How Do Individual Investors Take Risk? – A Study on Risk in Contribution-Defined Pension Plans

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Abstract

Studying individual investors' behavior is challenging because the context in which individuals invest is difficult to model and actual behavior is difficult to measure. Individual investors present several features which give their investment situation a special character: They have long but finite planning horizons, important non-traded assets such as the human capital and important illiquid assets such as housing. This study investigates the effect of socioeconomic variables on individual investor risk behavior using data on Swedish unit linked insurance plans within contribution-defined occupational pensions. To infer risk, we measure total risk, systematic risk and the proportion of idiosyncratic risk in the investment portfolio. We find strong evidence of a parabolically shaped relationship between risk and age where total risk increases up to the age of 43 from where it decreases at a growing rate until retirement. We also find that investors with a high willingness to take financial risk take higher total risk and systematic risk as well as a greater proportion of idiosyncratic risk. This could be the result of a well informed individual investor or a well working advisory system.

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1 Introduction

Individual investors and households present several features which give their investment situation a special character. They have long but finite planning horizons; an important part of their assets are non-traded, particularly the human capital, or illiquid, particularly their housing; finally, individuals and households face constraints on their abilities to borrow and on complexities in the tax code. Investment behavior of individual investors is hence a challenging topic to study; the context in which an individual makes investment decisions is difficult to accommodate in a model and actual behavior is difficult to measure and capture in good-quality data.[1]

Intimately related to how individuals invest is how they save for the long term, for example for a retirement pension, and how they approach financial risk. Due to the long investment horizons of retirement pension portfolios, small differences in annual returns can have a large impact on an individual's future financial wealth. The increasing responsibility for the individual to secure a decent income upon retirement and the growing number of investment possibilities available make it important to ask whether individuals understand how their willingness to take financial risk relate to the expected return of their savings.

With this study we aim to shed new light on how individuals invest for the long term and why. More specifically, we examine the effect of demographic, socioeconomic and attitudinal characteristics on financial risk observed in portfolios of Swedish unit linked insurance plans. We use three measures to infer risk in a portfolio: (i) the standard deviation of the portfolio's historical returns, depicting total risk; (ii) the absolute value of the portfolio beta times the standard deviation of the market portfolio's historical returns, depicting systematic risk; and (iii) the ratio of systematic risk over total risk, that is, the proportion of idiosyncratic risk in the portfolio. The data set used in the study is proprietary, of high quality and detail, and has not previously been used in research of this kind. The data include detailed demographic information on the insurance holder as well as precise information on the insurance provider, the units invested in and the market value of capital held in each unit. A subset of individuals has provided additional information in a survey regarding their willingness to take financial risk. For this subset of individuals, we include the stated risk tolerance as an additional control variable.

We investigate the impact of demographic and socioeconomic characteristics and stated risk tolerance on the three measures (i)-(iii) primarily using multiple regression analysis. We pay particular attention to the conventional wisdom recommending individuals to move from riskier assets like stocks to more conservative fixed-income securities as the individual ages. This conventional wisdom agrees with the advice often given to individuals and households by investment professionals. It also agrees with the strategies of most modern life cycle funds. We examine whether these ideas are analogue with evidence in the data.

Previous studies on individual investors' risk behavior provide widely different and contradictory results, indicating that risk behavior indeed is difficult to model and measure.

[1] See for example Campbell (2006) who addresses these challenges in greater depth. Campbell performs a recent and thorough investigation into why households often make inefficient investment decisions by comparing what households actually do (positive household finance) with what they should do (normative household finance).

While the notion of risky and risk-free assets is important in modern theory of capital asset pricing, risky assets need to have a clear definition in order for the results to be of any use. In this study we use a more delicate measure of risk than seen in most other studies in the field, and so we hope to get a more accurate picture of the explanatory factors behind individual investors' risk behavior. Instead of using a binary classification of risky and risk-free assets, we quantify risk by modeling a market portfolio and studying the historical returns of the market portfolio and the individual asset portfolios. This gives us the possibility to weigh the risk and quantify the magnitude of the risk, which as we know differ remarkably for different types of assets. Furthermore, it gives us the opportunity to dig deeper into the concept of risk and study not only total risk but also systematic and idiosyncratic risks. As a consequence, any obtained results should have a more sound theoretical and empirical foundation than those of studies which use binary measures of risk.

This study is distinguished from others also in that we study risk behavior in an isolated investment situation. This gives us a well defined market. Our model is valid only within the framework of unit linked insurances held as a part of an occupational retirement pension plan. The trade-off between the credibility and the generality of potential results becomes evident in studies of this kind. We believe removing some of the generality in the modeling will facilitate both the problem of modeling and measurement, the two main difficulties elaborated by Campbell (2006) and introduced in the beginning of this section. Although potential results are valid only in this specific framework, any results should provide a reliable picture of individual investors' risk behavior within it.

Other distinguished features are that we have the opportunity to control for not only actual portfolio risk, but also for the individual's attitude to financial risk, provided by a subset of the data. Lastly, as studies using US data are overrepresented in the field, we hope to shed new light on the ambiguous question of how individuals approach financial risk in their portfolio choice using a large, proprietary data set of Swedish investors.

We find strong evidence of a parabolically shaped relationship between portfolio risk and age. The total risk observed in the investigated portfolios increase up to a turning point at the age of 43 from where total risk begins to decrease. Total risk then decreases at a growing rate until retirement. A high salary seems to speed up the transition to the phase of taking decreasing risk, arriving at this phase at a younger age than do individuals of middle and low salary. Results further indicate that married individuals take less total risk and systematic risk but more idiosyncratic risk than their unmarried peers. Females take less total risk and systematic risk than men whilst the gender effect on idiosyncratic risk is insignificant. The direct effect of salary prove no significance and is hence less clear. The market value of portfolio capital has a significant effect only on the proportion of idiosyncratic risk in the portfolio, suggesting that individuals with a higher market value of savings diversify their risk less than do individuals with lower market value of savings. For the subset of individuals having provided their risk tolerance, we find that a high willingness to take risk has a statistically significant effect on the risk measures and hence should be included in any model explaining portfolio risk.

Our findings do not violate theoretical human capital models, previous empirical work or recommendations commonly made by investment professionals. However, they show that portfolio risk does not decrease over the complete life cycle but increases for a number of years before they commence to decrease. This observation could possibly be explained by a need to build up a capital base before any investment risks can be taken. Such an idea finds some support in the data which suggest that the threshold to decreasing risk tendencies is much higher for individuals with a low salary than for individuals with a high salary. Additional studies aiming to explain this behavior are needed, particularly since we suffer from an omitted-variable bias in that we have failed to control for aggregate wealth in our model.

The remainder of this paper is organized as follows: Section 2 provides background information on the Swedish occupational pension system and Section 3 presents the theoretical framework and reviews previous research in the field. Section 4 discusses the data set. Section 5 describes our methodology. Section 6 presents the results of the empirical investigations and Section 7 concludes.

2 Swedish Occupational Pension

We here aim to provide a short introduction to the Swedish pension system and the investment situation an individual faces as a holder of a unit linked insurance part of an occupational pension plan.

A first form of public pension was introduced in Sweden in 1914, payable from the age of 67 and consisting of an old age pension and disability insurance. Although the public pension plan was compulsory and applied to essentially the entire population, actual allowances were small and people had difficulties surviving on this revenue alone. As a consequence, additional saving plans financed by a reduction in salary were negotiated by labor unions for certain professions resulting in a complementary occupational pension. Other labor groups who lacked these agreements experienced an critical loss of income upon retirement. In 1960 a national supplementary pension scheme called ATP came into effect. This supplementary pension created a direct link between previous earnings and old-age pension; the retirement pension was no longer regarded as an allowance, but as a deferred salary. The ATP system has evolved and been subject to much debate over the years and was eventually removed as a reformed pension system came into effect in 2001 (Government Offices of Sweden, 2000).

Today, a person living in Sweden has three sources of pension: A national retirement pension based on the income, an occupational pension provided by the employer and finally any private pension savings. Occupational pension is generally regulated by collective agreements or can be arranged by the employer where no collective agreements exist. The historical heritage of a compulsory occupational pension system has likely contributed to the fact that a majority of Swedish employees are being covered by an occupational pension plan provided by their employer. The occupational pension does therefore represent an important factor of the total Swedish pensions.[2]

Since occupational pensions tend to be regulated by collective agreements, the occupational pension plans seen today are relatively homogeneous across the population[3] and

[2]See the Orange Report 2010 (Swedish Pensions Agency, 2010). According to this report, occupational pensions represent roughly a fifth of all pensions paid in Sweden.

[3]The most important occupational pension agreements include ITP, KAP-KL, PA-KFS, SAF-LO, KTP and PA03.

are either benefit-defined or contribution-defined[4]. A defined benefit plan guarantees a monthly income upon retirement as a function of the employee's final salary. The defined contribution plan requires the employer to contribute a fixed amount to the employee's pension savings but the final amount is not fixed; the cash value of the contribution-based pension varies according to the market value of the underlying assets. Capital in a defined-contribution plan is typically invested in a so called traditional insurance or a unit linked insurance. A traditional insurance necessitates little effort on the behalf of the policy holder, who cannot impact portfolio management and investment risk. In return, the policyholder is guaranteed a fixed rate of return on his pension savings. A unit linked insurance plan on the other hand allows for more flexibility. The units purchased are mutual funds chosen by the policy holder from the insurance provider's selection of products. The policy holder hence also bears the risk of a potential loss. Although the investment possibilities in a unit linked insurance are limited and often biased in favor of the provider's own products, most providers offer exposure to different asset classes, regions and sectors. One can note a specific segment of around 15 main actors in the insurance industry offering occupational pension insurances, the choice depending on the collective agreement as well as the employer's and the individual's choices.

The nature of the contribution-based occupational pension creates a rather particular and interesting investment situation. First, the amount invested is not defined by the investor himself but is a strict function of his current salary and the employer's pension plan. Secondly, the investment possibilities are restricted in that investments are made via an insurance provider offering an often limited selection of assets available for investment[5]. These circumstances give us a well defined market and an opportunity to study risk behavior in an isolated investment situation, namely, unit-linked insurances within Swedish occupational pension.

3 Literature Review

3.1 Theoretical Framework

Recent theory suggests that there should be age effects on portfolio choice, assuming older investors have shorter investment horizons than younger investors and older investors have less human capital relative to financial wealth than younger investors (Bodie et al., 1992, Campbell and Viceira, 2002). If the human capital corresponds to a risk level other than that of the investor's financial capital, the relative change of human versus financial capital over an investor's lifetime creates the need to change the risk level of the financial capital in order to maintain the same total risk level of the investor's total portfolio. The assumption that human capital in general is less risky than financial capital supports conventional wisdom advising a movement from riskier assets, like stocks, to more conservative fixed-income securities as an individual gets older. Models such as Bodie et al. (1992) show that human capital must be included in any model explaining investment,

[4] The prevalence and relative distribution of defined-benefit and defined-contribution plans vary between collective agreements and individuals' choices.

[5] Modern insurance plans with more generous investment possibilities have entered the market however. Together with legislative efforts to facilitate transfers between insurers this has opened up for a more flexible investment environment. In some insurance-based pension plans individuals can invest directly in stocks, structured products and other types of financial instruments. This appears to be a growingly attractive option but as individuals with such solutions still constitute a minor proportion of the raw data they are excluded from the scope of this study.

labor and consumption behavior of a rational economic agent. An investor's possibility to rebalance his financial investments decreases with age since the future earning power, the main asset of young investors, is expended over the life cycle; by retirement, the individual's financial wealth has grown but his human capital has decreased. Bodie et al. further emphasize that labor supply flexibility can play an important role in household asset allocation and incorporate the fact that individuals may have considerable flexibility in varying their work effort, including the choice of when to retire. They argue that it is reasonable to hypothesize that the degree of labor flexibility diminishes over the life cycle and that this is an additional explanation to a decline in an individual's effective human capital. The presence of non-risky human capital will therefore tend to raise young investors' risk tolerance[6]. With this, Bodie et al. suggest a rational basis for the common wisdom often accepted for a variety of, sometimes wrong[7], reasons. The theories of the effect of human capital on portfolio choice put forth by Bode et al. have been investigated theoretically by for instance Williams (1978) who analyzes the uncertainty of human capital in a life-cycle model where education is regarded as an opportunity for risky investment.

The development of modern portfolio theory set forth with Markowitz (1952) who formalized a model of portfolio selection using the impact of diversification on investment risk. He showed that a portfolio could have a standard deviation smaller than that of either of the individual component assets; prior to these findings, portfolio management mainly consisted of assessing the risks and rewards of individual securities. Markowitz introduced the minimum-variance frontier of risky assets, where, for any risk level, the investor chooses the portfolio with the highest expected return (Bodie et al., 2011).

A few years after Markowitz (1952), Tobin (1958) noted the so called separation property which separates the portfolio choice problem into two tasks: The first task is the computation of an optimal risky portfolio which is the same for all clients regardless of risk aversion. The second task is the allocation of a complete portfolio which entails a trade-off between risk and return. Hence this choice depends on the investor's risk aversion. In the 1960's Sharpe (1964), Lintner (1965) and Mossin (1966) developed the Capital Asset Pricing Model (CAPM) in its original form and coincidentally, the concepts of absolute and relative risk aversion were developed by Pratt (1964) and Arrow (1965). Pratt and Arrow thus gave name to the commonly used Arrow-Pratt coefficient of relative risk aversion depicting the proportion of wealth placed in a risky asset when the investment universe consists of one risky asset and one risk-free asset. Whilst these theories laid the foundation of portfolio selection, less was known on the explanatory factors behind risk aversion. Empirical studies on this matter (see below) became increasingly popular in the 1970's.

In the 1980's the above theoretical concepts where widely accepted and the interest of using them in real investments grew. Concepts in the field of applied portfolio management were worked out by people such as Zvi Bodie and Robert C. Merton. They developed a link between theoretical investment concepts and practical investment policies; with their work, life cycle models, human capital and age cohort effects were translated into financial

[6]Bodie et al. (1992) extend the discussion and consider also circumstances where human capital is treated as risky. For instance, if an individual's wage is very risky or if his wages become less risky as he moves through his working life, the individual should exhibit greater risk-taking with age.

[7]See Samuelson (1989) for a discussion of the conventional yet debated wisdom that we should be risk tolerant when young and exhibit more conservative risk behavior as we near retirement.

products, services and investment decisions.[8]

3.2 Empirical Evidence

A number of attempts to explain how socioeconomic variables affect individual investor risk behavior have been made. Empirical studies on risk aversion using data on households' aggregate wealth and debts became popular in the 1970's.

Although empirical studies confirm that demographic characteristics do affect risk aversion, evidence on how these factors affect risk aversion is mixed. Contributions such as Cohn et al. (1975) and Friend and Blume (1975) are still used as references in the domain. More recent studies include Riley and Chow (1992) and Schooley and Worden (1996). Cohn et al. find that relative risk aversion decreases with age. In the same year, Friend and Blume argue that the best approximation of the market place is that of constant relative risk aversion for households. Also Riley and Chow estimate relative risk aversion in a sample of U.S. households. They find evidence that relative risk aversion decreases with wealth, education, income, and age until 65, from where risk aversion increases. Schooley and Worden were one of the first to compare U.S. households' reported willingness to take financial risk with the riskiness of their asset holdings. They find that households do allocate assets in their portfolios consistently with their reported attitudes. Controlling for risk attitudes does otherwise not seem to be commonplace in the literature, probably caused by the difficulty to secure such information. Cohn et al. did however have access to risk attitudes for their sample but did not control for them in the econometric tests.

One potential explanation to the different range of results obtained in this field of research is that the matter of classifying risky assets has been addressed somewhat differently. Friend and Blume (1975) and Riley and Chow (1992) operationalize as a risk measure the individual's relative risk aversion, that is the proportional wealth invested in risky assets. Friend and Blume include as risk-free assets checking accounts, cash balances, savings bonds, the cash value of life insurances as well as treasury bills, notes, certificates, retirement plans and credit balances in brokerage accounts. These classifications are made without any further explanation. Riley and Chow use as risky assets all assets other than personal property, real estate, bonds and checking accounts. Cohn et al. (1975) take the classification issue further and argue that the important question is not whether an asset is risk-free, but whether the individual perceives the future benefits from holding the asset as free of uncertainty. Largely on an intuitive basis, they arrive at two different classifications of risky assets where each asset category binarily is classified as risky or risk-free. Cohn et al. also try different measures of aggregate wealth, one regarding total assets as wealth, the other only regarding financial assets as wealth. The results prove to be similar across the four measures, which Cohn et al. take as an indication that they may be comparable.

4 Data

The analyses made in this report are based on proprietary data obtained from a leading independent advisor of insurance products in Sweden. Data is a cross-section of client held unit linked insurance plans within contribution-defined occupational pensions. Individuals

[8] See for instance Bodie et al. (1992) for a discussion of labor supply flexibility and portfolio choice and Bodie et al. (1988) for a discussion of defined benefit versus defined contribution pension plans in the U.S. economy.

are included in the data as a result of their employer being a client of the advisor. Any handling of data is carried out with strict respect to confidentiality and the individuals' integrity.

The data contain detailed demographic information such as date of birth, gender, marital status, home postal code and employer as well as information on the investments made within the unit linked insurance. Data on unit linked insurances include the insurance provider, precise information on the units invested in and the market value of capital invested in each unit. These data are automatically imported from the insurance provider and can thus be considered exact and credible. We also have access to the range of mutual funds offered by each insurance provider as well as the mutual fund categories and management fees. The number of funds available to investors vary from 22 to 103 depending on the provider. Table A.1 presents the these different numbers of funds made available to investors. We lastly have access to data on daily, weekly, monthly or quarterly Net Asset Values (NAVs) for each mutual fund going back to the fund's start date as well as mutual fund sizes[9] as reported by Morningstar in Sweden.

For a subset of individuals, data include an explicit statement of the individual's risk tolerance level reported in a customer survey in terms of his willingness to take financial risk.[10] The question is (free translation from Swedish): "Which of the following risk profiles describes you best?" and has the following alternatives:

- "Very low risk - I want very low risk and small fluctuations in portfolio value and therefore I accept low returns."
- "Low risk - I want low risk and minor fluctuations in portfolio value and therefore I accept relatively low returns."
- "Moderate risk - I want relatively high returns and therefore I accept a certain risk of losses."
- "High risk - I want high returns and therefore I accept a risk of big losses."
- "Very high risk - I want the highest returns possible and therefore I accept a risk of very high losses."

The survey is either filled out before or at the first meeting with the advisor. It is recommended that the survey is filled out before the meeting, so that the individual can fill it out online in any desired location. We note that the risk tolerance as it is indicated by the individual may have been chosen with respect to the occupational pension plan exclusively, or may have been indicated as a more general measure of the individual's risk preference.

From the raw data set described above, we exclude individuals who possess unit linked insurances with underlying units having time series of monthly historical NAVs shorter than 18 months. We also exclude individuals who have not provided information on their annual salary and individuals who possess assets for which Morningstar does not store information on the NAV or the fund size. This comes down to a sample (hereafter referred to as the Sample) of 57,002 individuals in the possession of 104,163 unit linked

[9] The total value of cash and securities less any liabilities.

[10] In fact, all individuals in the data set have provided such information as a part of the advisory process. We include only those individuals who have replied to the survey online, as opposed to on paper.

insurances and a subsample (hereafter referred to as the Subsample) of 352 individuals having provided their risk tolerance level and possess a total of 692 unit linked insurances[11].

Table A.2 and Table A.3 illustrate the demographic characteristics of the Sample and the Subsample respectively. These data indicate that the Subsample may be representative of the Sample. Table A.4 provides an overview of the distribution of insurance providers in which the Sample individuals hold unit linked insurances. Table A.5 reports salary summary statistics. Table A.6 presents asset portfolio composition data. Note the importance of balanced mutual funds in the asset portfolio. Table A.7 provides the distribution of the stated risk profile answers for the Subsample.

The nature of the data and the sampling brings about a few important biases. First, the data set may not include the entire portfolio of a person's unit linked insurances since permission to import data from the insurance provider is granted only for accounts which are directly tied to a client agreement. Secondly, there is an important bias in the fact that all individuals are clients of the advisor. As such they have the possibility to use the advisor's services for their investment decisions although the design of the agreements and the extent to which this happens vary[12]. Furthermore, data may not depict the individual's full income situation in cases where the individual is employed part-time. Lastly, there is a bias where observations are removed as a consequence of missing data on salary or holdings. Holdings where no data is registered by Morningstar in Sweden often include fund portfolios for which data on the underlying assets are not reported.

The strength of the data set is its size, recency and level of detail. It includes people mainly on the basis of them being employed[13] and each individual provides the data in the context of planning his future retirement pension. We believe this opens up for higher accuracy in the data than would be obtained by means of a survey[14] where the individual's self-interest is insubstantial. An additional advantage is that surveys tend to imply self-selection biases.

5 Methodology

We examine the impact of demographic and socioeconomic characteristics and attitude to risk-taking on actual risk taken primarily using linear multiple regression analysis. Regardless of the number of unit linked plans possessed per person, we aggregate any holdings to arrive at one portfolio per person. We use three measures of risk to capture the effect on total risk, systematic risk and the proportion of idiosyncratic risk in the portfolio.

In a first stage we estimate the following regression model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 D_1 + \beta_5 D_2 + \beta_6 X_4 + \epsilon \qquad (1)$$

where Y is some measure of risk in the portfolio. On the right hand side of the equation, we include

[11]Observe that these may not be all insurances possessed by the included individuals.

[12]Unfortunately, actual advice is difficult to quantify and use as a control variable.

[13]Cohn et al. (1975) for instance use data obtained by means of a mail questionnaire. They arrive at a sample of 972 accounts.

[14]Studies based on survey data is dominant in the field. This is natural because making use of a survey is the easiest way to obtain data on household aggregate wealth.

(i) a constant β_0;

(ii) age X_1;

(iii) age squared X_2;

(iv) annual salary X_3;

(v) a dummy variable D_1 for gender, taking on the value of unity if the individual is a female and zero if the individual is a man;

(vi) a dummy variable D_2 for marital status, taking on the value of unity if the individual is married[15] and zero if he or she is single;

(vii) the total market value of capital in the portfolio X_4.

With this specification, we aim to examine the direct effects of our variables on Y. Following Wang and Hanna (1997) and Campbell (2006) we include age squared to capture a possible non-linear direct effect of age on observed investment behavior.

In a second stage, we use our cross-section of holdings in occupational unit linked insurance plans to estimate a regression model of the interacted effects of age and salary on Y. Age now takes the form of dummy variables representing age cohorts, resulting in a model specified as

$$\begin{aligned} Y = \beta_0 + \beta_1 D_1 + \beta_2 D_2 + \beta_3 X_4 + \beta_4 A_1 I_1 + \beta_5 A_1 I_2 + \beta_6 A_1 I_3 + ... + \\ + \beta_{15} A_5 I_1 + \beta_{16} A_5 I_2 + \beta_{17} A_5 I_3 + \epsilon \end{aligned} \tag{2}$$

where the following new variables are introduced:

(i) A_1 is a dummy variables representing the cohort of age between 0 and 30;

(ii) A_2 is dummy variable representing the cohort of age between 31 and 40;

(iii) A_3 is a dummy variable representing the cohort of age between 41 and 50;

(iv) A_4 is a dummy variable representing the cohort of age between 51 and 60;

(v) A_5 is a dummy variable representing the cohort of age of 61 and above;

(vi) I_1 is a dummy variable for high salary, taking on the value of unity if annual salary is greater than or equal to 720,000 SEK and zero otherwise;

(vii) I_2 is a dummy variable for middle salary, taking on the value of unity if annual salary is greater than or equal to 360,000 SEK but less than 720,000 SEK and zero otherwise;

(viii) I_3 is a dummy variable for low salary, taking on the value of unity if annual salary is less than 360,000 SEK and zero otherwise.

[15] A person for which information on marital status is missing is considered unmarried.

Explanatory variables no longer include age squared since potential nonlinear effects are captured by the dummy variables representing age cohorts. The base salary segment against which other segments are assessed consists of individuals with an annual salary of at least 360,000 SEK and less than 720,000 SEK. This choice of segments for the salary is made largely on an intuitive basis.

We use three different risk measures as left-hand side variables Y based on the portfolio variance relationship

$$\sigma_P^2 = \beta_P^2 \sigma_M^2 + \sigma^2(e_P). \tag{3}$$

First, we include the standard deviation σ_P of historical portfolio returns to depict total risk. To get a value for σ_P, we take the square root of the variance obtained as $\sigma_P^2 = w^T C w$ where w is a vector containing the weights[16] of each underlying portfolio asset and C is the covariance matrix of the individual covariances $Cov(r_i, r_j)$ between the returns of assets i and j of the portfolio. Secondly, we include as a measure the absolute value of the portfolio beta times the standard deviation of historical market portfolio returns $|\beta_P|\sigma_M$ to capture systematic risk. We compute β_P by taking the weighted sum of the underlying asset betas β_i defined as

$$\beta_i = \frac{Cov(r_i, r_M)}{\sigma_M^2} \tag{4}$$

for each asset i and where r_i is the net return of the asset and r_M is the net return of the market portfolio. Lastly, we include as a risk measure the proportion of idiosyncratic risk in the portfolio

$$\frac{\sigma(e_P)}{\sigma_P} = 1 - \frac{|\beta_P|\sigma_M}{\sigma_P} \tag{5}$$

to depict how much an investor is under diversified and where $\sigma(e_P)$ depicts a standard deviation attributable to idiosyncratic risk. We model the market portfolio as the selection of mutual funds in which at least one individual in the sample has invested. Each mutual fund's weight in the market portfolio is the fund size[17] divided by the sum of all fund sizes. Table B.1 presents the market portfolio weights per mutal fund category. We compute the covariances of historical fund returns pairwise for all pairs of non-missing historical returns at each time point. Each time series of historical fund returns[18] include at least 18 and up to 144 previous monthly observations.

We run the regressions (1) and (2) first for the Sample and thereafter for the Subsample to infer the effect of reducing the sample size. All regressions are run with heteroskedasticity robust standard errors. The indicated attitude to risk is then added to the regression specifications (1) and (2) for the Subsample, in the form of dummy variables representing low and high risk tolerance, setting the base risk tolerance to the middle level. Due to the lack of observations in these segments, very high and very low risk tolerance levels are substituted for high and low risk tolerance levels respectively.

Finally, we estimate the models (1) and (2) on the stated willingness to take risk, hence using stated risk tolerance as the measure Y. This additional specification examines the correlation between the demographic and socioeconomic variables and the stated attitude

[16] Each weight is the market value of capital invested in an asset divided by the total market value of the portfolio. Thus, the weight vector sum to unity for each individual.

[17] The total value of cash and securities less any liabilities.

[18] Fund return is based on closing monthly NAVs in SEK and expressed in seven decimal digits. The standard deviation of portfolio returns is expressed in ten decimal digits.

to risk. For this estimation, we use a Poisson regression where we assign the dependent variable to take on a value of 2 for a stated high risk tolerance, a value of 1 for medium risk tolerance and a value of 0 for low risk tolerance. A shown dependence would contribute to our assertion that stated risk tolerance needs to be included as an endogenous variable in the models (1) and (2). Additionally, this specification itself provides interesting insights on the explanatory factors behind the risk attitudes of today's individual investors.

The main concern with our model is the endogeneity problem related to the omission of some variables that have been found to be important in other studies and that intuitively should be explanatory factors behind risk behavior, such as the individual's aggregate wealth, debts, education, household size, home ownership, type of employment, etcetera. Moreover, the individual's risk tolerance is an omitted variable in both of our regression models. By studying the Subsample for which we have access to stated risk tolerance, we hope to get an idea of a more accurate size of the explanatory factor effects in (2) and use this insight when studying the results for the Sample.

6 Results

In this section we present descriptive statistics for our risk measures Y and the main regression results. We conclude with robustness tests.

6.1 Descriptive Results

Table B.2 reports summary statistics on the risk measures Y for the Sample and the Subsample. These statistics show a mean total risk of 0.0360 for the Sample, which as expected lies slightly above the mean systematic risk of 0.0305. The mean proportion of idiosyncratic risk is 0.191. Notice the slightly negative minimum value of -0.0373 for the proportion of idiosyncratic risk. A negative proportion obviously has no support in theory and entirely stems from a modeling error of the market portfolio. Being an approximation where missing mutual fund returns are ignored in the calculation of the market historical returns, the market portfolio is biased in favor of non-missing mutual fund returns. The exact effect of this error is unknown, however, but tentatively accepted. If we in our calculations include data points which are non-missing for all underlying assets[19] the minimum and maximum values of the proportion of idiosyncratic risk in the portfolio become 0.0330 and 1.000, supporting this hypothesis. Since such time series are undesirably short however, we place confidence in our risk measures despite the minor error.

6.2 Main Results

Table B.3 presents the regression results of model (1) for the Sample using both total risk, systematic risk and the proportion of idiosyncratic risk as dependent variables. All coefficient estimates, using total risk and systematic risk as measures, are negative except those for age and portfolio capital. The different signs of the estimates for age and age squared suggest that the relationship between risk and age is parabolically shaped with a peak at 43 years[20] for total portfolio risk, at 44 years for systematic portfolio risk and at 46 years for the proportion of idiosyncratic risk in the portfolio. Results further indicate

[19] These are the data points between today and 18 months' return history.

[20] Differentiating $\hat{Y} = \hat{\beta}_0 + \hat{\beta}_1 X + \hat{\beta}_2 X^2$ with respect to X yields a turning point at $X = -\frac{\hat{\beta}_1}{2\hat{\beta}_2}$.

that married individuals take less total risk and systematic risk but a greater proportion of idiosyncratic risk than their unmarried peers. Females take less total risk and systematic risk than men whilst the gender effect on idiosyncratic risk is insignificant. Worth noticing is that the coefficient estimates for salary are insignificant regardless of which measure of risk is used. The market value of portfolio capital has a significant effect only on the proportion of idiosyncratic risk in the portfolio, suggesting that individuals with a higher market value of savings diversify their risk less than do individuals with lower market value of savings.

In an effort to understand the combined effects of age and salary on risk we now turn to model (2) where age and salary are represented as dummy variables. In Table B.4 we report the coefficient estimates for this regression specification using both total risk, systematic risk and proportion of idiosyncratic risk as dependent variables. The coefficient estimates are visualized in Figure B.1. We see in Panel A and B of Figure B.1 that total risk and systematic risk increase at young ages and then start decreasing as the individual arrives at the turning age point. A high salary seems to speed up the transition to the phase of taking decreasing risk, arriving at this phase at a younger age than do individuals with middle and low salary. Panel C shows that investors with low salary take higher idiosyncratic risk. The tendency to diversify risk is hence more prevalent among individuals with high salary than those with middle or low.

In order to evaluate the effect of excluding stated risk tolerance from our regression specifications (1) and (2), we turn to the Subsample for which we add the previously omitted variable to the model. Table B.5 shows the regression results with and without including stated risk tolerance as an control variable. Comparing Table B.5 with Table B.3 where we deduce the direct effects of our variables on risk, we see that reducing the sample size results in a large fall in significance, indicating that our Subsample unfortunately is too small to be used in a trustworthy analysis. Yet we choose to present the interacted effects of age cohort and salary segment dummy variables in Table B.6 and Table B.7. Figure B.2 visualizes these results graphically. Despite the inadequate size of the Subsample which makes further interpretations dangerous, we observe by comparing Figure B.2 with those of Figure B.1 that the inclusion of stated risk tolerance in the model causes no considerable change in the other coefficient estimates. This strengthens our confidence that the omitted variable bias in (1) and (2) may be quite small. Table B.5 through Table B.7 do however suggest that the coefficient estimates for the dummy variable representing high risk tolerance are significant. We note a positive correlation between a stated high risk tolerance and total and systematic risks and a negative correlation between a stated high risk tolerance and the proportion of idiosyncratic risk. This finding implies that individuals who have indicated a high risk tolerance level also take higher total and systematic risks. An additional important result is that these risk-willing individuals diversify risk better, indicating that they do not only take higher risks, they also manage them better. Finally, our results for the Subsample confirm our previous observation that women take lower total and systematic risks. Women also indicate a preference to take lower risk at the five percent significance level. An additional insight obtained for the Subsample is that salary has turned out to be a significant variable in explaining total risk and systematic risk, which it did not for the Sample. A downturn for our Subsample however, is the insignificant coefficient estimates for age, which showed extreme significance for the Sample. This fact reaffirms our previous conclusion that the Subsample indeed is too small and that any results should be used with caution.

Using as dependent variable the individuals' stated risk tolerance, we obtain results shown in Table B.8 and Table B.9 as well as Figure B.3. It is apparent that an investor's willingness to take risk varies significantly with age and gender. Whereas the relationship between total or systematic risk and age is parabolic, Table B.3 suggests almost linear tendencies for the relationship between stated risk tolerance and age. Women clearly have lower willingness to take financial risk than men. Finally we note that neither annual salary, marital status nor the portfolio market value has a significant effect on the investor's willingness to take risk. Due to the inadequate size of the Subsample, we are hesitant to make any other interpretations.

Our findings in the multiple regression analysis show that, if both the Sample and the Subsample are representative of the population, the usage of an underspecified model for the Sample will cause a positive bias in the estimates for the age coefficient, a negative bias for the age squared coefficient and a negative bias for the female coefficient. These biases need to be recalled before any effort is made to analyze or use these results with the Sample.

6.3 Robustness Tests

In an attempt to test the robustness of our findings we include regression results for two modified analyses, where we have changed the time period used to calculate the covariance matrix C. In our main analysis we used time series of historical returns of at least 18 and up to 144 monthly observations to calculate C. In the first robustness test we shorten the time series to consist of at least 18 and up to 36 monthly time points, thus reducing the number of missing values in the series. In the second robustness test we change the requirement of minimum individual investment history available; instead of a return history of at least 18 months, we now require at least 24 months. Hence, time series here consist of at least 24 and up to 144 time points. This alteration reduces the sample size and produces a more biased sample in that individuals who are active investors and invest in newly established mutual funds are dropped to a higher extent. In return, any covariances should be computed with higher accuracy. The result of such a trade-off will be seen next.

Table B.10 reports the characteristics of the risk measures Y after the above mentioned modifications have been made to the analysis. The first robustness test where the number of missing values has been reduced gives, as expected, a more realistic value for the minimum proportion of idiosyncratic risk. The second robustness test does not change the sign of the minimum. Tables B.11 through B.14 present the regression results. Figure B.4 show plots of these findings, to be compared with Figure B.1. We will not comment on these results in detail but do observe that all main findings of this Section are valid even after they have been tested for robustness.

7 Conclusions and Implications

Data suggest a strong pattern of a parabolically shaped relationship between total or systematic risk and age. Total risk taken by the Sample increases up to a turning point at the age of 43 from where it decreases at a growing rate until retirement. These findings do not violate theoretical human capital models, previous empirical work or recommendations commonly made by investment professionals. However, they show that portfolio risk does not decrease over the complete life cycle but increases for a number of years before they commence to decrease. This observation could possibly be explained by a need to build up a capital base before any investment risks can be taken. Such an idea finds some support in the data which suggest that the threshold to decreasing risk tendencies is much higher for individuals with a low salary than for individuals with a high salary. Additional studies aiming to explain this behavior are needed, particularly since we suffer from an omitted-variable bias in that we have failed to control for aggregate wealth in our model.

The correlation between total or systematic risk and salary is less clear in that the direct effect of salary on risk is statistically insignificant. Nonetheless, the interacted terms of age and salary dummy variables demonstrate high statistical significance. In particular, our findings indicate that high salary individuals tend to diversify their investment risk much better than do individuals with middle and low salary levels. Similarly, individuals with high market value of savings diversify better. Whether these results derive from low salary individuals being less informed, less likely to diversify due to inadequate contributions to the pension, the advisory system working less well for these individuals or has other explanatory factors, these findings are intriguing. Additional studies on this subject are welcome.

The observation that the stated willingness to take high risk corresponds to actual investment risks taken must be considered good news for the individual investors independently of the reason behind this fact. An additional important result is that risk willing individuals diversify their risks better, indicating that they do not only take higher risks, they also manage them better. Whether this correlation is a result of either a well informed individual investor or a well working investment advisory system is not discernable in this study. More disappointing is perhaps the result that individuals with a particularly low willingness to take risk do not take significantly less risk than those in the middle segment. However, since we can conclude that stated risk tolerance is an explanatory factor behind actual risk behavior one should strive to include it in any model aiming to explain such behavior. We regret that this has not been possible for a sample of adequate size. Further studies should try to use a larger sample with stated risk willingness data in order to better assess the effect of omitting this variable.

It is obvious that this study is limited by an incomplete vision of the complete set of all components affecting an individual's investment risk behavior. It suffers from an omitted variable bias particularly from omitting total wealth and stated willingness to take risk for a sufficiently large sample. There is also a considerable bias in the data caused by sample individuals being clients of a financial advisor. We still hope and believe that the results presented in this report are a valuable source for understanding risk behavior within the Swedish pension system and to some extent also in other investment situations.

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Appendix A Sample Characteristics

Table A.1: Number of Mutual Funds in the Unit Linked Insurances.

This table reports the number of mutual funds available to investors in each of the unit linked insurances held by the individuals of the Sample.

Insurance Provider	Number of Funds Offered
AMF Pension	22
Danica Fondförsäkring	64
Folksam	63
Handelsbanken Liv	74
Länsförsäkringar	72
Movestic Livförsäkring	57
SEB Trygg Liv	103
SPP Liv	74
Skandia	103

Table A.2: Demographic Characteristics of the Sample.

This table reports the Sample's demographic characteristics. Regions refer to the 21 counties ("län") of Sweden. The number of observations is $N = 57,002$.

Region	Frequency	Percentage[a]
Blekinge	248	0.4
Dalarna	299	0.5
Gotland	46	0.1
Gävleborg	498	0.9
Halland	1,024	1.8
Jämtland	146	0.3
Jönköping	1,425	2.5
Kalmar	541	1.0
Kronoberg	553	1.0
Norrbotten	363	0.6
Skåne	3,901	6.8
Stockholm	18,566	32.6
Södermanland	555	1.0
Uppsala	1,896	3.3
Värmland	440	0.8
Västerbotten	618	1.1
Västernorrland	1,353	2.4
Västmanland	695	1.2
Västra Götaland	6,294	11.0
Örebro	1,040	1.8
Östergötland	1,206	2.1
(Missing)	15,295	26.8

[a]Percentages may not sum to 100 due to rounding.

Age	Frequency	Percentage
-30	4,329	7.6
31-40	17,833	31.3
41-50	19,226	33.7
51-60	10,493	18.4
61-	5,121	9.0

Gender	Frequency	Percentage
Woman	18,829	33.0
Man	38,173	67.0

Marital Status	Frequency	Percentage
Married	18,965	33.3
Single	7,047	12.4
Cohabitant	9,147	16.1
(Missing)	21,843	38.3

Table A.3: Demographic Characteristics of the Subsample.

This table reports the Subsample's demographic characteristics. Regions refer to the 21 counties ("län") of Sweden. The number of observations is $M = 352$.

Region	**Frequency**	**Percentage**
Blekinge	1	0.3
Dalarna	0	0.0
Gotland	0	0.0
Gävleborg	5	1.4
Halland	4	1.1
Jämtland	3	0.9
Jönköping	10	2.8
Kalmar	1	0.3
Kronoberg	2	0.6
Norrbotten	1	0.3
Skåne	34	9.7
Stockholm	81	23.0
Södermanland	4	1.1
Uppsala	32	9.1
Värmland	3	0.9
Västerbotten	1	0.3
Västernorrland	4	1.1
Västmanland	0	0.0
Västra Götaland	118	33.5
Örebro	1	0.3
Östergötland	1	0.3
(Missing)	46	13.1

Age	**Frequency**	**Percentage**
-30	38	10.8
31-40	113	32.1
41-50	108	30.7
51-60	65	18.5
61-	28	8.0

Gender	**Frequency**	**Percentage**
Woman	114	32.4
Man	238	67.6

Marital Status	**Frequency**	**Percentage**
Married	172	48.9
Single	63	17.9
Cohabitant	89	25.3
(Missing)	28	8.0

Table A.4: Insurance Providers.

This table reports the distribution of Sample individuals' unit linked insurances across the insurance providers. The number of observations refer to the insurance products. Note that the number of insurance products 77,828 exceed the number of individuals in the Sample $N = 57,002$.

Insurance Provider	Frequency	Percentage
Sample (77,828 observations)		
AMF Pension	2,498	3.2
Danica Fondförsäkring	1,670	2.2
Folksam	1,958	2.5
Handelsbanken Liv	1,860	2.4
Länsförsäkringar	19,532	25.1
Movestic Livförsäkring	3,395	4.4
SEB Trygg Liv	18,469	23.7
SPP Liv	13,473	17.3
Skandia	14,966	19.2
Other	7	0.0
Subsample (502 observations)		
AMF Pension	30	6.0
Danica Fondförsäkring	8	1.6
Folksam	15	3.0
Handelsbanken Liv	20	4.0
Länsförsäkringar	134	26.7
Movestic Livförsäkring	26	5.2
SEB Trygg Liv	86	17.1
SPP Liv	122	24.3
Skandia	61	12.2

Table A.5: Salary Distribution.

The distribution of annual salary for the Sample and the Subsample. The Sample mean salary is $506,670$ SEK and the Sample median salary is $450,000$ SEK. Number of observations $N = 57,002$. The Subsample mean salary is $505,250$ SEK and the Subsample median salary is $441,600$ SEK. Number of observations $M = 352$.

Annual Salary (SEK)	Frequency	Percentage
Sample (57,002 observations)		
-359,999	16,936	29.7
360,000-719,999	32,402	56.8
720,000-	7,664	13.4
Subsample (352 observations)		
-359,999	98	27.8
360,000-719,999	205	58.2
720,000-	49	13.9

Table A.6: Asset Portfolio Composition.

This table presents the asset portfolio composition of the Sample per mutual fund category. Percentages in the table refer to the proportion of market value of capital invested in each category.

Category	Percentage
Specialty Funds	*2.5*
Biotechnology	0.0
Commodities	0.4
Energy	0.1
Environmental	0.0
Financial	0.0
Health	0.8
Precious Metals	0.0
Real Estate	0.4
Technology	0.7
Other	0.1
Single-Country Funds	*18.3*
Asia (single countries)	0.5
Brazil	0.1
China	1.5
Europe (single countries)	0.1
India	1.0
Japan	0.4
Russia	2.7
Sweden	12.0
Regional Funds	*25.4*
Africa & Middle East	0.1
Asia	2.3
Eastern Europe	1.4
Emerging Markets	5.1
Euroland	0.0
Europe	2.7
Global	8.9
Latin America	1.3
Nordic Countries	0.9
North America	2.7

Category	Percentage
Fixed-Income Funds	*14.8*
Corporate Bond	0.0
High Yield Bond	0.7
Inflation Indexed Bond, SEK	2.5
Investment Grade Bond	0.6
Long-Term Bond, SEK	2.3
Short-Term Bond, SEK	8.5
Other	0.2
Balanced Funds	*37.4*
Aggressive Allocation, SEK	19.2
Conservative Allocation, SEK	1.2
Other	17.0
Hedge Funds	*1.5*
Market Neutral	0.2
Multi-Strategy	1.2
Other	0.1

Table A.7: Attitudinal Characteristics of the Subsample.

This table reports the distribution of attitudes of the individuals of the Subsample. Number of observations $N = 352$. In any analysis performed and presented in Appendix B, individuals with a very low or a very high risk tolerance have been given a substitute value of low and high risk tolerance respectively, due to the lack of observations in these categories.

Stated Risk Tolerance	**Frequency**	**Percentage**
Very Low	1	0.3
Low	123	34.9
Medium	172	48.9
High	49	13.9
Very High	7	2.0

Appendix B Results

Table B.1: Market Portfolio Weights.

This table presents the market portfolio weights per mutual fund category. The mutual funds of the market portfolio are those in which at least one individual in the Sample has invested. Each mutual fund's weight in the market portfolio is the fund size[a] divided by the sum of all fund sizes. Percentages in the table are based on the weights according to this model, that is the sum of the fund sizes per category divided by the sum of the market portfolio's total fund sizes. The total number of mutual funds in the market portfolio is 602.

Category	**Percentage**[b]
Specialty Funds	*10.1*
Biotechnology	0.0
Commodities	4.1
Energy	1.6
Environmental	0.1
Financial	0.1
Health	0.4
Precious Metals	1.8
Real Estate	0.3
Technology	0.5
Other	1.2
Single-Country Funds	*17.7*
Asia (single countries)	0.5
Brazil	0.7
China	4.1
Europe (single countries)	0.7
India	2.3
Japan	1.3
Russia	1.4
Sweden	6.7
Regional Funds	*44.4*
Africa & Middle East	0.2
Asia	8.9
Eastern Europe	1.4
Emerging Markets	9.3
Euroland	0.1
Europe	3.9
Global	9.0
Latin America	4.6
Nordic Countries	1.7
North America	5.3

Category	**Percentage**
Fixed-Income Funds	*16.7*
Corporate Bond	0.1
High Yield Bond	3.1
Inflation Indexed Bond, SEK	0.7
Investment Grade Bond	3.3
Long-Term Bond, SEK	2.2
Short-Term Bond, SEK	3.8
Other	3.5
Balanced Funds	*9.8*
Aggressive Allocation, SEK	3.5
Conservative Allocation, SEK	0.4
Other	5.9
Hedge Funds	*1.0*
Market Neutral	0.3
Multi-Strategy	0.5
Other	0.2
Others	*0.4*

[a]The total value of cash and securities less any liabilities of the fund.
[b]Percentages may not sum to 100 due to rounding.

Table B.2: Summary Statistics.

This table reports summary statistics on our dependent variables Y. Total risk σ_P is the standard deviation of the historical portfolio returns; systematic risk $|\beta_P|\sigma_M$ is the absolute value of the portfolio beta times the standard deviation of the market portfolio historical returns; the proportion of idiosyncratic risk is derived from the former measures as $1 - \frac{|\beta_P|\sigma_M}{\sigma_P}$. The risk measures are computed using time series of historical returns consisting of at least 18 and up to 144 monthly time points.

Risk Measure	**N**	**Mean**	**Std. dev.**	**Min**	**Max**
Sample					
Total risk	57,002	0.0360	0.0141	3.00e-06	0.114
Systematic risk[a]	57,002	0.0305	0.0141	1.57e-06	0.0971
Proportion of idiosyncratic risk	57,002	0.191	0.182	-0.0373[b]	0.998
Subsample					
Total risk	352	0.0346	0.0133	0.00573	0.114
Systematic risk	352	0.0277	0.0141	0.000296	0.0828
Proportion of idiosyncratic risk	352	0.249	0.197	0.0115	0.956

[a]Systematic and relative systematic risk are computed with respect to the standard deviation of the monthly historical market portfolio returns which is 0.0322.

[b]The negative min value of the proportion of idiosyncratic risk is a modeling error. See Section 5 and Section 6 for details.

Table B.3: Direct Effects on Risk.

This table reports the linear regression results using our three risk measures as dependent variables. The regression is specified by model (1) and is run on observations for the Sample.

	(1) **Total Risk**	**(2)** **Systematic Risk**	**(3)** **Proportion of Idiosyncratic Risk**
Age	0.00118***	0.00130***	-0.0175***
	(25.35)	(27.83)	(-25.71)
Age squared	-0.0000136***	-0.0000147***	0.000191***
	(-26.62)	(-28.84)	(25.84)
Annual salary	-2.11e-10	-1.79e-11	-2.93e-09
	(-0.89)	(-0.07)	(-0.86)
Female	-0.00224***	-0.00191***	0.00142
	(-18.39)	(-15.58)	(0.88)
Married	-0.000626***	-0.000704***	0.00628***
	(-4.77)	(-5.37)	(3.78)
Portfolio market value	1.05e-10	2.61e-10	6.62e-09**
	(0.69)	(1.75)	(3.03)
Constant	0.0128***	0.00406***	0.567***
	(12.63)	(3.95)	(37.66)
Observations	57,002	57,002	57,002

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.4: Interacted Effects on Risk.

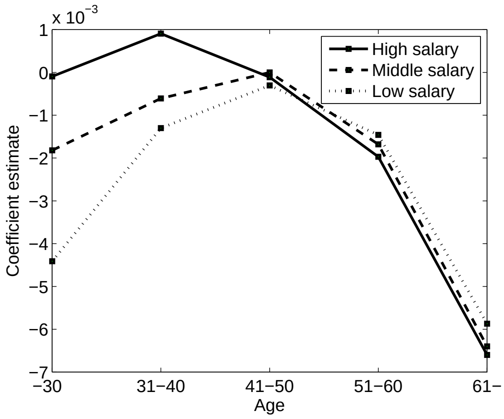
This table reports the linear regression results using our three risk measures as dependent variables. The regression is specified by model (2) and is run on observations for the Sample. The base level to which the interacted age cohort and salary segments are compared is the cohort of age between 41 to 50 with middle salary.

	(1) **Total Risk**	**(2)** **Systematic Risk**	**(3)** **Proportion of Idiosyncratic Risk**
Female	-0.00213***	-0.00179***	0.000218
	(-17.17)	(-14.27)	(0.13)
Married	-0.000645***	-0.000713***	0.00561***
	(-4.90)	(-5.43)	(3.37)
Portfolio market value	6.51e-11	2.42e-10	6.86e-09**
	(0.45)	(1.70)	(3.26)
High salary			
Age up to 30	-0.0000949	-0.00122	0.0338
	(-0.05)	(-0.72)	(1.72)
Age 31 to 40	0.000906*	0.000617	0.0130**
	(2.42)	(1.59)	(2.65)
Age 41 to 50	-0.000112	0.0000420	-0.00431
	(-0.39)	(0.15)	(-1.21)
Age 51 to 60	-0.00197***	-0.00191***	0.0137**
	(-5.08)	(-5.00)	(2.80)
Age above 60	-0.00660***	-0.00656***	0.0759***
	(-10.78)	(-10.79)	(8.45)
Middle salary			
Age up to 30	-0.00182***	-0.00255***	0.0483***
	(-4.91)	(-6.40)	(9.00)
Age 31 to 40	-0.000608**	-0.000988***	0.0224***
	(-3.27)	(-5.27)	(9.76)
Age 51 to 60	-0.00168***	-0.00160***	0.00852**
	(-7.48)	(-7.30)	(3.20)
Age above 60	-0.00640***	-0.00647***	0.0748***
	(-18.96)	(-19.67)	(15.97)
Low salary			
Age up to 30	-0.00441***	-0.00512***	0.0642***
	(-16.22)	(-18.36)	(14.61)
Age 31 to 40	-0.00130***	-0.00175***	0.0254***
	(-6.04)	(-8.04)	(9.09)
Age 41 to 50	-0.000305	-0.000499*	0.00810**
	(-1.28)	(-2.13)	(2.87)
Age 51 to 60	-0.00146***	-0.00165***	0.0172***
	(-4.57)	(-5.42)	(4.45)
Age above 60	-0.00587***	-0.00596***	0.0747***
	(-12.80)	(-13.64)	(12.07)
Constant	0.0383***	0.0329***	0.167***
	(259.27)	(226.91)	(94.48)
Observations	57,002	57,002	57,002

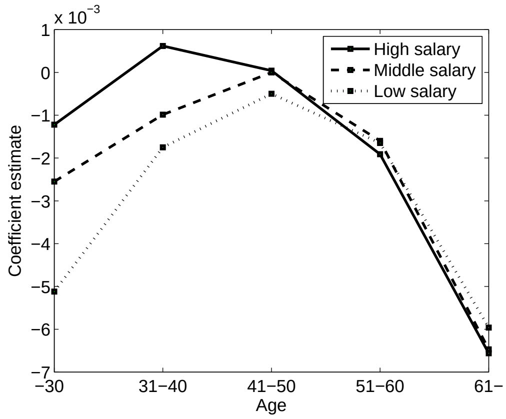
t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure B.1: Plots of the Interacted Effects on Risk.

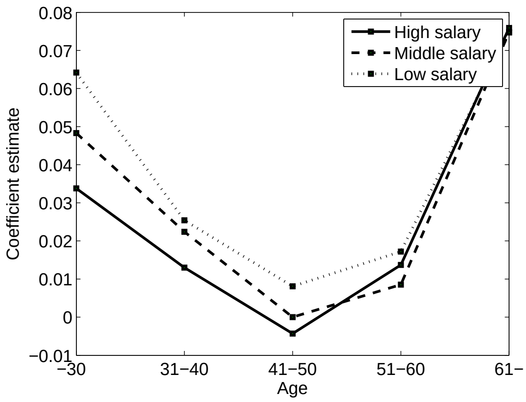
This figure shows the plotted coefficient estimates reported in Table B.4, obtained by running the regression specified by model (2) for the Sample ($N = 57,002$).



Panel A: Interaction terms of age cohort and salary segment dummy variables on total risk.



Panel B: Interaction terms of age cohort and salary segment dummy variables on systematic risk.



Panel C: Interaction terms of age cohort and salary segment dummy variables on the proportion of idiosyncratic risk.

Table B.5: Subsample Direct Effects on Risk.

This table reports the linear regression results using our three risk measures as dependent variables. The regression is specified by model (1) and is run on observations for the Subsample.

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Risk	**Total Risk**	**Systematic Risk**	**Systematic Risk**	**Proportion of Idiosyncratic Risk**	**Proportion of Idiosyncratic Risk**
Age	0.00000999	0.0000515	0.0000248	0.0000416	-0.0129	-0.00955
	(0.02)	(0.09)	(0.04)	(0.07)	(-1.55)	(-1.20)
Age squared	-0.000000985	-0.000000548	-0.000000710	0.000000230	0.000143	0.0000888
	(-0.14)	(-0.09)	(-0.10)	(0.03)	(1.55)	(1.00)
Annual salary	7.30e-09*	7.76e-09*	7.02e-09	7.59e-09*	-1.75e-08	-2.60e-08
	(2.30)	(2.54)	(1.96)	(2.23)	(-0.32)	(-0.52)
Female	-0.00351*	-0.00245	-0.00320	-0.00190	0.0499	0.0331
	(-2.25)	(-1.59)	(-1.86)	(-1.13)	(1.90)	(1.31)
Married	-0.000223	-0.000230	0.000655	0.000673	-0.00340	-0.00636
	(-0.15)	(-0.16)	(0.40)	(0.43)	(-0.15)	(-0.28)
Portfolio market value	-5.89e-09**	-6.40e-09***	-4.74e-09*	-5.35e-09**	2.35e-08	2.98e-08
	(-3.29)	(-3.78)	(-2.48)	(-3.09)	(0.85)	(1.19)
Low risk tolerance		-0.00152		-0.00241		0.0891*
		(-0.60)		(-0.88)		(2.24)
High risk tolerance		0.00763***		0.00895***		-0.0762**
		(4.38)		(4.43)		(-3.16)
Constant	0.0352**	0.0311**	0.0264	0.0221	0.509**	0.484**
	(2.78)	(2.67)	(1.97)	(1.75)	(2.95)	(2.89)
Observations	352	352	352	352	352	352

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.6: Subsample Interacted Effects on Total Risk.

This table reports the linear regression results using total risk as the dependent variable. The regression is specified by model (2) and is run on observations for the Subsample. The base level to which the interacted age cohort and salary segments are compared is the cohort of age between 41 to 50 with middle salary.

	(1) **Total Risk**	**(2)** **Total Risk**
Female	-0.00402*	-0.00295
	(-2.36)	(-1.74)
Married	-0.000507	-0.000437
	(-0.33)	(-0.28)
Portfolio market value	-4.73e-09*	-5.08e-09**
	(-2.56)	(-2.65)
High salary		
Age up to 30	0.00955***	0.00772*
	(4.34)	(2.04)
Age 31 to 40	0.00242	0.00165
	(0.59)	(0.45)
Age 41 to 50	0.00673*	0.00635*
	(2.25)	(2.11)
Age 51 to 60	0.0126**	0.0129***
	(3.27)	(3.44)
Age above 60	-0.00390	-0.00251
	(-0.53)	(-0.35)
Middle salary		
Age up to 30	0.00235	0.000160
	(0.47)	(0.03)
Age 31 to 40	0.00448*	0.00325
	(2.37)	(1.74)
Age 51 to 60	0.00218	0.00281
	(0.87)	(1.16)
Age above 60	-0.00404	-0.00241
	(-0.97)	(-0.58)
Low salary		
Age up to 30	0.000649	-0.000574
	(0.23)	(-0.21)
Age 31 to 40	0.00186	0.000952
	(0.67)	(0.34)
Age 41 to 50	0.00154	0.00134
	(0.45)	(0.40)
Age 51 to 60	0.00120	0.000658
	(0.40)	(0.23)
Age above 60	-0.00137	0.0000470
	(-0.14)	(0.01)
Low risk tolerance		-0.00144
		(-0.57)
High risk tolerance		0.00704***
		(3.97)
Constant	0.0352***	0.0344***
	(22.12)	(22.43)
Observations	352	352

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.7: Subsample Interacted Effects on Systematic and Idiosyncratic Risks.

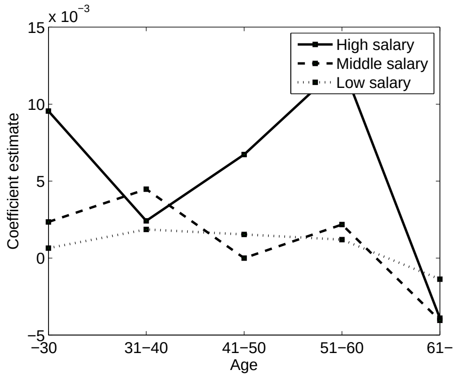
This table reports the linear regression results using systematic risk and the proportion of idiosyncratic risk as dependent variables. The regression is specified by model (2) and is run on observations for the Subsample. The base level to which the interacted age cohort and salary segments are compared is the cohort of age between 41 to 50 with middle salary.

	(1) Systematic Risk	(2) Systematic Risk	(3) Proportion of Idiosyncratic Risk	(4) Proportion of Idiosyncratic Risk
Female	-0.00383*	-0.00252	0.0577*	0.0402
	(-2.10)	(-1.41)	(2.12)	(1.54)
Married	0.000299	0.000397	-0.00440	-0.00742
	(0.18)	(0.25)	(-0.19)	(-0.34)
Portfolio market value	-3.42e-09	-3.84e-09*	1.36e-08	1.83e-08
	(-1.91)	(-2.11)	(0.57)	(0.80)
High salary				
Age up to 30	0.0117**	0.00954	-0.124	-0.0997
	(2.91)	(1.57)	(-1.90)	(-1.22)
Age 31 to 40	0.000108	-0.000738	0.116	0.114
	(0.02)	(-0.18)	(1.36)	(1.41)
Age 41 to 50	0.00681	0.00633	-0.0500	-0.0420
	(1.93)	(1.78)	(-1.31)	(-1.10)
Age 51 to 60	0.0141**	0.0145***	-0.109**	-0.133***
	(3.25)	(3.45)	(-2.87)	(-3.35)
Age above 60	-0.00270	-0.000917	0.0572	0.0201
	(-0.39)	(-0.14)	(0.44)	(0.16)
Middle salary				
Age up to 30	0.00255	-0.0000802	0.00826	0.0366
	(0.49)	(-0.01)	(0.10)	(0.40)
Age 31 to 40	0.00574**	0.00426*	-0.0558	-0.0403
	(2.63)	(2.00)	(-1.88)	(-1.34)
Age 51 to 60	0.00358	0.00442	-0.0240	-0.0432
	(1.34)	(1.69)	(-0.59)	(-1.10)
Age above 60	-0.00119	0.000965	-0.00497	-0.0550
	(-0.26)	(0.21)	(-0.07)	(-0.83)
Low salary				
Age up to 30	0.000326	-0.00111	0.0131	0.0235
	(0.10)	(-0.36)	(0.37)	(0.66)
Age 31 to 40	0.00145	0.000347	0.00469	0.0171
	(0.49)	(0.11)	(0.11)	(0.40)
Age 41 to 50	0.00269	0.00240	-0.0513	-0.0410
	(0.69)	(0.64)	(-1.15)	(-0.95)
Age 51 to 60	0.00298	0.00239	-0.0564	-0.0586
	(0.89)	(0.73)	(-0.97)	(-1.06)
Age above 60	-0.00186	0.0000966	0.101	0.0444
	(-0.25)	(0.01)	(1.10)	(0.50)
Low risk tolerance		-0.00218		0.0860*
		(-0.81)		(2.14)
High risk tolerance		0.00832***		-0.0712**
		(4.04)		(-2.90)
Constant	0.0270***	0.0260***	0.244***	0.249***
	(16.00)	(16.21)	(11.34)	(11.71)
Observations	352	352	352	352

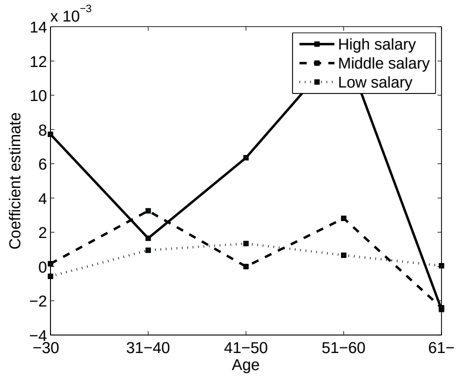
t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure B.2: Subsample Plots of the Interacted Effects on Risk.

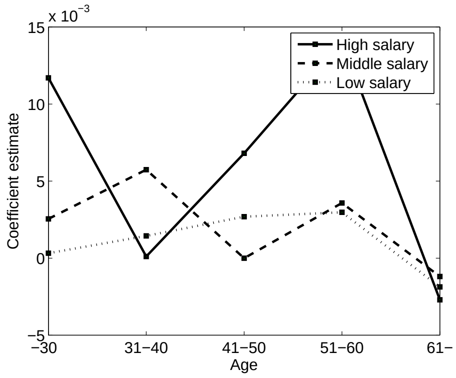
This figure shows the plotted coefficient estimates reported in Table B.6 and Table B.7, obtained by running the regression specified by model (2) for the Subsample ($N = 352$).



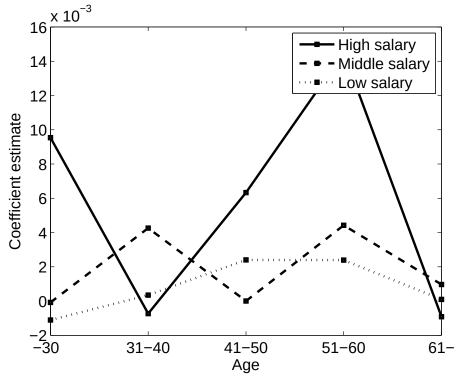
Panel A: Interaction terms of age cohort and salary segment dummy variables on total risk. Stated risk tolerance is not included as an additional control variable.



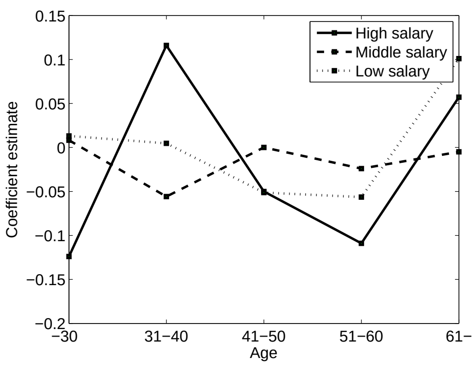
Panel B: Interaction terms of age cohort and salary segment dummy variables on total risk. Stated risk tolerance is included as an additional control variable.



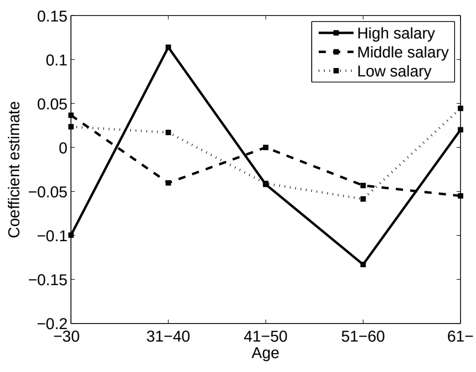
Panel C: Interaction terms of age cohort and salary segment dummy variables on systematic risk. Stated risk tolerance is not included as an additional control variable.



Panel D: Interaction terms of age cohort and salary segment dummy variables on systematic risk. Stated risk tolerance is included as an additional control variable.



Panel E: Interaction terms of age cohort and salary segment dummy variables on the proportion of idiosyncratic risk. Stated risk tolerance is not included as an additional control variable.



Panel F: Interaction terms of age cohort and salary segment dummy variables on the proportion of idiosyncratic risk. Stated risk tolerance is included as an additional control variable.

Table B.8: Subsample Direct Effects on Stated Risk Tolerance.

This table reports the Poisson regression results using the stated risk tolerance as the dependent variable. The dependent variable takes on a value of 2 for a stated high risk tolerance, a value of 1 for medium risk tolerance and a value of 0 for low risk tolerance. The regression is otherwise specified by model (1) and is run on observations for the Subsample. The base level to which the interacted age cohort and salary segments are compared is the cohort of age between 41 to 50 with middle salary.

	Stated Risk Tolerance
Age	0.0820*
	(2.01)
Age squared	-0.00127**
	(-2.76)
Annual salary	-6.88e-08
	(-0.41)
Female	-0.241*
	(-2.44)
Married	0.000976
	(0.01)
Portfolio market value	0.000000181
	(1.62)
Constant	-1.216
	(-1.40)
Observations	352

z statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

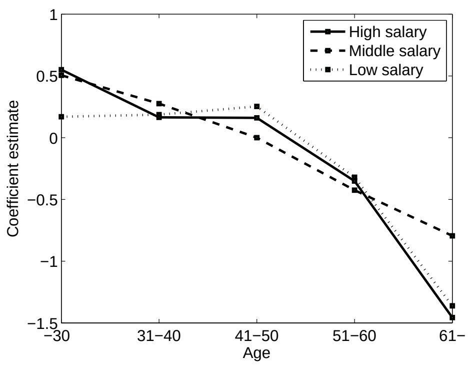


Figure B.3: Subsample Direct Effects on Stated Risk Tolerance.

This figure shows the plotted coefficient estimates reported in Table B.9 with stated risk tolerance as the dependent variable, obtained by running the regression specified by model (2) for the Subsample ($N = 532$).

Table B.9: Subsample Interacted Effects on Stated Risk Tolerance.

This table reports the Poisson regression results using the stated risk tolerance as the dependent variable. The dependent variable takes on a value of 2 for a stated high risk tolerance, a value of 1 for medium risk tolerance and a value of 0 for low risk tolerance. The regression is otherwise specified by model (2) and is run on observations for the Subsample. The base level to which the interacted age cohort and salary segments are compared is the cohort of age between 41 to 50 with middle salary.

	Stated Risk Tolerance
Female	-0.240*
	(-2.45)
Married	-0.00587
	(-0.06)
Portfolio market value	0.000000153
	(1.58)
High salary	
Age up to 30	0.551**
	(2.62)
Age 31 to 40	0.165
	(0.80)
Age 41 to 50	0.161
	(0.94)
Age 51 to 60	-0.351
	(-0.99)
Age above 60	-1.457
	(-1.59)
Middle salary	
Age up to 30	0.506*
	(2.28)
Age 31 to 40	0.276*
	(2.27)
Age 51 to 60	-0.425*
	(-2.11)
Age above 60	-0.795*
	(-2.21)
Low salary	
Age up to 30	0.170
	(0.84)
Age 31 to 40	0.187
	(1.07)
Age 41 to 50	0.253
	(1.71)
Age 51 to 60	-0.320
	(-0.88)
Age above 60	-1.362*
	(-2.09)
Constant	-0.207
	(-1.92)
Observations	352

z statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.10: Summary Statistics for the Robustness Tests.

This table reports summary statistics on our dependent variables Y, explicitly computed to perform the robustness tests. Total risk σ_P is the standard deviation of the historical portfolio returns; systematic risk $|\beta_P|\sigma_M$ is the absolute value of the portfolio beta times the standard deviation of the market portfolio historical returns; the proportion of idiosyncratic risk is derived from the former measures as $1 - \frac{|\beta_P|\sigma_M}{\sigma_P}$. The risk measures presented here are computed using shorter time series of historical fund returns than those of Table B.2. For the first robustness test, we compute the risk measures using time series of historical returns consisting of at least 18 and up to 36 monthly time points. For the second robustness test, we compute the risk measures using time series of historical returns consisting of at least 24 and up to 144 monthly time points.

Risk Measure	**N**	**Mean**	**Std. dev.**	**Min**	**Max**
First robustness test					
Total risk	57,002	0.0284	0.0113	2.56e-06	0.0978
Systematic risk	57,002	0.0231	0.0109	7.11e-07	0.0729
Proportion of idiosyncratic risk	57,002	0.219	0.163	0.0140	1.000
Second robustness test					
Total risk	44,262	0.0379	0.0146	5.51e-06	0.114
Systematic risk	44,262	0.0328	0.0141	1.54e-06	0.0970
Proportion of idiosyncratic risk	44,262	0.172	0.188	-0.035[a]	0.998

[a]The negative min value of the proportion of idiosyncratic risk is a modeling error. See Section 5 and Section 6 for details.

Table B.11: Direct Effects on Risk in First Robustness Test.

This table reports the linear regression results using our three risk measures as dependent variables, explicitly computed for the first robustness test where we compute the risk measures using time series of historical returns consisting of at least 18 and up to 36 monthly time points. The regression is specified by model (1).

	(1)	**(2)**	**(3)**
	Total Risk	**Systematic Risk**	**Proportion of Idiosyncratic Risk**
Age	0.000768***	0.000742***	-0.0112***
	(20.46)	(20.42)	(-18.92)
Age squared	-0.00000918***	-0.00000918***	0.000144***
	(-22.41)	(-23.21)	(21.97)
Annual salary	2.55e-10	5.17e-10**	-9.01e-09**
	(1.33)	(2.64)	(-2.67)
Female	-0.00205***	-0.00188***	0.00606***
	(-21.16)	(-20.13)	(4.25)
Married	0.000102	0.000422***	-0.0124***
	(0.98)	(4.21)	(-8.32)
Portfolio market value	3.05e-10*	5.40e-10***	2.06e-10
	(2.50)	(4.43)	(0.10)
Constant	0.0138***	0.00932***	0.425***
	(16.83)	(11.70)	(32.86)
Observations	57,002	57,002	57,002

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.12: Interacted Effects on Risk in First Robustness Test.

This table reports the linear regression results using our three risk measures as dependent variables, explicitly computed for the first robustness test where we compute the risk measures using time series of historical returns consisting of at least 18 and up to 36 monthly time points. The regression is specified by model (2).

	(1)	**(2)**	**(3)**
	Total Risk	**Systematic Risk**	**Proportion of Idiosyncratic Risk**
Female	-0.00188***	-0.00168***	0.00354*
	(-19.17)	(-17.69)	(2.45)
Married	0.0000347	0.000330***	-0.0115***
	(0.33)	(3.30)	(-7.78)
Portfolio market value	3.31e-10**	5.61e-10***	8.07e-10
	(2.81)	(4.83)	(0.42)
High salary			
Age up to 30	0.00147	0.00177	-0.0171
	(1.03)	(1.31)	(-1.01)
Age 31 to 40	0.00167***	0.00207***	-0.0193***
	(5.66)	(7.09)	(-4.48)
Age 41 to 50	-0.0000244	0.000223	-0.00862**
	(-0.11)	(1.00)	(-2.69)
Age 51 to 60	-0.00156***	-0.00164***	0.0204***
	(-5.06)	(-5.48)	(4.46)
Age above 60	-0.00507***	-0.00558***	0.0992***
	(-10.55)	(-11.80)	(11.71)
Middle salary			
Age up to 30	-0.000201	0.000387	-0.00872
	(-0.68)	(1.30)	(-1.95)
Age 31 to 40	0.000249	0.000552***	-0.00775***
	(1.69)	(3.87)	(-3.84)
Age 51 to 60	-0.00145***	-0.00160***	0.0194***
	(-8.04)	(-9.35)	(7.94)
Age above 60	-0.00477***	-0.00543***	0.0997***
	(-17.92)	(-21.26)	(22.52)
Low salary			
Age up to 30	-0.00324***	-0.00283***	0.0198***
	(-14.52)	(-13.19)	(5.67)
Age 31 to 40	-0.00114***	-0.00125***	0.0149***
	(-6.55)	(-7.45)	(6.05)
Age 41 to 50	-0.000616**	-0.000887***	0.0134***
	(-3.24)	(-4.92)	(5.39)
Age 51 to 60	-0.00146***	-0.00186***	0.0290***
	(-5.70)	(-7.80)	(8.36)
Age above 60	-0.00448***	-0.00497***	0.0883***
	(-12.31)	(-14.81)	(15.52)
Constant	0.0299***	0.0243***	0.208***
	(251.95)	(215.53)	(130.12)
Observations	57,002	57,002	57,002

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.13: Direct Effects on Risk in Second Robustness Test.

This table reports the linear regression results using our three risk measures as dependent variables, explicitly computed for the second robustness test where we compute the risk measures using time series of historical returns consisting of at least 24 and up to 144 monthly time points. The regression is specified by model (1).

	(1) **Total Risk**	**(2)** **Systematic Risk**	**(3)** **Proportion of Idiosyncratic Risk**
Age	0.00118***	0.00118***	-0.0146***
	(21.47)	(21.84)	(-18.09)
Age squared	-0.0000138***	-0.0000139***	0.000170***
	(-23.18)	(-23.91)	(19.57)
Annual salary	1.27e-10	4.24e-10	-5.04e-09
	(0.45)	(1.49)	(-1.24)
Female	-0.00242***	-0.00199***	-0.00154
	(-16.95)	(-14.28)	(-0.81)
Married	-0.0000679	0.000152	-0.00370
	(-0.43)	(1.01)	(-1.87)
Portfolio market value	-9.63e-11	-5.95e-11	1.28e-08***
	(-0.56)	(-0.36)	(5.13)
Constant	0.0149***	0.00996***	0.465***
	(12.25)	(8.34)	(25.87)
Observations	44,262	44,262	44,262

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table B.14: Interacted Effects on Risk in Second Robustness Test.

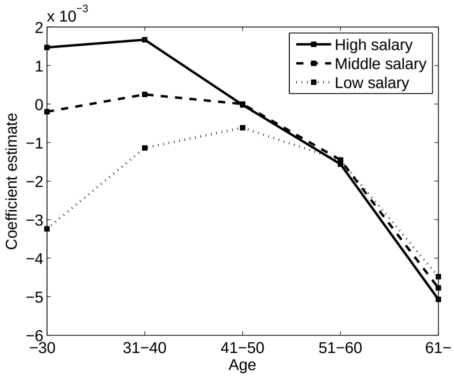
This table reports the linear regression results using our three risk measures as dependent variables, explicitly computed for the second robustness test where we compute the risk measures using time series of historical returns consisting of at least 24 and up to 144 monthly time points. The regression is specified by model (2).

	(1)	**(2)**	**(3)**
	Total Risk	**Systematic Risk**	**Proportion of Idiosyncratic Risk**
Female	-0.00223***	-0.00177***	-0.00316
	(-15.30)	(-12.50)	(-1.65)
Married	-0.000132	0.0000846	-0.00370
	(-0.84)	(0.56)	(-1.87)
Portfolio market value	-9.44e-11	-4.37e-11	1.33e-08***
	(-0.57)	(-0.28)	(5.37)
High salary			
Age up to 30	0.000639	0.000347	0.00484
	(0.29)	(0.18)	(0.21)
Age 31 to 40	0.00164***	0.00173***	-0.00195
	(3.58)	(3.81)	(-0.33)
Age 41 to 50	-0.0000106	0.000196	-0.00617
	(-0.03)	(0.60)	(-1.47)
Age 51 to 60	-0.00213***	-0.00211***	0.0160**
	(-4.74)	(-4.89)	(2.76)
Age above 60	-0.00746***	-0.00762***	0.0850***
	(-11.03)	(-11.44)	(8.36)
Middle salary			
Age up to 30	-0.000838	-0.000341	0.0129
	(-1.71)	(-0.69)	(1.84)
Age 31 to 40	-0.000168	-0.0000499	0.00623*
	(-0.76)	(-0.23)	(2.31)
Age 51 to 60	-0.00197***	-0.00200***	0.0107***
	(-7.72)	(-8.27)	(3.53)
Age above 60	-0.00696***	-0.00736***	0.0871***
	(-18.39)	(-20.12)	(16.25)
Low salary			
Age up to 30	-0.00479***	-0.00460***	0.0438***
	(-14.25)	(-13.90)	(8.05)
Age 31 to 40	-0.00174***	-0.00181***	0.0150***
	(-6.97)	(-7.50)	(4.75)
Age 41 to 50	-0.000692*	-0.000848***	0.00697*
	(-2.57)	(-3.30)	(2.20)
Age 51 to 60	-0.00194***	-0.00230***	0.0225***
	(-5.38)	(-6.84)	(5.13)
Age above 60	-0.00612***	-0.00654***	0.0822***
	(-12.15)	(-13.80)	(11.75)
Constant	0.0402***	0.0349***	0.154***
	(237.98)	(217.15)	(75.93)
Observations	44,262	44,262	44,262

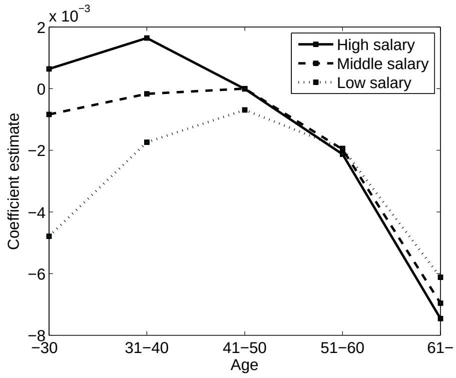
t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure B.4: Plots of the Interacted Effects on Risk in Robustness Tests.

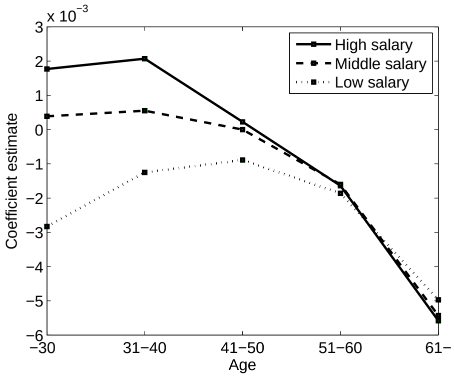
This figure shows the plotted coefficient estimates reported in Table B.12 and Table B.14, obtained by running the regression specified by model (2). For the first robustness test, we compute the risk measures using time series of historical returns consisting of at least 18 and up to 36 monthly time points. For the second robustness test, we compute the risk measures using time series of historical returns consisting of at least 24 and up to 144 monthly time points.



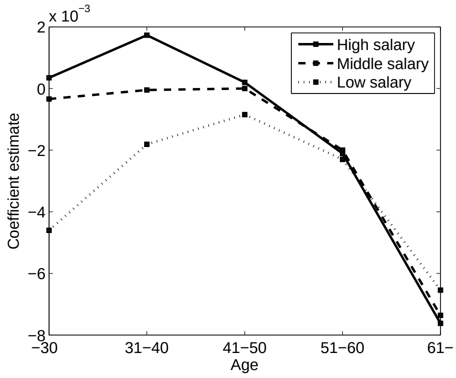
Panel A: Interaction terms of age cohort and salary segment dummy variables on total risk, in the first robustness test.



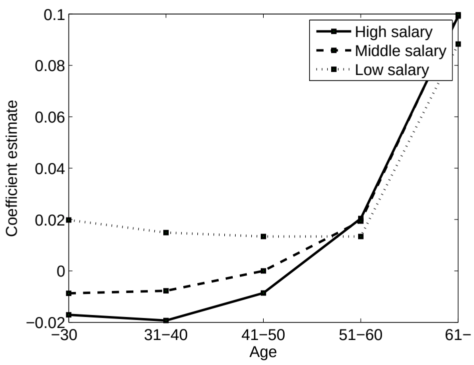
Panel B: Interaction terms of age cohort and salary segment dummy variables on total risk, in the second robustness test.



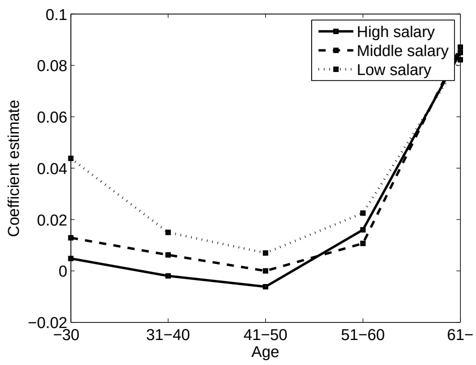
Panel C: Interaction terms of age cohort and salary segment dummy variables on systematic risk, in the first robustness test.



Panel D: Interaction terms of age cohort and salary segment dummy variables on systematic risk, in the second robustness test.



Panel E: Interaction terms of age cohort and salary segment dummy variables on the proportion of idiosyncratic risk, in the first robustness test.



Panel F: Interaction terms of age cohort and salary segment dummy variables on the proportion of idiosyncratic risk, in the second robustness test.