HOUSEHOLD PORTFOLIOS AND RISK BEARING OVER AGE AND TIME*

ALESSANDRO BUCCIOL†
University of Verona and Netspar

RAFFAELE MINIACI
University of Brescia

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Abstract

We exploit the US Survey of Consumer Finances from 1998 to 2007 to study households' portfolio risk bearing. We compare four alternative measures of risk, two based on a financial portfolio and two based on a broader portfolio also including human capital, real estate, business wealth and related debt. The measures consistently show that risk bearing fell after 2001, and it is positively correlated with wealth, income and financial sophistication. The measures, nevertheless, provide a different ranking of household risk bearing. Furthermore, the risk-age profile is sensitive to the definition of portfolio, although it looks flat for many years.

Keywords: household finance, risk bearing, background risk, real estate, human capital.

JEL classification codes: D81, G11, D14.

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† *Corresponding author*: Alessandro Bucciol, University of Verona, Dept. of Economics, Via dell'Artigliere 19, 37129 Verona, Italy. Telephone: +39 045.842.5448. Fax: +39 045.802.8529.
Email: alessandro.bucciol@univr.it.

1. Introduction

Households face portfolio allocation problems over their entire life-cycle, across different stages of the business cycle and with different levels of background risk. Understanding how their portfolio risk bearing varies over age and time is clearly important for policy analysis. However, findings on risk bearing (and their related policy implications) depend upon the specific measure of risk one takes.

In this paper we provide new insights on the evolution of households' portfolio risk bearing. We exploit data from the US Survey of Consumer Finances (SCF) from 1998 to 2007 to derive household portfolios, we estimate various measures of risk and study the correlation between risk bearing, wealth, age, cohort, time and the main household socio-demographic characteristics. In particular we consider four measures of risk bearing, two based on a narrow definition of portfolio including only financial assets (deposits, bonds and stocks) and two based on a broad definition of portfolio including also non-financial assets (human capital, real estate and business wealth) and related liabilities. In this latter case we focus on the financial component of the portfolio conditional on the non-financial one. Under the narrow portfolio definition we compute the share held in stocks and the expected standard deviation of investment returns; under the broad portfolio definition we compute (again) the expected standard deviation of investment returns and the risk tolerance implicit in investment holdings. This last measure is derived from the comparison between observed and mean-variance optimal portfolio holdings, following the approach in Bucciol and Miniaci (2011). The four measures do not necessarily provide the same ranking of risk bearing, as they are based on a different set of assumptions and a different information set. Indeed, while for the stock share only the information on the total level of financial wealth is required, for the standard deviation we also exploit the portfolio composition and the risk characteristics of the asset categories. In contrast, for the risk tolerance we consider the risk/return characteristics of the asset categories, as prescribed by the myopic mean-variance framework.

A large body of literature already investigates (among others) the relation between age and portfolio choices using micro data, but most of it relies on cross-sectional data for a single year, and therefore it cannot separate age effects from time and cohort effects (see Guiso *et al.*, 2001, for a review). In contrast, works trying to disentangle age, time and cohort effects focus their attention on either a specific part of the population or a restricted number of assets (e.g. Agnew *et al.*, 2003; Ameriks and Zeldes, 2004; Lusardi and Mitchell, 2007). Our analysis allows us to disentangle the age effects from time and cohort effects in a nationally representative dataset, including information on a broad number of assets.

We depart from previous works in three important directions. First, we consider two definitions of portfolio, with the broad one incorporating all the main sources of financial and non-financial risk. By using the SCF we can rely on a detailed description of household portfolios, keep the definition of portfolio constant over time and therefore have consistent repeated cross-section data for 9 years. Neglecting in particular non-financial assets may bias the analysis, because such assets usually account for most of household wealth, and they are more relevant in some groups of households (e.g., human capital for the youngest ones, business wealth for entrepreneurs). Second, as discussed above, we compare four alternative measures of risk bearing, all plausible but not necessarily providing the same ranking of risk distribution. The third departure of our work is on the treatment of constraints, such as habit and transaction costs, in portfolio composition. In fact, non-financial wealth is commonly subject to constraints that limit household decisions; ignoring these constraints we may get a wrong picture of the actual household risk bearing. For instance households hold owner-occupied housing for investment as well as consumption purposes; to deal with this issue, we follow Flavin and Yamashita (2002) by taking the holding of real estate (most of it is residential housing) as exogenous. In other words, we assume that households make their portfolio decisions keeping fixed their holdings of real estate. In addition, we assume that households keep fixed their holdings of business wealth and human capital. When dealing with the risk tolerance measure, we also consider short-selling restrictions on deposits and stocks, and we impose that debt cannot exceed the size of business wealth plus real estate (that is business wealth and real estate are used as collateral). Negative portfolio weights and loans higher than the collateral are difficult to implement in practice for households.

Our indicators show a similar time trend, with risk bearing falling between 2001 and 2004, and that many households bear only limited risk. In addition, the four measures of risk bearing increase with wealth, income, and some proxies for financial sophistication. However, the indicators are imperfectly correlated, and the correlation is particularly low when comparing a measure based on the financial portfolio with one based on the complete portfolio. The age profile of risk bearing, assuming that all the other household variables are constant, is also conditional on the type of portfolio considered. Using the two measures derived from the financial portfolio, risk bearing is constant up to age 60, and then it falls; using the two measures derived from the complete portfolio, risk bearing increases up to age 60, and then it remains stable. Overall, risk bearing seems constant for a large part of the life cycle.

The remainder of this paper is organized as follows. Section 2 surveys the literature on household portfolios, risk, age and time effects. Section 3 presents our measures of risk, while Section 4 describes our survey data. Section 5 shows our main findings and discusses some robustness checks. Finally, Section 6 concludes. The Appendix provides technical details on the construction of human capital in household portfolios. A supplementary appendix reports methodological details and the complete set of results for the robustness checks.

2. Household risk bearing, age, cohort and time effects

Economists, professionals and policy makers look at data and theories on household portfolios from different perspectives and with different aims, but all of them are interested in an accurate description of what households actually do with their own money. In particular, attention is paid to the risk borne by the households, and on how it changes with age and over time. For most of the theoretical and empirical literature this means to investigate the fraction of household financial wealth invested in risky assets, usually stocks.

Models that examine optimal portfolio choice in the presence of non-tradable labor income, including Heaton and Lucas (1997) and Viceira (2001), find that equity shares ought to decline throughout the life-cycle. This is because households initially choose an optimal share of wealth to invest in the risky asset while considering their future labor income as a safe asset. As the life-cycle progresses future labor income is realized and it is substituted with bonds, which they consider a tradable form of safe assets. If permanent income risk is the most relevant source of income risk for the elderly, then the former prediction is consistent with Angerer and Lam’s (2009) findings that an increase in permanent income risk is associated with a reduction in the risky asset share of the household portfolio. This intuitive result becomes weak when housing or non-homothetic preferences are considered. Cocco (2005) considers a life-cycle model with housing included in the utility function which predicts that younger households are highly invested in housing and thus have limited wealth to invest in stocks, which reduces the benefit of stock ownership. Wachter and Yogo (2010) consider the case of non-homethetic utility functions, with “basic” and “luxury” goods, which produces – together with an income profile increasing with age – an age profile for the risky asset share flatter than the one obtained with homothetic utility functions.

Empirical works are necessary to shed light on the relation between age and financial risk bearing, because there seems to be no agreement in the theoretical literature. Studies using a single cross section usually find that risk falls with age (for instance see McInish, 1982, Morin and Suarez, 1983, and Pallson, 1996), but their informative power is limited for at least two reasons: (i) they cannot disentangle age, cohort and time effects, (ii) the ratio of financial risky assets to household (net) financial wealth is not a sufficient statistic for the financial risk borne by the households.

Some papers improve the evidence based on a single cross section by considering either repeated cross sections, or panel data. Poterba and Samwick (1997) use the Survey on Consumer Finance (SCF) from 1983 to 1995 to show how age and cohort effects interact in describing portfolio shares and they show, among other things, that younger cohorts have a higher attitude to accumulate housing debt. Jianakoplos and Bernasek (2006) use 1989, 1995 and 2001 SCF data to show that the risky asset share decreases with age and that younger cohorts invest a smaller fraction of their wealth in risky financial assets. Using panel data sets, as the Panel Survey of Income Dynamics, it is possible to directly investigate the determinants of the entry – exit decision in the risky financial markets and of the portfolio rebalancing. With this respect, Brunnermeier and Nagel (2008) prove that households rebalance very slowly; Alan (2006) assesses to what extent the participation to the stock market over the life cycle is affected by entry costs for first time investors; Bilias *et al.* (2010) document that portfolio rebalancing is not related to market movement. This evidence suggests that it might be the case that at least some of the risk is passively borne by the household due to their inability to react to the new market conditions.

3. Measures of risk bearing

We consider four alternative indicators of risk bearing, whose main features are summarized in Table 1. For each indicator, a higher value means more portfolio risk bearing. The indicators, however, are derived from a different information set and, for this reason, not necessarily they provide the same ranking of risk bearing.

It should also be noticed that the four measures are derived from observations on household portfolio holdings at market value, which we assume reflect investors' choices. This assumption may be violated for households who had chosen their portfolio composition in earlier years, and then just kept it with no or limited adjustment (see, e.g., Calvet *et al.*, 2009). For such households we would then observe the original portfolio composition modified by the different historical realizations of the asset returns.

TABLE 1 ABOUT HERE

3.1. Stock share in a financial portfolio

Following the standard literature on risk, the first indicator is the share of the financial portfolio held in stocks. More generally, let us consider an economy with one risk free asset and a set of m risky assets. For each household $i, i=1,...,N$ observed at time *t*, we know the weights of its portfolio, $\omega_{it} = \left[\omega_{it,1} \quad \omega_{it,2} \quad \cdots \quad \omega_{it,m} \right]'$. In our application, $m=2$ as we consider (corporate and government) bonds and stocks as risky assets. Our measure of risk bearing is the portfolio share held in stocks.

Although popular for its simplicity, this measure neglects that not only stocks, but also other financial assets contribute to portfolio risk. For instance in a financial portfolio, corporate (government) bonds may be subject to firm- (country-) specific risk. In addition, the measure ignores that the same asset may be riskier in some years than in others. This aspect is certainly important, as shown by the recent crisis of the financial markets.

3.2. Standard deviation of excess returns in a financial portfolio

Our second measure acknowledges for this by computing the expected standard deviation of excess returns in the financial portfolio. Let us suppose that we know for the n risky assets the variances and covariances of their returns in excess from the return to the risk free asset; variances and covariances at time *t* are collected in the matrix Σ_t. For each household $i, i = 1, \ldots, N$ observed at time *t*, we then compute the portfolio standard deviation $\sigma_{it} = \left(\omega_{it}' \Sigma_t \omega_{it} \right)^{1/2}$.

This measure provides a thorough assessment of risk borne with a financial portfolio at the cost of knowing the variances and covariances of financial excess returns. However, it does not reflect the overall household portfolio risk; in fact, it ignores that other non-financial assets – which often account for a large amount of total wealth – are risky as well.

3.3. Standard deviation of excess returns in a complete portfolio

We then extend our definition of portfolio, and consider an economy with one risk free asset and a set of $n > m$ risky assets, where we know the variances and covariances of excess returns at time *t*, Σ_t. For each household $i, i = 1, \ldots, N$ at time *t*, we observe the weights of its portfolio, $\omega_{it} = \left[\omega_{it,1} \quad \omega_{it,2} \quad \cdots \quad \omega_{it,n} \right]'$. In particular, we consider as risky assets bonds and stocks (our financial portfolio), plus human capital, business wealth, real estate, and related liabilities; for sake of simplicity we group liabilities in the same category as bonds. We call this new portfolio, which includes $n = 5$ assets, "complete portfolio".

Real estate is certainly less liquid than financial assets, due to transaction costs; in addition, most of it is residential housing and is therefore constrained to satisfy consumption needs. Similar arguments can be made on the degree of liquidity in human capital and business wealth. In a short time horizon these assets may be seen as completely illiquid, which means that their holdings cannot be changed and are taken as exogenous in the portfolio choice problem (Flavin and Yamashita, 2002). Let us then distinguish the portfolio weights for household $i, i = 1, \ldots, N$ at time *t*, ω_{it}, in two components, $\omega_{it} = \left[\omega_{it}^{u\prime} \quad \omega_{it}^{c\prime} \right]'$. Weights $\omega_{i,t}^{u}$ include all the holdings of unconstrained risky assets (bonds and stocks), whereas weights $\omega_{i,t}^{c}$ include all the holdings of constrained assets (real estate, business wealth, and human capital). Accordingly we distinguish the components of the covariance matrix Σ_t in

$$\Sigma_t = \begin{bmatrix} \Sigma_t^{uu} & \Sigma_t^{uc} \\ \Sigma_t^{uc\prime} & \Sigma_t^{cc} \end{bmatrix}.$$

It can be shown (see Gourieroux and Jouneau, 1999, for details) that the overall portfolio variance is the sum of a conditional variance and a constrained variance,

$$\omega_{it}'\Sigma_t\omega_{it} = \omega_{it}^{u|c\prime}\Sigma_t^{uu}\omega_{it}^{u|c} + \omega_{it}^{c\prime}\Sigma_t^{cc|u}\omega_{it}^{c}$$

where $\Sigma_t^{cc|u} = \Sigma_t^{cc} - \Sigma_t^{uc\prime}\left(\Sigma_t^{uu}\right)^{-1}\Sigma_t^{uc}$ and the conditional weights are

$$\omega_{it}^{u|c} = \omega_{it}^{u} + \left(\Sigma_t^{uu}\right)^{-1}\Sigma_t^{uc}\omega_{it}^{c}. \quad (1)$$

Our third measure of risk is $\sigma_{it}^{u|c} = \left(\omega_{it}^{u|c\prime}\Sigma_t^{uu}\omega_{it}^{u|c}\right)^{1/2}$, that is, the standard deviation of excess returns on the conditional portfolio holdings. This measure differs from the one based on the financial portfolio because it depends through $\omega_{it}^{u|c}$ not only on the observed portfolio weights of the financial (unconstrained) assets, ω_{it}^{u}, but also on their covariance with the weights of the constrained assets, $\left(\Sigma_t^{uu}\right)^{-1}\Sigma_t^{uc}\omega_{it}^{c}$. Notice that the variance on the constrained assets plays no role in this measure.

Similarly to the standard deviation on the financial portfolio, this measure provides a comprehensive assessment of household portfolio risk, provided that one knows the variances and covariances of excess returns on financial assets, and the covariances between excess returns on financial and non-financial assets. The main limitation of this measure is that it neglects the trade-off between risk and returns in portfolio choice.

3.4. Risk tolerance implicit in a complete portfolio

So far, we described households' portfolio decisions in terms of portfolio shares and borne risk, where the latter coincides with the "ex ante" standard deviation of their portfolio excess returns. However, the relationship between borne risk (measured by portfolio variance) and risk attitude is not straightforward. In what follows we postulate that households are myopic (i.e., they have a one-year planning horizon) mean-variance (MV) optimizers, which means that at time *t* they choose the composition of their portfolio from the comparison between the covariance matrix Σ_t and the vector of asset expected excess returns η_t. In addition, we assume that asset returns are correlated with each other in a given time period, but they are distributed independently over time. We therefore follow Bucciol and Miniaci (2011), who suggest to estimate household's risk tolerance as the one which equalizes the variance of the observed household portfolio and the variance of the MV efficient one.

Our risk tolerance estimate for household $i, i = 1, ..., N$ at time t is the value of γ_{it} implicit in the following equation, which imposes an identity in the variance of the excess returns on two portfolios:

$$\omega_{it}' \Sigma_t \omega_{it} = w(\gamma_{it})' \Sigma_t w(\gamma_{it}) \quad (2)$$

where the variance in the left-hand side of the equation refers to the observed portfolio, and the variance in the right-hand side refers to the MV optimal portfolio, conditional on the household-specific risk tolerance γ_{it} and some equality and inequality constraints to portfolio allocation, described for a generic portfolio of weights w by the conditions

$$Aw = b$$

$$Cw \leq d .$$

In our empirical analysis we consider equality constraints on the non-financial assets – that is, we set as exogenous the holdings of business wealth, real estate and human capital – and inequality constraints to avoid short sales of deposits and stocks and a debt larger than its collateral (the sum of business wealth and real estate). Were we considering only the equality constraints, equation (2) would be equivalent to the comparison between conditional variances:

$$\omega_{it}^{u|c\prime} \Sigma_t^{uu} \omega_{it}^{u|c} = w^{u|c}(\gamma_{it})' \Sigma_t^{uu} w^{u|c}(\gamma_{it}) .$$

In general, the presence of inequality constraints prevents one from obtaining a closed-form expression for γ_{it}; see Bucciol and Miniaci (2011) for further details. The solution is then found numerically with quadratic programming.[1]

One could argue that there is no specific reason to derive risk tolerance from portfolio variances, and we could also look at, for instance, portfolio expected excess returns. In general, any portfolio along the efficient frontier is a potential candidate for our comparison. However, there are three reasons that make us opt for variances: first, the variance of an observed portfolio is a clear indicator of the risk borne by the household; second, it is more robust to estimation errors than the expected return (see, e.g., Merton, 1980; Chopra and

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[1] In the absence of any constraint, the risk tolerance estimate would differ from the variance of portfolio excess returns only for the market performance, $\gamma_{it} = \left(\omega_{it}' \Sigma_t \omega_{it} / \eta_t' \Sigma_t^{-1} \eta_t \right)^{1/2}$.

Ziemba, 1993); third, our approach is consistent with the analysis in terms of Certainty Equivalent Returns (CER) from standard expected utility theory (as in Calvet *et al.*, 2009). In fact, equation (2) is also the first order condition from the minimization of the distance between the expected utility under the observed portfolio and the expected utility under the optimal portfolio, where the utility is either the one in the MV framework, or the CRRA utility function; Bucciol and Miniaci (2011) derive this formally.

This measure has two main advantages compared to the alternatives discussed above. First of all, it provides an assessment of household risk from the trade-off between expected risk and expected return of a given portfolio. Another popular indicator, the Sharpe ratio, also considers both dimensions of the problem (expected risk and return of a portfolio). However, for our purpose the risk tolerance indicator is superior to the Sharpe ratio for at least two reasons. Indeed, the Sharpe ratio attributes the same weight to both dimensions, while different households may give more importance to either one. In addition, the Sharpe ratio may be instable over the years: since it measures the return premium per unit of portfolio risk, it depends linearly on the asset expected returns – which vary enormously over the years.

The second advantage of the risk tolerance indicator is that it is not linked to observed portfolio holdings with a one-to-one relationship; observed portfolios matter only in their relation with the optimal portfolios. They are then seen as a proxy for the real investment intentions, from which they may differ because of (i) infrequent rebalancing, which means that portfolios vary just because of gains or losses in asset prices and (ii) market imperfections (e.g., minimum investment size). The disadvantages of this measure are that it imposes the MV framework, and it needs to know not only variances and covariances of asset returns, but also their expected returns.

4. Data

4.1. Household portfolios

There are few surveys potentially useful to investigate how US households change their portfolio along the life-cycle. The Panel Study of Income Dynamics (PSID) is complemented by a Wealth Supplement run from 1984 to 1999 every five years, and every two years since 1999. The PSID is a longitudinal dataset, and thus it enjoys the typical advantages of panel data. However, with its information on assets holdings it is not possible to clearly separate the investment in risk free assets, such as deposits, from the investment in financial assets that entail some risk, such as government bonds. This limitation does not allow us to properly assess portfolio risk. Portfolio description is more detailed in the Health and Retirement Study, which is also a longitudinal study, but it focuses on the population over the age of 50. An obvious candidate dataset for our purpose is therefore the US Survey of Consumer Finances (SCF).

The SCF is a repeated cross-sectional survey of households conducted every three years on behalf of the Federal Reserve Board. It collects detailed information on assets and liabilities, including home ownership and mortgages, together with the demographic characteristics of a sample of US households. The survey deliberately over-samples relatively wealthy households to produce more accurate statistics; in our analysis we then use the sampling weights provided by the SCF to obtain unbiased statistics for the US population. The SCF also handles the high rate of item non-response typical of wealth-related microdata by imputing a set of five values that represent a distribution of possibilities. Multiple imputations of missing data increase the efficiency of estimation, allowing the researcher to use all available information, and have the distinct advantage of providing information on uncertainty in the imputed values. We exploit this information as suggested in Rubin (1987); we develop our analysis independently for each of the five completed datasets and our final statistics are the average of the estimates derived for each dataset; standard errors account for the variability both within and between these five datasets.

Our data on household portfolio holdings are taken from the waves from 1998 to 2007 of the SCF.[2] Our final sample consists of 15,064 households with head aged between 25 and 80. We consider two definitions of portfolio. The “financial” definition includes the main financial assets, grouped in three categories: deposits (that we treat as risk free), bonds, and stocks. The “complete” definition also includes human capital, business wealth, real estate, and related liabilities.[3] We include liabilities in the bond category, while the other three as-

[2] We neglect waves prior to 1998 because portfolios happen to be largely different from those observed in later waves, as they are more highly concentrated in deposits (also for a change in the questionnaire). We believe that including these waves would bias our analysis as changes in portfolios would merely reflect changes in the set of investment possibilities. For instance, 401(k) and other retirement assets were not yet widespread in 1995.

[3] In a robustness check (not reported) we also included credit card debt and debt for other reasons (such as student loans or loans for car purchase) . Credit card was taken as a separate asset category because its returns

sets form new categories. Human capital is estimated conditional on age, gender, race and education of the household head using an approach similar to Jorgenson and Fraumeni (1989). In a nutshell, it is a discounted projection of the future realizations of gross income, for the head and the spouse (if any); see Appendix A for details.

Over the period we analyze, the size of household wealth (in 2007 USD) rose markedly using either definition. The median value of financial wealth goes from 22,000 USD in 1998 to 30,550 USD in 2007; the corresponding values for the complete definition of wealth are 1,246,594 USD in 1998 and 2,021,287 USD in 2007. Wealth was indeed fueled by a rising stock market between 1998 and 2001, and by rising wages and house price markets between 2004 and 2007.

Each asset is classified as defined in Table 2, which also reports the composition of the aggregate complete portfolio, computed accounting for multiple imputations and sampling weights. The financial portfolio includes all the assets in the deposits, bonds, and stocks categories of the complete portfolio, therefore excluding mortgages and other liabilities. There is no exact correspondence in the questions of the various SCF waves, as for instance before 2004 we have no information on the fraction of balanced composite assets (IRA-KEOGH accounts, retirement accounts, annuities, trust-managed accounts) invested in stocks. We then exploit information from a question on the prevalence of deposits, stocks and bonds in these composite investments to impute their value to the corresponding asset class. However, the trend shown by these assets in the imputations before 2004 (with more wealth held in deposits and less in stocks) is consistent with the trend observed in other assets whose definition has remained constant across the waves (e.g., saving and money market accounts, directly held stocks, etc.).

Notice that the largest share in the aggregate portfolio is by far human capital (between 76% and 79%); which is roughly in line with simulation studies in Cocco (2005). In aggregate human capital falls over the years because of population ageing and because in the period under investigation its returns were lower than financial wealth (over the years 1998-2001) and real estate (2004-2007) ones. The second largest share of wealth is held in real estate (between 10% and 13%), mostly in owner-occupied residential housing. The inclusion of mortgages in the bonds class determines an aggregate short position in it.

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are markedly different from those on other liabilities. Results do not change qualitatively, primarily because credit card debt weighs relatively little in most household portfolios, and we omit this case from the analysis.

From the table we see that most financial wealth is held in stocks.[4] Interestingly, the share of the financial portfolio invested in stocks was around 60% in waves 1998 and 2001, and around 50% in waves 2004 and 2007. The decline between 2001 and 2004 is coupled with a corresponding increase in the holdings of deposits, from roughly 20% to 30%. In contrast, the holdings of bonds keep rather stable at 20% of the overall financial wealth. It should be noticed that bond returns in excess from returns to risk free assets have been rather stable between 2001 and 2004 (see Section 4.2): other things being constant bonds and deposit shares should have increased at the same pace. Our evidence thus suggests that the time variation in the composition of the aggregate portfolio does not merely reflect changes in the value of the assets, but also some households' willingness to reshape their portfolios.

TABLE 2 ABOUT HERE

To better understand the evolution of portfolios over the life-cycle, we group our observations by cohorts. Specifically, we define cohorts within a range of 5 birth years. Our sample contains 13 such cohorts, born between 1920 and 1984. Since the oldest and the youngest cohorts are built from few observations, in the following figures we will show cohort-specific statistics based on at least 100 observations.

We start with the cohort-specific age profile of wealth. For each cohort and for each wave we compute aggregate wealth as the average wealth holdings in the sample, weighted using the SCF sampling weights. Figure 1 shows the resulting age profile for the financial definition (left panel) and for the complete definition (right panel) of wealth. Values are reported in 2007 USD using the Consumer Price Index for all urban consumers (source: US Bureau of Labor Statistics). The figure shows for financial wealth the typical inverted U-shape profile, with remarkable cohort and time effects, with younger cohorts systematically richer than older ones. In contrast, total wealth falls monotonically with age, because human capital progressively decreases.

FIGURE 1 ABOUT HERE

[4] For instance, the share of stocks in the aggregate financial portfolio of 2007 is roughly 4.74 /(2.69 +2.03 +4.74) = 50.32%, where 2.03 is the total amount of (directly and indirectly) owned bonds (excluding liabilities).

We then turn our attention to the single asset holdings. Figure 2 reports the age profile of some key asset holdings for our complete definition of portfolio. Cohort portfolios are constructed as the aggregate portfolios from the (weighted) observations in our sample and conditional on cohorts and age (see Poterba and Samwick, 1997). Most of the variation in portfolio allocation is driven by human capital, which accounts for nearly 100% of wealth at the beginning of economic life and then it markedly falls with age, leaving all the other asset shares rise. The remaining age variation in portfolio allocation seems driven by the timing of housing investment. With volatile house prices, the insurance motive makes young households purchase their house early in life (see Sinai and Souleles, 2005 and Banks *et al.*, 2010a). In order to increase their housing consumption they resort to debt.[5] It is worth noticing that the stock share is increasing more markedly only when the negative bond position is decreasing. That is, debt positions primarily due to real estate investment make stock investment less attractive. This evidence is consistent with Becker and Shabani (2010) who find that households with mortgage debt are 10 percent less likely to own stocks and 37 percent less likely to own bonds compared to similar households with no outstanding mortgage debt.

Later in the life cycle, households are expected to downsize their housing investment. However, older households do not switch from homeownership to renting. Thus, if they reduce their position in primary residence, they do so by moving to a smaller, but still owned, house. This finding is consistent with Banks *et al.* (2010b), who show that the five year housing transition rate from owner to renter is only 4.3% for the US homeowners over 50 years old.

FIGURE 2 ABOUT HERE

4.2. Asset time series

Information on asset returns is essential to estimate our measures of standard deviation and risk tolerance. We take annual financial returns (bonds and stocks) from the "Merrill Lynch US Corporate & Government Master Index" and "MSCI USA Stock Index" time series of US asset total return indices (downloaded from Datastream). We consider as risk free annual return for deposits the yield of 3-month T-bills. Annual returns for business wealth are

[5] The percentage of households with a mortgage peaks at around the age of 45.

derived from proprietor's income from Bureau of Economic Analysis (BEA) . To measure annual returns on human capital we construct from BEA data a time series of labor income consistent with the definition we used in the SCF.[6]

It is more problematic to find a time series of real estate returns valid for our purpose. From the perspective of a household, we need a series that accounts for not only capital gains, but also earnings due to rents. We therefore combine a repeat-sale, purchase-only index calculated for the whole of the US from the Federal Housing Finance Agency (FHFA), with an estimate of imputed rents-price ratios for the US market calculated in Davis *et al.* (2008). The rent-price ratio decreased between 1979 and the second quarter of 2006 from 4.85% to 3.64%, and started rising again in the following years. The average ratio in our sample period is 4.76%, in line with estimates in Flavin and Yamashita (2002) and Pelizzon and Weber (2008).

All our time series of annual returns cover the years from 1979 to 2007 at a quarterly frequency. We derive excess returns of risky assets as the difference with risk free returns. In the benchmark analysis, we construct moments using a moving 20-year window (80 observations) for excess returns. Specifically, for the survey data collected in year *X* we assume that portfolio decisions are based on excess returns observed between year *X-19* and year *X*. As a result, households interviewed in different years have different expectations about future market movements.

Figure 3 informs on the outcome of this estimation exercise. The two top panels report the rolling expected excess return (top-left panel) and rolling standard deviation (top-right panel) for each asset from 1998 to 2007. The vertical lines show the data points we use in each wave, which are summarized in Table 3.

TABLE 3 ABOUT HERE

We see that expected excess returns on stocks rose dramatically in the first part of the period, and showed large fluctuations afterwards; expected excess returns on bonds grew until

[6] See Appendix A. We take the difference between personal income and earnings from rents, dividends, and capital gains. The resulting time series incorporates wage and salary disbursements, supplements to wages and salaries, proprietors' income with inventory valuation and capital consumption adjustments, and personal current transfer receipts, less contributions for public social insurance. BEA data refer to the whole US population, and thus they already incorporate unemployment spells and job-to-job mobility.

2001, while expected excess returns on real estate kept growing from 1999 to 2006, outperforming bonds since 2004. This is reflected in Figure 2, where stock shares systematically show a marked growth between the first and the second point of the curve for each cohort. The fall we instead observe in the age profile of stock shares between the third and fourth point of the curve for each cohort (that is, between 2001 and 2004) describes the shift of savings toward real estate, following the increase over this period in the returns of real wealth. Standard deviations are – unsurprisingly – more stable over time, but nevertheless, bond risk witnesses a remarkable reduction since year 2000. In order to assess the riskiness of household portfolios we also need to evaluate the pairwise correlations of excess returns. The two bottom panels of Figure 3 show the rolling estimates of the correlation between bonds (bottom-right panel) and the other excess returns (bottom-left panel), and between stocks and the other excess returns. The two panels suggest a marked change over the years, consistent with the remarkable change we observe in portfolio composition by wave, especially when going from 1998 to 2001; in particular the correlation between bonds and stocks fell from a very high level (around 50%) at the beginning of our sample period, consistently with the literature (e.g., Baele *et al.*, 2010). As a consequence, although the standard deviations of the asset excess returns are quite stable over time, the standard deviation of a portfolio may vary considerably due to the fluctuations of the correlations.

FIGURE 3 ABOUT HERE

We conclude this section by showing how observed portfolios perform in a MV space. Figure 4 reports this graphical analysis; the left panel refers to our financial definition, while the right panel is based on the conditional weights (see equation 1) of our complete definition. Both panels suggest wide heterogeneity of portfolio decisions, with many portfolios performing worse than others.

FIGURE 4 ABOUT HERE

As in the empirical exercise we rely on macroeconomic time series in order to assess the riskiness of human capital, business wealth and real estate, one might argue that we are under-estimating these risks since we completely ignore any idiosyncratic component. However, this is not a problem in our analysis. In fact, by imposing equality constraints on the holdings of the three non-financial assets, to matter for us is only the covariance between such assets and the remaining assets, which is likely driven by systematic rather than idiosyncratic risk.

5. Results

5.1. Distribution of risk bearing

We start our analysis by showing statistics on the evolution of risk bearing over time. The first part of Table 4 reports the measures of risk we derive from the aggregate portfolios in each SCF wave (those in Table 2), ignoring the heterogeneity in cohorts and other household characteristics. The four measures agree in indicating higher risk bearing in the years 1998 and 2001 rather than in the years 2004 and 2007, in correspondence to the highest stock shares, high volatility of bonds and stocks and high correlation between bonds and stocks.

The second part of Table 4 shows the median value of risk bearing as measured from household portfolios. The statistics thus account for the heterogeneity in household portfolios, especially regarding participation in the various asset markets. Even though the results from this exercise are quantitatively different from before (estimates are regularly smaller because many households in the sample hold poorly diversified portfolios with relatively little risk[7]), they qualitatively confirm our above conclusion: risk bearing was higher in 1998 and 2001. This time we also find more marked reduction of risk bearing in 2004 and 2007.

TABLE 4 ABOUT HERE

We then turn our attention to the distribution of the household-specific measures of risk. Figure 5 plots the cumulative distribution function (cdf) of our four indicators. All the measures report wide heterogeneity, reflecting different market conditions and portfolio allocation, and inform that a large part of the population has very little (if any) propensity to

[7] 8.98% of the households in the sample hold only risk free and human capital assets; 4.48% hold only risk free and human capital assets, plus either business wealth or real estate assets.

risk bearing. This is particularly evident for the stock share, that is set to 0 for a number of households between 40% and 50% of the sample in a given year. Notice that the cdfs referring to the waves 2004-2007 are typically drawn above the cdfs for the waves 1998-2001, which means that over those years the distributions are shifted toward lower levels of risk bearing.

FIGURE 5 ABOUT HERE

The four indicators then show a similar time trend and similar distributions of risk bearing. However, they may provide different results at the single household level. Figure 6 graphically compares the estimates of the households' specific indicators, taking all the four waves together. We observe wide heterogeneity over any pair of measures, especially when comparing estimates from financial portfolios with estimates from complete portfolios. The numbers within parentheses indicate the correlation for each pair of indicators, taken as average over the four waves. The correlation is very high (92.23%) between the two indicators based on the financial portfolio (stock share and standard deviation), and smaller (57.70%) between the two indicators based on the complete portfolio (standard deviation and risk tolerance). The correlation is rather small (29.40 or 42.75%) when we compare indicators based on the financial portfolio with indicators based on the complete portfolio. Then it seems that focusing on the complete portfolio rather than the financial one may lead to different conclusions.

FIGURE 6 ABOUT HERE

This all suggests that the choice of the portfolio definition and the risk bearing indicator is not irrelevant at the household level, since each indicator captures different aspects of risk bearing. Hence a household that is markedly risk tolerant according to one indicator, may be less risk tolerant using a different indicator.

5.2. Age profile

In this section we investigate the correlations between our measures of risk bearing, age and other household characteristics, time and cohort effects. To this end we run four quantile regression analyses, one for each measure, where the dependent variable is our risk bearing indicator. We opt for quantile regression, rather than OLS regression, since this method is less sensitive to large outliers. The specification includes five sets of explanatory variables, on wealth, demographics, financial sophistication, self-assessed measures, age, cohort, and time effects. In the set of wealth variables we consider the logarithm of financial wealth, and the levels of income, real estate plus business wealth net of debt, and debt; the levels are then divided by financial wealth. In the set of demographic variables we treat variables for race, gender, education, marital status, number of household members, children (yes or no), and occupational status of the household head. This specification is similar to the one in Sahm (2007)[8], who estimates risk attitude from hypothetical questions in the US Health and Retirement Study. In the same vein as Guiso and Jappelli (2005), we further include in the specification some proxies for financial sophistication: the number of financial institutions the household is involved with, and two dummy variables. The dummies are worth one respectively if there is regular consulting of a professional financial advisor, or the head works in the finance sector. We also include one dummy variable for the self-assessed good or excellent health status of the head.

We finally add variables meant to disentangle time and cohort effects from age effects. After trying alternative specifications, we choose one where age effects are captured with dummy variables covering a five-year age range (the baseline is age 25-29), time effects are measured with the average excess return of the stock market in the three years prior to the wave[9], and cohort effects are measured with the average excess return of the stock market when the head was between 20 and 24 years old.[10] This specification mimics one in Ameriks and Zeldes (2004), where in particular the variable on the cohort effect is meant to describe a "learning" process of the market behavior when young.

Table 5 shows the results of our analysis, separately for the four indicators rescaled by their median in the sample (to have comparable estimates). Overall we have 14,624 obser-

[8] Sahm (2007) focuses on cash-on-hand (wealth plus income) rather than wealth. We prefer our specification because cash-on-hand is highly correlated with income. For the same reason, we do not consider a measure of "life-cycle wealth" as described by the sum of wealth and human capital.
[9] Based on our time series of stock excess returns. For instance, for year 2007 we take the average from the 12 observations between 2005 and 2007.
[10] Our time series of stock excess returns does not allow to retrieve this information from the oldest cohorts. For this reason we refer to data available in Kenneth French's website. Specifically, we consider as excess market return the value-weight return on all NYSE, AMEX, and NASDAQ stocks (from CRSP) minus the one-month Treasury bill rate (from Ibbotson Associates).

vations with full information on the variables in the specification. We first focus on the two measures based on the financial portfolio definition. The stock share and the standard deviation of financial portfolio returns correlate positively with financial wealth (for instance as in Siegel and Hoban, 1982, and Morin and Suarez, 1983), income, the number of financial institutions where doing business, and with the dummy for individuals working in the finance sector, and negatively with debt[11] and the dummy variables for non-white and self-employed individuals. In addition, we find no cohort effect and an age effect insignificantly different from zero in the ages between 45 and 69. In contrast, we observe a strongly positive time effect. This means that the risk indicator rises when the stock excess return in the previous three years is high, such as in the first waves of our sample.

When we look at the two measures based on the complete portfolio definition, some – but not all – our previous findings are confirmed. We still find positive correlations between the conditional component of the standard deviation and the implicit risk tolerance and financial wealth, income, the number of financial institutions where doing business, and with the dummy for individuals working in the finance sector. In contrast we find a significant effect, but with the opposite sign (positive), for debt and self-employed individuals. This time we also find that risk bearing is higher among females, college graduates, and individuals with self-assessed good health.

The sign of the effects for debt and self-employment may be surprising if compared with the results in the first two columns of Table 2. In addition, the result that females are more risk tolerant goes against the evidence from previous works. There is a common explanation for these findings, that has to do with background risk. In fact females, debt holders and self-employed workers hold most of their wealth in non-financial assets: the median ratio of business and real wealth to financial wealth in the sample is 4.50 for females, 1.59 for debt holders, and 3.25 for self-employed workers, as opposed to 1.15 for males, 0.38 for no-debt holders, and 0.78 for employees. This implies that females, debt holders and self-employed workers have relatively little financial wealth to hedge against the background risk represented by non-financial wealth. They appear risk tolerant because they do not protect themselves enough from the exposure to exogenous shock. We believe the case of self-employed workers is paradigmatic. These individuals hold most of their wealth in a busi-

[11] The coefficient associated to the ratio of debt to financial wealth (divided by 1,000) is very large because the variable is usually very small in the sample: its median (times 1,000) is 0.014, as opposed to 1.562 for the ratio of income to financial wealth, and 1.036 for the ratio of real and business wealth to financial wealth.

ness. Ignoring this, and focusing on just their financial portfolio, would suggest that they are less risk tolerant than the baseline case (employees). Actually, they choose their financial portfolio having in mind that they already bear substantial business risk. In fact, when we consider a complete definition of portfolio, the effect of being a self-employed worker is reverted.

As for the indicators for the financial portfolios, we find a strong time effect that is now coupled with a strong cohort effect and an age effect always significantly different from zero, at least since age 45.

TABLE 5 ABOUT HERE

For sake of comparison we provide a graphical representation of the age effects estimated for the four indicators. In Figure 7 we depict the estimated age profile conditional on the median values of wealth, demographic and other household characteristics; for comparability reason, the profile is divided by the median observed risk bearing indicator. Each age profile is coupled with a 95% confidence interval derived from the covariance matrix of all the coefficient estimates.

There is marked difference between the measures based on the financial portfolio and the measures based on the complete portfolio. The former show an age profile that is essentially flat up to age 60, and then falls – especially as concerns the stock share, which is halved for the elderly. This evidence is somewhat more complex than common rules of thumb adopted by practitioners, e.g., to invest in stocks a fraction $(100-age)\%$ of the financial wealth. In contrast, the two measures based on the complete portfolio show an age profile that rises at young ages, up to 60, after which it becomes stable. Evidence of a rising age profile with the complete portfolio definition is not surprising given the portfolio shares shown in Figure 2. In fact, the complete portfolio is largely dependent on human capital, which naturally falls with age. As individuals get older, their portfolios exhibit higher investment in assets that carry relatively more risk than human capital. Our indicators capture this life-cycle effect in the change of the conditional portfolio weights of equation (1). These weights rise for two reasons. First, the portfolio shares in bonds and stocks tend to increase with age (see Figure 2); second, the term of hedging against human capital falls because the weight on human capital reduces with age. Inertia in portfolio adjustment is also likely to play a role. Consider the case of a household with a given complete portfolio. If this household does not intervene on her portfolio composition, and the market provides the same returns to all the assets, after three years the household holds less human capital. We then observe a relatively larger investment in bonds and stocks, which is used to hedge against a background risk that is lower than in the previous three years (since there is less human capital). This situation makes the household bear more risk now than in the past, even if her attitude toward risk bearing has not changed.

FIGURE 7 ABOUT HERE

5.3. Sensitivity analysis

The results obtained so far show that: (i) the way borne risk varies with age depends on the definition of portfolio, (ii) risk bearing is positively correlated with wealth, income and financial sophistication, and (iii) business cycle (captured by financial market indexes) helps explaining heterogeneity in household portfolio volatility and risk bearing. In this section we report the outcome of some robustness checks on our analysis. Methodological details and complete results can be found in the Supplementary Appendix; here we only comment on the relevant findings. Figure 8 shows the estimated age profiles of the four measures under the first three cases. Overall, the robustness checks confirm our benchmark results.

FIGURE 8 ABOUT HERE

Fixed moments

The variations we observe in risk bearing arise from changes in portfolio composition, but also from changes in the moments of the asset excess returns. It may be interesting to see which change is the main driver of the variations in risk bearing. To answer this issue, we repeat our analysis by keeping the moments of the asset returns fixed in all the waves, and equal to those we associate to wave 1998 in the benchmark analysis. In this environment, the stock share is identical to the benchmark, while the standard deviations and the risk tolerance indicator vary, and their variation reflects only changes in household portfolios.

In contrast to the benchmark case, we find that the two measures based on the complete portfolio definition are little correlated (16.60% on average, instead of 57.70% of the benchmark) and do not fall between 2001 and 2004: the median standard deviation (risk tolerance) in the sample is 0.60 (1.52) for year 2001, and 0.62 (1.59) for year 2004. In the regressions, the time effect is still significantly positive, while the cohort effect is never different from zero. The findings on the other key explanatory variables are preserved. The profile for the standard deviation based on the financial portfolio is barely unchanged relative to the benchmark case (Figure 8, first panel); in contrast, the profile for the two measures based on the complete portfolio is steeper since age 70. This suggests that households who face changes in asset return moments adjust their complete portfolios to offset such changes, in an effort to bear a risk relatively stable with age.

No hedging

The bottom panels of Figure 3 show wide variation over time of the covariance between our assets. There is no consensus in the literature on the treatment of the covariance between financial and non-financial asset returns. Some works find such covariances to be null (for instance see Flavin and Yamashita, 2002, for real estate, and Fama and Schwert, 1977, or Table 3 in Cocco *et al.*, 2005, for human capital). In our analysis based on the complete portfolios, these covariances play a role because they determine the hedging components in household portfolios (see equation 1). To investigate whether this role is important, we repeat the analysis by imposing null covariance between the excess returns of financial assets (bond, stock) and non-financial assets (human capital, business wealth, real estate). Clearly, this does not affect the two measures based on the financial portfolio.

In the regressions, our main findings are confirmed. We only find a significantly larger effect of the debt /financial wealth ratio (the coefficient is 33.36 for the standard deviation and 17.63 for the risk tolerance), and no significant cohort effect. The absence of cohort effects provides a steeper age profile (see Figure 8, second panel), with the two measures being now significantly higher at around retirement age, that is, when the portfolio weight on human capital has a sharp decline in favor of the weights on bonds and, especially, stocks.

Alternative moments

In our exercise we use estimates of the historical average and the variance-covariance matrix of excess returns. The estimates we provided so far are based on a 20-year backward horizon, as described in Section 4. Alternative estimates of the expected returns and variance-covariance matrix would imply a different assessment of the portfolio risk and its corresponding risk bearing indicators, in particular for what concerns the time effects. As identification of age, cohort and time effects are strictly related, it is relevant to check if our results change when we vary the time horizon considered for our estimates. We therefore provide new estimates in which the moments of the asset returns are derived from a time series of 15 years instead of 20 years. Similar conclusions arise using a 10-year window.

Shortening the estimation period affects remarkably the estimate of returns volatility and correlations. As a consequence, the indicators no longer show a steep decline between 2001 and 2004, and the regression outputs no longer find a significant cohort effect under the complete portfolio definition. Apart from this, the multivariate analysis on household portfolios does confirm our main results, and it gives rise to an age profile roughly in line with our previous findings (see Figure 8, third panel). The age profile under the complete portfolio definition, however, is essentially flat up to age 54, after which it rises.

Riskless human capital at retirement

In our main analysis we treat human capital from pension income exactly the same way as human capital from labor income. However, it may be plausible that pension income is less risky than labor income. In this robustness check we replicate the main analysis under the extreme situation where pension human capital is riskless. In this case, only the analysis of the complete portfolio case is potentially affected by the change. However, our previous findings are still confirmed; in particular the risk indicators rise up to age 60 and flatten out afterward.

Transaction costs

What we interpreted as heterogeneity in risk borne by the households, might in fact be due to heterogeneity in transaction costs (see Bucciol and Miniaci, 2011, for a detailed discussion of the issue). It is reasonable to expect that, the richer the investor, the less relevant the transaction costs are for her portfolio choice. Under this assumption, if we observe that our main results hold also when we restrict the sample to the top 20% wealthiest households, we can be confident that transaction costs do not significantly affect our results.

On average the sub-population of the wealthiest households is more highly educated and financially sophisticated, earns a higher income, and it has a financial wealth which is nearly four times the financial wealth of the full sample, its portfolios are riskier and their estimated implicit risk tolerance measures are higher. Nevertheless, the main results of our multivariate analysis still hold: there is a positive relation between risk bearing and wealth, and age and time effects are close to those of the benchmark case. However, in this case the confidence interval associated to the age effect is larger under the two measures based on the complete portfolio definition, and we cannot exclude that the the risk tolerance indicator is constant with age.

6. Conclusions

In this paper we use data from the waves 1998-2007 of the US Survey of Consumer Finances (SCF) to shed light on the evolution of US households' portfolio risk, and the correlation between risk bearing, wealth, age and the main household socio-demographic characteristics. The use of repeated cross sections allows us to disentangle age effects from time and cohort effects.

In our analysis we consider four different indicators of risk bearing, based on two different definitions of portfolio (financial and complete, including also human capital, business wealth, real estate, and related debt). The four indicators show a similar time trend with risk bearing falling between 2001 and 2004, and inform that the distribution of household risk bearing is skewed to the left, with many households bearing little risk. Moreover, in all the cases we find our measures of risk bearing to correlate positively with wealth, income, and some proxies for financial sophistication. However, the four indicators are imperfectly correlated, and the correlation is particularly low when comparing a measure based on the financial portfolio with one based on the complete portfolio. As regards the age profile of risk bearing, under the assumption that the other household characteristics remain fixed over the life-cycle, we also find different results when looking at the financial or complete portfolios. Looking at the financial portfolio, risk bearing is constant up to age 60, and then it falls; using the two indicators derived from the complete portfolio, risk bearing increases up to age 60, and then it remains stable.

Three out of four of the indicators we consider can be seen as simple statistical indexes, not requiring strong behavioral assumptions to justify their use. The fourth one, the implicit risk tolerance, is conditional on the assumption of myopic MV optimization. Despite a mere 58% correlation between the implicit risk tolerance index and the standard deviation of the complete portfolio returns, the regression analysis show that the heterogeneity of the two indexes is affected in a similar way by wealth and demographics. We interpret this as a signal of robustness of our conclusions, although some of the risk tolerance heterogeneity might still be due to differences in the experienced portfolio performance and planning horizon. Future research will develop a fully multi-period framework, closer to a life-cycle model of asset allocation, from which to infer risk attitude separately from time discounting.

Appendix A. Human capital calculation

We construct human capital using an approach similar to Jorgenson and Fraumeni (1989). The approach computes human capital as the net present value of the income flow that will be produced over an assumed lifetime, in the presence of survival probabilities. Expected future incomes are predicted from the observed incomes of the cross section of individuals. An advantage of this method is that it allows to estimate human capital even for those households who report no income (398 out of 19,165 in the sample, 0.91% considering the sampling weights).

Income arises from a process depending on several characteristics of the head, in particular gender (male, female), race (white, non-white) and education (high school or lower, college). We denote the realization of these three variables by group $x \in X$. The combination of the three variables gives rise to eight possible groups.

We describe human capital for household *i* at time *t*, whose head is aged *a* and belongs to group *x*, as follows:

$$HC_{it}^{a}\left(x\right)=y_{it}^{a}\left(x\right)+LI_{it}^{a}\left(x\right)$$

where $y_{it}^{a}\left(x\right)$ is the gross income reported in the survey for the household head and spouse (if any), and $LI_{it}^{a}\left(x\right)$ is imputed household lifetime gross income.[12] This measure is estimated from predictions of future income realizations, and it is defined as follows:

$$LI_{it}^{a}\left(x\right)=\sum_{b=a+1}^{T}\pi_{it}^{a,b}\left(x\right)y_{it}^{b}\left(x\right)\left(\frac{1}{1+r_t}\right)^{b-a}.$$

[12] On average in our data, gross income is around 4-5% of human capital.

That is, lifetime income is the sum of the predicted income levels, $y_{it}^{b}\left(x\right)$, conditional on age *b* and group *x*, weighted by a survival probability $\pi_{it}^{a,b}\left(x\right)$ of being alive at age *b* conditional of being alive at age *a* and time *t*, for individual *i* belonging to group *x*[13], and corrected by a discount rate $(1+r_t)$, computed as average over the 20 years before *t* of real risk free returns (3-month T-bill yields net of CPI growth).[14]

Income predictions up to age 64 are derived from the OLS regression of the logarithm of one plus income over a third-order polynomial on age, gender and race dummies, cohort dummies and time dummies respecting the Deaton-Paxson orthogonality constraints. Income predictions since age 65 are the income prediction at age 64 times a replacement rate. The rate is given by the ratio of average observed income between 65 and 69 to average observed income between 60 and 64, and it is computed separately by education groups. In all the cases we take into account imputations and sampling weights. For households with head older than 64, predicted income is the income predicted for their class times the replacement rate.

We estimate the regression and the replacement rate[15] from the waves 1995-2007 of the SCF dataset described in Section 4.1, separately for each imputation and for each education group. As one may expect, projected income is higher for households with a male, white and more highly educated head.

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[13] Actually, in our calculation survival probabilities differ by gender and not also by race or education, because no such data are available.

[14] This shows a decline from 5.96% of 1995 to 3.62% of 2007.

[15] We estimate an average replacement rate of 88.88% for high school graduates, and 71.95% for college graduates; we do not compute the replacement rate separately also by race and gender for sake of simplicity, as only education seems to matter.

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Table 1. Alternative risk bearing indicators

Measure	Portfolio		Features	Information required
Stock share	Financial	(+) (-)	Simple to compute Other assets are risky too	Financial portfolio share in stocks
Standard deviation	Financial	(+) (-)	Comprehensive measure of financial portfolio risk Other non-financial assets are risky too	All financial portfolio shares; Standard deviation and covariances of financial asset excess returns
Standard deviation	Complete	(+) (-)	Comprehensive measure of financial and non-financial portfolio risk Ignore risk-return trade-off	All financial and non-financial portfolio shares; Standard deviation and covariances of financial and non-financial asset excess returns
Risk tolerance	Complete	(+) (-)	Trade-off between risk and return Assumes that agents are mean-variance optimizers	All financial and non-financial portfolio shares; Mean, standard deviation and covariances of financial and non-financial asset excess returns

Note. (+): advantage; (-): disadvantage

Table 2. Portfolio weights and portfolio composition (%)

Category	SCF 1998	SCF 2001	SCF 2004	SCF 2007
Checking accounts	0.454	0.475	0.441	0.363
Savings and money market accounts	0.256	0.377	0.653	0.617
Call accounts at brokerages	0.116	0.138	0.093	0.076
IRA-KEOGH accounts	*0.212*	*0.232*	*0.175*	*0.186*
Retirement accounts	*0.449*	*0.463*	*1.130*	*1.202*
Annuities	*0.042*	*0.065*	*0.176*	*0.105*
Trust-managed accounts	*0.114*	*0.311*	*0.418*	*0.138*
DEPOSITS	**1.642**	**2.061**	**3.086**	**2.689**
Certificates of deposits	0.395	0.302	0.289	0.331
Savings bonds	0.071	0.069	0.052	0.039
Directly held govt. bonds	0.362	0.441	0.386	0.316
Directly held corp. bonds	0.136	0.080	0.106	0.055
Tax free mutual funds	0.179	0.198	0.128	0.212
Govt. bond mutual funds	0.050	0.036	0.038	0.063
Other bond mutual funds	0.118	0.041	0.087	0.067
½ Balanced mutual funds	0.048	0.065	0.051	0.063
½ Other mutual funds	0.001	0.000	0.051	0.071
Life insurances (cash value)	0.704	0.599	0.285	0.309
Loans on primary residence (-)	-2.567	-2.286	-2.704	-2.863
Loans on other real estate (-)	-0.650	-0.451	-0.785	-0.822
Loans on business (-)	-0.115	-0.118	-0.133	-0.147
IRA-KEOGH accounts	*0.274*	*0.371*	*0.477*	*0.490*
Retirement accounts	*0*	*0.000*	*0.002*	*0.000*
Annuities	*0.072*	*0.016*	*0.001*	*0.002*
Trust-managed accounts	*0.173*	*0.003*	*0.006*	*0.007*
BONDS	**-0.749**	**-0.634**	**-1.664**	**-1.807**
Directly held stocks	2.388	2.334	1.703	1.685
Stock mutual funds	0.916	0.929	0.948	0.976
½ Balanced mutual funds	0.048	0.065	0.051	0.063
½ Other mutual funds	0.001	0.000	0.051	0.071
IRA-KEOGH accounts	*1.175*	*1.285*	*0.934*	*0.957*
Retirement accounts	*0.994*	*1.163*	*0.644*	*0.669*
Annuities	*0.094*	*0.139*	*0.102*	*0.121*
Trust-managed accounts	*0.318*	*0.629*	*0.249*	*0.202*
STOCKS	**5.936**	**6.545**	**4.678**	**4.743**
BUSINESS WEALTH	**4.372**	**4.364**	**4.431**	**5.372**
Owner-occupied primary residence	7.415	7.417	8.774	9.341
Other real estate	2.683	2.704	3.301	3.395
IRA-KEOGH accounts	*0.028*	*0*	*0*	*0*
Retirement accounts	*0.015*	*0.005*	*0*	*0*
Annuities	*0*	*0*	*0*	*0*
Trust-managed accounts	*0.066*	*0.041*	*0*	*0*
REAL ESTATE	**10.206**	**10.167**	**12.075**	**12.736**
Labor human capital	63.870	61.412	59.256	57.301
Pension human capital	14.723	16.085	18.138	18.966
HUMAN CAPITAL	**78.593**	**77.497**	**77.394**	**76.267**
Number of observations	3607	3768	3906	3783

Note. The definition of financial portfolio considers only the assets in the deposits, bonds and stocks categories; all liabilities (mortgages, lines of credit and loans) are excluded.

Table 3. Risk and expected asset returns (%)

Wave	1998	2001	2004	2007
Risk free return	7.046	5.964	4.736	4.398
Bond excess return	3.223	4.905	4.742	3.237
	(9.584)	(7.966)	(6.687)	(5.308)
Stock excess return	6.830	6.985	6.987	5.470
	(16.170)	(17.075)	(16.800)	(16.035)
Business wealth excess return	0.034	1.710	2.152	2.092
	(7.907)	(6.441)	(4.671)	(4.593)
Real wealth excess return	2.731	3.363	5.006	5.181
	(3.057)	(2.759)	(3.072)	(3.522)
Human wealth excess return	-0.144	0.299	1.075	1.266
	(2.420)	(2.207)	(1.954)	(1.914)

Note. Standard deviation of excess returns in parentheses.

Table 4. Summary statistics (× 100)

Wave		1998	2001	2004	2007
Aggregate portfolio					
Stock share	Financial portfolio	58.421	60.451	48.117	50.159
Standard deviation	Financial portfolio	10.875	10.913	8.293	8.085
Standard deviation	Complete portfolio	1.488	1.280	0.718	0.791
Risk tolerance	Complete portfolio	3.765	9.379	4.803	4.669
Household portfolio (median)					
Stock share	Financial portfolio	22.642	32.434	5.350	4.025
Standard deviation	Financial portfolio	8.385	7.784	3.550	2.941
Standard deviation	Complete portfolio	0.680	0.532	0.261	0.249
Risk tolerance	Complete portfolio	1.814	2.974	0.798	0.428

Table 5. Heterogeneity of risk bearing

Quantile regression	Financial portfolio		Complete portfolio	
	Stock share	**Standard deviation**	**Standard deviation**	**Risk tolerance**
Ln(financial wealth/1000)	0.362***	0.201***	0.225***	0.310***
	(0.014)	(0.005)	(0.005)	(0.008)
(Income/	0.164***	0.076***	0.185***	0.205***
financial wealth)/1000	(0.030)	(0.012)	(0.011)	(0.030)
(Net real and business wealth/	0.004	0.003	-0.007*	-0.001
financial wealth)/1000	(0.010)	(0.004)	(0.004)	(0.006)
(Debt/	-8.566***	-3.745***	5.345***	1.274
financial wealth)/1000	(1.700)	(0.649)	(0.642)	(0.958)
Non-white	-0.276***	-0.101***	0.015	0.014
	(0.081)	(0.026)	(0.024)	(0.038)
Female	-0.068	0.011	0.229***	0.261***
	(0.099)	(0.033)	(0.031)	(0.047)
College graduate	0.555***	0.019	0.058**	0.166***
	(0.066)	(0.024)	(0.021)	(0.035)
Married	-0.108	-0.043	-0.025	-0.005
	(0.089)	(0.030)	(0.030)	(0.044)
N. household members	-0.022	-0.003	0.004	0.028
	(0.033)	(0.012)	(0.011)	(0.017)
With children	-0.033	-0.004	-0.037	-0.045
	(0.086)	(0.033)	(0.028)	(0.043)
Self-employed	-0.317***	-0.118***	0.113***	0.107**
	(0.080)	(0.033)	(0.026)	(0.039)
Retired	-0.033	-0.047	0.146***	0.039
	(0.107)	(0.041)	(0.041)	(0.062)
N. financial institutions	0.158***	0.022***	0.019***	0.070***
where doing business	(0.015)	(0.005)	(0.004)	(0.008)
With financial advisor	0.062	0.007	0.054**	0.038
	(0.062)	(0.022)	(0.020)	(0.031)
Works in finance sector	0.342***	0.126***	0.081**	0.105*
	(0.102)	(0.033)	(0.029)	(0.050)
Self-assessed good health	0.224***	0.018	0.066***	0.114***
	(0.065)	(0.024)	(0.019)	(0.032)
Time effect	0.796**	1.387***	2.921***	0.394**
	(0.280)	(0.111)	(0.101)	(0.150)
Cohort effect	0.008	0.005*	0.009***	0.012***
	(0.006)	(0.002)	(0.002)	(0.003)

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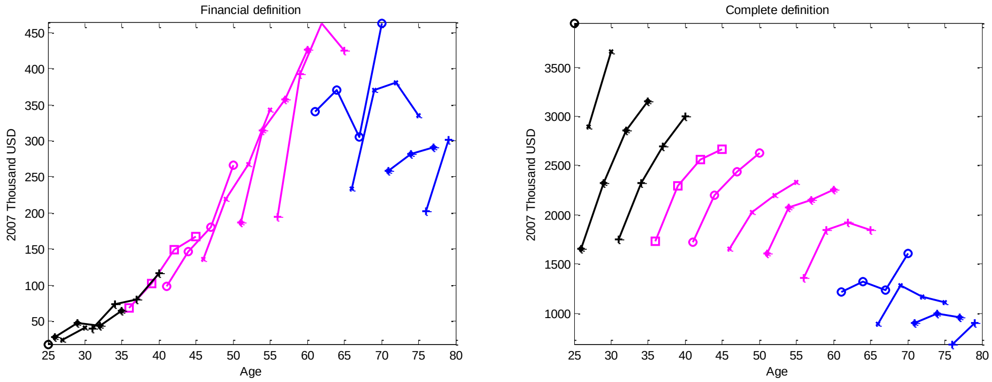
Age 30-34	0.132	0.085	-0.091**	-0.072
	(0.130)	(0.051)	(0.042)	(0.065)
Age 35-39	0.286**	0.128**	-0.030	0.058
	(0.120)	(0.047)	(0.041)	(0.062)
Age 40-44	0.229*	0.109**	0.051	0.189**
	(0.120)	(0.049)	(0.041)	(0.061)
Age 45-49	0.165	0.096*	0.184***	0.336***
	(0.124)	(0.051)	(0.043)	(0.064)
Age 50-54	0.068	0.066	0.177***	0.340***
	(0.136)	(0.053)	(0.048)	(0.068)
Age 55-59	0.202	0.062	0.332***	0.507***
	(0.131)	(0.051)	(0.046)	(0.068)
Age 60-64	-0.171	-0.038	0.327***	0.487***
	(0.142)	(0.054)	(0.052)	(0.076)
Age 65-69	-0.244	-0.074	0.362***	0.514***
	(0.154)	(0.059)	(0.062)	(0.091)
Age 70-74	-0.635***	-0.112*	0.380***	0.371***
	(0.172)	(0.064)	(0.071)	(0.088)
Age 75-79	-0.413**	-0.045	0.427***	0.571***
	(0.191)	(0.076)	(0.067)	(0.103)
Constant	-0.162	0.136***	-0.143***	-0.368***
	(0.134)	(0.048)	(0.047)	(0.071)
Observations	14624	14624	14624	14624
Minimum degrees of freedom	16.9	25.8	26.6	7.3
Median dep. var. (x 100)	12.572	5.729	0.476	1.454

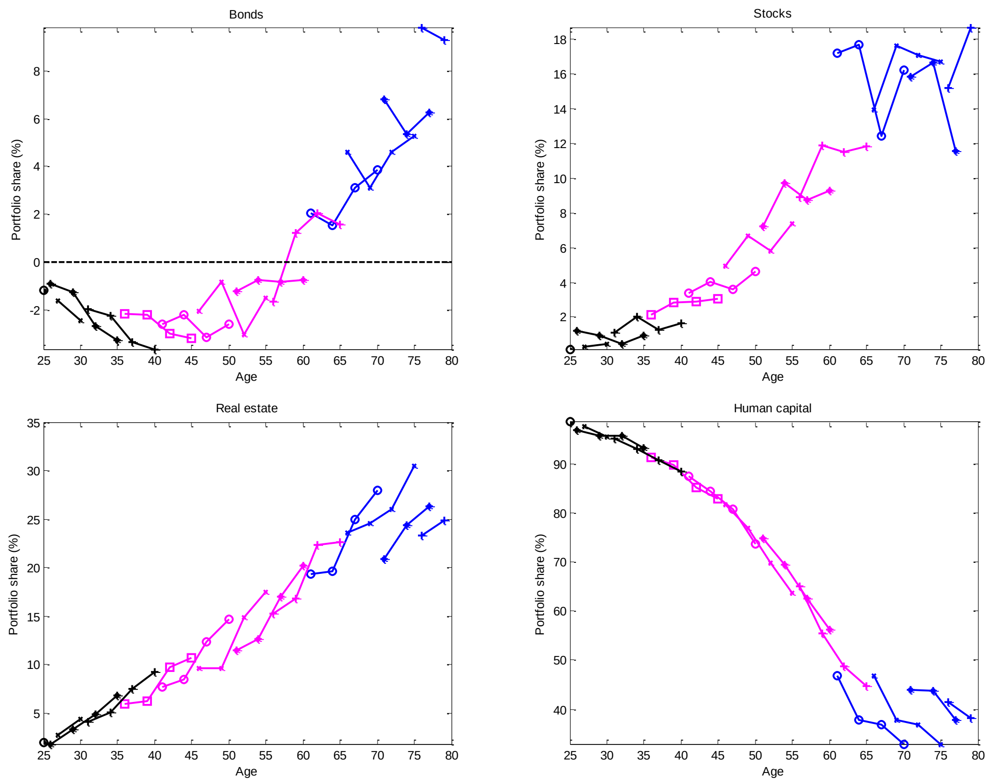
*Note. The dependent variable is rescaled by its median in the sample. Time effect: average market excess return in the three years prior to the wave. Cohort effect: average market excess return when 20-24 years old. Age effects: dummy variables covering a five-year age range. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.*

Figure 1. Cohort wealth size by age



Note. The definition of cohort includes all those born in a 5-year range.

Figure 2. Cohort portfolio holdings by age



Note. Conditional portfolio weights are derived as in equation (1). The definition of cohort includes all those born in a 5-year range.

Figure 3. Rolling excess return

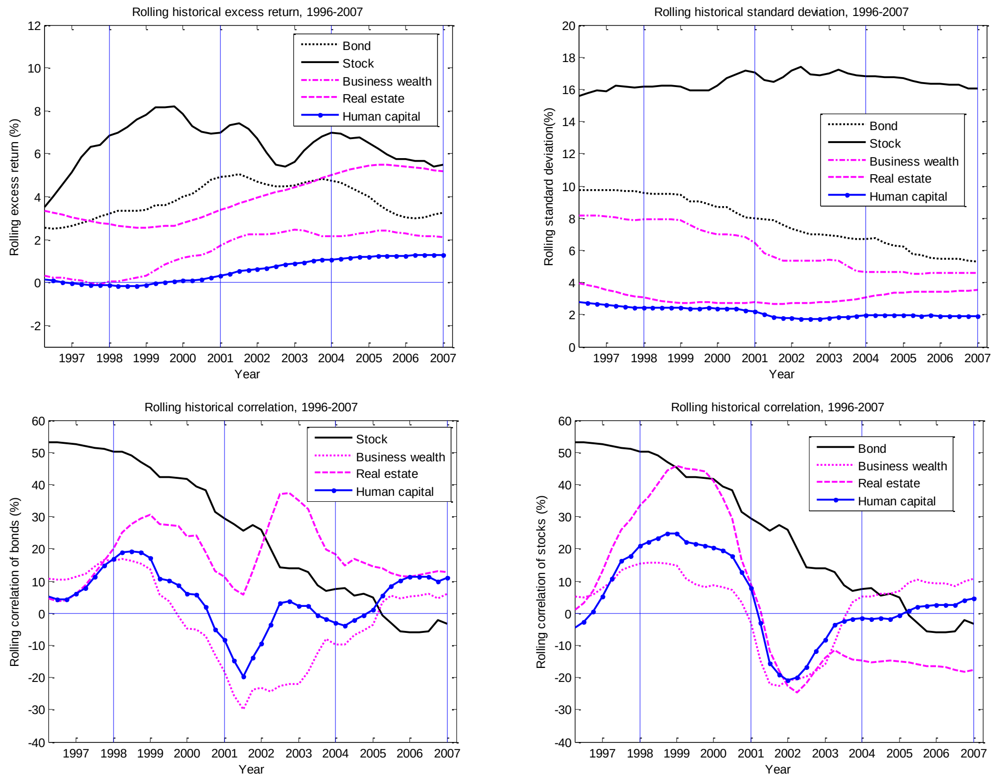


Figure 4. Household portfolios in the MV space

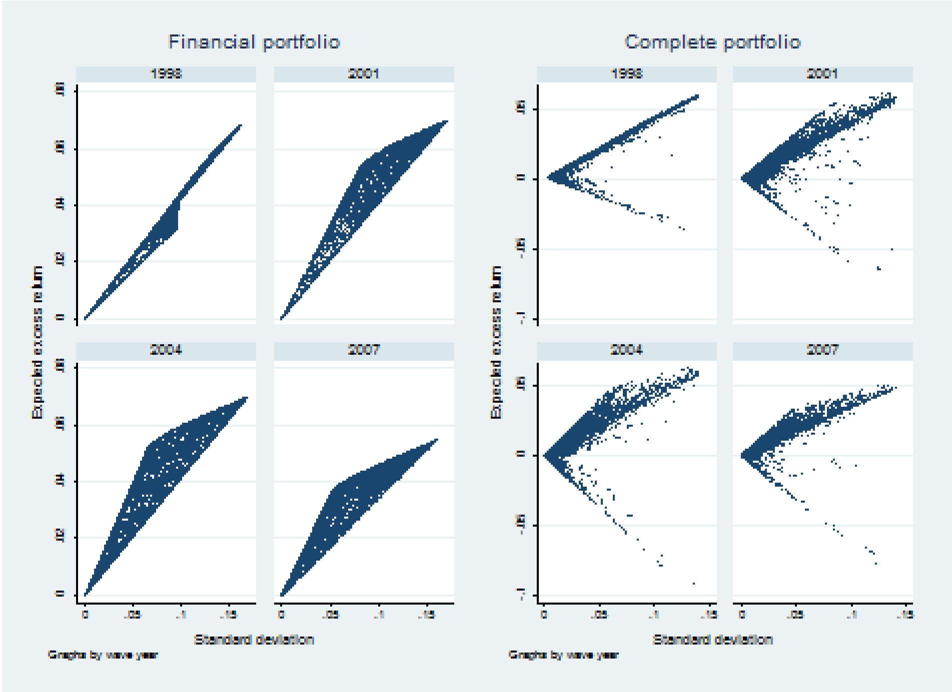


Figure 5. Empirical cdf of risk bearing

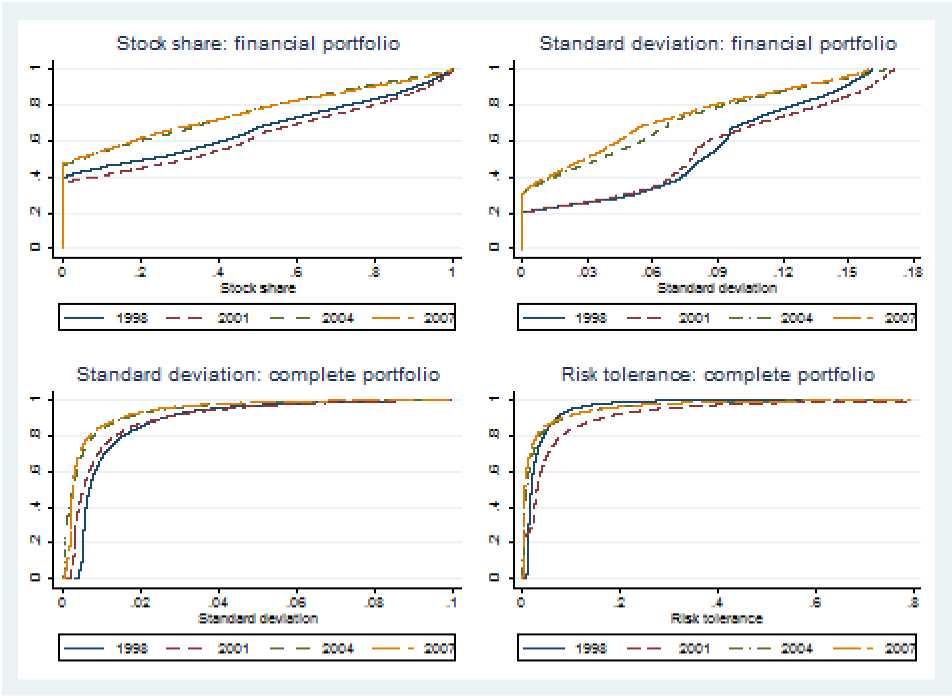
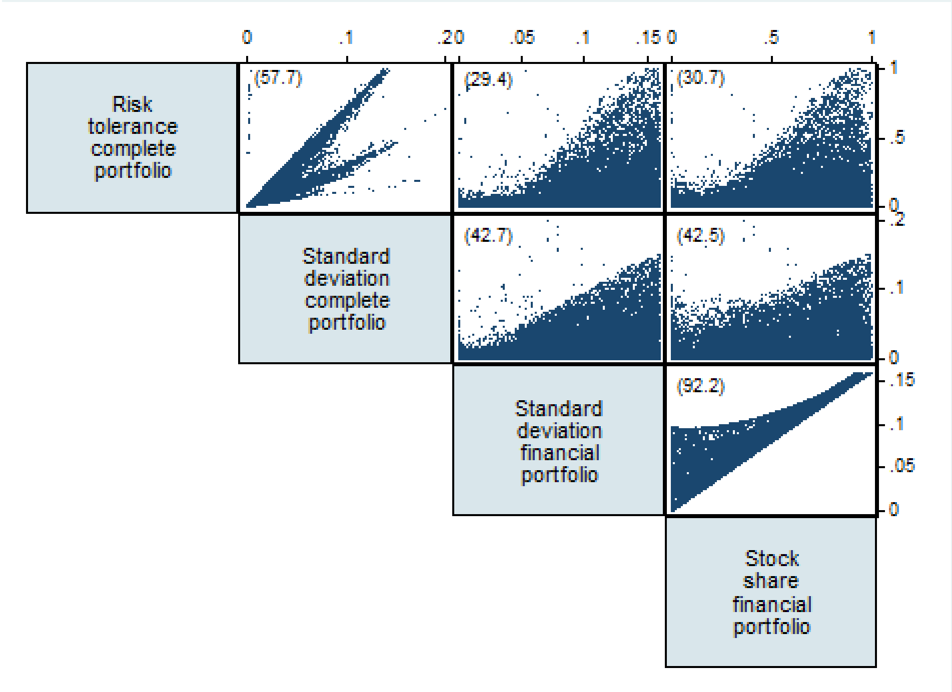
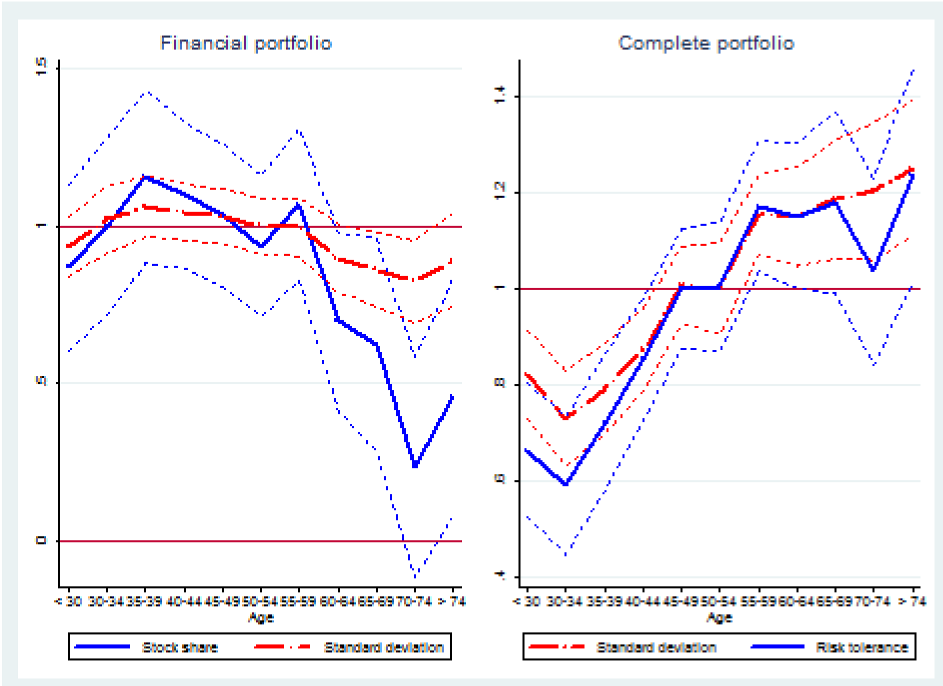


Figure 6. Correlations among risk bearing indicators



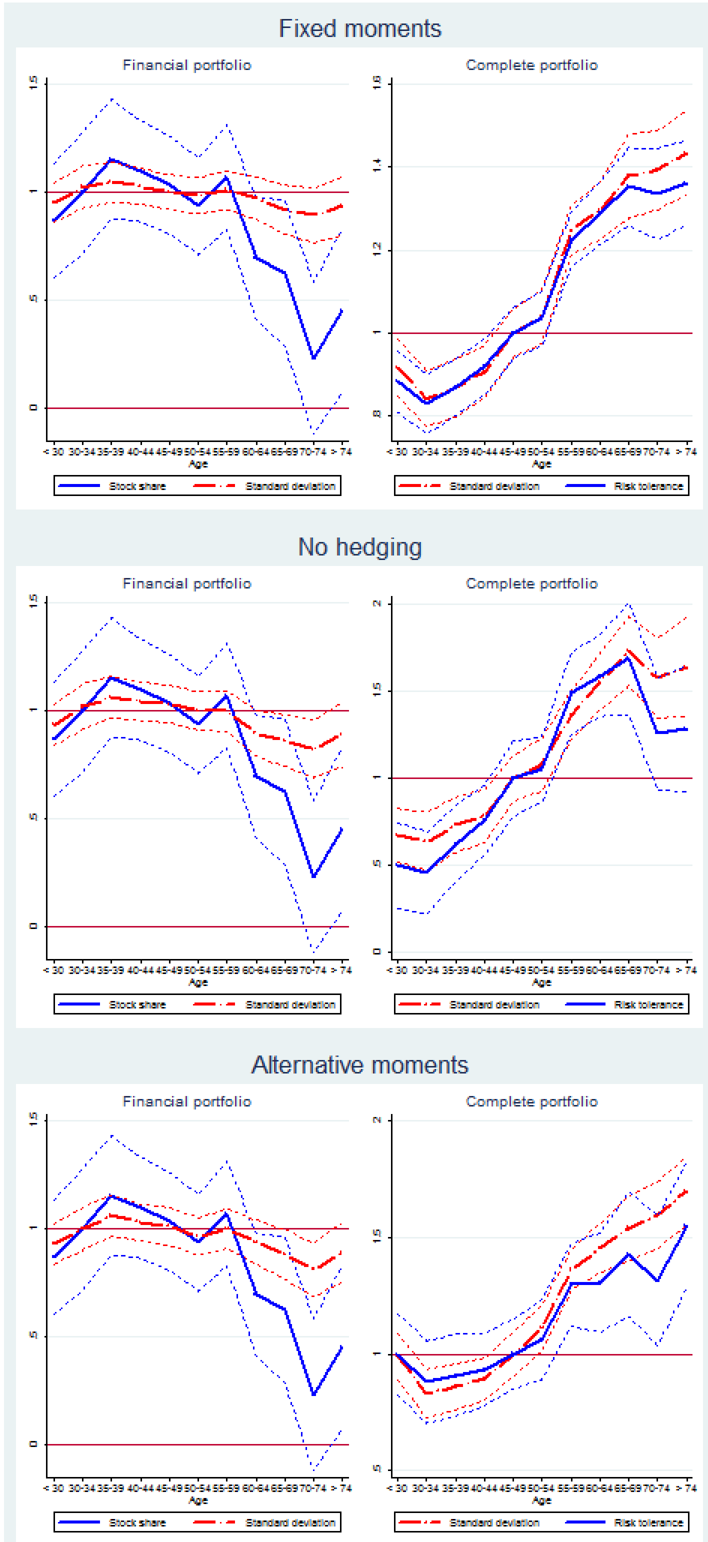
Note. Average percentage correlation by wave within parentheses.

Figure 7. Age profile of risk bearing



Note. In each curve, the age profile is reported as a ratio to the median risk bearing indicator in the sample. The dashed lines report a 95% confidence interval.

Figure 8. Age profile of risk bearing: robustness check



Note. In each curve, the age profile is reported as a ratio to the median risk bearing indicator in the sample. The dashed lines report a 95% confidence interval.