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Individual Risk Attitudes and the Composition of Financial Portfolios: Evidence from German Household Portfolios*

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INDIVIDUAL RISK ATTITUDES AND THE COMPOSITION OF FINANCIAL PORTFOLIOS:
EVIDENCE FROM GERMAN HOUSEHOLD PORTFOLIOS

Abstract

This paper explores the relationship between the self-declared risk aversion of private investors and their propensity to hold incomplete portfolios of financial assets. The analysis is based on household survey data from the German Socioeconomic Panel (SOEP) that provides a reliable measure of individual attitudes toward financial risk. Our findings suggest that more risk averse households tend to hold incomplete portfolios consisting mainly of a few risk-free assets. We also find that the propensity to acquire additional assets is highly dependent on whether liquidity and safety needs are met.

JEL: D14, G11

Keywords: private households, portfolio diversification, risk aversion

1 Introduction

According to modern portfolio theory and the capital asset pricing model (CAPM), investors should allocate their financial wealth across all assets available in the market, leading to diversified portfolios. However, numerous empirical studies find that portfolio composition varies significantly across investors and that a large portion of private investors hold under-diversified portfolios comprised of only a small subset of available assets (Hochguertel et al., 1997; King and Leape, 1998; Börsch-Supan and Eymann, 2000; Burton, 2001; Campbell, 2006; Yunker and Melkumian, 2010).

The literature offers a number of explanations for the incidence of under-diversified portfolios. Specifically, it is conjectured that high transaction and search costs (King and Leape, 1987; Merton, 1987), preferential tax treatment of certain assets (King and Leape, 1998), lack of information about investment opportunities (King and Leape, 1987), and investors' lack of financial sophistication (Goetzmann and Kumar, 2008) all result in portfolio under-diversification. Empirical tests prove that these factors do indeed play an important role in portfolio composition decisions, but they do not fully explain the differences in portfolio composition and the high incidence of under-diversified portfolios. For instance, it is hard to imagine that it is transaction costs that lead rich people to have under-diversified portfolios or that lack of information affects the portfolio choices of experienced and sophisticated investors.

In this paper we consider that, in addition to the factors mentioned above, investors' propensity to hold incomplete portfolios is strongly affected by another factor, namely, individual risk attitude. Risk aversion influences investors' preference for a specific portfolio composition because the level of portfolio risk depends on its composition. The direction of the relationship between risk aversion and willingness to hold an incomplete portfolio depends on the composition of the portfolio. For instance, if an incomplete portfolio is comprised of a single or very few risky assets, the preference for such a portfolio should be negatively related to the investor's risk aversion. The negative relationship should emerge because investors can reduce the risk by allocating wealth among a larger

number of assets (Markowitz, 1952). A positive relationship between risk aversion and willingness to hold an incomplete portfolio should emerge if the portfolio is comprised of only risk-free assets. In this case, adding more assets implies investing in risky assets, which results in higher portfolio risk. Hence, the effect of risk aversion depends on what assets are combined in a portfolio. Several empirical studies have included risk attitude as an explanatory variable in their models of explaining portfolio composition (King and Leape, 1987, 1998; Kelly, 1995). However, these studies do not discuss the effect risk attitude has on the probability of holding a particular combination of assets.

Our study takes a closer look at the relationship between investors' risk attitude and portfolio composition. The analysis is based on data on the asset holdings of German households collected by the German Socioeconomic Panel (SOEP). In the literature, the term "portfolio composition" usually refers to two types of decisions: (1) the ownership decision, i.e., what kinds of assets to own, and (2) the allocation decision, i.e., what portion of wealth to allocate to each of these assets. Our data do not provide information about the amounts invested in the individual assets and thus we analyze only one aspect of portfolio composition: the ownership of different assets. We ask: Given a certain risk attitude, what combination of different asset types do household heads tend to hold in their portfolio?

Specifically, we relate individuals' attitudes toward financial risks to their propensity to hold various combinations of six broad classes of financial assets: saving deposits, mortgage savings plans, fixed-interest securities, shares of listed companies, and equity of non-listed firms. Portfolio composition is measured two ways. The first measure is the number of distinct asset types held in a portfolio. Despite its simplicity, this measure reflects the decisions of individuals who follow a "naive" diversification strategy of "not putting all their eggs in one basket." Such a strategy is often engaged by nonprofessional investors who split their wealth evenly among all available assets types, hoping that this will reduce the risk of the entire portfolio (Benartzi and Thaler, 2001). The second measure of portfolio composition is designed to capture more sophisticated investment strategies. A sophisticated investor differentiates assets according to their return and risk properties

and thereby assigns them to different “return-risk” classes. Based on this classification, the investor then decides what combination of assets to hold.

The information about risk attitude that we use is collected in the SOEP survey by asking respondents how willing they are to take financial risks. Dohmen et al. (2005) show that the SOEP survey measure of risk attitude is behaviorally relevant, in the sense that it is predictive of actual risk-taking behavior.¹ The SOEP data also have several other advantages. First, information about the ownership of different asset types allows us to investigate actual portfolio decisions and hence provide more reliable evidence than would be possible in an experimental setting.² Second, the data set includes indicators of who is the main decision-maker in a household and provides detailed socioeconomic information on this individual as well as for the whole household. Third, the survey is conducted yearly and allows tracing individuals and households over time. Finally, a significant advantage of the data is the size of the sample. Even after we drop all observations with missing data and exclude cases where a decision-maker could not be identified, we have a sample of 2,628 individuals observed across four years—2004 to 2007—which amounts to a total of 10,512 observations.

The results of our analysis show that risk aversion has a significant effect on the propensity to hold an incomplete portfolio. Moreover, we find both a positive and a negative relationship effect. To preview our results, we find, as hypothesized, that when assuming that investors follow a naive investment strategy, the probability of holding only one asset type increases with risk aversion. Under the assumption that investors follow a sophisticated investment strategy, a positive relationship between the probability of an incomplete portfolio and risk aversion is found for the portfolio consisting of only risk-free assets.

A negative relationship between risk attitude and an incomplete portfolio is found in only one instance. Specifically, when considering the sophisticated investment strategy, we find that the probability of owning an incomplete portfolio decreases with risk aver-

¹Other studies also demonstrate that self-declared risk attitudes are good predictors of actual investment behavior (Kapteyn and Teppa, 2002; Fellner and Maciejovsky, 2007).

²Vlaev et al. (2008) present evidence that people behave in a more risk-averse manner when investing in real life than when making investment choices in laboratory experiments.

sion if the portfolio consists of only risky assets. Hence, as expected, risk-averse investors dislike incomplete portfolios limited to a subset of risky assets.

Furthermore, the probability of holding a fully diversified portfolio comprised of all asset types available in the market is negatively related to risk aversion. In this case, an incomplete portfolio may be preferred to a diversified portfolio when the latter contains no risky assets at all. This relationship is also found when the analysis is performed on a subsample of relatively wealthy people (i.e., their wealth exceeds the sample median wealth) or on a subsample of the richest people (those whose wealth exceeds the 75th percentile of the sample distribution). Hence, risk attitude affects the propensity to hold an incomplete portfolio independently of wealth.

We also find that the majority of under-diversified portfolios consist of safe assets only. This observation sheds some light on the reasons behind the negative relationship between risk aversion and willingness to hold a fully diversified portfolio. As argued by Keynes (1936), the economic activity of private households is dominated by safety and liquidity concerns. For an average household that is credit constrained, financial wealth works as a “safety buffer” against periods of low income. Since asset holdings are intended to provide safety in the first place, adding risky assets to a portfolio can be viewed as adding more risk and reducing the safety buffer. Thus, the tendency to view asset holdings as a safety buffer should be positively related to a decision-maker’s risk aversion and, indeed, this is exactly what we discover. We find that the more risk averse an investor, the more he or she will be inclined to hold an incomplete portfolio consisting of a few safe assets. Furthermore, when regressing the number of risky assets held in a portfolio on the holdings of safe assets, we find a positive effect of the number of safe assets on the number of risky assets. Hence, a decision-maker is more likely to add some risky assets to his or her portfolio when safety needs have been met.

Thus, due to the important role precautionary motives play in the portfolio decisions of private households and the positive relationship between risk aversion and accumulation of safe assets, risk aversion is positively correlated with holding an incomplete portfolio.

For this reason, individual risk attitude should be considered as an important factor in explaining differences in portfolio composition among households and the high incidence of under-diversified portfolios.

The remainder of the paper is organized as follows. In the next section, we review the literature on the role of risk aversion in portfolio diversification. The third section describes our data and provides more details on the portfolio diversification measures. The fourth section presents the indicator of individual risk aversion. In the fifth section, we test the main hypothesis and discuss the results. In Section 6, we analyze the role precautionary motives play in diversification, followed by a concluding last section.

2 Literature Review

Academic research into determinants of portfolio diversification dates back to Markowitz's (1952) mean-variance analysis. Markowitz develops a model that explains how investors select assets if they care only about the mean and variance of portfolio returns. One of the model's implications is that investors with high risk aversion prefer diversified portfolios with moderate expected returns to undiversified portfolios with high expected returns because diversification reduces the portfolio risk associated with variance of returns on individual assets. However, the capital assets pricing model (CAPM), which is derived from Markovitz's mean-variance analysis, does not predict any relationship between risk aversion and level of diversification. This model conjectures that investors should hold diversified portfolios regardless of their degree of risk aversion, and the investor's willingness to take risk is determinative only for the fraction of risky assets in the portfolio.

Despite the predictions of CAPM, numerous empirical studies show that investors – and especially private households – often hold incomplete portfolios consisting of a few risk-free assets (Hochguertel et al., 1997; King and Leape, 1998; Börsch-Supan and Eyermann, 2000; Burton, 2001; Campbell, 2006; Yunker and Melkumian, 2010). A great deal of empirical work is aimed at understanding why so many private investors hold under-diversified portfolios (Blume and Friend, 1975; Kelly, 1995; King and Leape, 1998; Benartzi

and Thaler, 2001; Campbell et al., 2003; Gomes and Michaelides, 2005; Polkovnichenko, 2005; Goetzmann and Kumar, 2008). However, only a few scholars analyze how risk aversion is related to portfolio holdings.

A theoretical study by Campbell et al. (2003) shows that the probability of holding multiple assets might be a hump-shaped function of risk aversion. Specifically, individuals with intermediate levels of risk aversion are predicted to hold multiple assets, including risky investments. In contrast, both extremely risk-averse and risk-loving investors should hold less diversified portfolios. The researchers explain this idea by noting that some risky assets can be used to hedge against fluctuations in their own future returns. This hedging feature should be attractive for investors with intermediate levels of risk aversion, thus forming the middle of the demand “hump”. On the slopes of the hump are the very conservative investors, who tend to avoid any risk, and the extremely risk tolerant investors, who have little interest in intertemporal hedging. Therefore, very risk averse investors should choose to hold under-diversified portfolios consisting mainly of safe assets; extremely risk-loving investors should hold under-diversified portfolios too, but their portfolios will contain only risky assets. Finally, investors with moderate risk aversion are expected to hold the most diversified portfolios consisting of all available assets.

Gomes and Michaelides (2005) formulate a model of intertemporal portfolio choice explaining preferences for two portfolio types: a portfolio comprised of a risk free asset and a risky one, and a portfolio comprised of a risk-free asset only. The results of the analysis imply that the probability of owning both types of assets is an increasing function of risk aversion. The explanation given for this relationship is that risk-averse investors are more prudent money managers and thus more likely to accumulate wealth than are their risk-loving counterparts. The availability of considerable financial resources in turn motivates investors to acquire additional assets. Risk-prone investors, in contrast, tend to accumulate very little wealth and thus most of them do not have enough means to cover the fixed costs of market participation and hence hold only a risk-free asset.

There is very little empirical evidence on how risk attitudes affect ownership of particular asset combinations. Kelly (1995) uses data from the 1983 Survey of Consumer Finances to assess the level of diversification in the financial portfolios of U.S. households. Diversification is measured in terms of the number of distinct stocks held in a portfolio. While controlling for a large number of investor characteristics, the author finds a negative effect of risk aversion on the number of stocks held in the portfolios of wealthy people. King and Leape (1987, 1998) also find evidence of a negative relationship between risk aversion and holding a mix of different assets. Yet, none of these studies discusses why risk attitude matters in this instance or why the relationship is negative.

As the above literature survey demonstrates, theoretical models of portfolio decision making are in disagreement as to the relationship between risk aversion and diversification. Furthermore, empirical evidence on the issue is scarce. This paper contributes to the literature by examining the effects of risk aversion using micro-level data from the SOEP survey.

3 Evidence on Household Portfolios from the SOEP

3.1 The Data Set

Our analysis is based on a sample of 2,628 individuals who participated in four subsequent waves, 2004 through 2007, of the German Socioeconomic Panel (SOEP) survey. The data set is a balanced panel. The unit of observation is the individual, either living alone or as a member of a multi-person household. Most of the socioeconomic data, including the risk attitudes, are collected at the individual level, but the survey also collected detailed information about the household to which the surveyed individuals belongs.

An important question that needs to be addressed in a study of investment behavior has to do with who is making the investment decisions in a multi-person household. To identify the decision-maker we use two indicator variables provided by the SOEP. The first variable indicates who is the household head. The SOEP defines “household head”

as the person with the best knowledge about the conditions under which the household functions. Using this information, we retain only household heads in our sample. The second variable provides information about money management within multi-person households. The exact wording of the survey question is: “How do you and your partner (or spouse) decide what to do with the income that either you or your partner or both of you receive?: (1) Everyone looks after his own money, (2) I look after the money and provide my partner with a share of it, (3) My partner looks after the money and provides me with a share of it, (4) We put the money together and both of us take what we need, (5) We put a share of the money in together, and both of us keep a share of it for ourselves.” Only those individuals who chose either alternative 1 or 2 are retained in our sample. We confine our analysis to these households because in the other cases the decision-maker is not identifiable and, hence, we cannot connect individual risk attitude with portfolio composition decisions. Thus, the sample consists of individuals who are household heads and are primarily responsible for managing the household’s money.

3.2 Ownership of Financial Assets

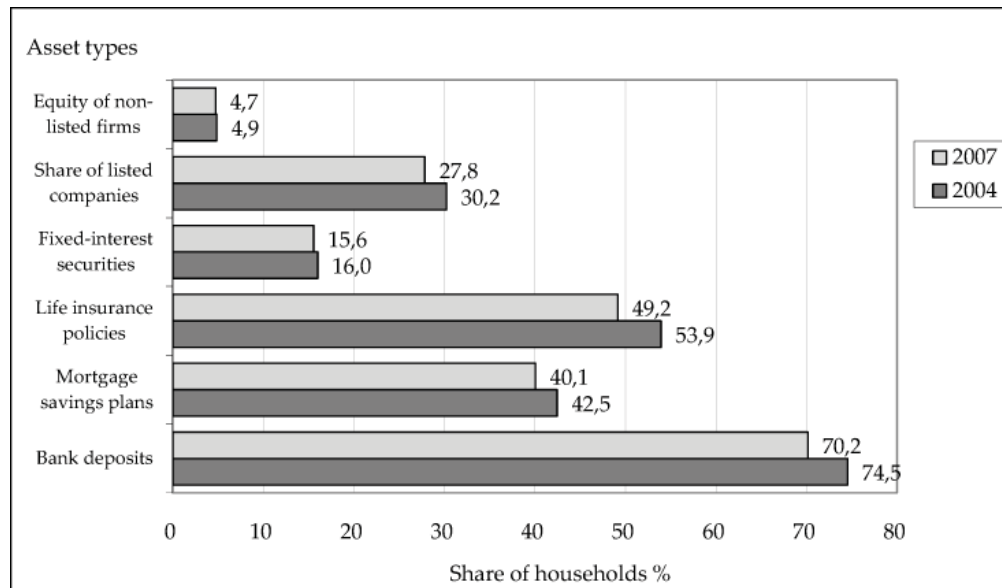
The SOEP survey contains information on whether a household owns any of the following six types of financial assets: bank saving deposits, mortgage savings plans,³ life insurance policies, fixed-interest securities (including federal savings bonds, saving bonds issued by banks, and mortgage-backed bonds), security papers of listed companies (including stocks, bonds, and equity warrants held directly or through mutual funds), and equity of non-listed firms. Information about the amount invested in each asset class is not provided.

Figure 1 documents the fraction of households owning the specified asset types at the beginning and end of the observation period. Bank deposits, life insurance, and mortgage savings plans are the most frequently held types of assets for the private households in our sample. The figures do not change very much over the four years, although a slight

³The German term is “Bausparvertrag”.

decline in ownership of bank deposits and life insurance is observable.

Figure 1: Ownership rates of different asset types in the sample



3.3 Portfolio Composition

Even though portfolio analysis has a long history, there is no common approach to measuring the composition of household portfolios. Empirical studies suggest various methods, depending on the data at hand. Blume and Friend (1975) consider the total number of distinct securities in a portfolio. Goetzmann et al. (2005) correct the total number of financial instruments for the correlation among returns on these instruments in order to account for passive diversification.⁴ The latter measure is well suited for portfolio analysis in the framework of Markowitz's mean-variance approach. However, it requires information about the share of wealth allocated to each individual security, information rarely provided in household surveys.

Most household surveys report which assets are held or, at most, what amounts are invested in broad groups of assets. In addition to the difficulty of obtaining exact financial

⁴Goetzmann et al. (2005) use the term "passive diversification" with regard to investment strategies when correlation between individual assets included in a portfolio is not taken into account and only the number of assets matters.

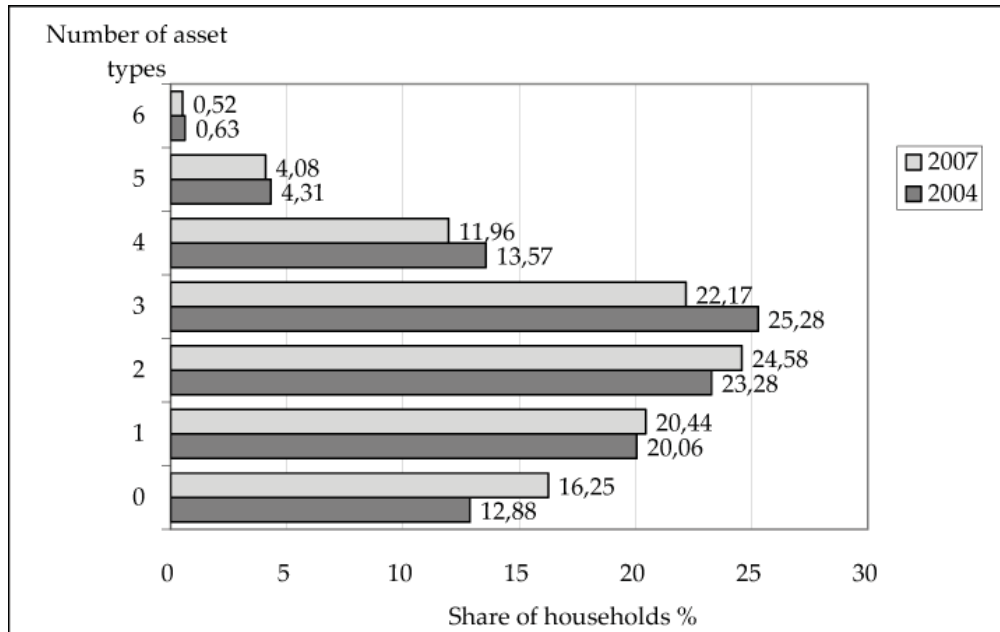
information from private persons, another reason for the usually unspecific information collected is because most households hold very simple portfolios. For example, Campbell (2006) shows that the majority of household financial portfolios in the United States are poorly diversified. Liquid assets (e.g., cash, demand funds) play the dominant role for the poor, while less liquid savings (e.g., savings accounts, life insurance contracts) dominate the portfolios of middle-class households. Carroll (1995) documents a similar pattern of portfolio composition among European households. Moreover, as shown by Benartzi and Thaler (2001); Goetzmann and Kumar (2008); DeMiguel et al. (2009), it is not rare for nonprofessional investors to follow some naive or heuristic diversification strategy, e.g., the *1/n strategy*, according to which investors split their wealth evenly among n available assets.

Taking into account the specific attributes of our data and the tendency of households to hold simple portfolios, we construct two alternative measures of portfolio composition. The first is intended to reflect “naive” investment strategies and the second one to reflect “sophisticated” investment strategies.

3.3.1 Naive Investment Strategy

In the following, the term “naive investment strategy” refers to investment behavior that ignores differences in the risk-return profiles of different asset types, instead relying on a “don’t put all your eggs in one basket” plan of action to diversify risk. Accordingly, a naive household tends to invest in as many asset types as possible. The SOEP data allow identification of six distinct asset types. Figure 2 shows the distribution of individuals in our sample by the number of asset types held. The largest fraction of individuals allocates wealth among two or three asset types; while owners of six-asset-types portfolios make up less than 1 percent of the sample.

Figure 2: Number of asset types held in portfolios



3.3.2 Sophisticated Investment Strategy

Our second measure of portfolio composition is constructed to capture more sophisticated investment patterns. It accounts not only for the number of assets, but also for their degree of risk and combination in a portfolio. The measure is constructed as follows.

The six available asset types are grouped into three classes according to their riskiness: *low risk*, *moderate risk*, and *high risk* (see Table A.1). Because we do not know the returns on each individual asset, defining riskiness according to the mean-variance approach is not possible. Instead, we use a more simple, but feasible, categorization drawing on Blume and Friend (1975) and Börsch-Supan and Eymann (2000).⁵

Under this categorization, bank deposits are deemed to be clearly safe because their returns exhibit no variation and they are guaranteed by the financial institution. The returns on fixed-interest assets are also stable; however, the real payoff depends on the duration and on the issuer's rating. Holders of life insurance policies do not bear the risk of losing the entire investment, but the real return upon termination is uncertain and

⁵This approach has also been applied by Alessie et al. (2000), Banks and Smith (2000), Bertaut and Starr-McCluer (2002), Guiso and Jappelli (2000).

can be significantly lower than the expected return. Listed securities and equity of non-listed firms are the most risky, since stock prices and dividends, as well as firm value, are volatile and uncertain. In accordance with the “no free lunch principle,” the lowest expected return is assigned to assets in the *safe class*; *relatively risky assets* are assumed to have moderate expected returns; the highest expected return is assigned to assets in the *risky class*. We assume that the defined asset classes are not perfectly positively correlated.

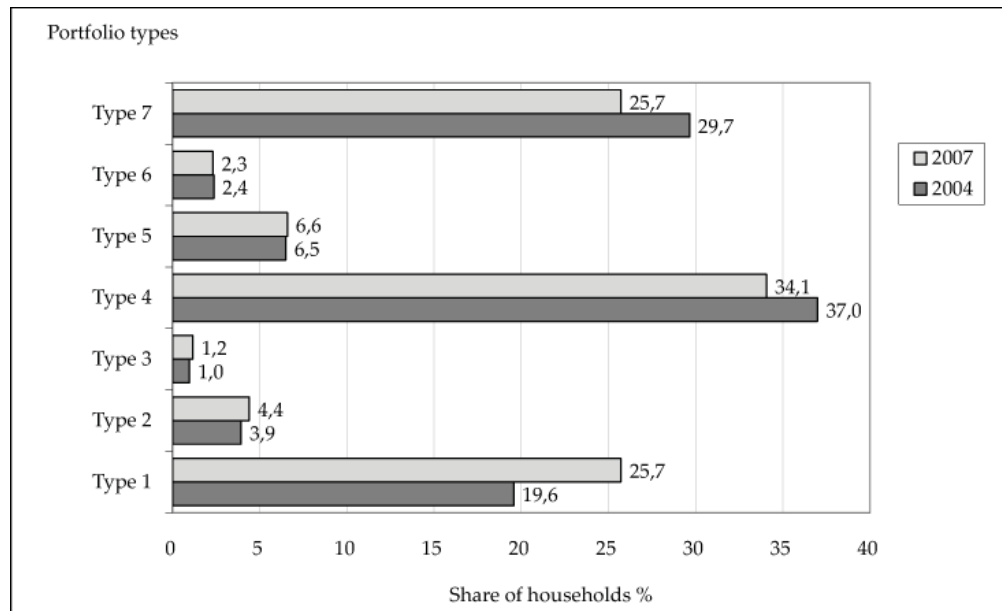
Based on this classification, we define seven portfolio types (Table A.2). A portfolio that consists of assets from only one class, i.e., either safe, relatively risky, or risky, has the least degree of diversification and is referred to as *undiversified*. Depending on what asset type is held, an undiversified portfolio can have low risk (Type 1), moderate risk (Type 2), or high risk (Type 3). A portfolio that includes assets from at least two different classes is referred to as *quite diversified*. Different types of quite diversified portfolios are defined according to the degree of risk of the included asset types: Type 4 includes safe and relatively risky assets, Type 5 consists of safe and risky assets, and Type 6 contains relatively risky and risky assets. Finally, the *fully diversified* portfolio (Type 7) is one that includes assets from all three classes.

The sample distribution with respect to the seven portfolio types (Figure 3) indicates that households have a strong tendency toward safety: most of them hold either incomplete portfolios of safe assets or a mix of safe and relatively risky assets. Individuals who diversify their investments over all three asset classes are also numerous. Owners of portfolios with few risky assets constitute a minority in our sample. Hence, if the risk-return profiles assigned to the six asset types are correct, we can argue that most households choose to forgo higher returns in favor of safety of their investments.

4 Risk Aversion

As a measure of risk aversion, we use individuals’ self-reported attitudes toward financial risks. This information was collected by the SOEP in 2004 by asking respondents to assess the strength of their willingness to take risks when investing money. The exact wording

Figure 3: Distribution of individuals by portfolio types



Type 1: undiversified portfolio of safe assets;
Type 2: undiversified portfolio of relatively risky assets;
Type 3: undiversified portfolio of risky assets;
Type 4: quite diversified portfolio comprised of safe and relatively risky assets;
Type 5: quite diversified portfolio comprised of safe and risky assets;
Type 6: quite diversified portfolio comprised of relatively risky and risky assets;
Type 7: fully diversified portfolio containing assets from all three risk groups.

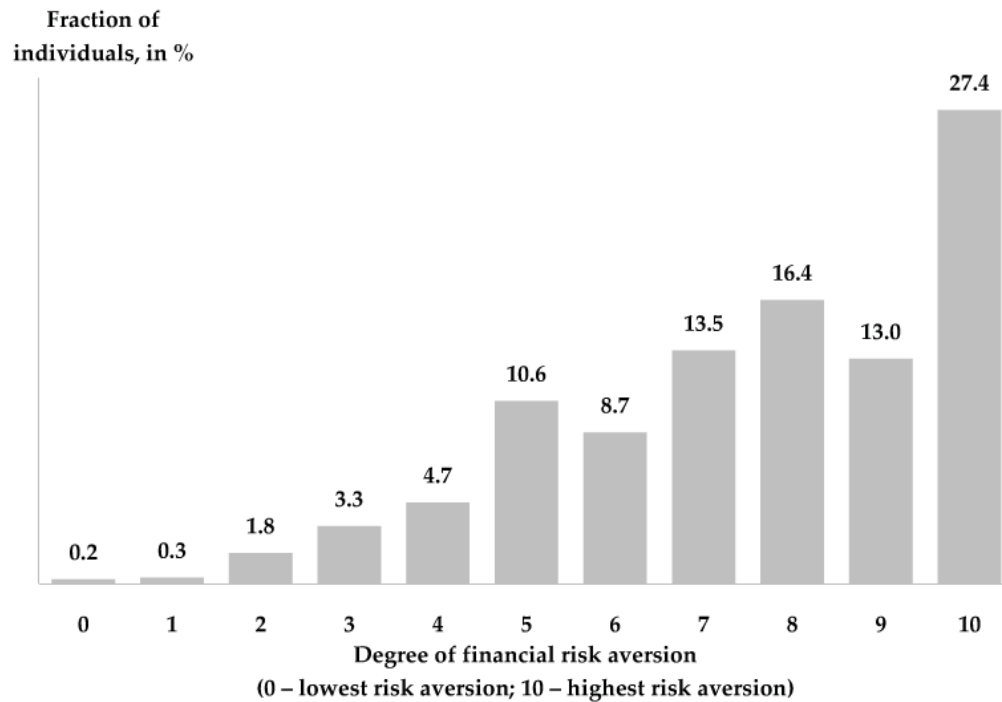
of the SOEP question is: “How would you rate your willingness to take risks in financial matters on a scale from 0 (not willing to take any risks) to 10 (fully prepared to take risks)?” The validity of the individuals’ responses to the question was verified experimentally and it was shown that the self-reported information did in fact reflect the individuals’ attitudes toward financial risks.⁶

Two adjustments are made to the original indicator of risk attitudes to make it suitable for the purposes of our analysis. First, we convert the indicator from a measure of risk tolerance to a measure of risk aversion. This is accomplished by reversing the scale so that higher numbers correspond to higher risk aversion: “0” denotes “fully prepared to take risks,” i.e., the lowest risk aversion, and “10” denotes “not willing to take any risks,” i.e., the highest risk aversion. The new discrete variable that emerges is called *FRA*. Figure 4 presents the sample distribution of individuals according to their level of risk aversion in

⁶For details and discussion of the validity tests, see Dohmen et al. (2005).

2004. Most respondents perceive themselves as highly risk averse.

Figure 4: Distribution of individuals by degree of risk aversion



Because information about risk attitudes is available for only one year, a further adjustment is necessary to make it applicable in a panel-data context. We treat the measure as a time-invariant variable assuming that attitudes toward risk remain stable over the four-year period, which appears to be a reasonable assumption for periods of normal economic conditions.⁷

To paint a preliminary picture of the relationship between risk attitudes and portfolio composition, we conduct a descriptive analysis. For instance, we plot the distribution of risk attitudes for subsamples of investors with distinct portfolio types. First, consider the portfolio types defined according to the naive investment strategy. Figure 5 shows the distribution of risk aversion among investors holding a specified number of distinct asset types. Investors with four, five, and six distinct assets are grouped together because

⁷We acknowledge that this assumption is quite restrictive as the literature does not unanimously support the presumption that risk attitude as an individual trait is time-invariant. For instance, Barsky et al. (1997) provide evidence that risk preferences are relatively stable over time, while El-Sehity et al. (2002) challenge this finding and argue that risk attitudes do vary over time.

the number of those holding more than four asset types is too small to allow a reliable statistical inference. For each of the distributions, we report in Table 1 the mean value of risk aversion, the quartiles of the distribution of risk aversion within the group, and the number of households in the group. We also report the results of a t-test of differences between the mean values of the groups. The groups are compared pairwise, and the respective t-statistics are reported together with p-values.

Figure 5: Distribution of risk aversion by the number of asset types in a portfolio

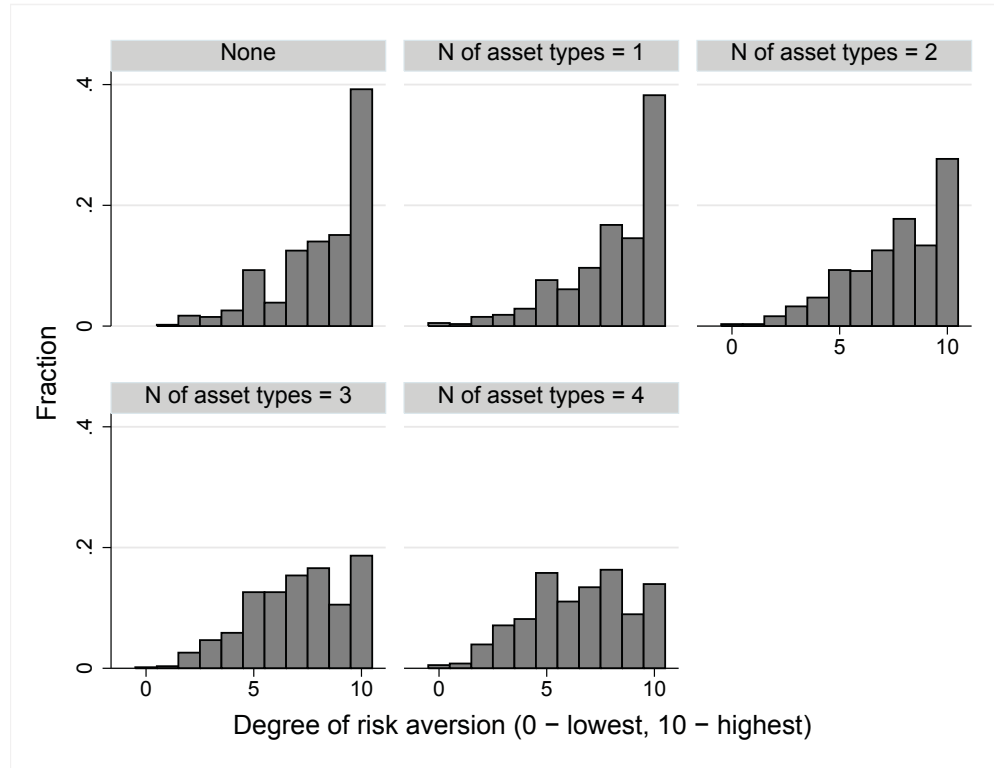


Table 1: Summary of risk aversion in household groups with different number of asset types

Asset holdings	mean	p25	p50	p75	N	t-Test of differences between the groups			
						none	1 asset type	2 asset types	3 asset types
none	8.16	7	9	10	464				
1 asset type	8.10	7	9	10	591	0.44			
2 asset types	7.60	6	8	10	614	4.17***	3.94***		
3 asset types	7.03	5	7	9	579	8.30***	8.29***	4.40***	
≥ 4 asset types	6.52	5	7	8	380	10.61***	10.64***	7.23***	3.35***

Levels of significance: * p-value<0.10, ** p-value<0.05, *** p-value<0.01

Judging from the reported statistics, the more asset types held in a portfolio, the lower the degree of risk aversion reported. The mean degree of risk aversion decreases with each additional asset type, and the differences are statistically significant for each pair of groups except for two: those who hold none of the considered asset types and those who hold only one asset type. Furthermore, the differences between distinct groups are not limited to the mean degree of risk aversion. Figures obtained for the sample quartiles show that the whole distribution of risk attitudes varies across groups. In particular, as the number of assets increases, the distribution is shifted toward the origin of the scale, implying a decreasing fraction of very risk averse people and an increasing fraction of less risk averse people.

Second, consider the portfolio types defined according to the sophisticated investment strategy. The distributions of risk attitudes reported by investors with distinct portfolio types are shown in Figure 6. Table 2 reports the mean degree of risk aversion for each group of investors, the quartiles of the distribution of risk aversion within the groups, and the statistical significance of differences between the group-specific mean values of risk aversion.

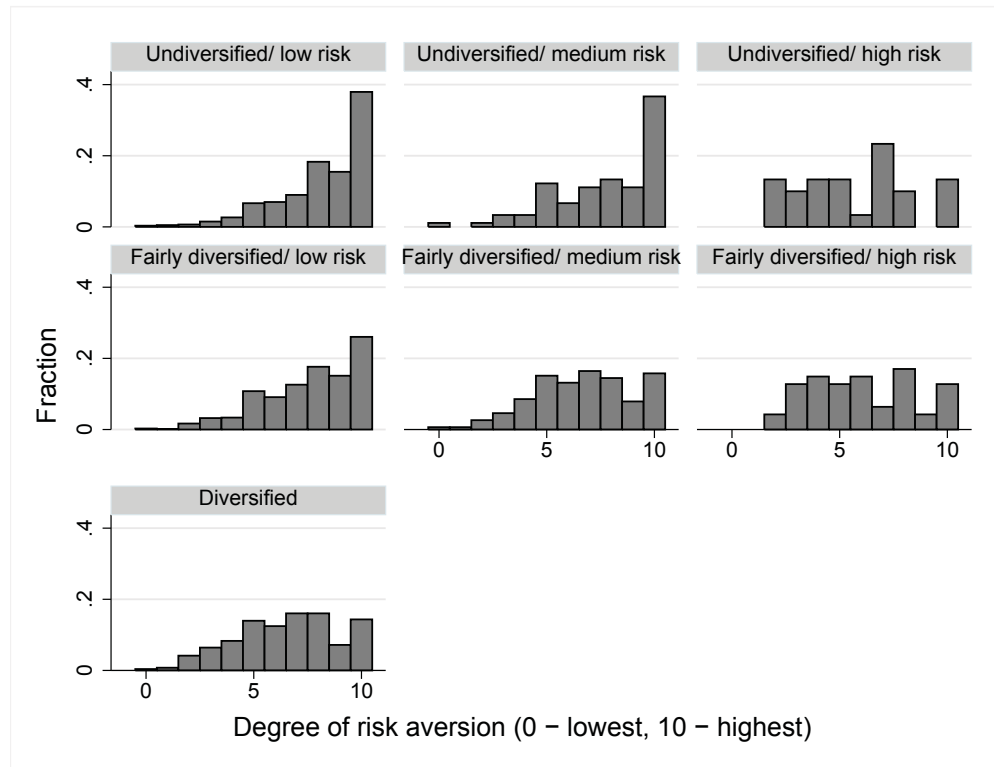
Table 2: Summary of risk aversion in household groups with different portfolio types

Portfolio type		mean	p25	p50	p75	N	t-Test of differences between the groups					
							Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Type 1	Undiversified/low risk	8.20	7	9	10	601						
Type 2	Undiversified/medium risk	7.78	6	8	10	90	1.81*					
Type 3	Undiversified/high risk	5.73	4	6	7	30	6.42***	4.02***				
Type 4	Fairly divers./low risk	7.61	6	8	10	714	5.06***	0.68	-4.61***			
Type 5	Fairly divers./medium risk	6.68	5	7	8	152	8.02***	3.55***	-2.03**	4.74***		
Type 6	Fairly divers./high risk	6.06	4	6	8	47	6.86***	4.01***	-0.57	4.70***	1.60	
Type 7	Diversified	6.55	5	7	8	530	12.75***	4.61***	-1.84*	8.29***	0.65	-1.35

Levels of significance: * p-value<0.10, ** p-value<0.05, *** p-value<0.01

According to the statistics, investors holding distinct portfolio types differ also with regard to their risk attitudes. On average, the highest risk aversion is reported by subjects holding portfolio type 1, comprised of only safe assets. A significantly lower risk aversion is reported by investors holding portfolio type 2, consisting of moderately risky assets. An even lower risk aversion is reported by investors with portfolio type 3, which is comprised

Figure 6: Distribution of risk aversion by number of asset types in a portfolio



of high-risk assets. Subjects holding a mix of safe and moderately risky assets (portfolio type 4) are on average somewhat less risk averse than investors holding only safe assets (portfolio type 2), but they are not significantly different from people holding only moderately risky assets (portfolio type 2) and are significantly more risk averse than owners of portfolio comprised of only highly risky assets (type 3). People with a fairly diversified portfolio containing safe and highly risky assets (portfolio type 5) are on average less risk averse than people with portfolio type 1 (only safe assets), type 2 (only moderately risky assets), or type 4 (a mix of safe and moderately risky assets), but are significantly more risk averse than owners of portfolio type 3 (only high-risk assets). Owners of portfolio type 6 (moderately and highly risky assets) report on average significantly lower risk aversion than owners of portfolio types 1, 2, and 4; however, they are not significantly different from owners of portfolio type 3 (only highly risky assets) or type 5 (a mix of safe and highly risky assets). Finally, investors with the most diversified portfolios comprised of

all types of assets (portfolio type 7) are significantly less risk averse compared to owners of under-diversified portfolios of type 1 (only safe assets) and type 2 (only moderately risky assets); are significantly more risk averse than the owners of portfolio type 3 (only highly risky assets); and do not differ significantly with regard to risk attitudes from owners of portfolio type 5 (a mix of safe and highly risky assets) or type 6 (a mix of moderately and highly risky assets). The reported quartiles of the group-specific distributions of risk aversion indicate that the groups differ not only with respect to the mean value of risk aversion, but also with respect to the form and location of the distribution: specifically, the distribution shifts further toward the origin when we move from less risky portfolios toward less risky portfolios.

In short, the reported summary statistics show that investors holding differently composed portfolios also differ in their risk attitudes. Moreover, the degree of risk aversion varies significantly among investors depending on how many distinct assets are held and what assets are combined. In particular, investors holding a larger number of distinct assets can be both more and less risk averse than investors holding a smaller number of assets. The first relationship emerges in cases where an under-diversified portfolio is more risky than a portfolio comprised of several distinct asset types, while the second relationship (i.e., less risk averse) emerges when an under-diversified portfolio is more safe than a portfolio consisting of different asset types. These observations provide preliminary evidence in favor of our research hypothesis: there seems to be a significant relationship between investors' risk attitudes and portfolio composition. Yet, this relationship may be confounded by other factors that are relevant for both risk attitude and investment decisions. We address this issue in the following sections of the paper.

5 Regression Analysis

5.1 The Model

Our main hypothesis is that risk aversion has a statistically and economically significant effect on the ownership of incomplete portfolios by private households, *ceteris paribus*. To test this hypothesis, we model the probability of observing a certain asset combination as a function of risk aversion and a set of socioeconomic variables. The latter comprise various factors from the household- and individual-specific level that are considered to be important determinants of investment behavior.⁸ Description of the variables is provided in Table A.4. Summary statistics are reported in Table 3.

The two measures of portfolio composition are categorical variables with J mutually exclusive and exhaustive alternatives. Specifically, the measure reflecting different combinations of assets according to the naive investment strategy takes on five successive values, from 0 to 4, according to the number of asset types owned by a household. The second measure, reflecting all possible combinations of assets according to the sophisticated investment strategy, takes on eight values corresponding to the portfolio types defined in Section 3.2.2, including the case when none of the specified asset types are held.

To test the effects of risk aversion under the assumption of a naive investment strategy, we should fit the data to an ordered logistic regression model because of the ordinal nature of the dependent variable. However, after we estimated the model, the results of the Brant (1990) test indicated that the parallel regression assumption (also called the proportional odds assumption) is violated and the data should be fitted to another model. Similar to Uhler and Cragg (1971), we employ a pooled multinomial logistic regression that relaxes the proportional odds assumption. Furthermore, the Hausman test for independence of irrelevant alternatives (IIA) confirmed that a multinomial logit model is more appropriate

⁸There is wide agreement in the empirical literature that investors' socioeconomic and demographic characteristics have significant influence on portfolio decisions. In particular, Uhler and Cragg (1971) and Tin (1998) find that differences in income, age, and education explain a large portion of variation in number of different financial assets held by U.S. households; evidence from more recent studies supports this finding. See, e.g., Börsch-Supan and Eymann (2000); Burton (2001); Campbell (2006); Hochguertel et al. (1997); King and Leape (1998).

in our case.

The model is specified as follows. For the case of J outcomes, where $J = 5$, the probability of observing a particular asset combination, $P(Y_j)$, is:

$$P(Y_j) = \frac{\exp(X'\beta_j)}{\sum_{n=1}^J \exp(X'\beta_n)} \quad (1)$$

$$n = 0, 1, 2, \dots, J; \quad j = 0, 1, 2, \dots, J; \quad j \neq n.$$

X is the vector of explanatory variables that includes the measure of financial risk aversion and a range of control variables. Year dummies are included to control for time-specific effects. We compute robust standard errors using the Huber-White “sandwich” estimator of variance that allows for clustering of observations by individuals.

The effects of risk aversion under the assumption of a sophisticated investment strategy are estimated using the same multinomial logistic regression model with the sole difference being that the number of outcomes, J , is now equal to 8. Control variables are the same as in the case of employing a naive investment strategy.

5.2 Impact of Risk Aversion Under the “Naive” Investment Strategy

The estimated marginal effects of explanatory variables on the predicted probabilities of holding a given number of assets are documented in Table 3. The marginal effects and probabilities are calculated at $FRA=5$, while continuous variables are held at their sample means and dummy- and count-variables are held at zero.

Overall, the predicted probabilities are largely in line with the sample distribution of individuals with respect to the number of asset types held in a portfolio. Individuals with a risk aversion score of 5 are most likely to hold portfolios of two assets, followed by portfolios containing one and three assets. The respective predicted probabilities are 30, 23, and 24 percent.

The estimated marginal effects suggest that risk aversion is an important determinant

of the number of assets held in a portfolio. The probability of holding one asset is predicted to increase by 1 percent when the level of risk aversion rises by one unit. The marginal effect of FRA on the likelihood of a two-asset portfolio is economically and statistically insignificant, suggesting that a small deviation from moderate risk aversion does not affect preferences for this portfolio. The probability of holding more than two assets is negatively related to risk aversion. Specifically, an individual is 0.8 percent less likely to invest in three different assets, while the likelihood of investing in four and more assets decreases by 0.7 percent, when risk aversion rises by one unit.

Because the effects of variables in a multinomial model may vary across the range of the variables' values, it is useful to look at the probabilities of outcomes predicted at all levels of risk aversion. Hence, to provide a more complete picture of the changing effects of risk attitude on diversification, we estimate the probabilities of holding a particular number of asset types for each degree of risk aversion (see Figure 7). We find, however, that the effects seem to be constant across the entire range of values. Moreover, the figures clearly show a negative relationship between risk aversion and the likelihood of holding multiple assets. The most risk tolerant individuals invest in at least four assets with a probability of 15 percent. Their very risk averse counterparts do the same with the much lower probability of 7 percent. The likelihood of a three-asset portfolio also decreases with rising levels of risk aversion. In contrast, the line describing the relationship between risk aversion and the probability of holding one asset rises with risk aversion.

Hence, our results reveal a negative link between risk aversion and the number of assets held in a portfolio. However, the results should be tested for robustness because investors may follow more sophisticated investment strategies rather than simply deciding on the number of distinct assets. This issue is investigated in more detail in the next section.

Table 3: The effects of financial risk aversion on “naive” diversification

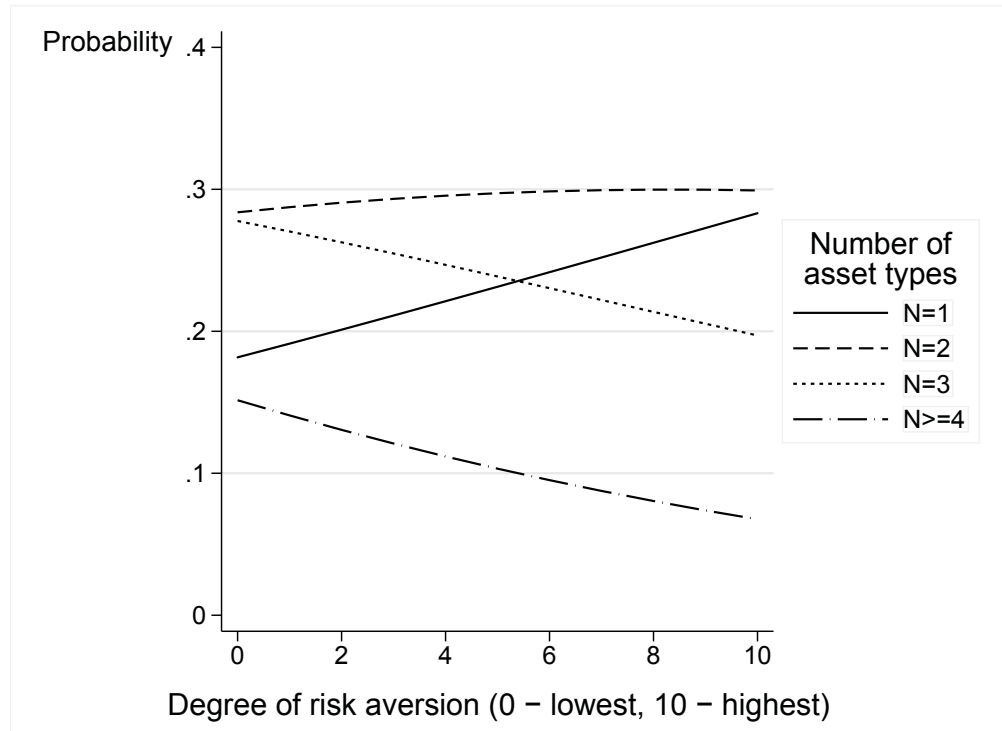
The table reports marginal effects after multinomial logit regression. The dependent variable is a categorical variable that takes seven successive values, according to the number of asset types held in a portfolio. *Probability of outcome* is the predicted probability of holding a given number of asset types. The variable *FRA* indicates the degree of financial risk aversion and takes values from 0 (lowest risk aversion) to 10 (highest risk aversion).

The marginal effects and predicted probabilities are calculated at $FRA = 5$, while other variables are held at their means. Cluster robust standard errors are reported in parentheses. Levels of significance: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

	$N_{assets} = 0$	$N_{assets} = 1$	$N_{assets} = 2$	$N_{assets} = 3$	$N_{assets} \geq 4$
FRA	0.005** (0.002)	0.010*** (0.002)	0.000 (0.002)	-0.008*** (0.002)	-0.007*** (0.001)
ln(Household income)	-0.116*** (0.008)	-0.140*** (0.011)	0.015 (0.012)	0.154*** (0.012)	0.088*** (0.007)
Household wealth50 (d)	-0.129*** (0.007)	0.004 (0.016)	0.047* (0.019)	0.044* (0.018)	0.034** (0.013)
Household wealth75 (d)	-0.123*** (0.010)	-0.033 (0.017)	0.033 (0.019)	0.054** (0.018)	0.069*** (0.014)
Household wealth100 (d)	-0.077*** (0.013)	-0.052** (0.020)	-0.023 (0.022)	0.060** (0.021)	0.092*** (0.017)
ln(Personal wealth)	-0.010*** (0.001)	-0.006*** (0.002)	0.002 (0.002)	0.008*** (0.001)	0.006*** (0.001)
Property (d)	-0.022* (0.011)	-0.041** (0.013)	0.010 (0.014)	0.036** (0.014)	0.017* (0.007)
Male (d)	0.021** (0.008)	0.009 (0.010)	0.032** (0.011)	-0.028** (0.009)	-0.033*** (0.005)
Age	0.000 (0.002)	-0.001 (0.002)	0.006* (0.002)	-0.003 (0.002)	-0.001 (0.001)
Age2	0.000 (0.000)	0.000*** (0.000)	-0.000** (0.000)	-0.000 (0.000)	-0.000 (0.000)
University (d)	-0.046*** (0.009)	-0.018 (0.013)	0.009 (0.013)	0.035** (0.012)	0.021** (0.007)
Employed (d)	-0.071*** (0.010)	-0.026 (0.015)	0.003 (0.016)	0.079*** (0.015)	0.015 (0.009)
Self-employed (d)	0.044* (0.020)	0.010 (0.024)	-0.017 (0.021)	-0.038* (0.016)	0.001 (0.009)
Retired (d)	-0.050*** (0.013)	-0.028 (0.019)	0.036 (0.022)	0.053* (0.023)	-0.012 (0.012)
Married (d)	-0.022 (0.012)	0.010 (0.017)	-0.001 (0.018)	-0.003 (0.015)	0.017* (0.008)
Separated (d)	0.047*** (0.011)	0.015 (0.015)	0.013 (0.015)	-0.047*** (0.013)	-0.029*** (0.007)
Adults	0.026*** (0.007)	0.004 (0.010)	-0.009 (0.010)	-0.019* (0.008)	-0.002 (0.004)
Children	0.030*** (0.005)	0.023** (0.008)	-0.007 (0.008)	-0.023*** (0.007)	-0.021*** (0.004)
Concerned	-0.033*** (0.006)	-0.025*** (0.007)	0.012 (0.008)	0.026*** (0.007)	0.020*** (0.004)
Year dummies	Yes	Yes	Yes	Yes	Yes
Probability of outcome	0.13	0.23	0.30	0.24	0.10

Probability(χ^2) = 0.00, Log-Likelihood = -14085, Pseudo- R^2 = 0.16, N_{obs} = 10,512

Figure 7: Effect of financial risk aversion on the probability of holding a particular number of asset types in portfolio



5.3 Impact of Risk Aversion Under the “Sophisticated” Investment Strategy

In this section we analyze the effects of individual risk aversion on portfolio diversification assuming that households follow a more sophisticated investment strategy. To this end, we estimate a model in which the dependent variable takes on seven values, each corresponding to a distinct portfolio type as defined in Table A.2. The estimated marginal effects of risk aversion on the probability of given portfolio types are reported in Table 4.

Households with average risk aversion score of 5 are most likely to hold portfolio “Type 4”, i.e., a quite diversified portfolio comprised of safe and relatively risky assets; the estimated probability is 32 percent. The marginal effect of the variable FRA indicates a positive but statistically insignificant effect of a small change in risk aversion on the likelihood of this portfolio. The estimated probability of a fully diversified portfolio is significantly lower, 18 percent, and is decreasing in risk aversion.

Table 4: The effects of *financial* risk aversion on “sophisticated” diversification

The table reports marginal effects after multinomial logit regression. The dependent variable is a categorical variable that takes eight different values corresponding to the seven portfolio types defined in Section 3.2.2 plus the category “no assets”. *Probability of outcome* is the predicted probability of holding a given portfolio type. The variable *FRA* indicates the degree of financial risk aversion and takes values from 0 (lowest risk aversion) to 10 (highest risk aversion).

The marginal effects and predicted probabilities are calculated at $FRA = 5$, while other variables are held at their means. Cluster robust standard errors are reported in parentheses. Levels of significance: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

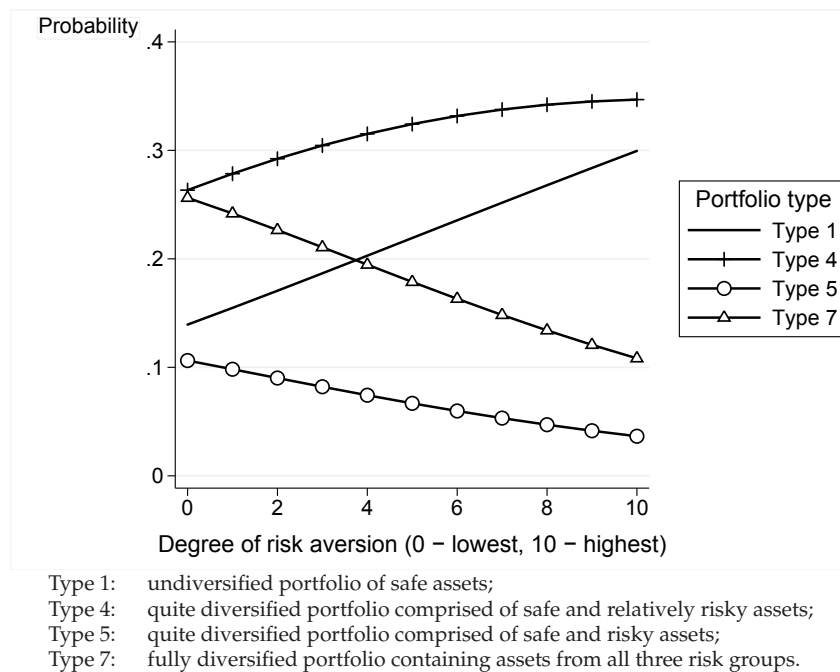
	No assets	Undiversified			Quite diversified			Fully diversified
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
FRA	0.005* (0.002)	0.016*** (0.002)	-0.000 (0.001)	-0.002*** (0.000)	0.004 (0.003)	-0.006*** (0.001)	-0.002*** (0.000)	-0.014*** (0.002)
ln(Household income)	-0.120*** (0.008)	-0.147*** (0.011)	-0.009 (0.006)	-0.000 (0.002)	0.088*** (0.013)	0.018** (0.005)	0.013*** (0.002)	0.157*** (0.009)
Household wealth50 (d)	-0.132*** (0.008)	0.068*** (0.018)	-0.028*** (0.005)	-0.002 (0.003)	0.037 (0.019)	0.029* (0.012)	0.002 (0.004)	0.026 (0.015)
Household wealth75 (d)	-0.125*** (0.010)	0.014 (0.019)	-0.024*** (0.006)	0.001 (0.003)	0.000 (0.020)	0.044** (0.014)	0.008 (0.005)	0.082*** (0.017)
Household wealth100 (d)	-0.081*** (0.013)	-0.041* (0.021)	-0.003 (0.007)	-0.002 (0.003)	-0.024 (0.023)	0.031* (0.015)	0.010* (0.005)	0.109*** (0.020)
ln(Personal wealth)	-0.010*** (0.001)	-0.004** (0.002)	-0.002*** (0.001)	-0.000 (0.000)	0.002 (0.002)	0.004*** (0.001)	0.000 (0.000)	0.011*** (0.001)
Property (d)	-0.021 (0.011)	-0.006 (0.014)	-0.013* (0.005)	0.004 (0.002)	0.051** (0.016)	-0.004 (0.006)	-0.000 (0.002)	-0.011 (0.010)
Male (d)	0.022** (0.008)	0.003 (0.010)	0.005 (0.004)	0.007** (0.002)	0.004 (0.011)	-0.004 (0.005)	0.000 (0.002)	-0.037*** (0.007)
Age	0.000 (0.002)	-0.006** (0.002)	0.006*** (0.001)	-0.000 (0.000)	0.005* (0.002)	-0.003** (0.001)	0.001* (0.001)	-0.003 (0.002)
Age2	0.000 (0.000)	0.000*** (0.000)	-0.000*** (0.000)	0.000 (0.000)	-0.000** (0.000)	0.000* (0.000)	-0.000* (0.000)	-0.000 (0.000)
University (d)	-0.047*** (0.010)	-0.019 (0.014)	0.000 (0.006)	0.007* (0.003)	-0.022 (0.014)	0.013* (0.006)	0.014*** (0.003)	0.053*** (0.010)
Employed (d)	-0.072*** (0.011)	-0.017 (0.015)	-0.003 (0.007)	-0.007* (0.003)	0.060*** (0.016)	0.020* (0.009)	-0.004 (0.004)	0.022 (0.012)
Self-employed (d)	0.051* (0.021)	-0.067** (0.022)	0.015 (0.010)	0.011* (0.005)	-0.053* (0.021)	0.026* (0.011)	0.013** (0.005)	0.004 (0.014)
Retired (d)	-0.053*** (0.013)	0.000 (0.020)	0.000 (0.009)	-0.008* (0.003)	0.035 (0.023)	0.040** (0.015)	-0.005 (0.004)	-0.010 (0.017)
Married (d)	-0.024 (0.012)	-0.022 (0.017)	0.018* (0.009)	0.001 (0.003)	0.019 (0.018)	-0.003 (0.007)	0.001 (0.003)	0.009 (0.011)
Separated (d)	0.048*** (0.012)	-0.022 (0.014)	0.012 (0.006)	0.005 (0.003)	0.020 (0.016)	-0.009 (0.006)	-0.002 (0.003)	-0.053*** (0.010)
Adults	0.028*** (0.007)	0.018 (0.010)	-0.004 (0.004)	-0.001 (0.002)	-0.002 (0.010)	-0.012* (0.004)	-0.004* (0.002)	-0.023*** (0.006)
Children	0.033*** (0.005)	0.023** (0.008)	0.006* (0.003)	-0.001 (0.001)	-0.006 (0.008)	-0.016*** (0.005)	-0.005** (0.001)	-0.034*** (0.005)
Concerned	-0.033*** (0.006)	-0.017* (0.008)	-0.006 (0.003)	0.002 (0.001)	0.007 (0.008)	0.011** (0.003)	0.003* (0.001)	0.033*** (0.006)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Probability of outcome	0.15	0.22	0.04	0.02	0.32	0.07	0.02	0.18

Probability(χ^2) = 0.00, Log-Likelihood = -15232, Pseudo- R^2 = 0.16, N_{obs} = 10512

Figure 8 illustrates how the probabilities of holding the specified portfolio types change with levels of financial risk aversion. The likelihood of undiversified portfolio “Type 1” rises almost linearly as risk aversion becomes stronger. The relationship between the probability of holding a quite diversified portfolio “Type 4” and risk aversion is also positive. However, the effect is especially strong for the lower-than-average levels of risk aversion and becomes substantially weaker for the above-average levels of risk aversion. For both portfolio types, the effect is plausible: as risk aversion increases, individuals tend to invest in safe assets.

An opposite relationship emerges when we look at the probability of a quite diversified portfolio “Type 5”; the probability decreases almost linearly when risk aversion becomes stronger. Since portfolio “Type 5” is a mix of safe and risky assets, it is not surprising that more risk averse investors are less willing to hold this type of portfolio than are their more risk tolerant counterparts.

Figure 8: Effect of financial risk aversion on the probability of holding a particular portfolio type according to the “sophisticated” investment strategy



Finally, the effect of risk aversion on the probability of holding fully diversified port-

folio “Type 7” is negatively related to risk aversion.⁹ Assuming that returns on different asset types are not perfectly positively correlated and there are no transaction or entry costs, we would expect that a fully diversified portfolio is more attractive to individuals with moderate risk aversion than to very risk averse or risk tolerant investors. Instead we find a strong and almost linear negative relationship. Thus, our findings disagree with the predictions of Campbell et al. (2003) and Gomes and Michaelides (2005) but are in line with findings of King and Leape (1998).

6 Extension 1: The Role of Precautionary Motives

Our analysis reveals a negative relationship between the manifested individual risk aversion and the probability of holding a diversified portfolio. Why? One explanation involves the motives behind saving by private households. Satisfaction of precautionary needs has long been considered as one of the main motives for personal saving. Keynes (1936) suggests that economic activity of private households is dominated by safety and liquidity needs.

⁹We also estimate the effects of risk aversion on the sophisticated diversification in a model where we additionally include ownership of commercial real estate and value of household total assets and liabilities as control variables. As the data on these variables are available for 2007 only, the model is estimated with a cross-sectional data set. Nevertheless, the results obtained for this specification once again confirm the negative relationship between risk aversion and the probability of holding a diversified portfolio.

Table 5: The effects of the number of safe assets on the number of risky assets held

The table reports marginal effects after multinomial logit regression. The dependent variable is a categorical variable that takes three successive values from 0 to 2, according to the number of risky assets in a portfolio. *Probability of outcome* is the predicted probability of holding a given number of asset types. $N_{safe\ assets}$ is a count variable indicating the number of safe assets in a portfolio. The variable *FRA* indicates the degree of financial risk aversion and takes values from 0 (lowest risk aversion) to 10 (highest risk aversion).

The marginal effects and predicted probabilities are calculated at $FRA = 5$, while other variables are held at their means. Cluster robust standard errors are reported in parentheses. Levels of significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

	No risky assets	One risky asset	Two risky assets
$N_{safe\ assets}$	-0.073*** (0.006)	0.071*** (0.006)	0.003*** (0.001)
FRA	0.024*** (0.002)	-0.023*** (0.002)	-0.001*** (0.000)
ln(Household income)	-0.155*** (0.011)	0.149*** (0.011)	0.006*** (0.001)
Household wealth50 (d)	-0.055** (0.019)	0.056** (0.018)	-0.002 (0.002)
Household wealth75 (d)	-0.127*** (0.020)	0.125*** (0.020)	0.001 (0.002)
Household wealth100 (d)	-0.141*** (0.023)	0.140*** (0.023)	0.001 (0.002)
ln(Personal wealth)	-0.011*** (0.001)	0.011*** (0.001)	0.001*** (0.000)
Property (d)	0.018 (0.012)	-0.017 (0.012)	-0.001 (0.001)
Male (d)	0.025** (0.009)	-0.023** (0.009)	-0.001 (0.001)
Age	0.003 (0.002)	-0.003 (0.002)	-0.000 (0.000)
Age2	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)
University (d)	-0.079*** (0.012)	0.074*** (0.011)	0.005*** (0.001)
Employed (d)	-0.017 (0.015)	0.018 (0.014)	-0.001 (0.000)
Self-employed (d)	-0.045* (0.020)	0.007 (0.018)	0.038*** (0.008)
Retired (d)	-0.008 (0.020)	0.010 (0.020)	-0.003 (0.002)
Married (d)	-0.001 (0.014)	-0.000 (0.014)	0.001 (0.001)
Separated (d)	0.051*** (0.012)	-0.051*** (0.012)	-0.000 (0.001)
Adults	0.036*** (0.008)	-0.035*** (0.008)	-0.001 (0.001)
Children	0.049*** (0.007)	-0.048*** (0.007)	-0.001* (0.000)
Concerned	-0.043*** (0.007)	0.042*** (0.006)	0.000 (0.001)
Year dummies	Yes	Yes	Yes
Probability of outcome	0.80	0.19	0.01

Probability(χ^2) = 0.00, Log-Likelihood = -5274, Pseudo- R^2 = 0.25, N_{obs} = 10512

A number of applied works, including Skinner (1988), Zeldes (1989), Caballero (1991), Wilson (2003) and Ventura and Eisenhauer (2005), confirm the relevance of the precautionary motive for saving.

The individual safety needs of any particular household should determine what mix

of assets is held in its portfolio. If this conjecture holds, then the most natural decision for a household would be first and foremost to invest in safe assets like cash and saving deposits. Only when basic precautionary needs are satisfied, will a household acquire other, more speculative assets like bonds or stocks. Thus, it is reasonable to assume that if a household owns only one asset type, that asset will be a safe one. This assumption matches what we observe in our sample (see Figure 3). Therefore, we expect that individuals' propensity to invest in risky assets is higher when their safety needs are met.

To test this hypothesis, we estimate an additional multinomial logit model. The dependent variable in this model represents the number of risky assets held in a portfolio. The explanatory variables include risk aversion and socioeconomic and wealth variables. In addition, we control for the number of safe assets held in a portfolio, $N_{Safe\ assets}$. Estimated marginal effects are reported in Table 5.

As expected, the results confirm a positive relationship between the number of safe assets and the ownership of risky financial assets. *Ceteris paribus*, ownership of a unit increment in the number of safe assets reduces by 7 percent the probability that a household refrains from risky assets, while the likelihood of owning one risky asset increases by 7 percent. The probability of holding two and more risky assets is also positively associated with a unit increment in safe assets, although the magnitude of the effect is small. Thus, we conclude that propensity to diversify by including risky assets in a portfolio is highly dependent on whether safety needs are met.

7 Extension 2: Wealthy Investors

Wealth plays a crucial role in portfolio decisions. To this point, we have attempted to control for the effect of wealth by including it as an explanatory variable in the regressions. The estimation results show that wealth has a strong effect (both economically and statistically) on diversification decisions. We also find that when wealth is fixed, risk attitude has a significant effect on the propensity to diversify. From these results, we conclude that risk attitude plays a significant role independently of wealth. However, risk attitude

and wealth are correlated. For instance, we find that risk aversion decreases as wealth increases.¹⁰ Simply including both variables in a regression model might be insufficient to disentangle their effects. Thus, it is possible that our main result regarding the negative relationship between diversification and risk aversion is due to collinearity between risk attitude and wealth.

To discover whether risk attitude is indeed a relevant factor in diversification decisions regardless of wealth, we perform the analysis conducted in the preceding sections on a subsample of wealthy people. Specifically, we construct two groups of wealthy individuals: (1) the relatively wealthy people with wealth exceeding the sample median and (2) the rich people with wealth exceeding the 75th percentile of the sample distribution. We then estimate the same regression models as reported in Tables 3 through 5 separately for each subsample. The specification of explanatory variables is similar to regressions reported in Tables 3 through 5, one exception being that instead of including dummy variables for the percentiles of the wealth distribution, we now include a continuous variable $\ln(Wealth)$, which is a natural logarithm of the household wealth. The results with respect to the effect of risk attitude on the probability of holding a particular combination of assets are reported in Table 6. The upper part of the table summarizes results obtained for asset combinations defined according to the naive investment strategy; the middle section of the table reports results for portfolio types defined according to the sophisticated investment strategy; and the bottom part of the table is devoted to the analysis of precautionary motives.

The results reveal that wealthy people are more likely to hold “richer” portfolios consisting of several distinct asset types with at least one risky asset among them. An important finding is that, even among the relatively wealthy, the richest individuals’ risk attitude is predicted to have a significant negative effect on the probability of holding a di-

¹⁰The coefficient of correlation between risk aversion and household wealth is -0.12 (the coefficient is statistically significant at 5% level) and between income is -0.23 (the correlation is statistically not significant). When we regress risk attitude on wealth and control for other socioeconomic characteristics of individuals, we find a statistically significant negative effect of household wealth and income on risk aversion. For brevity, we do not present the results here, but they are available upon request.

Table 6: The effects of financial risk aversion on the portfolio composition of wealthy investors

The table reports marginal effects of the financial risk aversion FRA on the probability of specified outcomes. The effects are estimated by means of multinomial logit regression. The estimations are performed on a sub-sample of people with wealth exceeding the sample median of 8,000 Euro, and on a sub-sample of people with wealth exceeding the 75th percentile of 134,000 Euro. Other control variables included in the regressions (but not reported) are: the logarithm of the household total wealth and the individuals personal wealth, age and age squared, binary indicators of gender, higher education, employment status, ownership of residential property, marital status and the number of adults and children in a household. The marginal effects and predicted probabilities are calculated at FRA = 5. Cluster robust standard errors are reported in parentheses. Levels of significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Outcome is the number of assets held								
	$N_{assets} = 0$	$N_{assets} = 1$	$N_{assets} = 2$	$N_{assets} = 3$	$N_{assets} = 4$			
Wealth > 50th percentile								
FRA	0.005**	0.010***	0.001	-0.003	-0.010***			
Probability of outcome	0.06	0.17	0.29	0.30	0.18			
Wealth > 75th percentile								
FRA	-0.000	0.003	0.006	0.005	-0.010***			
Probability of outcome	0.06	0.14	0.25	0.33	0.22			
Outcome is the portfolio type								
	No assets	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Wealth > 50th percentile								
FRA	0.005***	0.017***	0.000	-0.002***	0.014***	-0.007***	-0.003***	-0.024***
Probability of outcome	0.06	0.18	0.02	0.01	0.32	0.09	0.02	0.27
Wealth > 75th percentile								
FRA	-0.000	0.010***	0.000	-0.000	0.026***	-0.008***	-0.004***	-0.026***
Probability of outcome	0.06	0.15	0.03	< 0.01	0.33	0.07	0.02	0.33
Outcome is the number of risky assets held								
	No risky assets		One risky asset		Two risky assets			
Wealth > 50th percentile								
FRA	0.037***		-0.035***		-0.002***			
$N_{safe\ assets}$	-0.091***		0.085***		0.005***			
Probability of outcome	0.62		0.37		0.01			
Wealth > 75th percentile								
FRA	0.037***		-0.034***		-0.003***			
$N_{safe\ assets}$	-0.107***		0.103***		0.006			
Probability of outcome	0.58		0.41		0.01			

Sample size for people with wealth > 50th percentile =5,177

Sample size for people with wealth > 75th percentile =2,628

versified portfolio and on the probability of including risky assets in the portfolio. Hence, our results regarding the effects of risk attitude also hold for the subsample of households with considerable financial resources. Therefore, we conclude that risk attitude affects the portfolio composition decision independently of an investor's wealth.

8 Conclusions

This paper explores the link between self-declared risk aversion and the composition of financial portfolios held by private households. Taking into account a wide range of socioeconomic and demographic characteristics of households, we find that the probability of holding incomplete portfolios is positively related to the level of risk aversion. This result is at odds with both the mean-variance principle of Markowitz (1952), and the capital asset pricing model, which predicts that diversification is optimal irrespective of the investor's level of risk aversion. However, our findings are largely in agreement with Kelly (1995) and King and Leape (1998), who also find a negative influence of risk aversion on the number of assets held in a portfolio.

Our explanation of the finding is that most private households are credit constrained and hence prefer to hold safe and liquid assets as a "safety buffer" against periods of lower income and/or higher expenditures. Hence, for most individuals, the primary function of financial wealth is to meet their precautionary and liquidity needs; thus, adding any risky asset to the portfolio is perceived as reducing the safety buffer. The higher the risk aversion, the larger the safety buffer a household desires and the less likely it will own more risky types of assets. In effect, more risk averse people are more likely to hold incomplete portfolios consisting of only safe and liquid assets.

Variation in risk attitudes in the population itself does not suffice to explain the high incidence of incomplete portfolios. Other factors, including poor financial sophistication and participation costs, also play an important role. Therefore, the role of risk attitudes should be considered complementary to other factors important in explaining portfolio composition.

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A Appendix

Table A.1: Categorization of asset types according to their riskiness

Low Risk		Moderate Risk	High Risk
Bank deposits		Life insurance policies	Listed securities
Mortgage plans	savings	Fixed-interest securities	Equity of non-listed firms

Table A.2: Definition of portfolio types according to strategies of “sophisticated” diversification

Portfolio type	Level of diversification	Asset classes included in portfolio		
		safe	relatively risky	risky
Type 1	Undiversified	+	-	-
Type 2	Undiversified	-	+	-
Type 3	Undiversified	-	-	+
Type 4	Quite diversified	+	+	-
Type 5	Quite diversified	+	-	+
Type 6	Quite diversified	-	+	+
Type 7	Fully diversified	+	+	+

“+” indicates that at least one asset of particular type is owned, “-” indicates that no assets of particular type are owned.

Table A.3: Description of explanatory variables

Variable	Description
FRA	Degree of financial risk aversion, on a scale from 0 (very low) to 10 (very high)
Household income	Net annual income of all household members, in Euro
Household wealth	Total value of financial assets and real property owned by the household, in Euro ¹ . In the regression analysis, four dummy variables are used to indicate the level of wealth: <i>Household Wealth</i> 25 = 1 if household wealth is in the lower quartile of sample distribution and = 0 otherwise; <i>Household Wealth</i> 50 = 1 if household wealth > 25th and ≤ 50th percentile of the sample distribution and = 0 otherwise; <i>Household Wealth</i> 75 = 1 if household wealth is > 50th and ≤ 75th percentile of the sample distribution and = 0 otherwise; <i>Household Wealth</i> 100 = 1 if household wealth is > 75th percentile of the sample distribution and = 0 otherwise.
Personal Wealth	The value of personal share of the household's total assets owned by the household head, in Euro ¹
Real Property (d)	= 1 if household owns real property, = 0 otherwise
Female (d)	= 1 if household head is female, =0 if male
Age	Age of the household head in years
Age2	Square of <i>Age</i>
University (d)	= 1 if respondent has university degree, 0 otherwise
Employed (d)	= 1 if household head is employed, 0 otherwise
Self-employed (d)	= 1 if household head is self-employed, 0 otherwise
Retired (d)	= 1 if household head is retired, 0 otherwise
Adults	Number of adult household members (older than 18 years)
Children	Number of children up to 18
Concerned	A categorical variable indicating whether the individual is concerned about his or her financial standing (=1 very concerned, 2 = somewhat concerned, 3 = not concerned at all)

Note: (d) denotes dummy-variables. ¹ Data about financial and real assets were collected by the SOEP in 2002 and 2007 only. For years 2004 through 2006, we calculate total wealth based on the assumption that its value changes linearly over time.

Table A.4: Summary statistics of explanatory variables

Variable	2004		2007	
	Mean	Std. Dev.	Mean	Std. Dev.
FRA	7.53	2.28	7.53	2.28
Household income	25,657	16,014	27,343	20,841
Household wealth	12,883	44,021	13,917	50,304
Personal wealth	9,194	39,248	10,325	45,313
Real property	0.34	0.47	0.36	0.48
Female	0.44	0.50	0.44	0.50
Age	49	16.76	52	16.76
University	0.19	0.39	0.21	0.40
Employed	0.58	0.49	0.57	0.50
Self-employed	0.06	0.24	0.07	0.25
Retired	0.30	0.46	0.33	0.47
Married	0.28	0.45	0.29	0.45
Separated	0.42	0.49	0.45	0.50
Adults	1.66	0.72	1.64	0.74
Children	0.38	0.76	0.34	0.70
Concerned				
- very concerned	30.40	0.46	28.01	0.45
- somewhat concerned	50.42	0.50	48.82	0.49
- not concerned at all	19.18	0.39	23.17	0.42

Number of individuals in the panel, N = 2,628