ABOUT THIS REPORT:

Current 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 data from the Health and Retirement Study, this paper finds that the forced retirement risk is both significant and 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.
Forced Retirement Risk and Portfolio Choice∗

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Abstract

Current 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 data from the Health and Retirement Study, this paper finds that the forced retirement risk is both significant and 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, E21, G11, G12
1 Introduction

As the U.S. population ages, there is substantial concern about this group’s financial prospects upon retirement. Much of this discussion revolves around the question of whether aging households are saving enough to sustain a desired 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 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 address this gap in the literature by examining how older households should adjust allocations of their financial wealth between risky and safe assets. In particular, we focus on the impact of one specific risk older households face at the end of their working life—the risk of being forced into retirement before their planned retirement age—on the 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. Indeed, most life-cycle funds in the current financial market are designed based on this principle. An oft-cited justification for this strategy relates to changes in household human capital as a household ages (Jagannathan and Kocherlakota, 1996). That is, households approaching retirement expect less future labor earnings, thereby experiencing a decrease in their human capital. 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 not strongly correlated with stock returns—this decrease suggests they should reallocate toward more risk-free assets to make up for the loss.
in their 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—then they should reallocate toward more risky assets. These two possible scenarios illustrate that 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.

Most of the current literature on the role of human capital in financial portfolio choice models human capital risk in terms of pre-retirement earnings uncertainty. These studies conclude that human capital is bond-like since the estimated risk is small and not strongly correlated with stock returns, even after accounting for the 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 their retirement represents a greater source of uncertainty than their pre-retirement labor earnings process. 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 overlook such risk for two reasons. First, in empirically estimating the risk in labor income, they study only those who are not yet retired, thereby missing the uncertainty in retirement timing by construction. Second, in building their life-cycle portfolio choice models, they assume either that the retirement timing is fixed (e.g., Cocco, Gomes, and Maenhout, 2005) or that households have full control over deciding when to retire (e.g., Bodie, Merton, and Samuelson, 1992; Farhi and Panageas, 2007; Choi, Shim, and Shin, 2008; and Dybvig and Liu, 2010).

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 from the male sample
can be classified as involuntary: individuals were compelled to retire early for reasons that included health issues as well as employer decisions. Specifically, we find that on average about 4 percent (2 percent) of households in the age range of 60 to 64 (55 to 59) who want to keep working are forced to retire each year. An involuntary early retirement often represents a loss of several years’ worth of labor earnings. Most forced retirees do not return to the labor market, and only a small fraction rely on unemployment insurance or disability income. These findings imply that households close to retirement face a substantial risk in their human capital. Though the households at the bottom of the wealth distribution are more likely to be forced to retire, even those with relatively more wealth, who are more likely to participate in the stock market, still face a significant forced retirement risk. We further 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.

To examine the implications of this forced retirement risk for the optimal portfolio choice, we then build a life-cycle portfolio choice model with the estimated forced retirement risk. 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 of the common approach in the current literature by assuming that retirement timing is uncertain and exogenously determined. 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 and do not have much control over the retirement timing, which has been neglected in the literature. To be specific, this model assumes that households plan to work until a certain age, but may be forced to retire before reaching that age. The probability of this forced retirement is a function of age and is correlated with stock returns, calibrated based on the findings from the HRS data. The results from our model suggest that, under forced retirement risk, human capital exposed to this risk becomes stock-like. This suggests
that households should increase the share of risky assets in their financial portfolios as they approach and enter retirement, a strategy completely different than commonly espoused. Examining our model further, we find that the stock-like nature of human capital does not come from the forced retirement risk itself, but from its correlation with stock returns. Muting this correlation, we find that human capital becomes bond-like, with the effect of having a significant risk of labor earnings loss being dominated by the effect of having an income flow not correlated with stock returns. Under the correlation, we find that our main qualitative result is robust to alternative calibrations and specifications of the model.

This paper contributes to several streams of literature. First, it contributes to the literature on household portfolio choice by identifying an additional source of human capital risk not previously considered and by examining the implications of this risk for the optimal portfolio choice for older households. Most existing studies find 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). These papers, however, do not examine the role of retirement timing uncertainty, which is the most important source of risk in human capital for older households. Our paper relates to previous studies of other types of mechanisms through which human capital can become more stock-like. For example, Heaton and Lucas (2000) look at entrepreneurial risk; Benzoni, Collin-Dufresne, and Goldstein (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 that makes the human capital of these workers more stock-like. Our paper examines another channel through which human capital becomes a close substitute for a risky asset for older households—forced retirement risk.

Second, our paper contributes to a small but growing literature on the uncertainty of retirement timing. Chan and Stevens (2001, 2004) show that many U.S. households experience involuntary job loss and that returning to the labor market after a job loss becomes signifi-

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2 Fagereng, Guiso, and Pistaferri (2018) show that substantial wage insurance provided by firms can be one reason why shocks to the earnings process are typically very small.
cantly 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 (2018) examine the macroeconomic determinants of retirement timing. Our paper contributes to this literature by using a novel indicator of forced retirement: a self-assessed reason of retirement available in the HRS. The self-reported indicator enables us to overcome the issue of whether a retirement is voluntary or involuntary being 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. In this literature, some papers examine the economic implications of the retirement timing uncertainty. Smith (2006) and Dong and Yang (2017) 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. Our study relates the retirement timing uncertainty to household portfolio choice.

Finally, our paper contributes to the literature on the impact of age and retirement on portfolio choice. On the empirical side, Ameriks and Zeldes (2004) estimate life-cycle patterns in 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 (2019) 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 the time of retirement affect portfolio allocations. On the normative side, Michaelides and Zhang (2017) argue that setting the share of stock based on only households’ age or retirement horizon may be misleading under the presence of stock market predictability. Gollier and Zeckhauser (2002), Bommier and Rochet (2006), and Jeon, Koo, and Shin (2018) examine the implications of the underlying utility function for life-cycle portfolio choice. Our
paper adds to the normative literature by focusing on the role of forced retirement risk in understanding the optimal portfolio adjustment for households approaching retirement.

The remainder of this paper is organized as follows. Section 2 presents empirical evidence on the size of the forced retirement risk and its correlation with stock market returns. Section 3 sets up the life-cycle portfolio choice model with forced retirement risk. Section 4 presents the optimal portfolio choice under the presence of forced retirement risk. Section 5 concludes.

2 Empirical Evidence for Forced Retirement

In this section, we first establish that older male workers in the U.S. 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 or by receiving unemployment insurance or disability income. Though the probability of a forced retirement is smaller for wealthier households, even wealth-rich households face a sizable risk. Finally, we find that the risk of forced retirement increases after downturns 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 male workers in the U.S. The Health and Retirement Study (HRS) is a biennial panel study that started in 1992. It contains observations from more than 26,000 U.S. households over the age of 50 with information at the household and individual level, including 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

In our empirical analysis, we define retirees as those who: (i) consider themselves to be retired and (ii) do no market work. For the former, we use the following question on the self-assessed retirement status:

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.

To be classified as retirees in our study, respondents need to consider themselves to be either completely or partly retired. The HRS also has a separate question on current working status. Of those who report themselves to be retired, we find that a non-negligible share (especially among those partly retired) report that they are working.\(^3\) Therefore, we impose the second condition to be considered a retiree in our study: that a respondent not be currently working.

In addition to questioning respondents about their current retirement status, the HRS asks them to indicate 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 answers that he/she retired in 2009, we estimate that his/her retirement age is 61 and the retirement year is 2009.

Forced Retirement Indicator

If a respondent answers that he is partly or completely retired, the HRS gathers additional information on whether the respondent considers himself to be forced into retirement:

\(^3\)Among those who consider themselves to be retired, about 0.5% of the complete retirees and 24.6% of the partial retirees report that they are working.
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 they choose 2) forced into.\textsuperscript{4} Using this self-assessed determination of forced 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 Caliendo, Casanova, Gorry, and Slavov, 2016, for example). That is, our self-assessed determination of forced retirement excludes any early retirements that are voluntary from our analyses. In Section 2.4, we discuss how the results from using our measure of forced retirement correlate with those obtained using the conventional measure.

2.1.2 Sample Selection

To estimate forced retirement risk, we use as our unit of observation a transition in the labor market participation status for each respondent-year pair. Under the condition that a given respondent works in year $t$, we examine: 1) whether the respondent continues to work or retires in year $t + 1$, and 2) if the respondent retires, whether it is a voluntary or involuntary retirement.\textsuperscript{5}

Since the risk of forced retirement is the most relevant when survey respondents are close to typical retirement ages, we restrict our sample to transitions that occur when respondents are between 55 and 69 years old. While we include transitions that occur in both married and single households, we restrict our sample to male respondents.\textsuperscript{6} While the HRS started its first survey in 1992, the question about forced retirement was not included until 1994 and

\textsuperscript{4}In our analysis sample (introduced in the next subsection), the number of retirees who choose the third option is only about one-quarter of those who choose the second option.

\textsuperscript{5}Hence respondents who retire in year $t$ do not appear in the sample for our analysis on transitions after year $t + 1$, with the exception of our later analysis of whether forced retirees return to the labor market.

\textsuperscript{6}Among couples, the share for working females within our age range is low at around 30%. All the empirical findings reported in this section are qualitatively robust to reducing the sample to males with no working spouse (i.e., singles and couples with non-working females) for whom spouses’ earnings are less likely to provide a buffer against forced retirement risk.
the question was asked only for very few respondents even in 1994. Therefore, we restrict our sample to observations between 1996 and 2012. Even after 1996, the forced retirement question was not asked for all retirees. We further exclude transitions into retirement that cannot be confirmed to be either forced or not forced. Lastly, we exclude observations that are in a gray zone between retirement and working, namely those who consider themselves retired while working. After applying our sample selection criteria, we obtain 20,786 transitions in labor market participation status that occurred between 1996 and 2012.

2.2 Prevalence of Forced Retirement

To illustrate that many households in the U.S. do not have full control over their retirement timing, we first summarize the proportion of retirements in our sample that are self-assessed as involuntary. Table 1 shows the number of retirements and the proportion of forced retirements by age and year of retirement.

Overall, more than a quarter of retirees in our sample report that they were forced to retire against their will. The share of forced retirements also varies across age and year of retirement. The proportion of forced retirements decreases with age: while 38.6 percent of retirements between the ages of 55 and 59 are reported as being forced, this number drops to 19.9 percent for retirements that occur between the ages of 65 and 69. This decrease in the share of forced retirements reflects the increase in voluntary retirements near and after typical retirement ages. The proportion of forced retirements also varies greatly across years. For example, while the share of forced retirements was only 15.7 percent during the stock market boom in 2000, after the financial crisis, it reached 38.9 percent in 2009.

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 worker being forced to retire despite his willingness to continue working. As we will show in Section 3, this is the
Table 1: Number of Retirements and Forced Retirees (FR) Ratio

<table>
<thead>
<tr>
<th>Retirement Year</th>
<th>55-59</th>
<th>60-64</th>
<th>65-69</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of Retirements</td>
<td>% of FR</td>
<td># of Retirements</td>
<td>% of FR</td>
</tr>
<tr>
<td>1996</td>
<td>20</td>
<td>35.0</td>
<td>91</td>
<td>24.2</td>
</tr>
<tr>
<td>1997</td>
<td>41</td>
<td>29.3</td>
<td>95</td>
<td>18.9</td>
</tr>
<tr>
<td>1998</td>
<td>15</td>
<td>33.3</td>
<td>49</td>
<td>12.2</td>
</tr>
<tr>
<td>1999</td>
<td>28</td>
<td>28.6</td>
<td>92</td>
<td>15.2</td>
</tr>
<tr>
<td>2000</td>
<td>13</td>
<td>23.1</td>
<td>35</td>
<td>20.0</td>
</tr>
<tr>
<td>2001</td>
<td>20</td>
<td>35.0</td>
<td>87</td>
<td>24.1</td>
</tr>
<tr>
<td>2002</td>
<td>11</td>
<td>9.1</td>
<td>59</td>
<td>20.3</td>
</tr>
<tr>
<td>2003</td>
<td>22</td>
<td>50.0</td>
<td>65</td>
<td>24.6</td>
</tr>
<tr>
<td>2004</td>
<td>11</td>
<td>18.2</td>
<td>40</td>
<td>22.5</td>
</tr>
<tr>
<td>2005</td>
<td>22</td>
<td>45.5</td>
<td>62</td>
<td>12.9</td>
</tr>
<tr>
<td>2006</td>
<td>10</td>
<td>30.0</td>
<td>30</td>
<td>26.7</td>
</tr>
<tr>
<td>2007</td>
<td>33</td>
<td>51.5</td>
<td>41</td>
<td>14.6</td>
</tr>
<tr>
<td>2008</td>
<td>11</td>
<td>54.5</td>
<td>19</td>
<td>26.3</td>
</tr>
<tr>
<td>2009</td>
<td>21</td>
<td>47.6</td>
<td>34</td>
<td>41.2</td>
</tr>
<tr>
<td>2010</td>
<td>16</td>
<td>62.5</td>
<td>23</td>
<td>34.8</td>
</tr>
<tr>
<td>2011</td>
<td>31</td>
<td>48.4</td>
<td>67</td>
<td>34.3</td>
</tr>
<tr>
<td>2012</td>
<td>14</td>
<td>28.6</td>
<td>53</td>
<td>43.4</td>
</tr>
<tr>
<td>Total</td>
<td>339</td>
<td>38.6</td>
<td>942</td>
<td>23.3</td>
</tr>
</tbody>
</table>

Note: The data in this table are for retirements that occurred between 1996 and 2012 for male respondents aged between 55 and 69 at the time of retirement.

measure that will be used to investigate the implication of this risk for household portfolio choice. To measure this risk, which we call *forced retirement risk*, we use the following formula:

\[
ForcedRetirementRisk_{i,j} = \frac{N(ForcedRetirees_{i,j})}{N(ForcedRetirees_{i,j}) + N(Working_{i,j})},
\]

(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 individuals who are working in year \(j-1\) and want to keep working in year \(j\). The numerator captures those who could not do so because they were forced to retire.\(^7\)

\(^7\)Voluntary retirees are not included in either the numerator or the denominator as we analyze the risk that is relevant to those who want to continue working.
Using this formula, we estimate the forced retirement risk by age group and year and present our findings in Figure 1. On average, the risk of being forced to retire is not negligible. The average risk of being forced to retire is 3.2 percent, meaning that every year 3.2 percent of workers who want to keep working are forced to retire. We further see that the size of this risk increases with age. The forced retirement risk between the ages of 55 and 59 is 1.2 percent, while it increases to 2.7 percent between the ages of 60 and 64 and 4.5 percent between the ages of 65 and 69. These 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 13 percent. Forced retirement risk also varies across years, with noticeable increases immediately after the respective 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 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 versus non-forced retirees for each age group before age 65.\(^8\)\(^9\) We note that these findings should be interpreted with caution for several reasons. First, the expected retirement age question is asked only under a certain set of conditions, making the

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\(^8\)In this subsection we examine the economic significance of forced retirement for those under age 65, which has been historically considered as a normal retirement age in the U.S.

\(^9\)In case the same respondents answered the expected retirement age question in multiple waves, we use the most recent answer provided in the survey taken before their forced retirement.
This figure presents the probability of being forced to retire by age group and year. We sort our sample into three age groups: 55-59, 60-64, and 65-69. The probability of forced retirement is calculated using equation (1).

number of observations in this analysis small. Second, some households give unrealistically high or low expected retirement ages, making the observations in both tails less meaningful. Nonetheless, the results in Table 2 suggest that a forced retirement often involves a loss of many years’ worth of expected labor earnings. Among those forced to retire between ages 60 and 64, the median household loses three years’ worth of labor earnings, while a quarter of such households lose more than six years’ worth of labor earnings. For those who are forced to retire before age 60, these numbers increase to five and seven years, respectively. By contrast, these numbers are much smaller for non-forced retirees, with a median gap
between ages 60-64 (55-59) of one (one and a half) year(s).

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

<table>
<thead>
<tr>
<th>Percentile</th>
<th>25</th>
<th>50</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-59</td>
<td>-7</td>
<td>-5</td>
<td>-2</td>
</tr>
<tr>
<td>60-64</td>
<td>-6</td>
<td>-3</td>
<td>0</td>
</tr>
</tbody>
</table>

Panel A. Forced Retirees

Panel B. Non-Forced Retirees

<table>
<thead>
<tr>
<th>Percentile</th>
<th>25</th>
<th>50</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>55-59</td>
<td>-3.5</td>
<td>-1.5</td>
<td>0</td>
</tr>
<tr>
<td>60-64</td>
<td>-3</td>
<td>-1</td>
<td>1</td>
</tr>
</tbody>
</table>

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

To mitigate the earnings losses due to forced retirement, some households may choose to return to the labor market to work in a bridge job before fully retiring. Even if such a position comes with reduced earnings, it still provides some buffer against disastrous earnings losses. However, we find that only about 8 percent of the forced retirees in our sample return to the labor market. This is not surprising, as a number of studies suggest 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, their earnings from their new job are only 58% of that from their previous job.\(^{10}\)

Another potential way to mitigate the earnings loss for forced retirees is to claim unemployment compensation or Social Security disability insurance. To determine the prevalence of this option for our sample, we use the claim information for unemployment and worker’s compensation (UNWC) and Social Security disability insurance (SSDI) from the HRS.\(^{11}\)

We first summarize the share of forced retirees who receive either UNWC or SSDI. As

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\(^{10}\)The denominator in the replacement rate calculation is the average of income reported in the two previous surveys before retirement. Therefore, we drop from this analysis any respondents who did not participate in any of two consecutive survey waves before retirement.

\(^{11}\)In the HRS, the SSDI measure also includes Supplementary Security income.
shown in Table 3, among respondents who change their working status from working to
forced retirement, the proportions of UNWC recipients are 22.6 and 19.9 percent for the age
groups 55-59 and 60-64, respectively. The proportions of SSDI recipients are slightly lower:
20.7 and 13.8 percent for the age groups 55-59 and 60-64, respectively. For comparison, we
also provide the respective proportions of UNWC and SSDI recipients in the full sample of
retirees (both forced and voluntary). Relative to all retirees, the proportion of UNWC and
SSDI recipients is higher among the forced retirees. Nonetheless, those who receive UNWC
and SSDI comprise a small fraction of the forced retirees.

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

<table>
<thead>
<tr>
<th>Status</th>
<th>Age</th>
<th>Total</th>
<th>UNWC</th>
<th>SSDI</th>
<th>UNWC  (Median)</th>
<th>SSDI  (Median)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working -&gt; Retirees</td>
<td>55-59</td>
<td>578</td>
<td>77 (13.3%)</td>
<td>57 (9.9%)</td>
<td>9.2%</td>
<td>18.6%</td>
</tr>
<tr>
<td></td>
<td>60-64</td>
<td>1560</td>
<td>151 (9.7%)</td>
<td>91 (5.8%)</td>
<td>10.7%</td>
<td>10.4%</td>
</tr>
<tr>
<td>Working -&gt; Forced Retirees</td>
<td>55-59</td>
<td>217</td>
<td>49 (22.6%)</td>
<td>45 (20.7%)</td>
<td>11.7%</td>
<td>18.6%</td>
</tr>
<tr>
<td></td>
<td>60-64</td>
<td>392</td>
<td>78 (19.9%)</td>
<td>54 (13.8%)</td>
<td>14.7%</td>
<td>28.5%</td>
</tr>
</tbody>
</table>

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 drop from this analysis any respondents who did not participate in any of 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 the income reported in the two previous surveys before retirement. The median income replacement rates of UNWC are 11.7 percent and 14.7 percent for the age groups 55-59 and 60-64, respectively. The income replacement rates of SSDI are higher (18.6 percent and 28.5 percent for age groups 55-59 and 60-64, respectively). While these numbers are slightly higher than the replacement rates for the full group of retirees, they are still 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 these income sources play a limited role in mitigating income losses from forced retirement. The role of
unemployment benefits is even further limited given the short claim period. These benefits are usually available for only up to 26 weeks, much shorter compared to the difference between the actual and expected retirement ages for forced retirees.\textsuperscript{12}

\section*{2.5 Heterogeneity in Forced Retirement Risk By Wealth Level}

In this subsection, we examine whether forced retirement risk varies with household wealth. Specifically, we are interested in whether this risk is significant only for those households with limited financial assets. If so, then the impact of forced retirement risk on household financial portfolio choice should be limited. While defined-contribution pensions and individual retirement accounts have increased stock market participation across wealth levels, the question of optimal financial portfolio choice is still 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).

To examine the size of the forced retirement risk by wealth level, we divide our sample into three groups based on self-reported household wealth.\textsuperscript{13} Figure 2 shows that forced retirement risk decreases with an increase in wealth, with the least wealthy group experiencing about 40 percent greater risk than the wealthiest group. Nonetheless, we find that the wealthiest group still faces sizable forced retirement risk. Moreover, we find that the variation in forced retirement risk across years is similar for all 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 changes in the size of the forced retirement risk within the range presented in this analysis.

\textsuperscript{12}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, this expansion was temporary.

\textsuperscript{13}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. In this figure, we estimate the forced retirement risk at a biannual frequency because we do not observe financial wealth between surveys.

2.6 Correlation between Forced Retirement Risk and 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. Based on our observed pattern of increases in forced retirements after the beginnings of the recessions in 2002 and 2007 (Figure 1), we conjecture that an increase in forced retirement risk follows a downturn in the stock market.
To test 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. Since we have data for only 17 years, we cannot precisely estimate the correlation between the two variables. However, 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 coefficients are reported in Panel A of Table 4). The estimated effect is not small. For example, the probability of a household between ages 60 and 64 being forced to retire is about 3 percent after a 20 percent positive return, while the probability of this household being forced to retire after a 20 percent negative return is 4 percent, an increase by about one third. The estimated slope for the age group 60-64 is statistically significant notwithstanding the small sample size.

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

<table>
<thead>
<tr>
<th></th>
<th>55-59</th>
<th>60-64</th>
<th>65-69</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A. Total Forced Retirement Risk</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.012</td>
<td>-0.027*</td>
<td>-0.052</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.015)</td>
<td>(0.031)</td>
</tr>
<tr>
<td><strong>Panel B. Health-Related Forced Retirement Risk</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.002</td>
<td>-0.005</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.008)</td>
<td>(0.009)</td>
</tr>
<tr>
<td><strong>Panel C. Non-Health-Related Forced Retirement Risk</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-0.010</td>
<td>-0.023**</td>
<td>-0.053*</td>
</tr>
<tr>
<td></td>
<td>(0.008)</td>
<td>(0.010)</td>
<td>(0.027)</td>
</tr>
</tbody>
</table>

Notes: This table summarizes the slope coefficients 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 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.

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 the purely idiosyncratic risk of forced retirement due to health issues. We confirm this by
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.

Among the 693 retirees in the sample who claim that they were forced to retire between 1996 and 2012, we find that 237 retirees (34.2%) consider poor health a very important reason for their retirement.\textsuperscript{14} Among the 693 retirees in the sample who claim that they were forced to retire between 1996 and 2012, we find that 237 retirees (34.2%) consider poor health a very important reason for their retirement.\textsuperscript{15} We take advantage of this

\textsuperscript{14}Specifically, the HRS asks the respondents whether poor health was a very important reason for your retirement, a moderately important, somewhat important, or not important at all.

\textsuperscript{15}The economic consequences of health-related forced retirements can be larger if they also accompany an increase in medical expenditures. As we show in Section 4, however, the impact of the forced retirement risk on the optimal stock share is mostly through its correlation with stock returns. Therefore, as long as the additional medical expenditure risk is uncorrelated with stock returns—which is likely given the results in Table 4 and Figure 4—the impact of this additional medical expenditure risk on portfolio choice would be
information to distinguish between health-related and non-health-related forced retirement risk and we plot the relationship between respective type of forced retirement risk and lagged stock returns in Figure 4 (the estimated coefficients are reported in Panel B and C in Table 4). As expected, non-health-related forced retirement risk is strongly negatively correlated with the aggregate stock return, while health-related forced retirement risk is not. In short, we establish two findings. First, the majority of forced retirements are not driven by health conditions. Second, the forced retirements classified as “not-health-related” are likely to be driven by pressure to leave during an economic downturn, given its strong correlation with stock returns.

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

Note: These two figures show 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, while Panel (b) uses non-health-related forced retirement risk only. The slope coefficients are summarized in Table 4 Panels B and C, respectively.

of second-order importance. Hence, we do not explicitly model the medical expenditure risk in our life-cycle portfolio choice model introduced in Section 3.
2.7 Summary

Overall, the findings in this section indicate that older Americans face a significant risk of forced retirement and its resulting large financial losses. These losses are rarely recouped by either returning to the labor market or relying on unemployment insurance or Social Security disability income benefits. Our findings further show that even wealth-rich households face a significant, albeit smaller, forced retirement risk. Finally, we show that a downturn in the stock market is associated with a subsequent increase in forced retirement risk. The size of the forced retirement risk as well as its correlation with stock returns suggest that human capital can be stock-like in nature for those close to retirement age. In the next two sections, we examine this idea further by incorporating forced retirement risk into a 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). Households choose how to allocate their savings between risky and safe assets as well as how much to consume and save in each period. The model features aggregate stock return risk, idiosyncratic income risk, and mortality risk.
3.1 Preference

Households maximize the following objective function:

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

(2)

where $i$ is an index for an individual household, $C_{it}$ is the consumption in age $t$, $D_{it}$ is the amount of the bequest that it will leave if it dies at age $t$, $\delta$ is the time discount factor, $b$ is the weight that it puts on the bequest, $\gamma$ is the risk aversion coefficient, $P_t$ is the survival probability to age $t$ conditional on being alive at age $t-1$, and $T$ is the maximum lifespan. The function represents the present value sum of flow utility when households face uncertainty over the length of their lifetime and have a bequest motive.

3.2 Labor Income Process before Retirement

While they are still working, households face idiosyncratic risks in their labor income. The labor income process is as follows:

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

(3)

$$\varepsilon_{it} \sim N(0, \sigma^2_\varepsilon)$$

(4)

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

(5)

$$u_{it} \sim N(0, \sigma^2_u).$$

(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 permanent ($\nu_{it}$) and temporary ($\varepsilon_{it}$) shocks, with permanent shocks modeled as a random walk process. While the innovation ($u_{it}$) to this random walk process can be correlated with stock returns, temporary shocks are independent.

---

16 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.
3.3 Retirement Income

Retirement income from Social Security as well as most defined benefit pension plans is calculated based on the earnings made over the household’s working life. Let $\Psi_{it}$ denote the average labor income the household $i$ has until age $t$. While households are working, it evolves according to the following equation:

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

(7)

A household that retires at the normal retirement age $K$ receives a fixed amount of annual retirement income that is calculated as:

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

(8)

where $\lambda$ is the replacement rate and $\Psi_{iK}$ is the average earnings up to the retirement age calculated using equation (7).

However, if a household is forced to retire at age $s$ that is lower than age $K$, this negatively affects the retirement income of this household in two ways. First, we assume that it is still the average earnings until age $K$ ($\Psi_{iK}$) that goes into the retirement income formula, and this is negatively affected by having zero earnings in the years spent not working before the normal retirement age:

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

(9)

Equation (9) captures the fact that early retirement can negatively impact pension benefit accruals (and, to a degree, Social Security income) by reducing service years. Second, the replacement rate ($\lambda_s$) will now be a function of the retirement age ($s$) and will be lower than $\lambda$ for all $s < K$. We calculate $\lambda_s$ such that early retirement does not affect the expected present value sum of total retirement income given $\Psi_{iK}$. In other words, we allow an actuarially fair...
early retirement benefit from the age of forced retirement, regardless of when it happens. Then the retirement income of a forced retiree is calculated as:

\[
\log(Y_{it}) = \log\lambda_s + \log(\Psi_{iK}), \quad \forall t \geq s.
\] (10)

In reality, how a forced retirement affects retirement income depends on each pension plan’s benefit formula as well as a retiree’s specific work history. In certain cases, the effect of a forced retirement on \( \Psi_{iK} \) may be limited (e.g., Social Security income for those who have worked more than 35 years). It may also be that 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 examine the robustness of our main results to an alternative specification where forced early retirement does not affect pension benefit accrual (\( \Psi_{iK} \)).

### 3.4 Uncertainty in Retirement Age

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

In our model, we incorporate the forced retirement risk and do not allow 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, for example, 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 and do not have much control over the retirement timing,
an issue that has been neglected in the literature.

We assume that the probability of being forced to retire in the following year, \( \Omega_t \), is zero for those who are 55 years or younger. For those who are still working between the ages of 56 and 63,\(^\text{17}\) 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, \( \kappa_t \) determines how much this probability is affected by aggregate shocks (both parameters are specific to age \( t \)), and \( \iota_t \) is an aggregate shock that affects the risk of forced retirement.\(^\text{18}\)

### 3.5 Financial Assets

Our model specifies 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:

\[
R_{t+1} - \bar{R}_f = \mu + \eta_{t+1} \tag{12}
\]

\[
\eta_{t+1} \sim N(0, \sigma^2_\eta) \tag{13}
\]

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

where \( \mu \) is the risk premium and \( \eta_{t+1} \) is a stock return shock. This stock return shock may be correlated with a permanent income shock.

Households need to choose how to allocate their savings between the two assets.\(^\text{19}\) They

\(^{17}\)For those who are currently 64 years old, since the expected age of retirement is 65, they do not face forced retirement risk.

\(^{18}\)An alternative modeling choice is to incorporate forced retirement risk as an additional source of persistent shocks to earnings process (3)-(6). We made our choice to focus on the distinctive role played by forced retirement risk, compared to other earnings risks that are already captured in (3) - (6) including unemployment spells before retirement. Our reduced-form modeling also helps us model the relationship between forced retirement risk and stock market returns observed in the data.

\(^{19}\)Note that we abstract from housing wealth. This allows a clear comparison between our results and those of Cocco, Gomes, and Maenhout (2005) as well as the conventional wisdom since they also focus on allocations within financial portfolio. Including housing wealth in the portfolio choice problem requires
cannot borrow and they cannot short stocks. Hence, the share of assets invested in stocks, which we denote by $\alpha_{it}$, will 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 follows:

$$X_{it} = W_{it} + Y_{it}$$  \hspace{1cm} (15)

$$W_{i,t+1} = R_{i,t+1}^P (W_{it} + Y_{it} - C_{it})$$  \hspace{1cm} (16)

$$R_{i,t+1}^P \equiv \alpha_{it} R_{t+1} + (1 - \alpha_{it}) \bar{R}_f$$  \hspace{1cm} (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, $R_{i,t}^P$.

Using the scalability of the problem, we normalize all variables with respect to $\exp(\nu_{it})$. Let $\tilde{C}_t$, $\tilde{X}_t$, and $\tilde{\Psi}_t$ be the normalized values of $C_t$, $X_t$, and $\Psi_t$ ($\tilde{C}_{t+1}$, $\tilde{X}_{t+1}$, and $\tilde{\Psi}_{t+1}$ are the normalized values of $C_{t+1}$, $X_{t+1}$, and $\Psi_{t+1}$ with respect to $\exp(\nu_{i,t+1})$). Then the Bellman equation can be expressed as follows:

$$V_{it}(\tilde{X}_{it}, \tilde{\Psi}_{it}, Ret_{it}, RA_{it}) = \max_{\tilde{C}_{it} \geq 0, 0 \leq \alpha_{it} \leq 1} \left[ \tilde{C}_{it}^{1-\gamma} \frac{1}{1-\gamma} + \delta P_t E_t \exp(u_{it,t+1})^{1-\sigma} V_{i,t+1}(\tilde{X}_{i,t+1}, \tilde{\Psi}_{i,t+1}, Ret_{t+1}, RA_{t+1}) + \delta (1 - P_t) b \frac{(\tilde{X}_{it} - \tilde{C}_{it})^{1-\gamma}}{1-\gamma} \right]$$  \hspace{1cm} (18)

under constraints (3) - (17), where $Ret$ is a dummy variable that captures whether a 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. Calibration of the forced retirement risk ($\Omega_t$) is one of the most important contributions of this paper. Based on the evidence assumptions regarding its risk properties as well as both objective and subjective transaction costs.
from the HRS, we calibrate $\bar{\Omega}$ to be 0.014 (0.031) for the age group 55-59 (60-63). The hazard rates may seem trivial, but they are not. According to the calibrated parameters, the chance of forced retirement before the age of 60 for a household that is working at age 55 is roughly 7 percent, while the chance of forced retirement before the normal retirement age (65) for this household is about 20 percent. Hence, forced retirement is indeed a significant risk for older households.

Based on the observed correlation patterns between the stock returns and the forced retirement risk, we calibrate $\kappa$ to be 0.012 (0.027) for the age group 55-59 (60-63), while letting $\iota_t = -\eta_t$. For example, a 10 percentage point increase in the return on the risky asset reduces the forced retirement risk by 0.12 (0.27) percentage point for the age group 55-59 (60-63). This calibration reproduces the regression lines estimated in Figure 3.

Table 5: Calibration of Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Own calibrations</strong></td>
<td></td>
</tr>
<tr>
<td>Mean of forced retirement risk ($\bar{\Omega}$) for age 55-59</td>
<td>0.014</td>
</tr>
<tr>
<td>Mean of forced retirement risk ($\bar{\Omega}$) for age 60-63</td>
<td>0.031</td>
</tr>
<tr>
<td>Effect of stock returns on forced retirement risk ($\kappa$) for age 55-59</td>
<td>0.012</td>
</tr>
<tr>
<td>Effect of stock returns on forced retirement risk ($\kappa$) for age 60-63</td>
<td>0.027</td>
</tr>
<tr>
<td><strong>Calibrations from Cocco et al. (2005)</strong></td>
<td></td>
</tr>
<tr>
<td>Normal retirement age ($K$)</td>
<td>65</td>
</tr>
<tr>
<td>Discount factor ($\delta$)</td>
<td>0.96</td>
</tr>
<tr>
<td>Risk aversion ($\gamma$)</td>
<td>10</td>
</tr>
<tr>
<td>Bequest motive ($b$)</td>
<td>0</td>
</tr>
<tr>
<td>Average labor income ($f(t, Z_t)$)*</td>
<td></td>
</tr>
<tr>
<td>Variance of transitory income shocks ($\sigma^2_\varepsilon$)</td>
<td>0.0738</td>
</tr>
<tr>
<td>Variance of permanent income shocks ($\sigma^2_u$)</td>
<td>0.0106</td>
</tr>
<tr>
<td>Correlation between (permanent) labor income shocks and stock returns ($\rho$)</td>
<td>0</td>
</tr>
<tr>
<td>Riskless rate ($R_f - 1$)</td>
<td>0.02</td>
</tr>
<tr>
<td>Risk premium ($\mu - 1$)</td>
<td>0.04</td>
</tr>
<tr>
<td>Std. of stock return ($\sigma_\eta$)</td>
<td>0.157</td>
</tr>
</tbody>
</table>

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

For the parameters that also appear in Cocco, Gomes, and Maenhout (2005), we use the same values as those in their benchmark model, including the income process before
We use the National Center for Health Statistics mortality tables to obtain the conditional probabilities of survival ($P_t$). The model starts at age 20 and goes up to age 100.

### 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 the 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. We repeat this procedure up to the first period.

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 $\bar{Ψ}_t$, are discretized using 400 and 80 grid points, respectively. Increasing the number of grid points does not change our results. In evaluating the continuation values off the grid points, we use cubic interpolation.

### 4 Results

In this section, 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 effect of forced retirement risk. 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 portfolio choice.

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\( ^{20} \)In the benchmark model of Cocco, Gomes, and Maenhout (2005), the labor income process is calibrated based on a subsample that have completed high school but do not have a college degree. Changing this to calibrations based on a more or less educated subgroup does not change our results noticeably since the effect of forced retirement risk dominates that of labor income risk for employees when a household is close to retirement.
choice mainly comes from the risk itself or from the correlation between the two. We then construct age profiles of wealth and stock share by simulating the model to demonstrate that the optimal portfolio adjustment over age under the forced retirement risk is markedly 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-on-hand ($\tilde{X}$). Panel (a) represents age 56, the lowest age when a household can be forced to retire, while Panel (b) represents age 60. The blue curve corresponds to a household that is still working while the red one corresponds to a household that has been forced to retire at the respective age (55 or 60). Under the normalization $exp(\nu_{it}) = 1$, the annual labor earnings of a household that is still working are approximately 25. Hence, the cash-on-hand range in Figure 5 maps to the wealth-to-income ratio (defined as cash-on-hand divided by labor earnings) between 0 and 10. The most relevant range of the wealth-to-income ratio, in terms of the most likely value in both the model and the empirical data on stockholders (see Ameriks, Caplin, Lee, Shapiro, and Tonetti, 2014 for the latter), is around 2-8 (i.e., $\tilde{X}$ in 50 - 200). While the normalized average labor income in the past ($\tilde{\Psi}$) is not explicitly shown in the figure, we assume it to be 20, which is close to the average value of this variable in this age range.

Figure 5 shows that 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 by either stock market performance or forced retirement.\textsuperscript{21} This part of human capital functions as a close substitute to a risk-free asset, as in Cocco, Gomes, and Maenhout (2005), so the larger the financial wealth (i.e., the lower the share of ‘risk-free’ human capital in the entire portfolio including human capital), the lower the optimal share of risky assets in the financial portfolio.

\textsuperscript{21}Recall that, in the baseline model, a forced retirement affects the retirement income only through its impact on $\Psi_{iK}$. Recall also that its magnitude is relatively small.
Figure 5: Stock Share Comparison: Workers versus Forced Retirees

(a) Age 56

Note: In both panels, the blue curve is the optimal stock share for 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 respective age. 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 $\Psi = 20$, which is close to the average value in this age range.
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 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. This impact is larger for households with 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

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

Once we turn off the correlation, we find the opposite result. Figure 6 shows that the optimal stock share is higher for those who are still working, across both ages. While
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 respective age. Under the normalization with $exp(\nu_t) = 1$, the value of labor earnings of the employed household is about 25 in this age range. We assume $\Psi = 20$, which is close to the average value in this age range.
working households still face forced retirement risk, if that risk is not correlated with stock returns, the effect of having forced retirement risk is dominated by the effect of having a flow of income that is uncorrelated with stock returns. Quantitatively, the size of the impact of having additional income on the optimal stock share is relatively small, as seen by the relatively small difference between the blue and red curves.

By comparing the optimal stock share for working households with and without the correlation across Figures 5 and 6, we can see that the effect of the correlation between the forced retirement risk and stock returns on the portfolio choice is large. Though the coefficients in the regression of lagged stock returns on forced retirement risk appear not to be large (Table 4), they imply a significant increase in forced retirement risk during downturns of the stock market. 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 by only 0.43 percentage point. However, that is a 14 percent increase in the hazard rate (from 3.10 to 3.53 percentage points). The correlation also means that the chance of having a large negative stock return becomes much higher when the household is forced to retire. To hedge against the risk of experiencing a simultaneous loss in both investment and human capital, a working household chooses to have less risky financial portfolio.

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 returns. By contrast, when we incorporate the forced retirement risk that is correlated with stock returns in our analysis, we find the opposite result.\textsuperscript{22}

\textsuperscript{22}Heaton and Lucas (2000) use entrepreneurial income risk to explain the risk premium puzzle. We show that even non-entrepreneurs may view at least part of their human capital as a close substitute for stocks.
4.3 Age Profiles for Optimal Wealth and Stock Share

The policy functions in the previous section illustrate the different optimal stock shares, conditional on wealth, for households forced to retire versus those who are still working. A forced retirement, on the other hand, 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).

In Figure 7, we plot the life-cycle profiles from the baseline model for households that work until the normal retirement age of 65 (blue line) and for those forced to retire at age 60 (red line), based on the averages of 10,000 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 profiles, we see a wide gap in the curves once the households represented in the red curve are forced to retire at an earlier age. While most of this reflects the policy function difference across the two groups shown in Figure 5, some of the gap comes from the fact that the forced retirees now have less wealth, which increases their optimal stock share even further compared to that of the working households. As the groups approach the normal retirement age, this gap shrinks, as the size of the working households’ human capital subject to forced retirement risk decreases. The gap that remains after the normal retirement age results solely from the different levels of wealth.

From Figure 7, we see that the optimal portfolio adjustment around the retirement age is almost the opposite of the conventional wisdom that households should reduce the share of risky assets as they approach their retirement. Under forced retirement risk, households should increase their stock share as they approach the normal retirement age and when they are forced to retire—i.e., as the 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
Figure 7: Life-cycle Profiles of Wealth and Stock Share: Baseline

(a) Wealth

(b) Stock share

Note: The blue curves assume that households are not forced to retire until the normal retirement age (65), while the red curves assume that households are forced to retire at age 60. The profiles are constructed as the averages of 10,000 simulations.

baseline model. In this specification, on the other hand, households invest a larger fraction in risky assets, which provide a higher return on average, thereby accumulating more wealth. Given the fairly small effect of the additional human capital possessed by those who are still
Figure 8: Life-cycle Profiles of Wealth and Stock Share with No Correlation between Forced Retirement Risk and Stock Returns

(a) Wealth

(b) Stock share

Note: The blue curves assume that households are not forced to retire until the normal retirement age of 65, while the red curves assume that households are forced to retire at age 60. The profiles are constructed as the averages of 10,000 simulations.

working on the optimal stock share (Figure 6), the stock-share profile does not show a significant adjustment around retirement. When households are forced to retire under this specification, their stock share becomes smaller than that of those still working due to the
Figure 9: Life-cycle Profiles of Wealth and Stock Share without Forced Retirement Risk

(a) Wealth

(b) Stock share

Note: The profiles are constructed as the averages of 10,000 simulations.

policy function difference shown in Figure 6. This relationship later 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 in Cocco, Gomes,
and Maenhout (2005) except for a minor difference in modeling retirement income. 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 (Figure 9). The comparison between our baseline result and that from Cocco, Gomes, and Maenhout (2005) thus highlights the role that forced retirement risk (and its correlation with stock returns) plays in generating optimal portfolio adjustment patterns that go against the conventional wisdom.

4.4 Alternative Specifications

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

4.4.1 No effect of forced retirement on $\Psi$

In the baseline model, we assume that forced retirement reduces the average labor income variable ($\Psi$) used in calculating retirement income by indicating zeros earnings for each year between the forced and expected retirement 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 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 from the set of years with the highest earnings, then forced retirement can affect the pension benefit accrual directly by reducing the number of service years (and potentially 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 forced retirement on $\Psi$ can only be marginal for Social Security income.

To examine the opposite extreme relative to what has been assumed in the baseline model, 

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23To calculate retirement income, Cocco, Gomes, and Maenhout (2005) multiply the replacement rate with the income from the last year of work, while we multiply it with the average of income until the normal retirement age.
we reexamine the optimal portfolio choices assuming that forced retirement does not affect $\Psi$. 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 the sensitivity of our results 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 our baseline model (Figure 10, Panel (a)).24 Those still working should invest less in stocks than those forced to retire. Quantitatively, the human capital of those still employed is less stock-like compared to that of 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. Compared to the gap across the curves in Figure 5, the gap from this alternative specification is about 40 percent smaller for most of this wealth range. Recall that our baseline model considers the impact of forced retirement through both lost labor earnings and reduced retirement income (through its effect on $\Psi$). Conversely, this alternative specification considers only its effect through lost labor earnings, showing that this component accounts for about 60 percent of the effect in the baseline model.

4.4.2 Under a Smaller Forced Retirement Risk

In our baseline model, we base our calibration of forced retirement risk on our estimates from a representative sample of older Americans in the HRS. However, it could be argued that a better sample for calibration would be those who are 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

24All the panels in Figure 10 compare the optimal stock share policy functions for those still working and those forced to retire at age 60.
Figure 10: Stock Share Comparison: Alternative Specifications (Age 60)

(a) No effect on $\Psi$

(b) Smaller forced retirement risk

(c) With a bequest motive

Note: In all panels, the blue curve is the optimal stock share for households still working while the red curve is the optimal stock share for households that are forced to retire. Under the normalization with $exp(\nu_d) = 1$, 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.
also examine whether our main results still hold under a smaller forced retirement risk, calibrated from the high wealth group defined in Section 2.5. Specifically, we recalibrate the level of forced retirement risk as 70 percent of the baseline value (i.e., reducing both $\bar{\Omega}$ and $\kappa$ by 30 percent from the baseline values).

Panel (b) of Figure 10 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 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).

A bequest motive does not change our main result (Figure 10, 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-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 that experiences a 10 percent loss

\footnote{$b = 3$ implies that a 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.}
in its investment soon before death also sees an approximately 10 percent reduction in the bequest, and the retirement income flow that it could have had conditional on surviving does not help protect the bequest.

4.5 Discussion: Comparison with Empirical Patterns

The life-cycle portfolio choice model with the estimated forced retirement risk suggests that households should increase the share of risky assets in their portfolios as they get closer to and enter retirement. This is a normative result, and we do not necessarily expect to find portfolio adjustment patterns consistent with this result from household data for the following reasons. First, conventional wisdom that goes against our normative result has influenced not only target-dated or life-cycle funds, which became common default options in many DC pensions (Bodie and Treussard, 2007; Mitchell and Utkus, 2020), but also the standard guidance from financial advisors. Second, the household finance literature finds only limited reflections of what theory suggests in empirical portfolio choice patterns, even for theoretically noncontroversial relationships such as the role of risk preferences and stock return expectations (e.g., Ameriks, Kezdi, Lee, and Shapiro, 2019; Giglio, Maggiori, Stroebel, and Utkus, 2019). Potential explanations for those findings include strong inertia in portfolio choice (e.g., Brunnermeier and Nagel, 2008) and limited cognitive ability (e.g., Caplin and Dean, 2015). Notwithstanding these issues, for completeness, we also examine how the empirical patterns of late-in-life portfolio adjustments from the HRS compare to the optimal strategy suggested by our model. In particular, we focus on how stock share changes as households transition into retirement, as our model provides a reason that an increased stock share in the post-retirement period may be optimal.

Figure 11 plots the age profile for stock share from the HRS data, separately for retirees (red dash) and non-retirees (blue solid).\textsuperscript{26} Before age 65, the two curves mostly overlap,

\textsuperscript{26}We use data from 1996 to 2012 to be consistent with the empirical analysis in Section 2. The age and retirement status are those of the household head, where the household head is defined as the person whose average income is the highest over the years with an observation. The stock share is calculated as the share
while after age 65, the retirees tend to have a higher stock share. The difference is about 2 percentage points, or 10 percent of the average stock share. This comparison of the unconditional age profiles, however, is affected by many confounding factors, most importantly by the fact that retirees at lower ages and non-retirees at higher ages can be very selected groups of people.

Figure 11: Stock-share Age Profiles from the HRS

Notes: This figure presents the average stock share of households by the age and retirement status of household heads using the HRS data (1996–2012). Only households with positive financial assets are included. For calculations of the stock share and the definition of retirement status, see the main text.

To address this issue, we also implement the following fixed-effect estimation:

\[ ss_{it} = \beta_{ret} ret_{it} + \beta_{X} X_{it} + \alpha_i + \gamma_t + \varepsilon_{it}, \tag{19} \]

where \( ss \) is the stock share, \( ret \) is the dummy variable of the household head being retired, of stocks, mutual funds, and investment trusts out of total financial assets. Only those with positive financial assets are included.
and $X$ indicates time-varying controls of households that include age, age squared, household size, the health of the household head, log of total household income, and log of total household wealth. $\beta_{ret}$ is the coefficient of interest that shows how retirement affects the households’ stock share. $\beta_X$ is the vector of the coefficients on the time-varying controls, $\alpha_i$ and $\gamma_t$ are household and wave fixed effects, and $\varepsilon_{it}$ is an i.i.d. error term. $\beta_{ret}$ is estimated to be 1 percentage point with a standard error of 0.5 percentage point, making it statistically significant under the 5-percent significance level. This means that transition into retirement is, on average, associated with one percentage point increase in the stock share. Note, however, that even though this specification controls for the selection issue that impacts the unconditional age profiles in Figure 11, it still captures correlations within households, not causal effects. In particular, households may have decided to retire earlier after experiencing positive stock returns. To address this issue, we also estimate a specification where the retirement dummy is instrumented by dummy variables of whether the household head is eligible for early-retirement and full Social Security benefits. In this specification, the effect of retirement is actually much larger (10 percent points) though much less precisely estimated (with a standard error of 4.7 percent points, making the estimate significant under the 5-percent significance level).

Our results show that the transition into retirement is on average associated with an increase in the stock share, contrary to what one would expect under the conventional wisdom. This, however, does not confirm that households’ recognition of the risk in pre-retirement human capital is an active channel behind this adjustment. Around retirement, households also experience other big changes in their finances—for example, deciding whether or not to roll over their DC pensions into IRAs and whether or not to withdraw their DB pensions in lump sums and use that money for financial investments. All of these, in turn, may affect households’ financial portfolio adjustment. A more comprehensive empirical

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27 We use the same sample as in Figure 11, but with a somewhat larger age range, from 55 to 75 (instead of from 55 to 70). This allows for enough observations per household to have a reliable estimate from the fixed-effect specification. The number of observations is 38,375, while the number of unique households is 9,047. We get almost identical results by extending the age range even further, to 50–75 and 50–80.
analysis of key determinants of the late-in-life portfolio choice are important but beyond the scope of this paper and hence left for future research.

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 this risk makes human capital 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 that suggested by conventional wisdom, namely that households should reduce their stock shares as they approach retirement.

Our finding also provides an alternative explanation for the risk premium puzzle. While households reach their highest levels of financial wealth before retirement, these households also face a forced retirement risk. 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 to quantitatively examine the contribution of forced retirement risk to the risk premium.
References


