, we assume that health transition probabilities are the same for all ages before age 65. This is to limit the number of parameters that we need to estimate with a limited target. Third, we take the initial (age-21) health distribution for the U.S. and Sweden from MEPS. MEPS asks its participants to self-report their health status in the same way as in HRS. However, the self-reported health status distribution at age 65 is different between HRS and MEPS, which suggests either that the questions are asked differently, or the sample is different. For tractability, we assume that the self-reported health status distribution at age 21 in MEPS captures the U.S. health distribution at age 21 well. We use the same initial health distribution for Sweden, since there is no such information for Sweden. In additional experimentation, we found that the initial health distribution is not important for age-65 health distribution since the age-65 distribution is mostly determined as the ergodic distribution of the transition matrix, independent of the initial distribution. Finally, we pose the following parameterized form for the health transition probabilities, given b, and for all i:

$$\pi^{m}_{i,b,m,m'} = \begin{bmatrix} 0 & \rho_{b,1} & 1-\rho_{b,1} & 0 \\ 0 & 0 & \rho_{b,2} & 1-\rho_{b,2} \\ 0 & 0 & 1-\rho_{b,1} & \rho_{b,1} \end{bmatrix} \tag{B.1}$$

Zeros in the left column indicates that mortality risk is zero before age 65. The matrix is characterized by two parameters, $\rho_{b,1}$ and $\rho_{b,2}$, with the former representing persistence of excellent and poor health states, and the latter representing persistence of good health status. Since this is age-independent, and there are five income levels, this parameterization implies that we have 10 parameters to be estimated. Given the initial (age-21) health status distribution, and guesses for the 10 parameters ($\rho_{b,1}$ and $\rho_{b,2}$ for all b), we can simulate the health status distribution up to age 65 and compare the health distribution at age 65 generated by the model with the actual health status distribution according to HRS for the case of the U.S. (SHARE for Sweden). The parameters are pinned down to minimize the sum of absolute distance between the distribution of health status generated by the model and the data. Notice there are five income bins, and two health states (the proportion of the third health status is automatically obtained as the residual), which means we have 10 parameters for 10 targets. Since the 2 parameters for each income level can be estimated to match the two distribution targets at age 65 independently from other parameters, the age-65 health distribution can be perfectly matched.

Table B.1 shows the initial (age-21) distribution of health (first column), and joint distribution of income and health at age 65, in the data (second column) and in the model (third column). The resulting estimated parameter values for the U.S. and Sweden are summarized in Table B.2. The estimated health transition probabilities generate the following features of the data successfully: (1) higher-income individuals are already healthier at age 21, (2) health deteriorates between age 21 and 65 for all income groups and (3) there are more individuals with excellent (poor) health in the higher (lower) income bins at age 65. We proceed similarly for Sweden. The last two columns compare the joint distribution between income and health in the data (fourth column) and generated by the model (last column). Our calibration procedure successfully replicates the fact that dispersion of health states is smaller, both overall and for each income group, in Sweden.

Table B.1: Joint Distribution of Income And Health at Age 65

	U.S., 21 Data	U.S., 65 Data	U.S., 65 Model	Sweden, 21 Data	Sweden, 65 Data	Sweden, 65 Model
Overall						
1 (excellent)	0.710	0.442	0.442	0.710	0.375	0.375
2 (good)	0.237	0.326	0.326	0.237	0.331	0.331
3 (poor)	0.053	0.232	0.232	0.053	0.294	0.294
Income Bin 1 (Bottom)						
1 (excellent)	0.696	0.262	0.262	0.696	0.313	0.313
2 (good)	0.262	0.332	0.332	0.262	0.302	0.302
3 (poor)	0.042	0.406	0.406	0.042	0.385	0.385
Income Bin 2						
1 (excellent)	0.701	0.409	0.409	0.701	0.327	0.327
2 (good)	0.261	0.357	0.357	0.261	0.390	0.390
3 (poor)	0.038	0.234	0.234	0.038	0.284	0.284
Income Bin 3 (Middle)						
1 (excellent)	0.639	0.463	0.463	0.639	0.349	0.349
2 (good)	0.301	0.351	0.351	0.301	0.363	0.363
3 (poor)	0.059	0.186	0.186	0.059	0.288	0.288
Income Bin 4						
1 (excellent)	0.725	0.545	0.545	0.725	0.384	0.384
2 (good)	0.222	0.270	0.270	0.222	0.399	0.399
3 (poor)	0.053	0.185	0.185	0.053	0.217	0.217
Income Bin 5 (Top)						
1 (excellent)	0.787	0.532	0.532	0.787	0.503	0.503
2 (good)	0.141	0.319	0.319	0.141	0.199	0.199
3 (poor)	0.071	0.150	0.150	0.071	0.298	0.298

Sources: MEPS 2006 (age 21), HRS 2006 (U.S., age 65) and SHARE 2006 (Sweden, age 65).

Table B.2: Estimated Parameter Values for Health Transition Probabilities

	U.S.		Sweden	
	$\rho_{b,1}$	$\rho_{b,2}$	$\rho_{b,1}$	$\rho_{b,2}$
Income Bin 1 (Bottom)	0.9565	0.9138	0.9644	0.9186
Income Bin 2	0.9758	0.9619	0.9659	0.9513
Income Bin 3 (Middle)	0.9854	0.9771	0.9728	0.9554
Income Bin 4	0.9871	0.9697	0.9715	0.9659
Income Bin 5 (Top)	0.9823	0.9775	0.9799	0.9223

Sources: Authors' estimates.

C Health Transition Probabilities: Post-65

Since we want to keep consistency between the full life-cycle model developed in this paper and the model only in retirement which is commonly used in the literature, including our previous work, we follow the same procedure as in past work in constructing health transition probabilities, for both the U.S. and Sweden. Specifically, we use HRS (for the U.S.) and SHARE (for Sweden) and estimate directly transition probabilities between health states, conditional on age and income level. Notice that health transition probabilities include mortality risk, as a transition from $m > 0$ (excellent, good, or poor) to $m' = 0$ (dead). For the U.S., we use our estimated health transition probabilities from our previous work (Nakajima and Telyukova (2020)). We use HRS, which is a longitudinal dataset, to estimate the probabilities that an individual with income bin b and the current health status m becomes a certain health status m' in the next period (two years later). Since HRS has a large sample, it is relatively a straightforward exercise.

Estimating the health transition probabilities for Sweden is more involved, because we only have one two-year panel (2004-2006) with SHARE and the sample size is smaller than HRS. For a robustness exercise, we construct the health transition probabilities for four other Northern European countries (Austria, Germany, Denmark, and the Netherlands), take the average of the health transition probabilities of the five (including Sweden) countries, and refer to this as the Nordic health transition process. At the end of this section we investigate the robustness of the estimated Swedish health transition probabilities by comparing the Swedish ones with the Nordic ones. Below we explain in detail the steps we take to estimate health transition probabilities using SHARE.

C.1 Computing Income Adjustment Factor

We want to control for changes in income due to changes in the number of adult household members, since a spouse might be receiving pension as well. Therefore, in later analysis, we want to divide household income in SHARE by a factor if the household is a couple with two adult members. We denote the income adjustment factor ψ_s, with $s = 1$ meaning single household and $s = 2$ meaning a couple household. $\psi_1 = 1$ by definition. We compute ψ_2 for five countries. For comparison, in our previous work using HRS, we obtained $\psi_2 = 1.48$ for the U.S.

We use SHARE longitudinal data 2004-2006. We only use the observations that satisfy the following criteria:

1. Age in 2004 is between 63 and 101. Since elsewhere we use 5-year age bins, and we use ages 65 to 99, we include ages between 63=65-2 and 101=99+2.
2. Household income is above zero in both 2004 and 2006. This automatically eliminates any missing values for income.
3. Number of adults in the household is either 1 (single) or 2 (couple) in both 2004 and 2006.
4. Respondent weight in 2004 is positive.
5. Households are marked as retired in both 2004 and 2006.

Once we apply these selection criteria, we take households whose household size changes from 2 in 2004 to 1 in 2006. Then we compute the following:

$$\psi_2 = \frac{\sum w_{2004} y_{2004}}{\sum w_{2004} y_{2006}} \tag{C.2}$$

where w_{2004} is respondent weight, y_{2004} and y_{2006} are household income in 2004 and 2006, respectively. We compute the ratio of the averages, instead of the averages of the ratio, in order to avoid extreme values affecting the result disproportionally. But we found that the two methods provide very similar values of ψ_2. We also compute the median of the ratio, to check robustness. Table C.1 shows the results:

Table C.1: Income Adjustment Factor

	Mean	Median
Sweden	2.420	2.678
Austria	1.688	1.539
Germany	1.859	1.545
Denmark	2.687	2.671
Netherlands	1.703	1.677

C.2 Constructing Income Bins

Next step is to classify individuals' income into 5 income bins, since we want to estimate health transition probabilities for five income groups separately. We again use the 2004-2006 longitudinal dimension of SHARE. We first apply the following selection criteria.

1. Age in 2004 is between 63 and 67, which is five year age band around age 65.
2. Household income is above zero in 2004.
3. Number of adults in the household is either 1 (single) or 2 (couple) in 2004.
4. Respondent weight in 2004 is positive.
5. Household is retired in 2004.

For these individuals, we construct adjusted household income. Adjusted household income is the (raw) household income divided by ψ_s where s is the household size in 2004. Then we sort households by the adjusted household income, and create five equal-sized income groups. Each income group includes 20% of the sample households. We label them $b = 1, 2, 3, 4, 5$, with $b = 1$ the lowest 20% and $b = 5$ the highest 20%. We compute median adjusted household income in each income group, to represent income of each group in the model simulations. We also record the threshold values of adjusted household income. Table C.2 summarizes the results.

Table C.2: Income Bins

	Sweden	Austria	Germany	Denmark	Netherlands
Income bin 1	8,553	11,258	8,925	7,706	7,523
Income bin 2	14,031	15,028	12,632	10,556	12,037
Income bin 3	17,093	18,866	15,249	13,484	16,927
Income bin 4	21,940	23,750	19,928	16,207	23,774
Income bin 5	32,295	37,321	33,388	25,326	44,929
Income threshold: 1 and 2	11,932	13,481	10,985	9,231	9,285
Income threshold: 2 and 3	15,855	17,417	13,731	11,944	14,090
Income threshold: 3 and 4	19,150	21,014	17,671	14,569	18,808
Income threshold: 4 and 5	25,083	29,720	23,630	19,265	31,344
Wage growth rate: 1996-2006 (%)	2.33	1.01	0.38	1.55	0.53

There is one more complication. Since we use cross-sectional data of SHARE to compute health transition probabilities, we might not want to apply the same income bin criteria to different age groups in one cross-section, since they are from different cohorts. We are concerned about this issue because if we apply the same income bin thresholds shown above to Swedish cross-sectional data, the distribution across income groups shifts towards lower income bins as individuals age. This is opposite of what we think should happen, since higher-income households tend to be healthier, and live longer, so if anything, the distribution across income bins should shift towards higher income bins as individual ages. We concluded that this is happening since we apply the same income bin thresholds for different cohorts in one cross-sectional data. In order to deal with this issue, we decided to adjust the income bin thresholds for different age groups (cohorts). In particular, the income bin thresholds are adjusted using the average wage growth rate, shown in the bottom row of Table C.2. The idea is that older individuals worked in earlier years, and thus their wages are lower than younger retirees, which should show up as on average lower retirement income of older individuals. So we adjust the income bin thresholds by the average wage growth rate. For age 65, there is no adjustment. For age 67, for example, age thresholds are adjusted by dividing the thresholds for age 65 by $(1.0233)^2$. In general, for age-i individuals, income bin thresholds are computed as follows:

$$y_i = \frac{y_{65}}{(1+g_w)^{i-65}} \tag{C.3}$$

where y_{65} is an income threshold for age-65 individuals (shown in Table above), y_i is the income bin threshold for age-i individuals. g_w is the annual wage growth rate. For example, $g_w = 0.0233$ for Sweden. With this adjustment, distribution across income bins in Sweden shifts towards higher income bin as individuals age, which is what we expect to see.

C.3 Constructing Health Transition Probabilities

Now we are ready to construct health transition probabilities, using the longitudinal data 2004-2006 in SHARE. For age-i, we apply the following sample section criteria:

1. Age in 2004 is between i-2 and i+2, which is five year age bin around age i.
2. Household income is above zero in 2004.
3. Number of adults in the household is either 1 (single) or 2 (couple) in 2004.
4. Respondent weight in 2004 is positive.
5. Household is retired in 2004.
6. Self-reported health status in both 2004 and 2006 are valid (0 (dead), 1 (excellent), 2 (good), or 3 (poor)).

For those individuals that satisfy the criteria, we compute the adjusted household income in 2004 (dividing raw household income by ψ_s where s is the household size in 2004). Then we apply the age-dependent income bin thresholds constructed in the previous subsection to determine which income bin ($b = 1, 2, 3, 4, 5$) each individual falls into. Then the health transition probabilities $\pi^m(i, b, m, m')$ can be computed as follows:

$$\pi^m(i, b, m, m') = \frac{\text{Total respondent weights of individuals with } (i, b, m, m')}{\text{Total respondent weights of individuals with } (i, b, m)} \tag{C.4}$$

where i is age in 2004, b is income bin, m and m' are health status in 2004 and 2006, respectively.

The problem here is that there is not large enough number of individuals for a given (i, b, m). In order to overcome this problem, we apply two procedures. First, we introduce wider definition of income bins. In particular, we assume $\tilde{b} = 1$ includes $b = 1, 2$, $\tilde{b} = 2$ includes $b = 1, 2, 3$, $\tilde{b} = 3$ includes $b = 2, 3, 4$, $\tilde{b} = 4$ includes $b = 3, 4, 5$, and $\tilde{b} = 5$ includes $b = 4, 5$. This makes the difference across income groups potentially less stark since we allow mixing across true income bins, but we need this adjustment to keep a reasonable number of individuals for any given (i, b, m) cell. We replace b with $\tilde{b}$. Second, we apply the following linear regression to health transition probabilities, in order to account for smaller sample sizes for older age groups (above age 80).

$$\pi^m(i, b, m, m') = \beta_{0,b,m,m'} + \beta_{1,b,m,m'} i \tag{C.5}$$

We apply this regression for each of (b, m, m'), except for one $\tilde{m'}$, since health transition probabilities must sum up to one. We pick $\tilde{m'}$ with the fewest observations and $\pi^m(i, b, m, \tilde{m'})$ as a residual after obtaining $\pi^m(i, b, m, m')$ for all m' other than $\tilde{m'}$.

As we mentioned at the beginning of this section, we implement the procedure above separately for five European countries. Then we create $\pi^m(i, b, m, m')$ for what we call NE-A5, which is the simple unweighted average of $\pi^m(i, b, m, m')$ across five Northern European countries (Austria, Germany, Denmark, the Netherlands, and Sweden). Tables C.3, C.4, and C.5 summarize the obtained health transition probabilities for the U.S., Sweden, and Northern European countries, respectively.

Table C.3: Health Status Transition: U.S. (%)

	Low income				**Median income**				**High income**			
Age 65	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	0.4	71.6	22.6	5.4	1.1	71.4	22.3	5.2	1.5	77.2	18.7	2.6
Good	3.7	24.8	52.0	19.6	1.7	25.5	54.2	18.6	1.4	30.0	53.4	15.3
Poor	9.9	5.0	17.0	68.1	9.7	5.3	19.0	65.9	5.9	10.3	32.1	51.7
Age 75	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	3.7	58.2	27.1	11.0	3.0	60.3	25.7	11.1	4.4	64.7	26.7	4.2
Good	6.8	21.3	46.9	25.0	7.7	23.4	41.3	27.6	6.3	16.6	52.3	24.8
Poor	12.5	4.4	16.7	66.4	19.7	4.4	18.3	57.6	15.0	4.3	19.2	61.5
Age 85	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	10.9	39.3	31.5	18.3	11.0	47.8	25.9	15.3	8.3	56.3	27.9	7.6
Good	19.3	21.1	34.8	24.9	11.6	17.3	39.1	32.0	15.5	15.9	44.0	24.7
Poor	26.6	5.6	14.2	53.7	29.5	3.9	15.3	51.4	26.1	9.2	17.2	47.4
Age 95	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	47.5	34.2	12.0	6.3	24.5	27.7	14.7	33.1	16.7	60.2	23.1	0.0
Good	53.8	5.9	26.7	13.7	26.5	9.5	30.1	33.9	60.3	0.0	20.9	18.8
Poor	34.5	9.6	15.5	40.4	54.0	5.7	13.5	26.9	43.7	0.0	13.7	42.6

Note: Individuals are grouped into five equal income bins with low income = bin 1, median income = bin 3, and high income = bin 5. Sources: HRS 1996-2006 for the U.S., SHARE 2004-2006 for European countries. Five Northern European countries are Austria, Germany, Denmark, the Netherlands, and Sweden.

Table C.4: Health Status Transition: Sweden (%)

	Low income				**Median income**				**High income**			
Age 65	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	3.7	61.9	33.2	1.1	0.0	72.9	27.1	0.0	0.0	62.1	21.8	16.2
Good	0.0	21.6	47.4	31.0	0.0	13.8	41.3	44.9	0.0	14.6	53.4	32.0
Poor	4.0	10.1	6.0	79.9	7.0	4.8	12.2	76.0	0.0	0.0	7.6	92.4
Age 75	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	3.6	42.0	27.9	26.4	4.0	52.7	20.9	22.5	3.5	57.4	26.1	13.1
Good	7.0	17.1	32.7	43.3	5.7	14.0	37.7	42.6	3.4	11.7	49.8	35.1
Poor	16.8	8.1	12.3	62.8	12.9	4.2	10.5	72.4	11.2	2.5	5.2	81.1
Age 85	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	3.5	22.1	22.7	51.7	7.4	30.7	13.9	48.0	17.5	46.1	28.1	8.3
Good	21.6	10.9	14.3	53.2	23.1	12.6	29.3	35.0	17.6	7.2	40.5	34.8
Poor	29.6	6.2	18.6	45.7	18.8	3.6	8.7	68.8	29.3	1.3	2.6	66.8
Age 95	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	3.3	2.2	17.4	77.0	10.8	8.6	7.0	73.6	31.5	34.8	30.2	3.4
Good	32.2	4.7	0.0	63.1	40.5	11.1	20.9	27.5	31.7	2.6	31.2	34.5
Poor	42.4	4.2	24.9	28.5	24.8	3.0	7.0	65.2	47.4	0.1	0.0	52.5

Note: Individuals are grouped into five equal income bins with low income = bin 1, median income = bin 3, and high income = bin 5. Sources: HRS 1996-2006 for the U.S., SHARE 2004-2006 for European countries. Five Northern European countries are Austria, Germany, Denmark, the Netherlands, and Sweden.

Table C.5: Health Status Transition: Average of Five Northern European Countries (%)

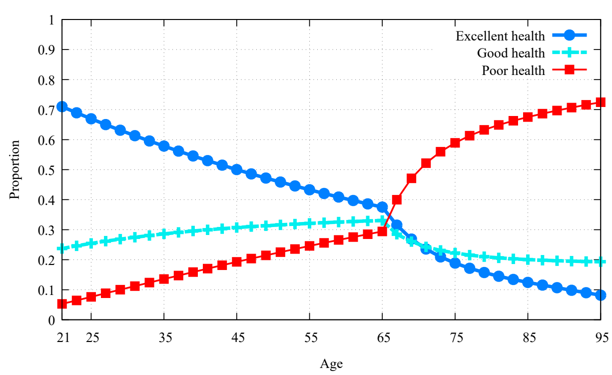
	Low income				Median income				High income			
Age 65	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	0.9	48.5	43.7	6.9	1.1	59.2	30.6	10.1	1.1	53.9	29.6	15.4
Good	2.4	17.6	49.0	31.0	2.1	20.1	40.4	37.4	1.2	21.9	45.0	31.8
Poor	0.8	3.6	21.3	74.4	1.4	3.8	21.6	73.2	1.0	7.5	17.8	73.7
Age 75	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	1.0	51.3	33.8	13.9	5.8	48.0	31.2	14.9	6.5	45.3	32.9	15.3
Good	5.2	17.9	43.5	33.4	5.0	18.1	41.6	35.2	3.6	19.1	45.2	32.0
Poor	13.9	4.4	17.3	64.4	12.0	4.9	17.6	65.6	9.5	7.4	16.5	66.6
Age 85	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	0.7	44.9	29.1	25.3	16.6	33.4	29.4	20.6	21.8	31.9	32.5	13.8
Good	15.5	16.8	34.3	33.4	15.1	14.8	39.8	30.3	12.1	15.6	41.8	30.4
Poor	35.2	2.3	12.0	50.5	27.1	2.9	13.1	56.9	27.8	3.1	14.0	55.0
Age 95	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor	Dead	Exce	Good	Poor
Exce	0.7	35.4	27.7	36.2	22.2	18.8	29.9	29.0	35.0	18.4	32.1	14.4
Good	24.0	14.5	28.5	33.0	25.2	11.6	37.9	25.3	20.4	12.6	38.2	28.7
Poor	55.2	0.9	8.4	35.5	42.1	1.1	8.6	48.2	45.6	0.2	11.5	42.8

Note: Individuals are grouped into five equal income bins with low income = bin 1, median income = bin 3, and high income = bin 5. Sources: HRS 1996-2006 for the U.S., SHARE 2004-2006 for European countries. Five Northern European countries are Austria, Germany, Denmark, the Netherlands, and Sweden.

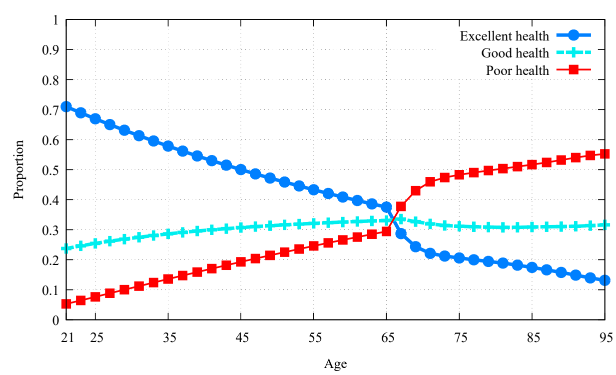
D Comparison of Swedish and Nordic Health Transition Probabilities

The number of observed individuals, especially at older ages, in Swedish data is not large, particularly if we want to slice the data into different ages, income bins, and health statuses, to estimate the health transition matrix which depends on these characteristics. While we implement various pooling measures to overcome this issue, we want to know if the resulting Swedish health transition matrix is robust. In order to answer this question, we build what we call a "Nordic" health transition matrix, which is the simple average of health transition matrices of four Northern European countries (Austria, Germany, Norway, and the Netherlands) that are similar to Sweden in terms of dissaving profiles (see Nakajima and Telyukova (2016)) and Sweden. Tables C.4 and C.5 show the obtained health transition probabilities of Sweden and the Northern European countries, respectively.

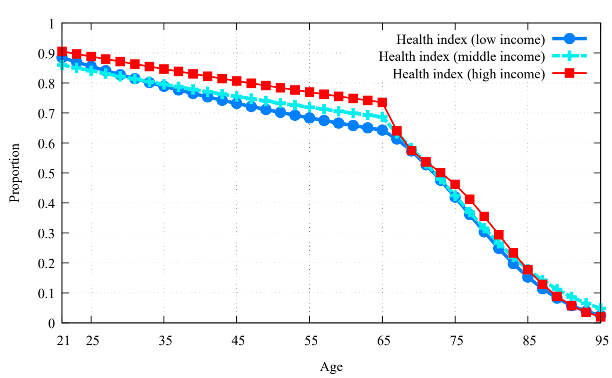
Figure D.1 compares characteristics of the Swedish health transition matrix (on the left) and the Nordic one (on the right). Panels (a) and (b) compare how the health status distribution changes over the life cycle, for Sweden and the Nordic countries. In both Swedish and Nordic models, the distribution shifts towards poor health with age, but the degree of health deterioration is less pronounced and closer to the U.S. counterparts (shown in Figure 5(a)) in the Northern European model, which implies that Swedish households are more pessimistic with



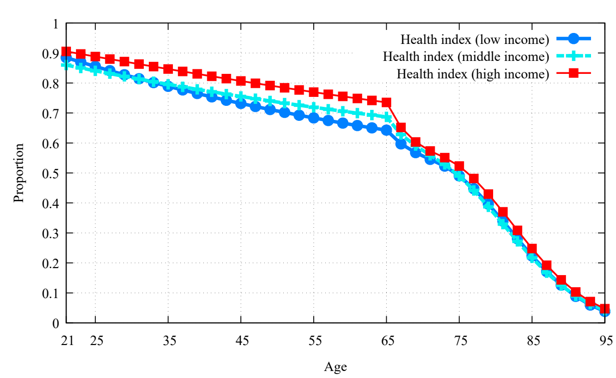
(a) Health Distribution: Sweden



(b) Health Distribution: Nordic

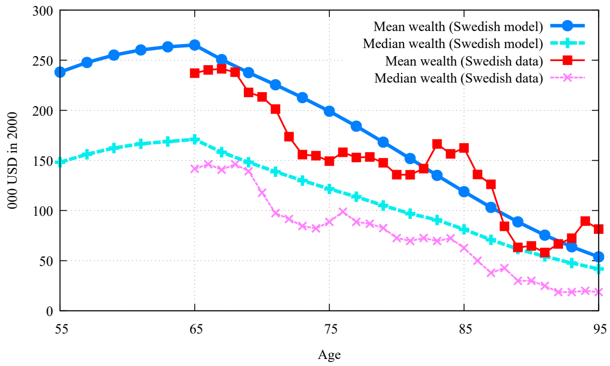


(c) Health Index by Income: Sweden

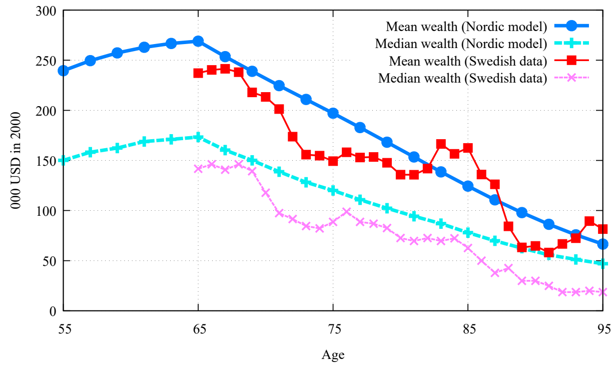


(d) Health Index by Income: Nodric

Figure D.1: Comparison of Health Transition Matrices: Sweden and Northern Europe



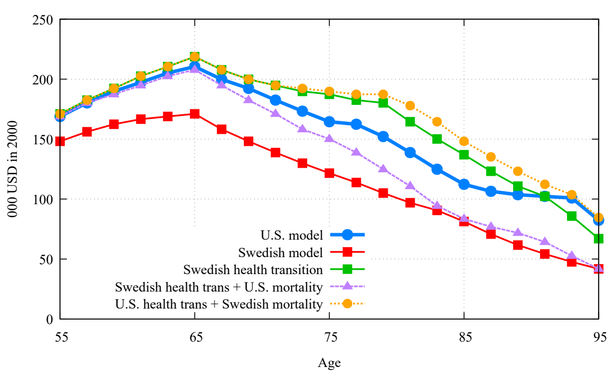
(a) Median Wealth: Sweden



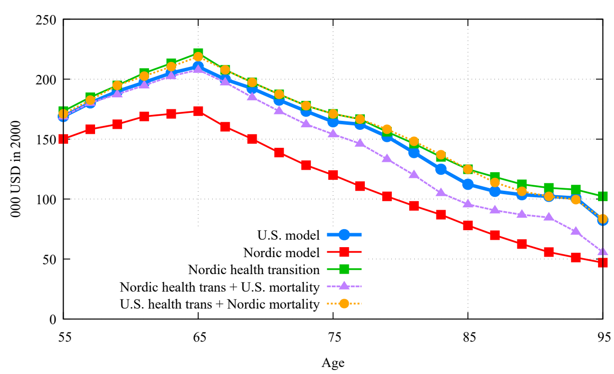
(b) Median Wealth: Nordic

(c) Percentiles of Wealth: Sweden

(d) Percentiles of Wealth: Nordic



(e) Health Transition and Median Wealth: Sweden



(f) Health Transition and Median Wealth: Nordic

Figure D.2: Comparison of Swedish and Northern European Model

their own health status compared with Northern European and U.S. counterparts. Panels (c) and (d) show how health status changes for different income groups over the life cycle. The health index shown in Panels (c) and (d) takes the value between 0 (all individuals are dead) and 1 (all individuals have excellent health) and represents the average health status of each income group. We assign the value 1, 2/3, 1/3, 0, to excellent, good, poor, and dead health status, and compute the average value across all individuals in the group. We can see that (i) the health index deteriorates with age for all income groups in both Sweden and Northern Europe,

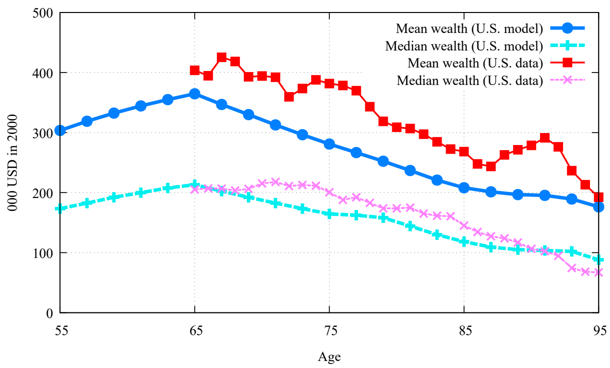
(ii) higher-income individuals tend to have a higher health index especially before retirement age, but (iii) the dispersion is smaller in both countries compared with the U.S.

Regardless of this slight difference in terms of dynamics of health, the effects on the wealth decumulation profile turns out to be modest. Figure D.2 compares wealth profiles of the Sweden model (on the left) and the Nordic model (on the right), which is the same as the Swedish model except for the health transition matrix, in various experiments implemented in the paper. Comparison of mean and median wealth profiles (panels (a) and (b)) and the wealth percentiles (panels (c) and (d)) confirms that, regardless of the differences in health deterioration pace with age between the Swedish and Nordic models, wealth decumulation profiles are very similar. This is due to the fact that out-of-pocket medical expenses in Sweden and Nordic countries (the Swedish medical expense shock is used) are low regardless of health status.

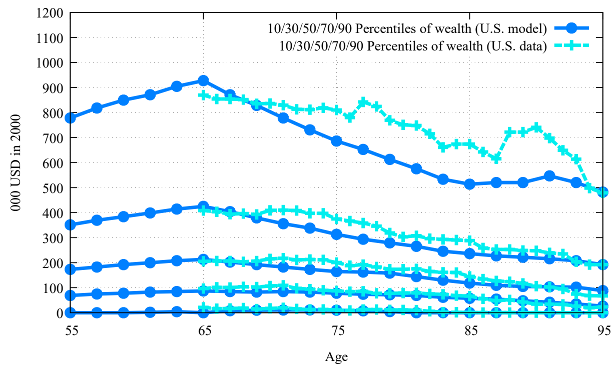
Panels (e) and (f) of Figure D.2 dig deeper into the implications of the different health transition matrices. These panels correspond to Figure 9(a) in the main text. Panel (e) shows the U.S. model (blue), the Swedish model (red), the U.S. model with the Swedish health transition matrix (green), the U.S. model with the Swedish health transition matrix modified to exhibit U.S. mortality rates (purple), and the U.S. model with U.S. health transition matrix modified to exhibit Swedish mortality rates (orange). Panel (f) shows the same set of experiments for the Nordic model. If the health transition matrix is swapped to the Swedish one in the U.S. model, wealth decumulation further slows down, since households have to keep more wealth to pay for medical and non-medical expenses for longer periods late in life. This intuition is confirmed when the U.S. health transition matrix is modified with Swedish mortality rates. If U.S. mortality rates are retained, but household health decreases as with the Swedish health matrix, wealth decumulation becomes significantly faster; households do not expect to live as long as Swedish households, but they expect to and end up paying more as their health deteriorates faster than in the U.S. benchmark. Panel (f) shows that the Nordic health transition implies qualitatively the same results as the Swedish health transition.

E Model without Discount Factor Heterogeneity

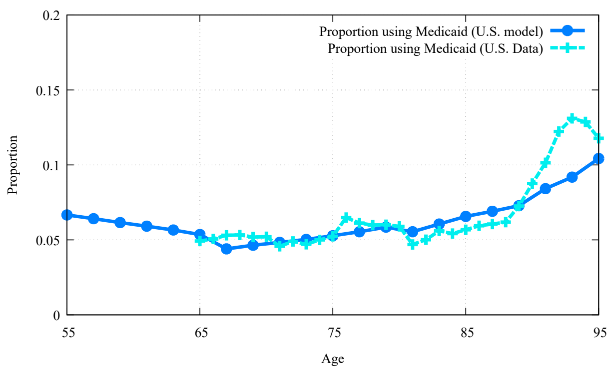
We assume discount factor heterogeneity in our baseline model, which is supported by other studies, so that the model can match mean, median, and percentiles of wealth. Meanwhile, related papers, including our own previous work, use a (post-retirement) model without discount factor heterogeneity. In this Appendix, we estimate an alternative life-cycle model without discount factor heterogeneity and present some results. Estimated parameter values are $\beta = 0.9695$, $\sigma = 3.8551$, $\gamma = 5.2121$, $\zeta = 8,651$, and $\underline{c} = 5,869$. Since parameters are identified in the same way as our baseline model with discount factor heterogeneity, the estimated parameter values are similar. β is higher in order to match both mean and median wealth to a certain degree. Figure E.1 compares the estimated U.S. model to data. Figure E.2 compares the Swedish model, which uses the same parameter values as the U.S. model but introduces all the Swedish institutional features, to Swedish data. Figure E.3 contains the results of some of the same experiments that we conducted for the baseline model. Table E.1 is equivalent to Table 6 for the baseline model, but compares the decomposition of the contribution of Swedish elements between the baseline model with discount factor heterogeneity (top half of the table) and the alternative model without (bottom half). The takeaway is that results without discount factor heterogeneity are close to those obtained using our baseline model with discount factor heterogeneity, and thus the main results of the paper are robust to shutting down discount factor heterogeneity.



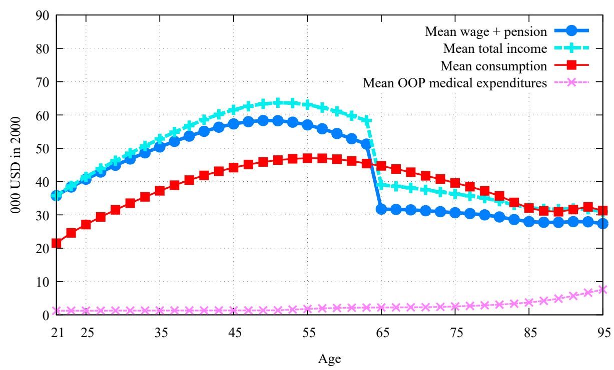
(a) Mean and Median Wealth



(b) Percentiles of Wealth

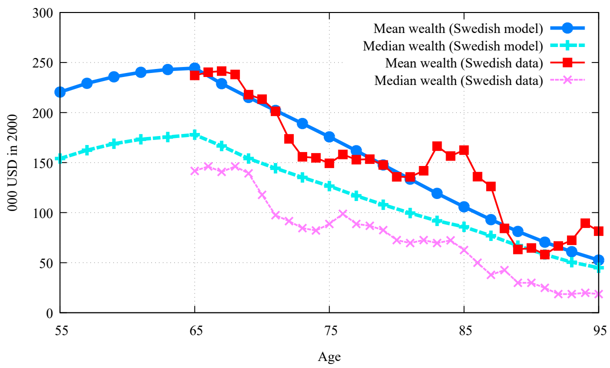


(c) Proportion with Medicaid

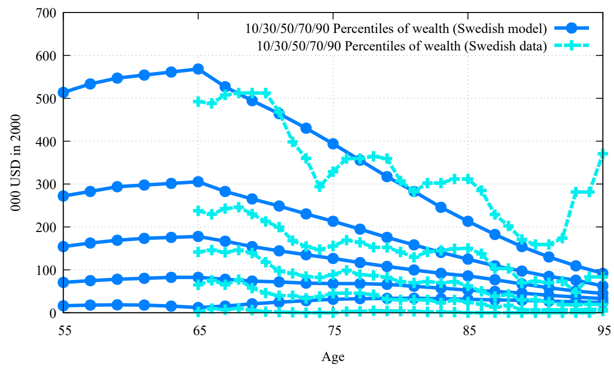


(d) Income and Consumption

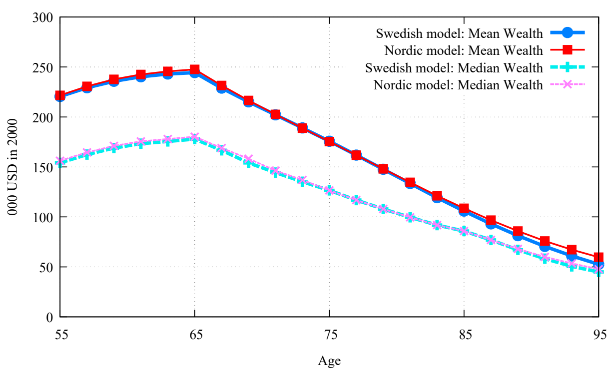
Figure E.1: Model without Discount Factor Heterogeneity: U.S. Model and Data



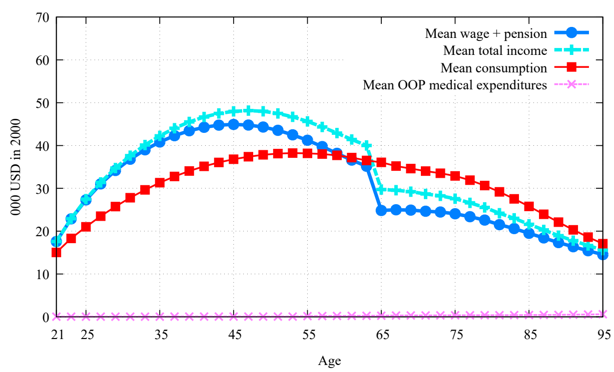
(a) Mean and Median Wealth



(b) Percentiles of Wealth

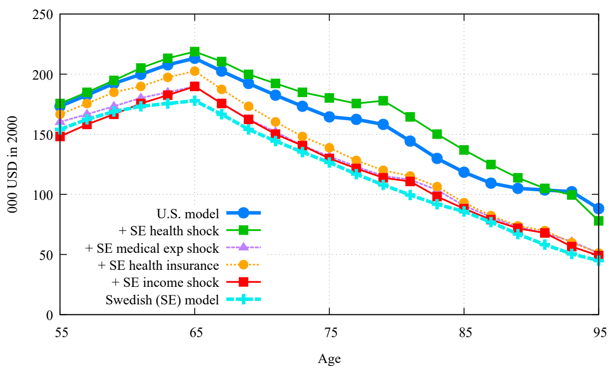


(c) Wealth: Sweden and Northern Europe

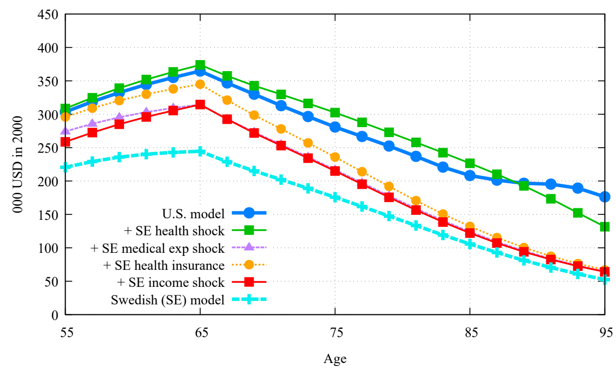


(d) Income and Consumption

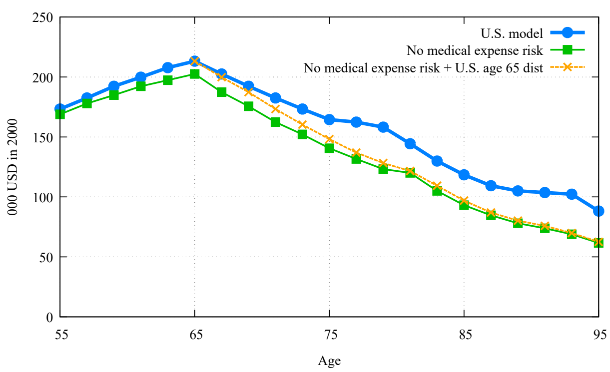
Figure E.2: Model without Discount Factor Heterogeneity: Swedish Model and Data



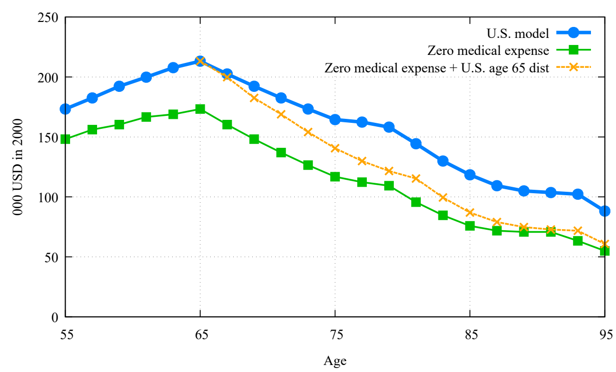
(a) Median Wealth



(b) Mean Wealth



(c) No Medical Expense Risk: Median Wealth



(d) Zero Medical Expense: Median Wealth

Figure E.3: Model without Discount Factor Heterogeneity: Experiments

Table E.1: Quantifying the Contribution of Swedish Elements: Models with and without Discount Factor Heterogeneity[1]

		Contribution to Faster Decumulation		
Percent	W_{65}/W_{65}^{US}	Age 75	Age 85	Age 95
Baseline Model with β-Heterogeneity: Median wealth				
Swedish data	68.4	100.0	100.0	100.0
Swedish model	81.6	24.5	16.8	81.9
Swedish health transition	104.4	–25.9	–26.5	47.3
Swedish gross medical expense risk	88.2	36.9	32.1	59.1
Swedish OOP medical expense risk	83.7	37.1	32.4	57.7
Swedish health insurance coverage	90.5	36.7	30.2	47.0
Swedish health insurance financing	107.1	6.8	7.6	13.6
Baseline Model with β-Heterogeneity: Mean wealth				
Swedish data	55.9	100.0	100.0	100.0
Swedish model	62.6	54.8	94.0	163.8
Swedish health transition	99.5	–39.2	–18.7	88.3
Swedish gross medical expense risk	81.7	104.8	117.7	141.3
Swedish OOP medical expense risk	79.9	108.2	119.2	140.0
Swedish health insurance coverage	86.6	86.7	94.8	96.9
Swedish health insurance financing	102.8	6.1	9.4	14.5
Alternative Model without β-Heterogeneity: Median wealth				
Swedish data	68.4	100.0	100.0	100.0
Swedish model	84.8	20.9	20.9	89.4
Swedish health transition	104.4	–18.0	–20.2	31.7
Swedish gross medical expense risk	90.5	30.2	31.4	61.7
Swedish OOP medical expense risk	87.1	36.5	35.1	64.7
Swedish health insurance coverage	92.9	30.0	31.2	51.8
Swedish health insurance financing	107.1	3.3	6.0	17.4
Alternative Model without β-Heterogeneity: Mean wealth				
Swedish data	55.9	100.0	100.0	100.0
Swedish model	57.7	46.8	76.0	125.7
Swedish health transition	88.2	–35.0	–19.3	61.6
Swedish gross medical expense risk	73.7	91.4	101.2	111.5
Swedish OOP medical expense risk	72.0	96.8	103.3	109.7
Swedish health insurance coverage	77.4	80.8	86.4	78.6
Swedish health insurance financing	90.7	5.3	9.3	13.2

[1] The top half of this table is for the baseline model with discount factor heterogeneity and is the same as Table 6. The bottom half of the table is for the alternative model without discount factor heterogeneity. See the notes for Table 6 and detailed explanation of the table in Section 6.4.

F Interpretation of Bequest Parameters

In this appendix, we follow De Nardi et al. (2010) and present a way to interpret bequest-related parameters.[24] In particular, we compute (i) the minimum level of wealth where households start leaving bequests and (ii) the marginal propensity to bequeath, once the level of wealth goes above the minimum level.

Assume a single (one-adult) household of age-I (last year of life). In the last year of life, by assumption, future value consists only of the utility of bequest. The problem of such a household can be represented as follows:

$$\max_{c,e} \frac{c^{1-\sigma}}{1-\sigma} + \beta\gamma \frac{(e+\zeta)^{1-\sigma}}{1-\sigma} \tag{F.6}$$

subject to

$$e = (x-c)(1+r), \tag{F.7}$$

where c is last period consumption, x is the wealth holding at the beginning of the last period (after paying medical expenses), e is the amount of bequests, and r is the saving interest rate. By taking the first order condition with respect to consumption, we can derive the following decision rule for the optimal amount of bequests:

$$e^* = \frac{1+r}{1+r+\Lambda}(\Lambda x - \zeta), \tag{F.8}$$

where $\Lambda = (\beta\gamma(1+r))^{\frac{1}{\sigma}}$. From Equation (F.8), we can easily see that the optimal amount of bequests is positive if $x \geq \frac{\zeta}{\Lambda}$. Moreover, the marginal propensity of bequests can be calculated as

$$\frac{\partial \frac{e^*}{1+r}}{\partial x} = \frac{\Lambda}{1+r+\Lambda}. \tag{F.9}$$

In our U.S. model, we have $r = 0.02$, $\beta = 0.9673$, $\sigma = 3.8505$, $\gamma = 5.1554$, and $\zeta = 8,844$. From these parameter values, we can obtain the threshold value of x of $\$5,797$ and the marginal propensity to bequeath of 0.60. For the estimated model of De Nardi et al. (2010), $r = 0.02$, $\beta = 0.970$, $\sigma = 3.84$, $\gamma = 2,360$, and $\zeta = 273,000$. These parameters imply that the threshold value of wealth is $\$36,225$ and the marginal propensity of bequeath is 0.881. In both our benchmark model and the estimated model of De Nardi et al. (2010), once the wealth exceeds the threshold, the marginal propensity to bequeath is high (0.60 for us, 0.88 for them), but our elasticity is lower, and our estimated bequest threshold ($\$5797$) is lower compared with that of De Nardi et al. (2010) ($\$36,225$). This is likely because we include both single and couple households in building estimation targets, and thus households on average hold higher wealth compared with De Nardi et al. (2010), who only include single households in their estimation targets. We also include statistics of bequest distribution as targets, as can be seen in the main text.

[24] Appendix D of the working paper version of their paper.