Forced Retirement Risk and Portfolio Choice

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Abstract

The literature on the effect of labor income on portfolio choice overlooks that workers face a risk of being forced to retire before their planned retirement age. Using the Health and Retirement Study data, this paper finds the forced retirement risk to be significant and also highly correlated with stock market fluctuations. Using a life-cycle portfolio choice model, this paper shows that forced retirement risk makes labor income near retirement stock-like. Therefore, contrary to conventional wisdom, those who are still working but near retirement should have a lower share of risky assets in their financial portfolios than retirees do.

Keywords: Forced Retirement, Human Capital, Portfolio Choice

JEL Classification: D14, E11, G11, G12

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1 Introduction

An aging US population is giving rise to concerns over older Americans' financial well-being in retirement. Most of discussions on this topic focus on whether households build an adequate level of savings to sustain a desirable level of consumption in retirement (see Poterba, Venti and Wise, 2011 and Poterba, 2014, for a good summary of the literature). What is less studied, however, is how households should manage their financial savings as they approach their retirement. With the transition from a defined-benefit pension system to a defined-contribution system, households become more responsible for managing their own financial assets, but there is surprisingly little guidance for older households on portfolio management that is based on both a correct understanding of the risks that older households face and rigorous economic theory. In this paper, we examine how older households should adjust allocations of their financial wealth between risky and safe assets. In particular, we focus on how a specific risk they face at the end of their working life—the risk of being forced into retirement before planned retirement age—affects their optimal financial portfolio choice.

A long-standing rule of thumb for portfolio adjustment over age is that households should reduce the share of risky assets in their financial portfolios as they approach retirement. Most life-cycle funds in the current financial market are designed based on this principle. An often-cited justification for this strategy relates to changes in the human capital of households (Jagannathan and Kocherlakota, 1996).[1] As households approach retirement, the size of their human capital shrinks as they expect less future labor earnings. *If* their human capital is bond-like—i.e., if the size of risk they have in their labor earnings is not large and/or if it is not strongly correlated with stock returns—a decrease in human capital justifies a shift toward risk-free assets in their financial portfolio because they are losing buffer against negative stock return shocks. Alternatively, *if* their human capital is stock-like—i.e., if the risk in human capital is large and strongly correlated with stock returns—an adjustment in the opposite direction can be justified. Therefore, correct estimation of the size and characteristics of risk in households' human capital is crucial in designing the right portfolio adjustment strategy as retirement nears.

[1] Another common justification for this strategy is that younger households have a longer investment horizon and therefore have more time to recover from any loss they might experience in the short term. However, as Samuelson (1979) has shown, this argument is fallacious as long as stock returns are independent over time.

Most of the literature on the role of human capital in financial portfolio choice models the risk in human capital in terms of the uncertainties in the earnings process faced by households *before* their retirement. Papers using this approach have concluded that human capital is bond-like since the estimated risk is small and not strongly correlated with stock returns, even after accounting for a possibility of disastrous shocks such as unemployment (see e.g., Viceira, 2001; Cocco, Gomes and Maenhout, 2005; and Hugget and Kaplan, 2016). However, for older households that are close to retirement, the *timing* of retirement represents a greater source of uncertainty than their labor earnings process *before* their retirement. The estimated size of the risk in their human capital can be much larger if households face a risk of being forced to retire before their planned retirement age. Such a risk can make human capital much more stock-like if the risk of forced retirement is correlated with the performance of the stock market. Existing papers in this stream of literature fail to capture such risk for two reasons. First, in empirically estimating the risk in labor income, they only use the sample who are not yet retired, missing uncertainty in retirement timing by construction. Second, in building the life-cycle portfolio choice model, they assume that either the retirement timing is fixed or households have full control over deciding when to retire (for an example of the latter, see Bodie, Merton and Samuelson, 1992).

In this paper, using the Health and Retirement Study (HRS) data, we first document that older Americans face a significant risk of being forced to retire before their planned retirement age. We identify forced retirement using the responses to the question on the self-assessed reason for retirement. About a quarter of retirements turn out to have been involuntary: individuals were compelled to retire early for reasons that included health issues and their employers' decisions. Every year, on average, about 4 percent (2 percent) of households in the age range of 60 to 64 (55 to 59) who wanted to keep working are forced to retire. An involuntary early retirement often involves a loss of several years' worth of labor earnings. Most forced retirees do not return to the labor market, and only a small fraction of forced retirees rely on unemployment insurance and disability income. These findings imply that households close to retirement face a substantial risk in their human capital. Even those households with relatively more wealth, who are more likely to participate in the stock market, still face a significant forced retirement risk though less than those at the bottom of the wealth distribution. Furthermore, we find a negative correlation between the probability of being forced to retire and stock market performance. In other words, an increase in the probability of forced retirement is associated with a large negative return in the stock market.

We then build a life-cycle portfolio choice model with the estimated forced retirement risk to examine the implications of forced retirement risk for the optimal portfolio choice. In this model, households plan to work until a certain age, but they may be forced to retire before reaching that age. The probability of forced retirement is a function of age and correlated with stock returns, calibrated based on the findings from the HRS data. The results from the model suggest that forced retirement risk makes the part of human capital that is exposed to this risk stock-like; in such cases, the optimal portfolio adjustment for households is to increase the share of risky assets in their financial portfolios as they approach and enter retirement. This strategy goes against conventional wisdom. We also show that what is behind the stock-like human capital is not the existence of the forced retirement risk per se but the correlation between stock returns and forced retirement risk. Once we mute this correlation in our model, the effect of having a significant risk of losing labor earnings is dominated by the effect of having a flow of income not correlated with stock returns, so human capital becomes bond-like. Under the correlation, our main qualitative result is robust to alternative calibrations and specifications of the model.

This paper relates to a number of literatures. First, this paper contributes to the literature on household portfolio choice by documenting additional source of human capital risk that has not been previously considered and by examining its implications for the optimal portfolio choice. Existing studies have found that human capital is bond-like even under a counterfactually high correlation between earnings shocks and stock returns (Viceira, 2001; Cocco, Gomes and Maenhout, 2005; and Hugget and Kaplan, 2016). Fagereng, Guiso, and Pistaferri (2016), by showing that firms provide substantial wage insurance to workers, present one reason why shocks to the earnings process are typically very small. On the other hand, Hugget and Kaplan (2016) show that the left-skewed earnings growth distribution makes human capital more stock-like, but its effect is still limited. None of these papers focus on the role of retirement timing uncertainty, which is the most important source of risk in human capital for older households. In existing papers in this literature, retirement timing is either fixed (Cocco, Gomes and Maenhout, 2005, for example) or determined by households (Bodie, Merton and Samuelson, 1992). In the latter case, households can use the timing of retirement as a buffer against negative asset return shocks. Based on the observation that retirement timing is not a choice variable but rather a shock for a significant fraction of older households, we take the opposite extreme, where retirement timing is purely determined by demand side in the labor market. We are not arguing that no household can use the retirement timing as a buffer against negative asset return shocks at all. We choose this set-up to focus on how close human capital comes to being a risky asset for households that are exposed to this risk, which has been neglected in the literature. There are several papers that focus on mechanisms through which human capital can become more stock-like. Heaton and Lucas (2000) look at entrepreneurial risk; Benzoni, Collin-Dufresne and Goldsten (2007) consider cointegration between wage and stock returns; and Chang, Hong and Karabarbounis (2018) focus on uncertainty in the career paths of young workers as a factor making their human capital stock-like. This paper shows a different channel through which human capital becomes a close substitute for a risky asset.

Second, this paper contributes to a small but growing literature on the uncertainty in retirement timing. Chan and Stevens (2001, 2004) show that in the US involuntary job loss is not rare, and returning to the labor market after a job loss becomes significantly more difficult at older ages. Dorn and Sousa-Poza (2010) show that involuntary early retirement is common in European countries. Gorodnichenko, Song and Stolyarov (2013) and Gustman, Steinmeier and Tabatabai (2016) discuss macroeconomic determinants of retirement timing. This paper contributes to this literature by using a novel indicator of forced retirement: a self-assessed reason of retirement available in the HRS. This enables us to overcome the issue that whether a retirement is voluntary or involuntary is a fundamentally subjective matter. The indicator also allows us to capture involuntary early retirements that take subtler forms than what will be recorded as a job loss in surveys on employment history. By using the HRS data, we document that in the U.S. the probability of being forced to retire is fairly high at older ages and negatively correlated with stock returns. Some papers examine the economic implications of the uncertainty in retirement timing. Smith (2006) and Dong and Yang (2016) point to involuntary retirement to explain the "retirement consumption puzzle"—i.e., a downward shift in consumption expenditure at retirement (Modigliani and Brumberg, 1954; Friedman, 1957; Heckman, 1974; Haider and Stephens, 2007; Battistin, Brugiavini, Rettore and Weber, 2009). Caliendo, Casanova, Gorry and Slavov (2016) show that uncertainty about the timing of retirement is a major source of risk to individuals' lifetime consumption. This paper relates the uncertainty in retirement timing to household portfolio choice.

Third, this paper relates to the literature on the age effect and the retirement effect on portfolio choice. Ameriks and Zeldes (2004) document age effect on household portfolio choice. Rosen and Wu (2004), Berkowits and Qiu (2006), Fan and Zhao (2009), Love and Smith (2010), Goldman and Maestas (2013), and Lee (2015) examine how health status changes or health expenditure risks at older ages affect household portfolio choice. Addoum (2017) studies how changes in negotiation power between spouses around retirement affect portfolio allocation. Michaelides and Zhang (2017) argue that setting the share of stock as a function of age or retirement horizon only may be misleading under the presence of stock market predictability. This paper focuses on the role of forced retirement risk in understanding the optimal portfolio adjustment over age around retirement.

2 Empirical Evidence for Forced Retirement

In this section, we first establish that older workers face a significant forced retirement risk. A large share of retirements turn out to be involuntary early retirements. A forced early retirement typically means a loss of several years' worth of labor earnings, rarely mitigated by returning to the labor market later or by relying on unemployment insurance or disability income. Though there is heterogeneity in the size of the forced retirement risk faced across households with different wealth levels, even wealth-rich households face a sizable risk. We also show that the forced retirement risk is strongly correlated with stock market performance. The probability of being forced to retire tends to increase after having a downturn in the stock market.

2.1 Data

We use the Health and Retirement Study (HRS) data to estimate the size of the forced retirement risk faced by older Americans. The Health and Retirement Study (HRS) is a biennial panel study that started its first survey in 1992. It contains observations from more than 26,000 households over the age of 50 with information at the household and individual level that includes the participants' demographic characteristics, health, income, wealth, and asset allocation. In particular, we take advantage of the detailed questions on retirement in the HRS to analyze forced retirement risk. In this section, we describe the key variables we use to determine forced retirement risk and explain our sample selection criteria in detail.

2.1.1 Key Variables

Retirement Status

The HRS provides the current retirement status of survey respondents by asking the following question:

> *Q: At this time do you consider yourself to be completely retired, partly retired, or not retired at all?*
>
> *A: 1) not retired; 2) completely retired; 3) partly retired*

Based on the answers to this question, we classify as retirees both the respondents who consider themselves completely retired and those who answer that they are partly retired.[2] In addition to questioning respondents about their current retirement status, the HRS also asks for the year and month of retirement:

> *Q: In what month and year did you [partly/completely] retire?*

From the answers to this question and the ages of the participants in the survey year, we can determine the year of retirement and age at retirement at an annual frequency, even though the survey is biennial. For example, if a participant in the 2010 HRS whose age is 62 answered that he/she retired in 2009, we estimate that his/her retirement age is 61 and retirement year is 2009.

Forced Retirement Indicator

Among the respondents who consider themselves partly or completely retired, the HRS gathers additional information on whether they were forced into retirement:

> *Q: Thinking back to the time you [partly/completely] retired, was that something you wanted to do or something you felt you were forced into?*
>
> *A: 1) Wanted to do; 2) Forced into; 3) Part wanted, part forced*

We classify respondents as forced retirees if in response to this question they replied *2) forced into.*[3] Using self-assessed reasons for retirement has a clear advantage over the conventional measure of retirement uncertainty (i.e., the difference between the actual and expected ages of retirement; see

[2] We classify the latter group as retirees because they typically have no labor earnings and rarely return to the labor market.

[3] In our analysis sample (introduced in the next subsection), the number of retirees who chose *3)* is only about a quarter of those who chose *2)*.

Caliendo, Casanova, Gorry and Slavov, 2016, for example). By considering self-assessed reasons for retirement, we can exclude early retirements that are voluntary in identifying risks in retirement timing. In the next section, we show how this measure is correlated with the conventional measure.

2.1.2 Sample Selection

The unit of observation in estimating forced retirement risk is a transition in the labor market participation status for each respondent-year pair. Under the condition that a given respondent worked in year t, we examine 1) whether the respondent continued to work or retired in year $t+1$, and 2) if the respondent retired that year, whether it was voluntary or involuntary.[4]

The forced retirement risk mainly matters when survey respondents are close to typical retirement ages. Therefore, we restrict our sample to transitions that happened when respondents were aged between 55 and 69. We include transitions from both married and single households, but we restrict our sample to male respondents. The sample composition of the HRS data changed significantly in 1998, when the Asset and Health Dynamics Among the Oldest-Old (AHEAD) cohort was merged into the original HRS data. To maintain a consistent sample size throughout the survey years, we exclude the sample before the 1998 survey. Our sample is further reduced as we exclude observations from retirees who have not been asked the forced retirement question. After applying our sample selection criteria, we obtain 15,366 transitions in labor market participation status that occurred between 1998 and 2012.

2.2 Prevalence of Forced Retirement

We first summarize the proportion of retirements that are considered involuntary to show that many households in the US do not have full control over their retirement timing. Table 1 shows the number of retirements and the proportion of forced retirements by age and year of retirement.

Overall, among all the retirements occurred during our sample period, the share of forced retirement is about 28 percent. More than a quarter of US retirees report that they were forced to retire against their will. The share of forced retirement also varies across age and year of retirement. The proportion of forced retirements decreases with age: more than 40 percent of

[4] Hence respondents retired in year t do not appear in the sample in the analysis on transitions after year $t+1$, except for in our analysis of whether forced retirees return to the labor market.

retirements between 55 and 59 are forced retirements, but this number drops to 23 percent for retirements between 65 and 69. This simply reflects the fact that more voluntary retirements occur near and after typical retirement ages. The proportion of forced retirements also varies greatly across years. For example, it reached the highest value of 45.6 percent in 2009, right after the financial crisis. On the other hand, during the stock market boom in 1999, the proportion of forced retirements was only 20 percent.

Table 1: Number of Retirements and Forced Retirees (FR) Ratio

	Retirement Age							
	55-59		60-64		65-69		Total	
Retirement Year	# of Retirements	% of FR	# of Retirements	% of FR	# of Retirements	% of FR	# of Retirements	% of FR
1998	28	39.3	62	16.1	32	12.5	122	20.5
1999	41	31.7	124	18.5	62	14.5	227	19.8
2000	17	29.4	45	22.2	37	13.5	99	20.2
2001	23	30.4	114	21.1	48	18.8	185	21.6
2002	15	6.7	80	20	27	22.2	122	18.9
2003	36	50	88	22.7	52	26.9	176	29.5
2004	25	24	50	22	30	23.3	105	22.9
2005	27	48.1	72	13.9	66	21.2	165	22.4
2006	16	31.3	36	30.6	42	23.8	94	27.7
2007	39	43.6	51	19.6	58	20.7	148	26.4
2008	12	50	26	23.1	20	20	58	27.6
2009	44	52.3	62	43.5	59	33.9	165	42.4
2010	42	61.9	51	41.2	29	17.2	122	42.6
2011	44	45.5	86	31.4	40	27.5	170	34.1
2012	27	44.4	69	40.6	29	37.9	125	40.8
Total	436	42	1016	25	631	22.3	2083	27.7

Note: The data in this table are for retirements that occurred between 1998 and 2012 for male respondents aged between 55 and 69 at the time of retirement.

2.3 Forced Retirement Risk

While the previous subsection establishes that forced retirement is prevalent among older Americans, it does not provide a good measure of the likelihood of a given worker's forced retirement despite a willingness to continue working. As we will show in Section 3, this is the measure we need to use to investigate the implication of this risk for household portfolio choice. To measure this risk, which we call the *forced retirement risk*, we use the following formula:

$$ForcedRetirementRisk_{i,j} = \frac{N(ForcedRetirees_{i,j})}{N(ForcedRetirees_{i,j}) + N(Working_{i,j})}, \quad (1)$$

where $N(ForcedRetirees_{i,j})$ is the number of individuals in age group i that are forced to retire between the years $j-1$ and j, and $N(Working_{i,j})$ is the number of people in age group i that are working in both year $j-1$ and year j. The denominator captures all the individuals who were working in year $j-1$ and wanted to keep working in year j. The numerator captures those who could not do so because they were forced to retire.[5]

Based on this definition, we estimate the forced retirement risk by age group and year as shown in Figure 1. On average, the risk of being forced to retire is not negligible. For the entire age group considered, the average size of risk is 3.2 percent, meaning that every year 3.2 percent of workers who want to keep working are forced to retire. The size of risk increases with age. The forced retirement risk between the ages of 55 and 59 is 2.2 percent, while it increases to 4.9 percent between the ages of 65 and 69. The estimates (at an annual frequency) suggest that, for a 60-year-old worker who plans to retire at age 65, the chance of being forced to retire before the planned retirement age is about 15 percent. Also, note that the size of forced retirement varies across years, with noticeable increases right after the stock market downturns following the burst of the dot-com bubble (in 2002) and the Great Recession (in 2008). We provide a more systematic examination of the correlation between the forced retirement risk and stock market performance in Section 2.6.

2.4 Economic Significance of the Forced Retirement Risk

The probability of being forced to retire is in and of itself insufficient for establishing the economic significance of the forced retirement risk. Another important factor is, conditional on being forced to retire, how many years prior to the planned retirement age these individuals are forced to stop working. If a household is forced to retire one year before the expected retirement age, that is a significant loss of earnings, but still a much smaller shock compared to losing five years' worth of earnings.

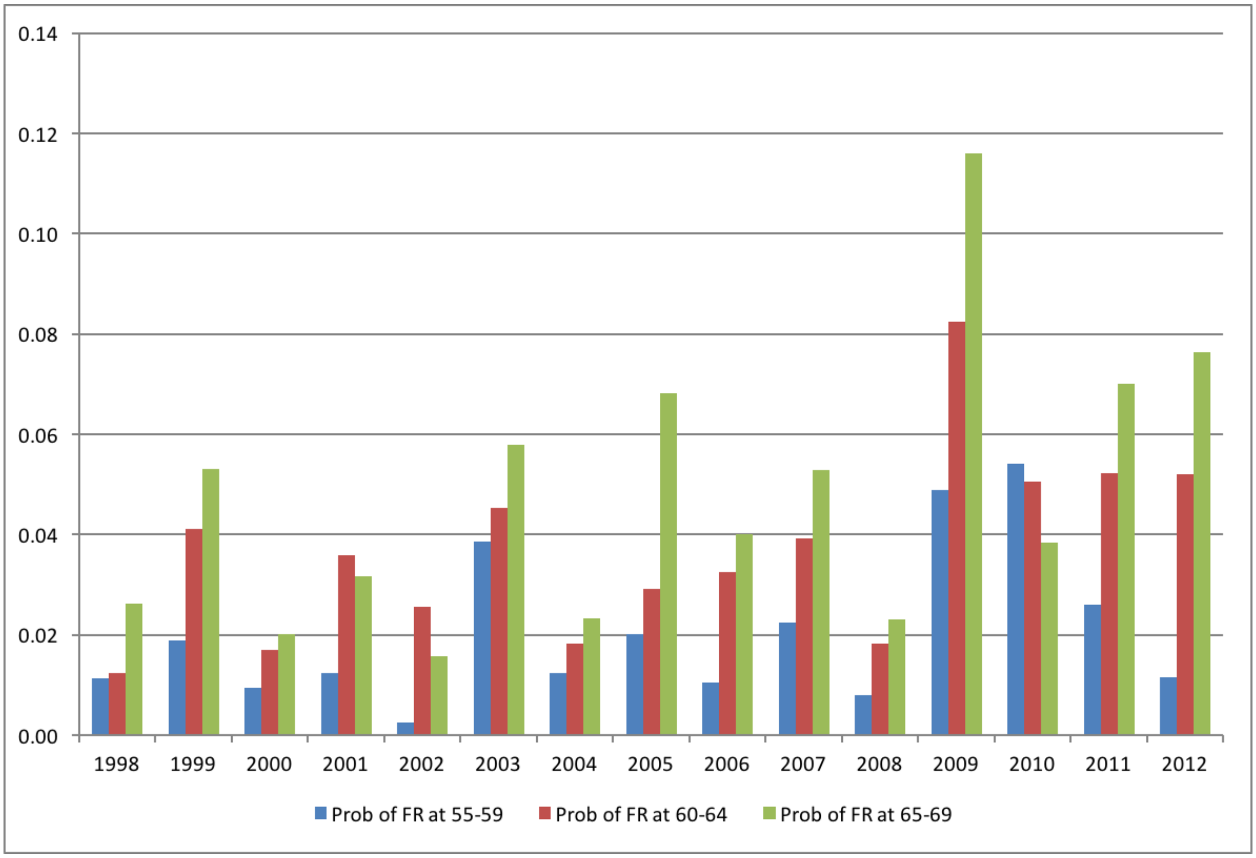
Table 2 shows the distribution of the difference between the actual and expected retirement ages of forced retirees for each age group before age 65.[6,7] Before discussing the result, however,

[5] Voluntary retirees are not included in both the numerator and the denominator as we analyze of the risk that matters to those who want to continue working.

[6] In this subsection we examine the economic significant of forced retirement for those under age 65, which has been historically considered as a normal retirement age.

[7] In case the same individual answered the expected retirement age question in multiple waves, we use the most recent one observed before their forced retirement.

Figure 1: Forced Retirement Risk



This figure presents the probability of being forced to retire by age group and year. We have three age groups: 55-59, 60-64, and 65-69. The probability of forced retirement is calculated using equation (1).

we should note that the expected retirement age measure in the HRS is very noisy. It is asked only under a certain set of conditions. Hence, many respondents are not asked this question, so the number of observations used in this analysis is small. Also, some households give unrealistically high or low expected retirement ages, making observations in both tails less meaningful. Still, the results suggest that a forced retirement often involves a loss of many years' worth of expected labor earnings. If forced to retire between ages 60 and 64, the median household loses two years' worth of labor earnings, while a quarter of such households lose more than four years' worth of labor earnings. For those who are forced to retire before age 60, these numbers increase to six and seven years, respectively.

There are possible channels through which households can mitigate the impact of these shocks.

Table 2: Distribution of Gaps between Actual and Expected Retirement Ages for Forced Retirees

	Percentile					N
	10	25	50	75	90	
55-59	-10	-7	-6	-3	0	193
60-64	-6	-4	-2	0	2	302

Note: This table tabulates the distribution of age gaps between actual and expected retirement ages for forced retirees. In cases where individuals answered the expected retirement age question in multiple waves, we use the most recent responses given before their forced retirement.

One way is to return to the labor market to work in a bridge job before fully retiring. Even with the reduction in earnings compared to what they had in previous jobs, this will provide some buffer against disastrous earnings losses. But we find that only about 8 percent of forced retirees return to the labor market. Returning to the labor market being rare at old ages is also consistent with the findings of a number of studies suggesting that the demand-side constraints of the labor market hinder post-career employment (e.g., Hurd, 1996, Scott, 2004, and Kantarci and van Soest, 2008). Conditional on returning to the labor market, workers also tend to make much less earnings than what they had before forced retirement. At median, earnings from the new job is only 58% of earnings from the previous job.[8]

Forced retirees may claim unemployment compensation or Social Security disability insurance, reducing the financial impact of forced retirement. To figure out whether forced retirees take advantage of this possibility, we use the claim information in the HRS data for unemployment and worker's compensation (UNWC) and Social Security disability insurance (SSDI).[9]

We first summarize the share of forced retirees who receive either UNWC or SSDI. As shown in Table 3, among respondents who change their working status from working to forced retired, the proportions of UNWC recipients are 22.4 and 20.2 percent for the age groups 55-59 and 60-64, respectively. The proportions of SSDI recipients are slightly lower: 18.0 and 13.3 percent for the age groups 55-59 and 60-64, respectively. For comparison, we also provide the proportion of recipients

[8]The denominator in the replacement rate calculation is the average of income reported in the two previous surveys before retirement. Therefore, we dropped the respondents who did not participate in two consecutive survey waves before retirement.

[9]More specifically, we use RwIUNWC and RwISSDI variables in the RAND version of HRS data. According to the RAND HRS codebook, RwISSDI is the sum of the respondent's income from Social Security disability (SDI) and Supplement Security income.

of UNWC and SSDI for all retirees (including both forced and voluntary retirees). Relative to all retirees, the proportion of recipients of both UNWC and SSDI is higher among the forced retirees. Still, relying on these sources of income is limited to a small fraction of the forced retirees.

Table 3: Share of UNWC/SSDI Recipients and Income Replacement Rate

			Number of Recipients		Income Replacement Rate (Median)	
Status	Age	Total	UNWC	SSDI	UNWC	SSDI
Working -> Retirees	55-59	554	67 (12.1%)	45 (8.1%)	10.6%	18.9%
	60-64	1,481	148 (10.0%)	83 (5.6%)	12.2%	12.2%
Working -> Forced Retirees	55-59	183	41 (22.4%)	33 (18.0%)	12.9%	19.1%
	60-64	361	73 (20.2%)	48 (13.3%)	17.7%	29.4%

Note: Respondents who have non-zero income are defined as recipients for each income category. The denominator in the replacement rate calculation is the average of income reported in the two previous surveys before retirement. Therefore, we dropped the respondents who did not participate in two consecutive survey waves before retirement.

Table 3 also provides the median income replacement rate for UNWC and SSDI recipients. The replacement rate is estimated by dividing the income from UNWC or SSDI by the average of income reported in the two previous surveys before retirement. The median income replacement rates of UNWC are 12.9 percent and 17.7 percent for the age groups 55-59 and 60-64, respectively. The income replacement rates of SSDI are higher (19.1 percent for 55-59 and 29.4 for 60-64). These numbers are slightly higher than the replacement rates for retirees overall, but even among forced retirees receiving these benefits, the replacement rates tend to be fairly low.

Overall, the low incidence rates of UNWC and SSDI benefits and the low replacement rates of pre-retirement income among those receiving these benefits imply that the role of these income sources in mitigating the impact of the forced retirement risk is limited. Additionally, unemployment compensation benefits are usually available for only up to 26 weeks.[10] Because of this short claim period compared to the difference between the actual and expected retirement ages for forced retirees, the role of unemployment benefits in compensating for earnings losses is even more limited.

2.5 Heterogeneity in Forced Retirement Risk: By Wealth Level

The stock market participation rate has been increasing in past decades with the introduction of defined-contribution pensions and individual retirement accounts. But still, many US households

[10] According to Farber and Valletta (2015), UI benefits are normally available for 26 weeks in the United States under the joint federal-state Unemployment Compensation (UC) program established under the Social Security Act of 1935. While the duration of UI benefits was expanded in some states during and after the great recession, the expansion was temporary.

near retirement have limited amounts of financial assets, and hence the question of optimal financial portfolio choice is most relevant for the upper half of the wealth distribution among those nearing retirement age (Poterba, Venti and Wise, 2011; Poterba, 2014; and Ameriks, Caplin, Lee, Shapiro and Tonetti, 2014). If the forced retirement risk is significant only among wealth-poor households, then its impact on household financial portfolio choice and hence on aggregate demand for stocks should be limited.

To address this issue, we examine how the size of the forced retirement risk varies with wealth level. We divide our sample into three groups based on self-reported household wealth and estimate the size of the forced retirement risk for each group.[11] Figure 2 shows forced retirement risk by wealth group. As the figure shows, forced retirement risk decreases with wealth, and on average, the forced retirement risk of the wealthiest group is 0.039, which is about 36 percent lower than the risk for the least wealthy group. Still, the size of the forced retirement risk faced by the wealthiest group is not negligible. Moreover, we find that the variation of the forced retirement risk over years is similar across wealth groups, with the correlations being about 0.9 for any pair. In Section 4.4, we show that our main finding is robust to the changes in the size of the forced retirement risk within the range presented in this analysis.

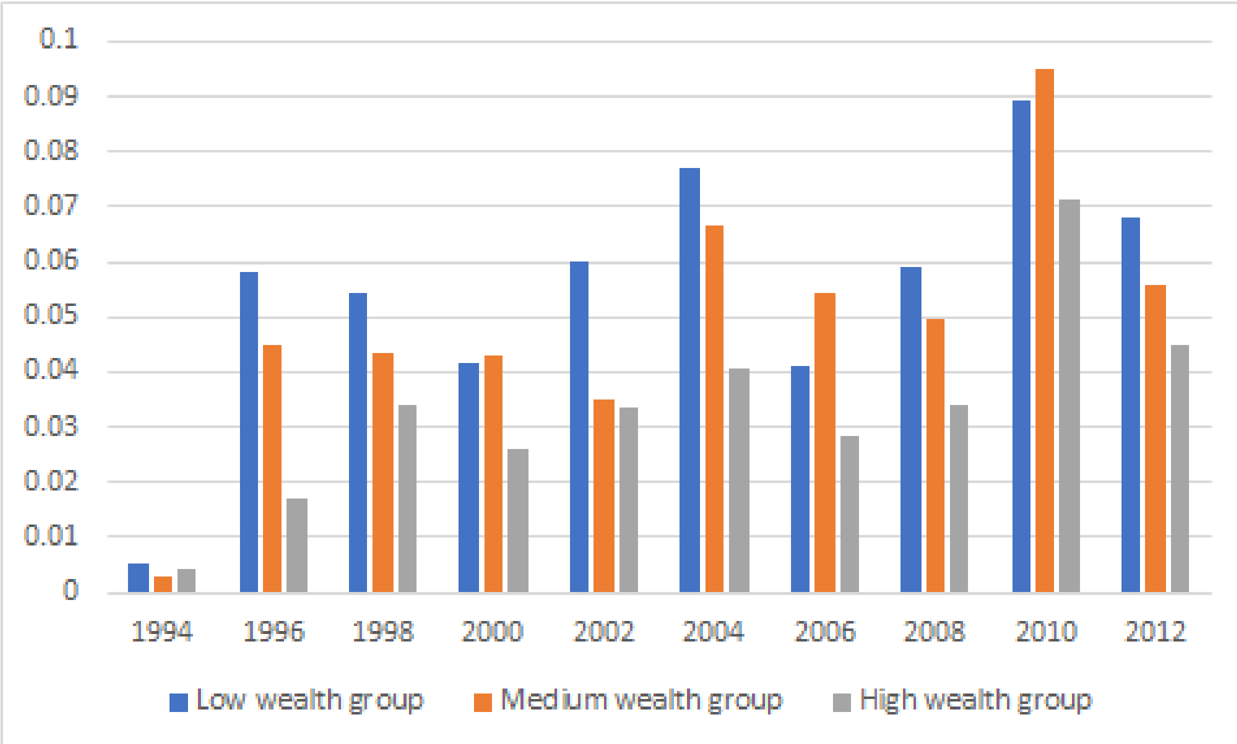
2.6 Correlation with Stock Returns

Having established that older Americans face a significant forced retirement risk, we now turn to the correlation between the size of the forced retirement risk and stock returns. Figure 1 showed a surge in forced retirements after the beginnings of recessions in 2002 and 2007, so we conjecture that an increase in the forced retirement risk follows downturns in the stock market.

To confirm this conjecture, we regress the probability of being forced to retire in each year on the annual S&P 500 returns from the previous year. Admittedly, we only have data for 15 years so we cannot precisely estimate the correlation between the two variables. But the estimated regression lines in Figure 3 suggest that the probability of being forced to retire increases after having negative returns in the stock market. The estimated effect is not small. For example, after having a positive 20 percent return on the S&P 500, the probability of a household between ages

[11] For this exercise only, we estimate the forced retirement risk at a biannual frequency because we do not observe household wealth between surveys.

Figure 2: Forced Retirement Risk by Wealth



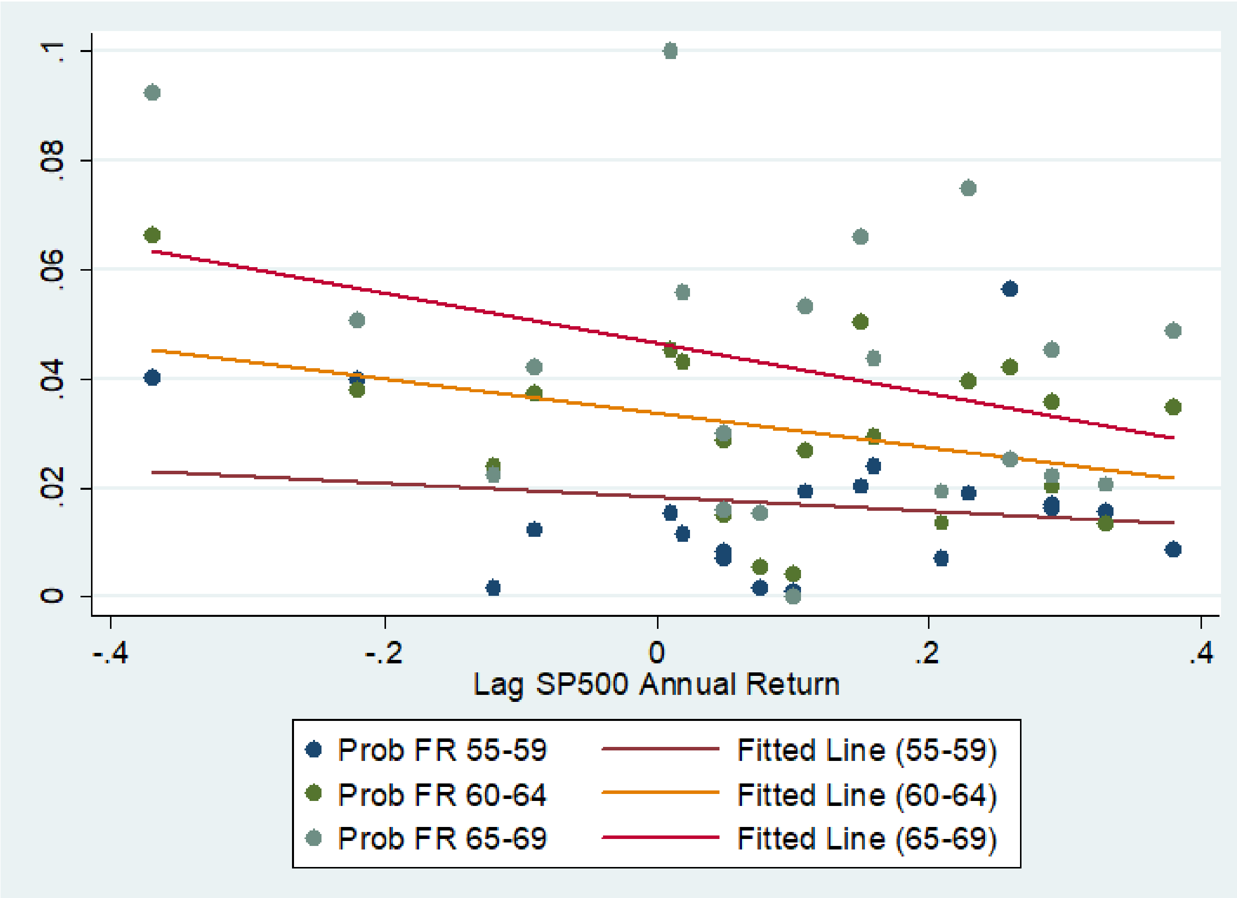
Note: This figure tabulates forced retirement risk by wealth group across different waves. Here we classify wealth groups into High, Medium, and Low based on wealth terciles within each wave. We estimate the forced retirement risk at a biannual frequency because we do not observe financial assets between surveys.

60 and 64 being forced to retire is about 3 percent, while it goes above 5 percent after having a negative 20 percent return on the S&P 500. The estimated slope for the age group 60-64 turns out to be statistically significant notwithstanding the small sample size.

Older workers are forced to retire for various reasons. Poor health is often the reason for early retirement, but massive layoffs during economic downturns can also force workers to retire earlier than expected. Any correlation between stock returns and forced retirement should come from forced retirement due to aggregate economic conditions, not from forced retirement due to health issues that is a purely idiosycratic risk. We confirm this by using the question that specifically queries forced retirees about whether poor health was an important reason for their retirement.[12] Among the 693 retirees in the sample who claim that they were forced to retire between 1998

[12] More specifically, the HRS asks *whether poor health was a very important reason for your retirement, a moderately important reason, somewhat important, or not important at all.*

Figure 3: Forced Retirement Risk and S&P Returns



Note: This figure presents the scatter plots together with the fitted lines from univariate linear regressions of forced retirement risk on lagged S&P 500 annual returns for the age groups 55-59, 60-64, and 65-69. The slope coefficients are summarized in Panel A of Table 4.

and 2012, we find that 237 retirees (34.2%) consider poor health a *very important* reason for their retirement. We take advantage of this information to distinguish forced retirement risk because of health reasons from forced retirement risk out of other reasons. After we estimate the health-related and non-health-related forced retirement risks separately for each year, we plot the relationship between the estimated forced retirement risks and lagged stock returns in Figure 4. As expected, non-health-related forced retirement risk is more strongly negatively correlated to the aggregate stock return, while we no longer find such a relationship for health-related forced retirement risk. In short, we establish two findings. First, the majority of forced retirements are not driven by health conditions. Second, the forced retirements that are classified as "not-health-related" are likely to

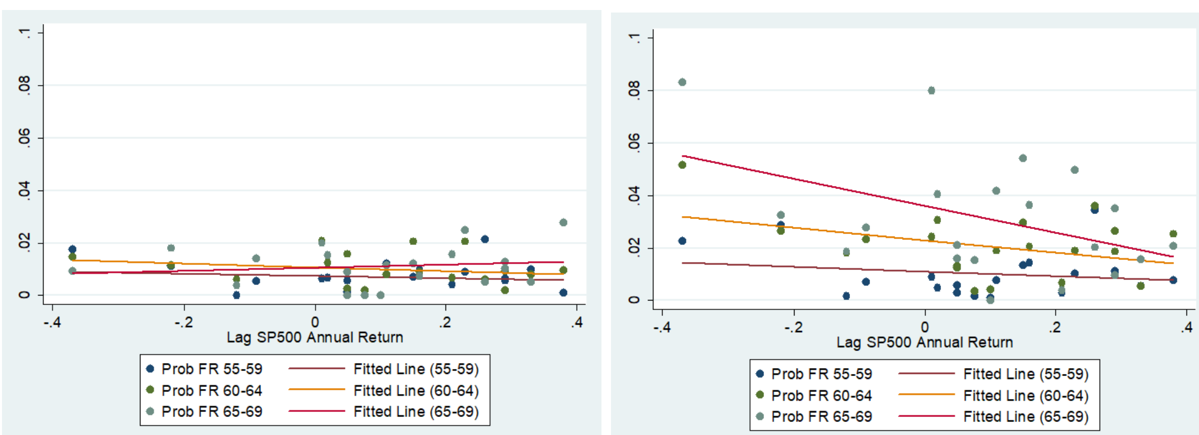
Table 4: Slope Coefficients of Univariate Regressions of Forced Retirement Risks on Lagged S&P 500 Annual Returns

55-59	60-64	65-69
Panel A. Total Forced Retirement Risk		
-0.013	-0.031*	-0.046
(0.018)	(0.018)	(0.031)
Panel B. Health-Related Forced Retirement Risk		
-0.004	-0.007	0.006
(0.007)	(0.008)	(0.010)
Panel C. Non-Health-Related Forced Retirement Risk		
-0.009	-0.024*	-0.052**
(0.011)	(0.013)	(0.025)

Notes: This table summarizes the slope coefficient from univariate regressions of forced retirement risk on lagged S&P 500 annual returns for different forced retirement risks across age groups. Panel A reports the slope coefficients by using the total forced retirement risk. Panels B and C report the coefficients for health-related forced retirement risk and non-health-related forced retirement risk, respectively. The standard errors are reported in Parentheses. ** Significant at the 5 percent level,* Significant at the 10 percent level.

be driven by pressures to leave during economic downturns, given its strong correlation with stock returns.

Figure 4: Health Related versus Non-Health Related Forced Retirement Risk and S&P Returns



(a) Health Related

(b) Not Health Related

Note: These two figures are scatter plots together with fitted lines from univariate linear regressions of forced retirement risk on lagged S&P 500 annual returns. Panel (a) uses health-related forced retirement risk only, and Panel (b) uses non-health-related forced retirement risk only. The slope coefficients are summarized in Table 4 Panels B and C, respectively.

2.7 Summary

The finding so far is that the probability of older Americans being forced to retire is not negligible, and once a forced retirement occurs it accompanies significant financial losses. The losses are rarely compensated by returning to the labor market or by relying on unemployment insurance or Social Security disability income benefits. The risk is also not confined to a certain socio-economic status. Even wealth-rich households still face a significant forced retirement risk, though somewhat smaller than that of the average household. In addition, after having a negative return stock market, households face an increased probability of being forced to retire. The size of the forced retirement risk, and its correlation with stock returns, are the key elements in determining how much human capital can be stock-like close to retirement. In the next two sections, we examine whether human capital that is subject to forced retirement risk can be stock-like, by incorporating this risk into the household's financial portfolio choice problem.

3 Life-cycle Portfolio Choice Model

In this section, we build a life-cycle portfolio choice model to investigate how the forced retirement risk documented in the previous section affects the portfolio choice of households. In this model, the retirement age is exogenously determined and uncertain. This uncertainty may also be correlated with stock returns. Otherwise, the model is close to standard models used in the literature, particularly in Cocco, Gomes and Maenhout (2005). Every period, households choose how to allocate their savings between risky and safe assets as well as how much to consume and save. The model features aggregate stock return risk, idiosyncratic income risk, and mortality risk.

3.1 Preference

Households maximize the following objective function:

$$E_1 \sum_{t=1}^{T} \delta^{t-1} (\prod_{j=0}^{t-2} P_j \{P_{t-1} \frac{C_{it}^{1-\gamma}}{1-\gamma} + b(1-P_{t-1}) \frac{D_{it}^{1-\gamma}}{1-\gamma}\}), \tag{2}$$

where i is an index for an individual household, C_{it} the consumption in age t, D_{it} is the amount of bequest that it will leave if it dies at age t, δ is the time discount factor, b is the weight that it puts on bequest, γ is the risk aversion coefficient, and P_t is the survival probability between ages $t-1$ and t.[13] This is basically the present value sum of flow utility where households face uncertainty over the length of lifetime and have a bequest motive.

3.2 Labor Income Process before Retirement

Households that are still working face idiosyncratic risks in their labor income. The labor income process is as follows:

$$log(Y_{it}) = f(t) + \nu_{it} + \varepsilon_{it} \tag{3}$$

$$\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2) \tag{4}$$

$$\nu_{it} = \nu_{i,t-1} + u_{it} \tag{5}$$

$$u_{it} \sim N(0, \sigma_u^2). \tag{6}$$

The labor income (Y_{it}) fluctuates around its conditional mean ($f(t)$), where the latter is a function of age. The deviation between the actual labor income and its conditional mean is determined by both the permanent shocks (ν_{it}) and temporary shocks (ε_{it}), where the former is modeled as a random walk process. The innovation (u_{it}) to the random walk process can be correlated with stock returns, while temporary shocks are independent.

3.3 Retirement Income

For most defined benefit pension plans and also for Social Security, the retirement income depends on the average earnings made over the household's working life. Let Ψ denote the average labor income the household had in its working life. While households are working, it evolves according to:

$$\Psi_{it} = \frac{(t-1)\Psi_{i,t-1} + Y_{it}}{t}. \tag{7}$$

If a household is retired at the normal retirement age K, it starts to receive a fixed retirement

[13] As in Cocco, Gomes and Maenhout (2005), we do not model the joint survival process of spouses. Hence the model describes the optimal portfolio choice of single investors.

income every year that is calculated as:

$$log(Y_{it}) = log\lambda + log(\Psi_{iK}),\ \forall t \geq K. \tag{8}$$

This models the social security and private defined benefit pension income of households, where λ is the replacement rate.

If a household is forced to retire at age s that is lower than K, then the retirement income is calculated as:

$$log(Y_{it}) = log\lambda_s + log(\Psi_{iK}),\ \forall t \geq s. \tag{9}$$

where

$$\Psi_{iK} = \frac{s\Psi_{is}}{K}(= \frac{s\Psi_{is} + (K-s)0}{K}). \tag{10}$$

Hence, forced retirement affects the retirement income stream in two ways. First, it reduces Ψ_{iK} that goes into the formula of the retirement income calculation because having zero earnings for the years spent not working before the normal retirement age lowers the average earnings. This captures the fact that for certain defined benefit pension plans (and also for Social Security income up to a point), early retirement negatively affects the pension benefit accrual. Second, given Ψ_{iK}, forced retirement also affects the annual income flow by changing the replacement factor λ_s. We calculate λ_s such that early retirement does not affect the expected present value sum of total retirement income given Ψ_{iK}. In other words, we allow an actuarially fair early retirement benefit from the age of forced retirement, regardless of when it happens.

In reality, how a forced retirement affects retirement income depends on the benefit formula of defined pensions as well as their specific work history. In certain cases, either the effect of a forced retirement on Ψ_{iK} is limited (e.g., Social Security income for those who worked more than thirty five years) and/or an actuarially fair early retirement benefit is not available before certain ages (e.g., Social Security income is not available before age 62). Later we will also examine robustness of our main results to an alternative specification where a forced early retirement does not affect pension benefit accrual (Ψ_{iK}).

3.4 Uncertainty in Retirement Age

In the household portfolio choice literature, retirement age has been considered either to be fixed (e.g., Cocco, Gomes and Maenhout, 2005 and Gomes and Michalides, 2005) or to be a choice of households (Bodie, Merton and Samuelson, 1992). But as we have shown in the previous sections, many households are forced to retire, so for them retirement is not a buffer against shocks but rather a shock itself. Furthermore, this uncertainty over retirement age can be correlated with stock returns, which may amplify the implications of the forced retirement risk for portfolio choice.

We incorporate the forced retirement risk into our model, while not allowing households to choose their retirement age. This means that retirement timing is purely determined by the demand side in the labor market, an opposite extreme to what is assumed in Bodie, Merton and Samuelson (1992). We are not arguing that no household can use the retirement timing as a buffer against negative asset return shocks. We choose this set up to focus on how close human capital comes to being a risky asset for households that are exposed to a forced retirement risk, an issue that has been neglected in the literature.

We assume that the probability of being forced to retire in the following year, Ω_t, is zero for those who are not older than 55. For those who are still working between the ages of 56 and 63,[14] the probability that they will be forced to retire in the following year is:

$$\Omega_t = \bar{\Omega}_t + \kappa_t \iota_t, \tag{11}$$

where $\bar{\Omega}_t$ is the average value of this probability and κ_t determines how much this probability is affected by aggregate shocks (both parameters are specific to age t), and ι_t is an aggregate shock that affects the risk of forced retirement.[15]

[14] For those who are currently 64 years old, they do not face forced retirement risk since they plan to retire in the next year.

[15] An alternative modeling choice is to incorporate the forced retirement risk to earnings process (3)-(6) as an additional source of persistent shocks. We made our choice to investigate the distinctive role played by the forced retirement risk, compared to other earnings risks that are already captured in (3) - (6) including unemployment spells before retirement, more easily. Our reduced form modeling also helps us model the relationship between the forced retirement risk and stork market returns found in the data.

3.5 Financial Assets

The model has two financial assets, a risk-free asset and a risky asset. The risk-free asset has a fixed gross return $\bar{R_f}$. The return process for the risky asset is:

$$R_{t+1} - \bar{R_f} = \mu + \eta_{t+1} \tag{12}$$

$$\eta_{t+1} \sim N(0, \sigma_\eta^2) \tag{13}$$

$$Corr(\eta_{t+1}, u_{t+1}) = \rho, \tag{14}$$

where μ is the risk premium and η_{t+1} is a stock return shock. The stock return shock may be correlated with a permanent income shock.

Households need to choose how to allocate their savings between the two assets. They cannot borrow and they cannot short stocks. Hence, the share of assets invested in stocks, which we denote by α_{it}, needs to be between 0 and 1.

3.6 Optimization Problem

Let X_{it} be the cash-on-hand at the beginning of the period. It is determined as:

$$X_{it} = W_{it} + Y_{it} \tag{15}$$

$$W_{i,t+1} = R^P_{i,t+1}(W_{it} + Y_{it} - C_{it}) \tag{16}$$

$$R^P_{i,t+1} \equiv \alpha_{it} R_{t+1} + (1 - \alpha_{it})\bar{R_f} \tag{17}$$

where $W_{i,t}$ is the assets at the beginning of the period, determined by the amount of savings in the previous period and the performance of the overall portfolio, R^p_{it}.

Using scalability of the problem, we normalize all the variables with respect to $exp(\nu_{it})$. Let $\tilde{C}_t$, $\tilde{X}_t$, and $\tilde{\Psi}_t$ be normalized values of C_t, X_t, and Ψ_t. Then the Bellman equation can be expressed as following:

$$V_{it}(\tilde{X}_{it}, \tilde{\Psi}_{it}, Ret_t, RA_t) = Max_{\tilde{C}_{it} \geq 0, 0 \leq \alpha_{it} \leq 1}[U(\tilde{C}_{it}) + \delta P_t E_t exp(\nu_{i,t+1})^{1-\sigma} V_{i,t+1}(\tilde{X}_{i,t+1}, \tilde{\Psi}_{i,t+1}, Ret_{t+1}, RA_{t+1})] \tag{18}$$

under constraints (3) - (17), where Ret is a dummy variable capturing whether the household is retired or not, and RA captures the age of retirement once the household is retired.

3.7 Calibration

Table 5 summarizes the calibration of the parameters. For the parameters that also appear in Cocco, Gomes and Maenhout (2005), we use the same values as in their benchmark model. Conditional probabilities of survival (P_t) are from the mortality tables of the National Center for Health Statistics. The model starts with age 20 and goes up to age 100.

Table 5: Calibration of parameters

Parameter	Value
Own calibration	
Mean of forced retirement risk ($\bar{\Omega}$) for age 55-59	0.02
Mean of forced retirement risk ($\bar{\Omega}$) for age 60-63	0.035
Effect of stock returns on forced retirement risk (κ) for age 55-59	0.013
Effect of stock returns on forced retirement risk (κ) for age 60-63	0.031
From Cocco et al. (2005)	
Normal retirement age (K)	65
Discount factor (δ)	0.96
Risk aversion (γ)	10
Bequest motive (b)	0
Average labor income ($f(t, Z_{it})$)*	
Variance of transitory income shocks (σ_ε^2)	0.0738
Variance of permanent income shocks (σ_u^2)	0.0106
Correlation between (permanent) labor income shocks and stock returns (ρ)	0
Riskless rate ($R_f - 1$)	0.02
Risk premium ($\mu - 1$)	0.04
Std. of stock return (σ_η)	0.157

Notes: Benchmark values used for the model.
* See Table 2 in Cocco, Gomes and Maenhout (2005).

Calibration of the forced retirement risk (Ω_t) is one of the most important contributions of this paper. Based on the evidence from the HRS, we calibrate $\bar{\Omega}$ to be 0.02 for the age range 55-59 and $\bar{\Omega}$ to be 0.035 for ages 60-63. Also, based on the observed correlation patterns between the stock returns and the forced retirement risks, we calibrate κ to be 0.013 for ages 55-59 and 0.031 for ages 60-63, while letting $\iota_t = -\eta_t$. For example, when the return on the risky asset goes up by 10 percentage points, it reduces the forced retirement risk by 0.13 percentage point for ages 55-59 and by 0.31 percentage point for ages 60-63. This calibration reproduces the regression lines estimated in Figure 3.

The hazard rates may seem trivial, but they are not. According to the calibrated parameters, for a household that is working at age 55, the chance of being retired involuntarily before age 60—i.e., losing more than five years worth of earnings—is roughly 10 percent. The chance of being forced to retire before the normal retirement age (65) goes up to above 20 percent. Hence, this is indeed a significant risk that older households face before their retirement.

3.8 Computational Strategy

We solve this model using backward induction. The last period problem is trivial since it is a static maximization problem (i.e., allocation between its own consumption in the last year and bequest). This gives us the value function in the last year. Using this as the continuation value, we solve the maximization problem of the penultimate year. This procedure is repeated until the first period.

In the maximization, we use grid search to determine the optimal combination of consumption and portfolio choice. We use Gaussian quadrature to discretize the distribution of shocks and numerically integrate over them. The continuous state spaces, $\bar{X}_t$ and $\bar{\Psi}_t$, are discretized using 400 and 80 grid points, respectively. Increasing the number of grid points does not affect the results. In evaluating the continuation values off the grid points, we use cubic interpolation.

4 Results

We first compare the policy function for the stock share in financial wealth between those who are still working and those who are forced to retire. This comparison identifies how the part of human capital that is exposed to forced retirement risk affects the portfolio choice of households. We further investigate the mechanism behind the estimated effect. To be specific, we turn off the correlation between forced retirement risk and stock return risk to examine whether the impact of forced retirement risk on the portfolio choice mainly comes from the existence of the risk itself or from the correlation. We then construct age profiles of wealth and stock share by simulating the model to demonstrate that the optimal portfolio adjustment with age under the forced retirement risk is dramatically different from the long-standing consensus that one should reduce investment on risky assets as retirement approaches.

4.1 Portfolio Choice under Forced Retirement Risk

Figure 5 plots the optimal stock share over normalized cash-in-hand ($\tilde{X}$). Panel (a) is for age 56 that is the lowest age when a household can be forced to retire, while Panel (b) is for age 60. The blue curve corresponds to a household that is still working and the red one corresponds to a household that has been forced to retire at the age considered in each panel. Under the normalization $exp(\nu_{it}) = 1$, the annual labor earnings of a household that is still working are approximately 25. Hence the wealth-to-income ratio range shown in the figure is between 0 and 10. The most relevant range, in terms of the most likely value both in the model and in the empirical data on stock holders (see Ameriks, Caplin, Lee, Shapiro and Tonetti, 2014 for the latter) is around 2-8 (i.e., $\tilde{X}$ in 50 - 200). One state variable that is not explicitly shown in the figure is the normalized average labor income in the past ($\tilde{\Psi}$). In this figure, we assume $\tilde{\Psi}$ to be 20, which is close to the average value of this variable in this age range.

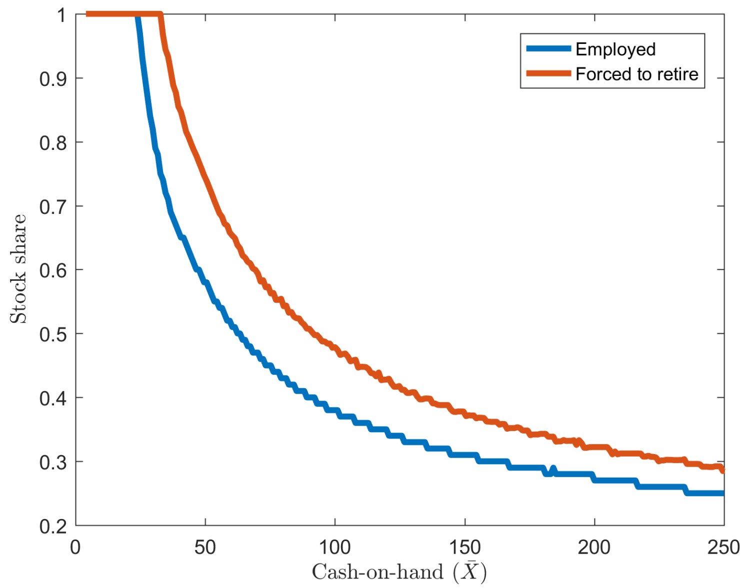
The optimal stock share is a decreasing function of financial wealth regardless of current working status. For households nearing retirement age, a large fraction of human capital is composed of retirement income that is largely unaffected either by the performance of the stock market or forced retirement.[16] That part of human capital functions as a close substitute to a risk-free asset, as investigated in Cocco, Gomes and Maenhout (2005), so the larger the financial wealth (i.e., the lower the share of 'safe' human capital in the entire portfolio including human capital), the lower the optimal share of risky assets in the financial portfolio.

The difference between the blue and red curves, on the other hand, reveals the role of the part of human capital that is exposed to forced retirement risk. Note that the only difference between the households represented by the blue curve and those represented by the red curve is that the former have additional human capital because they are still working. Comparison of two households that are identical except for their current labor force participation demonstrates how this part of human capital, exposed to forced retirement risk, affects the portfolio choice. For both age 56 and age 60, the optimal stock share is much lower for those who are still working. In other words, the part of human capital exposed to the forced retirement risk is considered as a close substitute for the risky asset, so holding this human capital crowds out risky asset investment in the financial portfolio.

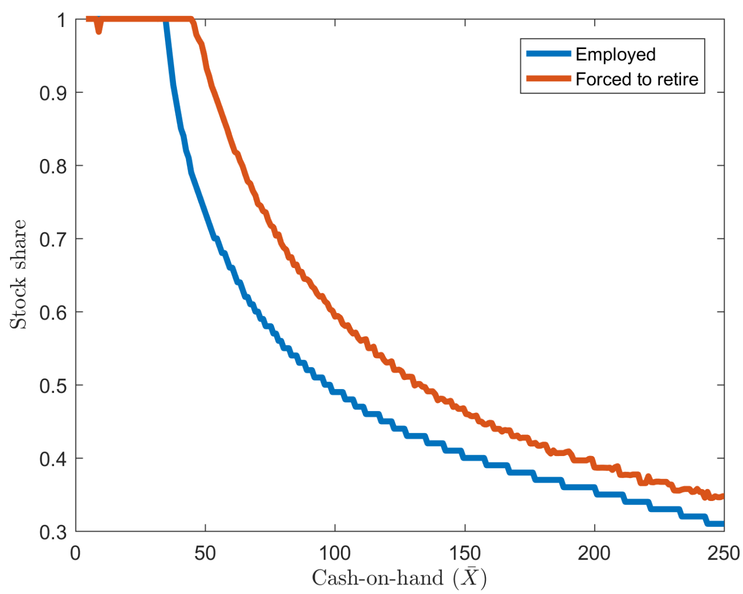
[16] Recall that in the baseline model a forced retirement affects the retirement income only through its impact on Ψ_{iK} and the magnitude of it is relatively small.

Figure 5: Stock share comparison: workers vs. forced retirees

(a) Age 56



(b) Age 60



Note: In both panels, the blue curve is the optimal stock share for the households that are still working while the red curve is the optimal stock share for the households that have been forced to retire under the considered age in each panel. Under the normalization with $exp(\nu_{it}) = 1$, the value of labor earnings of the employed household is about 25 in this age range. We assume $\bar{\Psi} = 20$, which is close to the average value in this age range.

The impact is larger when households have fewer financial assets, and the effect is similar between ages 56 and 60. For both ages, the difference between the two curves is about 20 percentage points when the wealth-to-income ratio is 2 (cash on hand is 50), and it decreases to about 5 percentage points when the wealth-to-income ratio is 8 (cash on hand is 200). As we show in Section 4.3, due to this stock-like human capital, the optimal stock share increases with age rather than decreases, contrary to conventional wisdom.

4.2 Role of Correlation between Stock Returns and Forced Retirement Risk

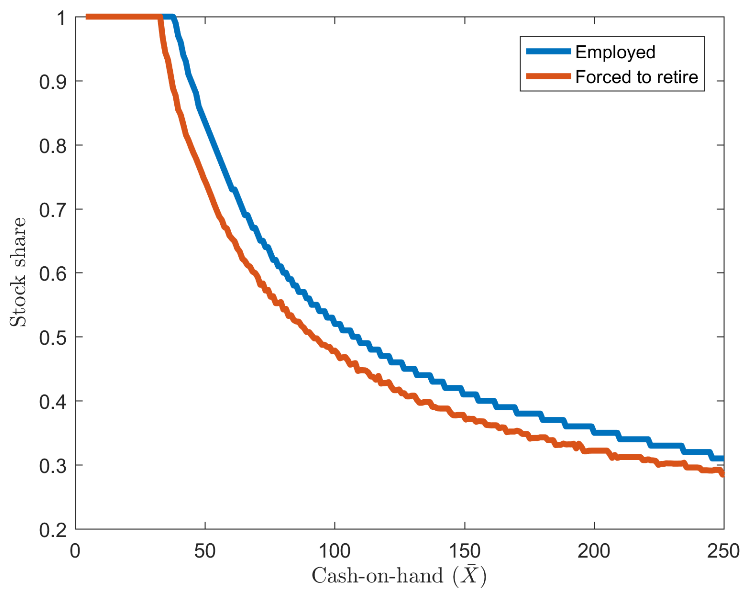
But what makes the part of human capital exposed to forced retirement risk a close substitute for a risky asset? Is it the existence of the forced retirement risk per se, or is it the correlation between this risk and the stock return risk? To investigate the mechanism behind the result in the previous subsection, we revisit the comparison of the stock share policy function under no correlation between the forced retirement risk and stock returns.

Once we turn off the correlation, we find the qualitatively opposite result (Figure 6). Now the optimal stock share is higher for those who are still working, for both ages considered. Working households still face the forced retirement risk. But as long as that risk is not correlated with stock returns, the effect of having an additional risk is dominated by the effect of having a flow of income that is uncorrelated with stock returns. Quantitatively, the size of the effect of having additional income on the optimal stock share is relatively small, demonstrated by the small gap between the blue and red curves.

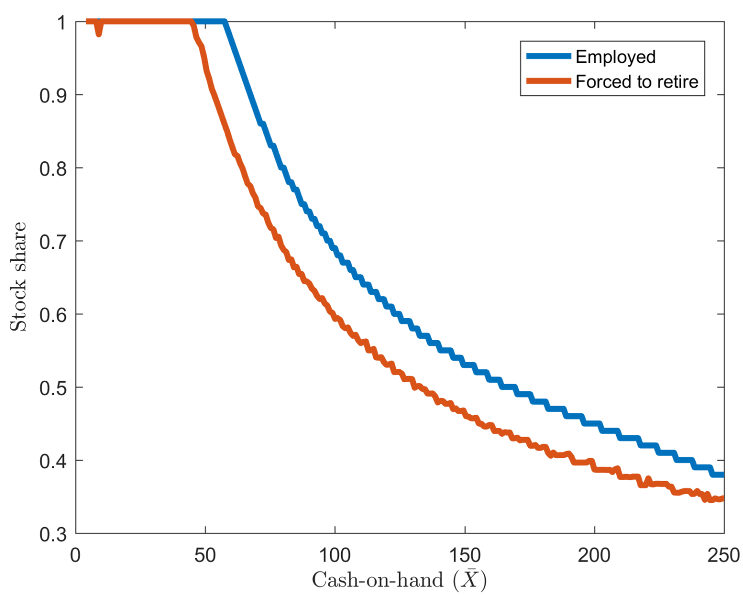
By comparing the blue curves in Figure 5 and Figure 6, we can see that the effect of the correlation between the forced retirement risk and stock returns on the portfolio choice is large. One might find it puzzling because stock market fluctuations, though correlations are significant, do not seem to largely affect the size of forced retirement risk according to our calibration. For example, between the ages of 60 and 64, a negative stock return shock that corresponds to one standard deviation (i.e., 10 percent loss) increases the probability of being forced to retire only by 0.5 percentage point. However, that is a 15 percent increase in the hazard rate (from 3.5 to 4 percentage points). On the other hand, the correlation also means that the chance of having a large negative stock return becomes much higher when the household is forced to retire. Given that it is more likely to have a loss in its stock investment at the same time it loses a significant fraction of

Figure 6: Stock share comparison: under no correlation between forced retirement risk and stock return

(a) Age 56



(b) Age 60



Note: In both panels, the blue curve is the optimal stock share for the households that are still working, while the red curve is for the households that have been forced to retire under the considered age in each panel. Under the normalization with $exp(\nu_{it}) = 1$, the value of labor earnings of the employed household is about 25 in this age range. We assume $\bar{\Psi} = 20$, which is close to the average value in this age range.

human capital, a household that faces the forced retirement risk hedges this risk by investing more in the safe asset.

Note that in Viceira (2001), retired households almost always have a lower share of risky assets in their financial portfolios compared to working households, even under an unrealistically high correlation between permanent labor income shocks and stock return shocks. We show that one can easily overturn his findings by incorporating the forced retirement risk and the correlation between that risk and stock returns. On the other hand, Heaton and Lucas (2000) resort to entrepreneurial income risk to explain the risk premium puzzle. We show that even non-entrepreneurs may view (a part of) their human capital as a close substitute for stocks.

4.3 Age Profiles of Optimal Wealth and Stock Share

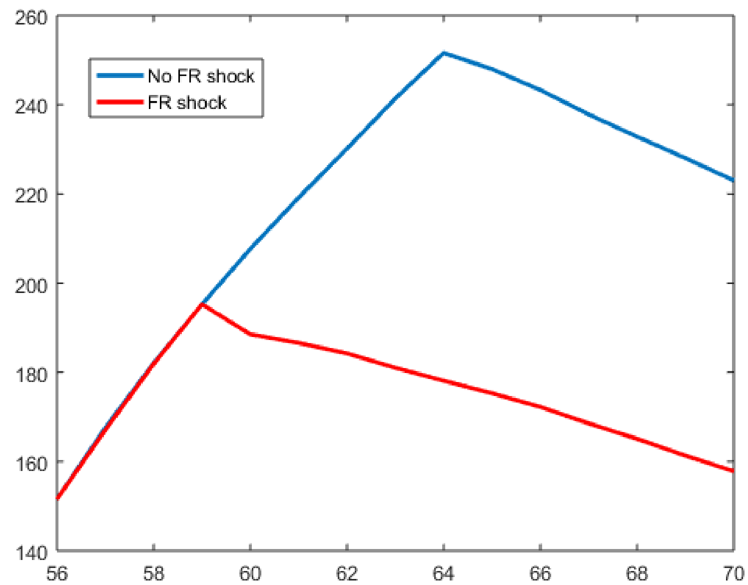
The above policy function comparisons examine how the optimal stock shares differ, conditional on wealth, between those who are forced to retire and those who are still working. A forced retirement, however, also reduces the level of wealth. To examine how a forced retirement affects the optimal portfolio choice through its direct effect on the policy function and its indirect effect through changes in wealth, we construct life-cycle profiles of wealth and the optimal stock share around the retirement age (55-70).

Life-cycle profiles from the baseline model are shown in Figure 7. The blue curves assume that the households work until the normal retirement age (65), while the red curves assume that the households are forced to retire at age 60. The profiles are constructed as the averages of 1,000 simulations. For the wealth profiles, there is nothing surprising. Households accumulate wealth while they are working and then decumulate once they retire. For the stock share, once the households represented in the red curve retire, we see a wide gap between the two curves. Most of this is driven by the policy function difference shown in Figure 5, while part of it comes from the fact that the forced retirees now have less wealth, which increases the optimal stock share even further compared to that of the working households. The gap shrinks as they approach the normal retirement age, as the size of working households' human capital that is subject to the forced retirement risk decreases. The gap that remains after the normal retirement age results solely from the different levels of wealth.

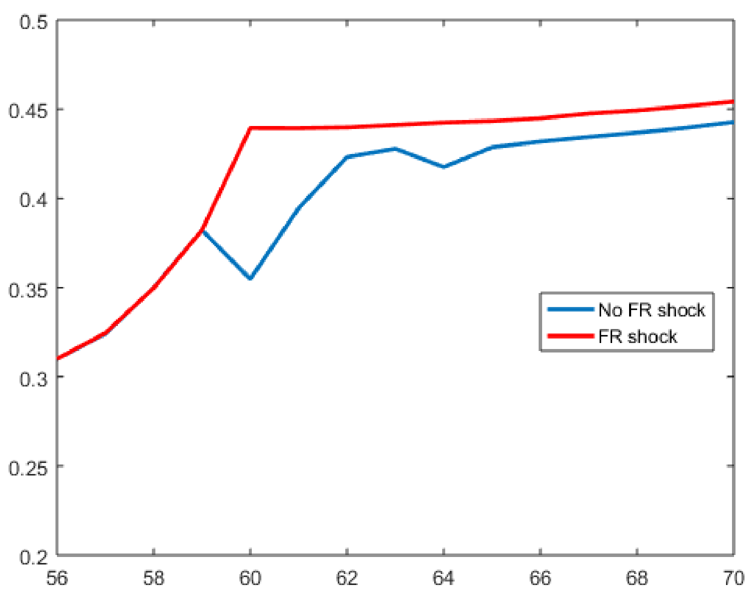
From this figure, we see that the optimal portfolio adjustment around the retirement age is

Figure 7: Life-cycle profiles of wealth and stock share: baseline

(a) Wealth



(b) Stock share



Note: The blue curves assume that the households are not forced to retire until the normal retirement age (65), while the red curves assume that the households are forced to retire at age 60. The profiles are constructed as the averages of 1,000 simulations.

almost the opposite of the conventional wisdom that households should reduce the share of risky assets as they approach their retirement. Under the existence of forced retirement risk, households *increase* their stock share as they approach the normal retirement age and when they are forced to retire—i.e., as the size of human capital that is exposed to the forced retirement risk shrinks.

This pattern disappears when we turn off the correlation between forced retirement risk and stock returns (Figure 8). The wealth profiles are almost the same as those from the baseline model. In this specification, households on average accumulate more wealth as they can invest a larger fraction of their financial savings in the risky asset, which provides a higher return on average. As Figure 6 showed, the effect of the additional human capital of those who are still working on the optimal stock share is fairly small under this specification. As a result, the stock-share profile does not show a significant adjustment around retirement. Once the households represented in the red curve are forced to retire, their stock share becomes smaller than that of those who are still working due to the policy function difference shown in Figure 6. Later on, the relationship flips, again due to the lower wealth level of forced retirees.

Note that if we further remove forced retirement risk itself (not just the correlation between the risk and stock returns) then the model goes back to that of Cocco, Gomes and Maenhout (2005). The optimal stock share profile from that model is exactly the opposite to our baseline result and consistent with the conventional wisdom: It monotonically decreases with age until retirement. The comparison between our baseline result and that from Cocco, Gomes and Maenhout (2005) thus highlights the role of forced retirement risk (and its correlation with stock returns) in generating the optimal portfolio adjustment patterns that go against the conventional wisdom.

4.4 Alternative Specifications

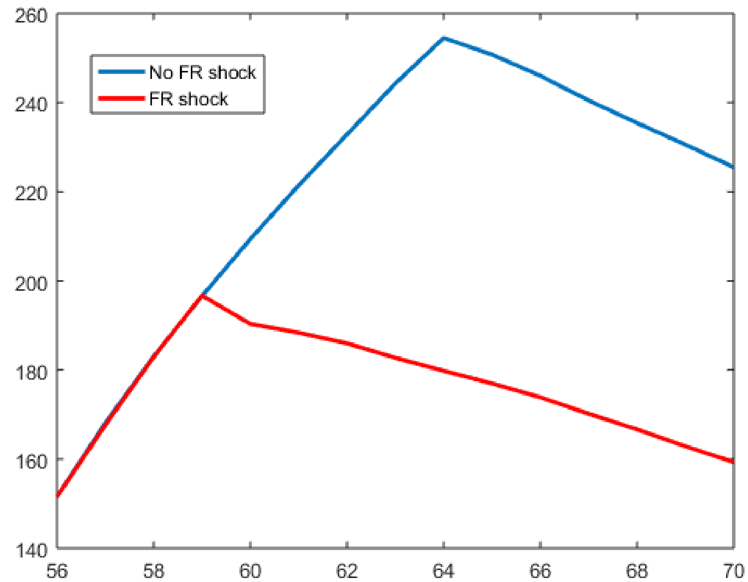
In this section, we examine robustness of the main results to alternative specifications of the model.

4.4.1 No effect of a forced retirement on Ψ

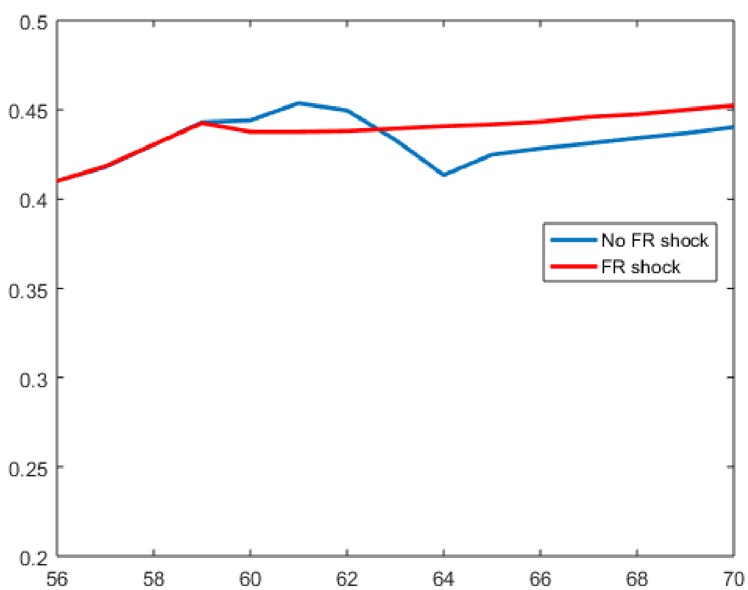
In the baseline model, we assume that forced retirement reduces the average labor income variable (Ψ) used in retirement income calculation as having zeros earnings before the normal retirement age reduces the average earnings until that age. Whether this is a realistic description of the defined benefit pensions and Social Security or not depends on the exact formula of benefit calculations and

Figure 8: Life-cycle profiles of wealth and stock share: under no correlation between forced retirement risk and stock return risk

(a) Wealth



(b) Stock share



Note: The blue curves assume that the households are not forced to retire until the normal retirement age (65), while the red curves assume that the households are forced to retire at age 60. The profiles are constructed as the averages of 1,000 simulations.

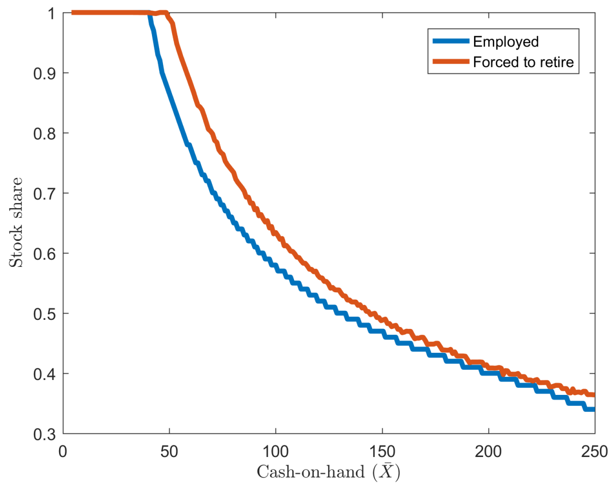
the work history of workers. For example, if benefit accrual under a defined-benefit pension plan is a function of the number of service years and the average earnings over a certain number of years with the highest earnings, then forced retirement can affect the pension benefit accrual directly by reducing the number of service years (and also by reducing the average highest earnings if the individual's earnings have been increasing over time). On the other hand, if someone has been working for more than 35 years, then the effect of a forced retirement on Ψ can only be marginal for Social Security income.

To examine the opposite extreme relative to what has been assumed in the baseline model, we reexamine the optimal portfolio choices assuming that forced retirement does not affect Ψ. In other words, if someone is forced to retire at age $s < K$, then we use $\Psi_K = \Psi_s$ in the calculation of retirement income. Examining sensitivity of the result to this aspect of the model specification also informs us about the potential effects of unemployment insurance and disability income benefits that partly compensate for earnings losses (Section 2.4).

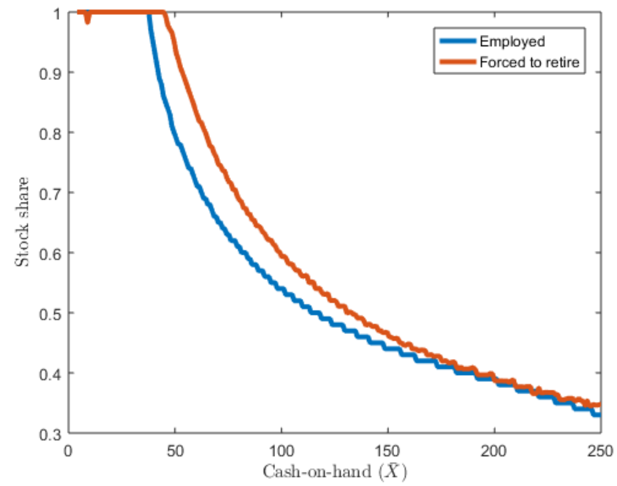
Under this specification, we find the same qualitative result as in the baseline model (Figure 9, Panel (a)).[17] Those who are still working should invest less in stocks than those who are forced to retire. Quantitatively, the human capital of those still employed is less stock-like compared to the baseline. The gap between the two curves becomes negligible at high wealth-to-income ratios, though for a large part of the wealth-to-income ratio range that is common among stockholders (between 2 and 8, which corresponds to between 50 and 200 in $\bar{X}$), the result still suggests that households should have a lower stock share before retirement. By comparing with Figure 5, we can see that the gap between the blue and red curves in this specification is about 40 percent smaller for most of this wealth range. Note that in the baseline model a forced retirement affects households' financial resources via two channels: on one hand through the lost labor earnings and on the other hand through the reduced retirement income (through its effect on Ψ). The current specification isolates the effect through the first channel, and it shows that the first channel accounts for about 60 percent of the effect in the baseline model.

[17] All the panels in Figure 9 consider comparisons of stock share between those who are still working and those who are forced to retire at age 60.

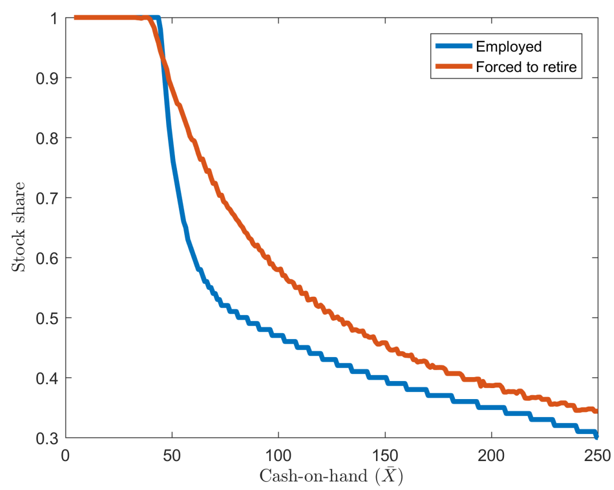
Figure 9: Stock share comparison: Alternative specifications (age 60)



(a) No effect on Ψ



(b) Smaller forced retirement risk



(c) With a bequest motive

Note: In all the panels, the blue curve is the optimal stock share for the households that are still working while the red curve is the optimal stock share for the households that are forced to retire under the considered age in each panel. Under the normalization with $exp(\nu_{it}) = 1$, the value of labor earnings of the employed household is about 25 in this age range. We assume $\bar{\Psi} = 20$, which is close to the average value in this age range.

4.4.2 Under a Smaller Forced Retirement Risk

In the baseline model, the calibration of the forced retirement risk is based on our estimates from the representative sample of the older Americans in the HRS. One might think that a more proper calibration would be based on a part of the population that is more likely to participate in the stock market—i.e., those with relatively more wealth. Though the exercises with the baseline specification are meaningful given that stock market participation becomes more common with the transition from the defined-benefit to the defined-contribution pension system, we also examine whether our main result still holds under a smaller forced retirement risk, calibrated from the high wealth group defined in Section 2.5. To be more specific, we recalibrate the level of forced retirement risk to be 70 percent of the baseline value (i.e., reducing both $\bar{\Omega}$ and κ by 30 percent from the baseline values).

Panel (b) of Figure 9 shows that the additional human capital of working households is still stock-like even when the size of forced retirement risk is smaller. The result is almost identical to that in Panel (a). The gap between the two curves becomes negligible at high wealth-to-income ratios, but for a large part of the wealth-to-income ratio range that is common among stockholders, households that are still working should invest less in the risky asset.

4.4.3 With a Bequest Motive

Following Cocco, Gomes and Maenhout (2005), we turn off the bequest motive in the baseline model by assuming $b = 0$. Here we examine whether our main result is robust under a bequest motive by setting b at 3, which is the median value considered in the robustness check exercises in Cocco, Gomes and Maenhout (2005).[18]

A bequest motive does not change our main result (Figure 9, Panel (c)). Households that are still working should invest less of their wealth in stocks than those who are already retired. The gap between the two curves is comparable to the one from the baseline (Figure 5). The levels of both curves are lower with a bequest motive, which means that a bequest motive makes households less willing to take risks in their investments. This result is intuitive. Retirement income from defined-

[18] $b = 3$ implies that the household wants to finance three years of consumption for their descendants. For example, if the household is at its last year and there is no uncertainty, it will consume one fourth of its wealth and then leave the remainder as a bequest.

benefit pensions and Social Security functions as a good hedge against longevity and bad investment outcomes for those mainly concerned with financing their own consumption. For those who have a strong bequest motive, retirement income cannot be a good hedge against bad investment outcomes because households cannot bequeath unrealized retirement income. If a household experiences a 10 percent loss in its investments and dies soon after that, the bequest will be reduced approximately by 10 percent and the retirement income flow that it could have had conditional on surviving does not help protect the bequest.

5 Conclusion

In this paper, we find that older Americans face a significant forced retirement risk that is strongly correlated with stock returns. Using a life-cycle portfolio choice model with the estimated forced retirement risk, we show that the forced retirement risk makes the part of human capital that is exposed to such risk stock-like, resulting in a lower optimal stock share for workers than for retirees. This portfolio adjustment is almost the opposite of the conventional wisdom that households should reduce their stock shares as they approach retirement.

Our finding also provides an alternative explanation for the risk premium puzzle. Households right before their retirement reach the highest levels of financial wealth, on one hand, and but they face a forced retirement risk on the other hand. Hence their reduced demand for stocks, attributable to forced retirement risk, should have a large impact on asset pricing. It is for future research to extend our framework to a general equilibrium model and quantitatively examine the contribution of forced retirement risk to the risk premium.

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