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Who takes Risks When and Why: Determinants of Changes in Investor Risk Taking*

MARTIN WEBER[1], ELKE U. WEBER[2] and ALEN NOSIĆ[1]
[1]*Universität Mannheim, and* [2]*Columbia Business School*

Abstract. Between September 08 and June 09, a period with significant market events, we surveyed UK online-brokerage customers at 3-month intervals for their willingness to take risk, 3-month expectations of returns and risks for the market and their own portfolio, and self-reported risk attitude. This unique dataset allowed us to analyze how these variables changed over time, and whether changes in risk taking were related to changes in expectations and/or risk attitudes. Risk taking changed substantially during the period, as did return and risk expectations. Numeric assessments of return and risk expectations were only weakly correlated with corresponding subjective judgments. Consistent with the risk-as-feelings hypothesis, changes in risk taking were associated with changes in subjective expectations of market portfolio risk and returns, but less with changes in numeric expectations.

JEL Classification: G02, G11, G21

1. Introduction

The recent global financial crisis and its aftermath bring questions about risk taking back to the fore. What determines how much risk private investors take? How and why does risk taking change when shocks to the system occur? How long do such changes in risk taking last? Malmendier and Nagel (2011) found long lasting cohort effects in investors who experienced the great depression but today's investors and their experiences are very different, and today's economic depressions of shorter duration may not have the same impact.

The recent financial crisis also renewed calls for greater consumer information and protection, initiatives that require better knowledge about the investment decision processes of the public. Consumer finance has recently been identified as a field vastly understudied given its importance to the

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national and international economy (Campbell, 2006; Tufano, 2009; Campbell *et al.*, 2011). Such relative neglect is due, at least in part, to the fact that economic transactions of individuals and households are hard to observe and interpret with traditional economic methods. As a result, psychologists and behavioral economists have started to use panel data, where representative sets of respondents answer questions about their values, beliefs, and expectations,[1] which in addition to socioeconomic variables can then be related to their hypothetical or real choices, a methodology also employed by our study. Far from being a negative, the hypothetical nature of such investment decisions allows people to show what they would do, based on their beliefs and expectations at a specific point in time, without constraints by inertia or other factors. For an overview of the pros and cons of survey data see Manski (2005). By repeating such surveys over time, we can assess the effect of external events on beliefs and expectations and test the strong assumption that decision makers have objectively correct, i.e., rational expectations.

Our online survey, designed in collaboration with the behavioral finance team at *Barclays*, questioned the bank's online-brokerage customers between September 08 and June 09 in 3-month intervals about their expectations of risk and returns of market and personal portfolios, their risk attitudes, and hypothetical risk taking behavior. Figure 1 charts the Financial Times Stock Exchange (FTSE) share index of all eligible companies listed on the London Stock Exchange's main market over the time period of our surveys. The figure shows that this was a period of high stock market uncertainty and volatility, beginning in September 08 before some important financial crisis events like Lehman Brothers and AIG in the USA, and Northern Rock, HBOS and other banks in the UK, and continuing through some additional declines and then some market recovery in 2009. Our respondents were online investors who frequently trade in stocks and other securities, providing greater external validity to our results than those of studies that have used student samples (Harrison *et al.*, 2005; Baucells and Villasis, 2010).

All four surveys measured financial risk taking with the task of investing £100,000 either into the UK stock market (FTSE-All-Share) or into a risk-free asset with a guaranteed interest rate of 4%. Greater percentages

[1] For example, in the US the University of Michigan Health and Retirement Study (HRS) survey http://hrsonline.isr.umich.edu/index.php?p=qnaires and the Survey of Economic Expectations http://www.disc.wisc.edu/econexpect/Index.html, accessed 15 June 2012; in Germany, the ZEW Bankprognosen survey http://www.zew.de/de/publikationen/bankprognosen/index.php and the Socio-Economic Panel http://www.diw.de/deutsch/soep/29004.html, accessed 15 June 2012.

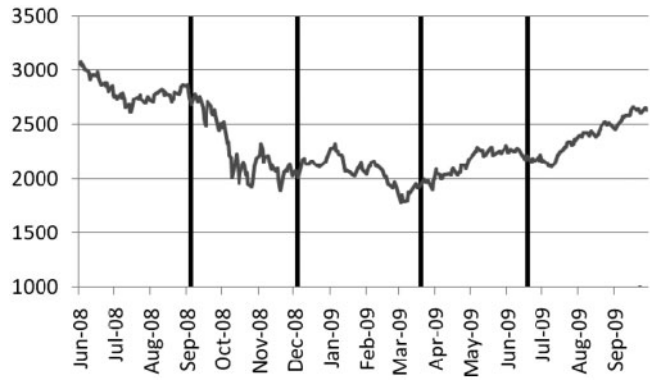

Figure 1. Value of FTSE all-share index representing approximately 98% of the UK's market capitalization from June 08 to September 09.

invested into the stock market are indications of greater risk taking. We expected changes in risk taking over the period of the survey, given external events. Commenting on the financial crisis in September 08, the New York Times reported that "investors around the world frantically moved their money into the safest investments like Treasury bills," and changes in risk taking have also been reported in other situations (Staw, 1976; Thaler and Johnson, 1990; Weber and Zuchel, 2005; Malmendier and Nagel, 2011). The more important question is what drives such changes in risk taking. Our goal is to decompose risk taking into different contributing variables and to examine the influence of changes in these variables on any observed changes in risk taking.

Classic portfolio theory (Markowitz, 1952) assumes that investors' individual risk taking depends on investors' risk attitude as well as on investors' estimates about the expected return and volatility (variance) of the investment. In this model, risk attitude, i.e., the trade-off between expected return and volatility is determined by the curvature of the investor's utility function. Note that investors can have different subjective estimates of expected return and volatility:

$$\text{Risk Taking} = \text{f}(\text{Expected Return}, \text{Volatility}, \text{Risk Attitude}).^{2} \qquad (1)$$

Equation (1) allows for heterogeneous beliefs but still specifies return and risk at the first two moments of the return distribution which might be individually estimated. A more general risk–return framework (Sarin and

[2] All Equations (1)–(3) are for an individual investor i, i.e., Risk Taking_i = f(Expected Return_i, Volatility_i, Risk Attitude_i). We omit the subscripts for reasons of simplicity.

Weber, 1993; Weber and Milliman, 1997; Jia *et al.*, 1999) allows subjects to have return and risk estimates not necessarily equal to the moments of the distribution or even measured on quantitative scales. Here risk attitude determines the trade-off between risk and return and might be directly assessed by asking the investor:

$$\text{Risk Taking} = \text{f}(\text{Return}, \text{Risk}, \text{Risk Attitude}). \quad (2)$$

In the Markowitz model (1) as well as in such a psychophysical risk–return model (2), (Weber and Johnson, 2008), changes, denoted Δ, in risk taking can result from changes in one or more of these three determinants of risk taking, e.g., for the psychophysical model:

$$\Delta\text{Risk Taking} = \text{f}(\Delta\text{Return}, \Delta\text{Risk}, \Delta\text{Risk Attitude}). \quad (3)$$

Better understanding the determinants of investor risk taking is not only of theoretical interest, but also has practical implications for financial regulatory requirements in Europe and ongoing discussions about such regulation in the USA. The Markets in Financial Instruments Directive (MiFID) by the European Parliament and the European Council (2004 and 2006) requires investment firms to obtain "information as is necessary for the firm to understand the essential facts about the customer" (Article 35, 1) and to elicit the customer's "preferences regarding risk taking, his risk profile, and the purpose of the investment" (Article 35, 4). However, MiFID provides no guidelines about how or how often investment advisors need to elicit risk preferences and risk profiles, and what "essential facts about the customer" should be collected. To close this gap, our study examines whether risk attitudes and/or risk or return estimates of investors change over time, and which of these changes impact risk taking.

Model components were elicited in two different ways. Individual numeric judgments of best guess (median) returns and volatility in returns (computed from median, worst-case and best-case percentage return estimates) can serve as proxies of individual investor beliefs most closely related to the return and risk variables of the classical risk—return model of risk taking of Equation (1). In contrast, elicitations of investors' more qualitative risk and return expectations on subjective rating scales ranging from "extremely bad" to "extremely good" for returns, and from "not at all risky" to "extremely risky" for risk as in Equation (2) allow investors to incorporate feelings of hope or fear (Loewenstein *et al.*, 2001), i.e., sentiments that may not make it into numeric estimates of such quantities but may nevertheless determine financial decisions (Barberis *et al.*, 1998; Weber and Hsee, 1998; Baker and Wurgler, 2006). Building on results for expected risk by E. Weber

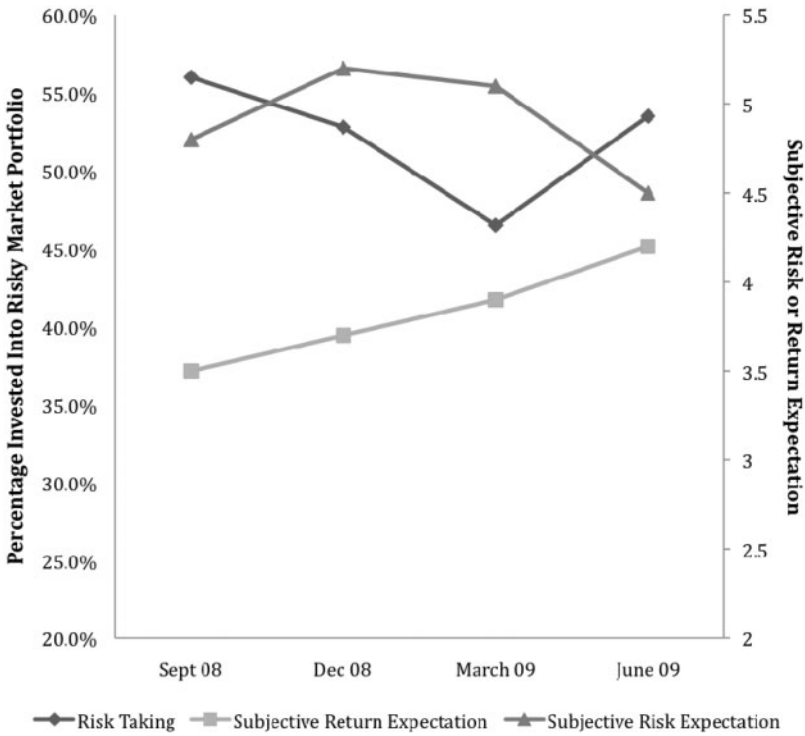

Figure 2. Mean percentage invested into risky market portfolio (diamond symbols), mean subjective market risk expectation (triangle symbols), and mean subjective market return expectation (square symbols) at four consecutive assessed time points.

et al. (2005), we predict and find that the numeric and subjective measures of risk and return expectations are not highly correlated and that subjective expectation measures predict risk taking far better than numeric expectations.

As shown in Figure 2, risk taking, i.e., the percentage of their hypothetical £100,000 stake investors would invest into the UK stock market for the next 3 months changed significantly over the surveyed period. Investments into the risky asset versus a guaranteed 4% return asset dropped from 56.0% in September 08 to 52.8% in December 08, and even lower to 46.5% in March 09, but then increased again to 53.5% in June 09. Over that same time period, self-reported risk attitudes further described below were stable on average. In contrast and also shown in Figure 2, subjective market portfolio risk expectations and return expectations, the measures most predictive of risk taking, changed across assessment periods. Changes in risk expectations mirrored changes in risk taking, with risk expectations increasing from

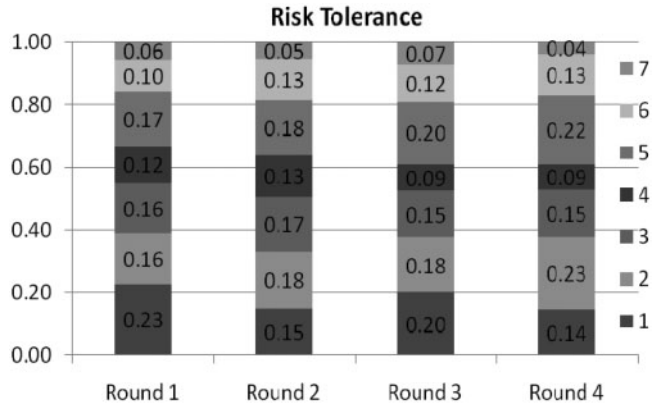

Figure 3. Distribution in percentage of self-reported risk attitudes (Risk Attitude 2: "It is likely I wold invest a significant sum in a high risk investment" with categories ranging from 1 = strongly disagree to 7 = strongly agree), by time of elicitation (Round 1 = Sept 08, Round 2 = Dec 08, Round 3 = March 09, Round 4 = June 09).

September 08 to December 08, staying at the same level in March 09, and then decreasing in June 09. Subjective market portfolio return expectations were quite wrong in the first rounds of the survey; however, the increases in March 09 and June 09 were roughly in line with the real market.

Previewing our results, changes in risk taking were explained by changes in subjective risk and return expectations for the market portfolio and to a lesser degree by changes in self-reported risk attitude. This result remains stable even when we control for investors' previous 3-month personal stock market experience and for memories of recent market performance.

Our results have important practical implications as risk attitude (Figure 3) is pretty stable, it does not need repeated assessment. In contrast, subjective risk and return expectations change with external market events, though not necessarily in a rational way. This suggests more frequent assessment of these quantities and some educational interventions to correct faulty expectations.

Our results extend the empirical and experimental literature on risk taking in several important ways. Whereas previous studies have documented changes in risk taking, using either field data (Brunnermeier and Nagel, 2008; Malmendier and Nagel, 2011) or lab data in reaction to prior gains and losses (Thaler and Johnson, 1990; Weber and Zuchel, 2005), our study is the first to identify mediators of such changes, namely changes in subjective risk and return expectations, and to do so for a sample of online investors. Previous studies that examined changes in expectations and/or risk attitudes

looked at only one of these variables in isolation: risk expectations (Weber and Milliman, 1997; Glaser and Weber, 2005), return expectations (Shiller *et al*., 1996; Johnson *et al*., 2004; Hanoch *et al*., 2006), and risk attitudes (Sahm, 2007; Klos, 2008). Most of these studies did not relate changes in expectations and risk attitudes to changes in risk taking. In addition, we extend the results of Vissing-Jorgensen (2003) and Dominitz and Manski (2007), who used survey data to show that greater expected equity returns were associated with a greater probability of holding stocks, in several ways: by including risk expectations and risk attitudes as predictor variables, by examining changes in return and risk expectations and their influence on changes in risk taking, and by using a different measure of risk taking, namely asset allocation. Finally, we extend results about the superiority of subjective over numeric judgments of risk to predict risk taking (Weber *et al*., 2005), by showing that the same is true for subjective over numeric judgments of returns.

Section 2 of this article provides a literature review that motivates our hypotheses. Section 3 presents information on survey respondents and the survey design. The main results are reported in Section 4, and Section 5 discusses the implications of our results.

2. Theory and Hypotheses

Anecdotal evidence suggests that risk taking of individual investors, i.e., their allocation of wealth to risky and risk free assets, can substantially vary over time and in response to market events. According to the Deutsche Aktieninstitut (2008), 6.2 million people in Germany in 2000 at the height of the internet boom directly held part of their wealth in stocks, whereas this number dropped to 3.5 million by the end of 2008, the time of the financial crisis. The Wall Street Journal (2008) similarly reports on December 5 2008 that, in response to the dramatic events on financial markets, investors pulled $72 billion from stock funds in October alone and moved their money into government bonds and cash holdings.

Lab studies also show that risk taking is far from stable. Because preferences are constructed and stochastic, small differences in choice context can sometimes lead to preference reversals (Lichtenstein and Slovic, 2006). Camerer (1989) and Hey and Orme (1994) gave respondents the same set of choice options twice, about 10 days apart, and found that 25–30% of choices were different across the two time periods. Staw (1976) showed that risk taking depended on previously experienced outcomes, with respondents taking significantly more risks on the same investment opportunity following

a loss than a gain, a phenomenon he labeled escalation of commitment. This is consistent with the disposition effect identified by Odean (1998) and Weber and Camerer (1998), where investors are more reluctant to sell losing stocks than winning stocks. Thaler and Johnson (1990), on the other hand, found the reverse effect, i.e. enhanced risk taking after gains than after losses, which they called the house money effect. Weber and Zuchel (2005) subsequently reconciled the conflicting escalation of commitment and house money effects by showing that the framing of the situation matters. The "house money effect" is prevalent when the situation is framed as a lottery, whereas the escalation of commitment effect is predominant when the situation is framed as an investment. Weber *et al.* (2002) also found differences in risk taking for risky financial choices when choices were described as gambling decisions than when they were described as investment decisions.

These studies show that the personal experience of winning or losing can influence subsequent risk taking, presumably because the affective reactions to prior gains or losses influence perceptions of risk and/or return of subsequent choice options (Loewenstein *et al.*, 2001). In other situations, outcome feedback has a learning function. Positive or negative outcomes provide additional information about expected returns and risks of this option. Weber *et al.* (2004) showed that risk taking is more variable for decisions from experience where the decision maker must gradually learn about choice options from repeated outcome feedback than for decisions from description where outcomes and their likelihood are numerically or graphically described. This is especially true, when low probability events are involved. Risk taking for decisions from experience is more variable because outcomes that recently occurred have a large impact. This suggests that economic shocks should increase risk expectations and lower return expectations and should thus decrease risk taking, and that these effects should disappear as outcomes become more favorable again. Malmendier and Nagel (2011) found that the great depression had a surprisingly long lasting impact by reducing risk taking of people who lived through it, though this may have been the result of the extended time period (more than a decade) over which negative outcomes were experienced.

In summary, there are reasons to expect that people's risk taking will vary from September 08 to June 09, which included at least one large market shock in the first month:

Hypothesis 1(a)
Financial risk taking will vary over survey period, i.e., the proportion of the initial endowment of £100,000 invested into the UK stock

market (FTSE-All-Share) and not into the risk-free asset with a guaranteed interest rate of 4% will be statistically different from time period to time period.

Rational models allow for changes in risk attitudes as the result of changes in income or wealth. The fact that an increase in wealth should result in a greater risk taking or a decrease in relative risk aversion is a key implication of difference habits models. When Brunnermeier and Nagel (2008) tested this implication empirically, they found that, while wealth changes affected investors' decision to participate in stock markets, they hardly had any effect on asset allocation decisions, i.e., on the proportion a household invested in risky versus risk-free assets. Guiso *et al.* (2003) analyzed stock ownership in major European countries and also found that the percentage of wealth invested in the stock market was independent of investors' absolute level of wealth.

Lab and field experiments that infer risk attitudes directly from choices (e.g., Holt and Laury, 2002) confound possible individual or situational differences in expected risks and returns with true differences in attitude toward risk (Weber and Milliman, 1997; Weber and Hsee, 1998; Weber and Johnson, 2008). When risk taking is equated with risk attitude, risk attitude often appears to be domain specific, because risk taking varies across domains. Investment risk taking, for example, is typically not very highly correlated with risk taking in lottery tasks (Weber *et al.*, 2002; Nosić and Weber, 2010). Panel surveys such as the Socio-Economic Panel (Dohmen *et al.*, 2011) or the Michigan Health and Retirement Survey have assessed risk attitude with psychometric methods instead, i.e., from answers to attitudinal statements on Likert-scales, a method also used in our survey. As one would expect of a trait measure, Klos (2008) found individual risk attitudes reported in the 2004 and 2006 Socio-Economic Panel to be stable over time. Sahm (2007) also reported relatively high stability of risk attitudes within individuals over time using the Health and Retirement panel data set with more than 12,000 observations. Hence, we expected self-reported attitude toward risk to be stable across our sampling period.

Hypothesis 1(b)
Risk attitudes will be stable over survey period, i.e., self-reported risk attitudes will not be statistically different from time period to time period.

Changes in return expectations have been analyzed extensively empirically. Dominitz and Manski (2005) investigate the dynamics of expectations in the Survey of Economic Expectations (1999–2001) and in the Michigan

Survey of Consumers (2002–04) and found that expectations were not perfectly stable over time but that differences between individuals were larger than differences within person over time. Using cross-sectional UBS/Gallup surveys, Fisher and Statman (2002) and Vissing-Jorgensen (2003) showed that people's long- and short-term return expectations change substantially over time. Using data from the 1998 to 2003 surveys, Vissing-Jorgensen (2003) showed that average 1-year expectations range from a high of 15.8% in January 2000 to a low of around 6% at the end of 2002, a change in expectations largely in line with returns experienced at the time, and thus a result consistent with documented recency effects in experience-based learning and choice (Weber *et al.*, 2004). In contrast, also using between-subject data, Glaser and Weber (2005) showed that return expectations after the 9/11 event of 2001 and the subsequent market downturn were not in line with recently experienced returns, but significantly higher than return expectations before the event, suggesting that respondents believed in some form of market mean reversion.

Risk expectations can also be assumed to relate to individuals' past experiences with similar events or situations (Weber and Hsee, 1998). Loewenstein *et al.* (2001) argue that risky choice options are evaluated affectively ("risk as a feeling"), and that prior outcomes, good as well as bad ones, influence this emotional response and the way individuals perceive the risk of a situation. Weber and Milliman (1997) and Mellers *et al.* (1997) experimentally showed that risk perceptions change after participants have experienced either good or bad outcomes. Consistent with such experiential learning, Glaser and Weber (2005) found volatility estimates to be significantly higher after the terror attacks of September 11 than before.

In summary, previous evidence suggests that both risk and return expectations can vary substantially over time, as the result of macroeconomic events or individually experienced gains or losses. Whereas perceptions of risk consistently increase under adverse conditions, expectations of returns at times reflect experienced events and trends and at other times reflect a belief in mean reversion.

Hypothesis 1(c)
Risk and return expectations will fluctuate over survey period, i.e., will be statistically different from time period to time period.

Our data will allow us to test what drives changes in risk taking. Consistent with the previously presented literature, we hypothesize that changes in risk taking over time are driven by changes in risk and return expectations and not by changes in risk attitude.

Hypothesis 1(d)
Changes in risk taking will be mediated by changes in risk and return expectations.

Hypothesis 1(c) raises questions about both the origin and the target of investors' risk and return expectations. Behavioral research suggests that investors' expectations may not be based only on economic data, but also on affective reactions such as hopes and fears. Asking investors to predict median as well as worst- and best-case returns for the next 3 months is the standard way to measure numeric risk and return expectations, but this method does not allow respondents to express their hopes and fears which may, nevertheless, influence their investment choices (Weber *et al.*, 2005). This suggests the following hypothesis.

Hypothesis 2
Subjective measures of risk and return expectations will predict risk taking better than numeric measures, i.e., subjective measures of risk and return expectations will account for a greater proportion of the variance in risk taking across investors than numeric measures.

3. Data

3.1 SURVEY RESPONDENTS AND PROCEDURE

Our online survey was designed in collaboration with the behavioral finance team at *Barclays* and administered in September 08, December 08, March 09, and June 09. Over 90% of respondents completed the September 08 survey before the 12th of September, i.e., before the bankruptcy of Lehman Brothers and the subsequent downturn on financial markets.[3] Respondents were selected as a stratified sample of Barclays Stockbrokers' client base, where Age, Number of deals per year, Number of holdings, and Portfolio value were used as strata. This provided a representative sample, while also accommodating our collaborating bank's desire to undersample clients who trade very little (number of deals per year $\leq$1) or had a relatively low portfolio value (Portfolio value $<$£1,000).[4]

[3] Barclays did not collect the specific date on which each respondent completed the survey. However, the online service remained open only for a maximum of 2 weeks, with the majority of participants answering within the first week.

[4] In all strata in which trades were less than once a year or portfolio value of less than £1,000, a lower percentage of clients were invited to participate in the survey than in the

A total of 19,251 clients, approximately 5% of customers, were invited by email in late August/early September to participate in the survey. Of those, 4,520 (23%) opened the email. Of those who opened the email, 849 (20%) went to the website and in the end, 479 out of these 849 subjects completed the survey. This response rate is slightly lower but in the same ballpark as response rates in similar studies by Dorn and Huberman (2005) and Glaser and Weber (2007). It took respondents on average 24 min to answer the survey.

The 479 investors who answered the September 08 survey were contacted again by email in late November/early December 08 and invited to participate in a shorter version of the earlier survey.[5] Of those, 240 participated for a second time in December. In addition, *Barclays* sent out an email invitation to a different set of 700 customers who had not been previously contacted, in order to increase the sample size.[6] This resulted in an additional 138 respondents who joined the panel in December and who completed the longer version of the survey at this point. In March 09 and June 09, all 617 investors who had previously participated in at least one round were contacted again and invited to participate in one more round, with the shorter version of the survey. Overall, 259 investors participated only once, 138 twice, 131 three times, and 89 all four times.

In contrast to previous studies of online brokerage customers (Dorn and Huberman, 2005; Glaser and Weber, 2007) that analyzed one-period survey responses, our dataset provided repeated observations of the same investors over time, thus allowing us to regress changes in the dependent measure (risk taking) onto changes in a series of predictor variables. Such analysis requires participants who completed at least two consecutive surveys, i.e., in September and December, in December and March, in March and June, or participated in three or four consecutive periods.

To identify potential selection biases, we compared survey participants to the adult British population, and also compared investors who participated only once with those that participated twice, three or four times, respectively. Table I provides mean demographics for all participants of our study ($Group^{all}$) and for the adult British population (GB^{all}), respectively. The next four columns provide mean demographics separately for respondents

remaining strata. Note that although we did undersample, we did not exclude these clients, and more than 16% of approached individuals had a portfolio value below £1,000.

[5] The first version of the survey included more demographics, individual characteristics, and various behavioral client profiling questions, that are used by Barclays Wealth within their advisory process.

[6] These 700 had previously participated in another marketing related event of *Barclays Wealth* and had indicated their willingness to participate in surveys.

Table I. Demographic characteristics

The first two columns compare mean demographics for survey participants ($Group^{all}$) to the adult British population (GB^{all}) (from the UK Office for National Statistics). The next four columns report mean demographics for the subsets of participants who took part in only one survey ($Group^{once}$), two surveys ($Group^{twice}$), three surveys ($Group^{thrice}$), or all four surveys ($Group^{four}$). Age, Number of dependants, and Median gross income are self-explanatory. Gender and Marital status are dummy variables that take the value 1 if the investor is male and married or cohabitating, respectively. Investable wealth is measured in nine categories from 1 (£0–£10,000) to 9 (>£1 million).

	$Group^{all}$	GB^{all}	$Group^{once}$	$Group^{twice}$	$Group^{thrice}$	$Group^{four}$
Age	51.42	47.66	50.77	50.65	51.43	54.45
Number of dependents	1.14	–	1.12	1.23	1.17	1.00
Gender	0.93	0.49	0.92	0.93	0.95	0.96
Median gross income (in £)	60,000	30,000	60,000	60,000	65,000	53,000
Marital status	0.74	–	0.76	0.70	0.77	0.72
Investable wealth (in £)	4.80	–	4.50	4.53	5.03	5.73

who participated only once, twice, three times, and in all four surveys. The average age of survey participants was 51.4 years, 4 years older than the average British adult. Survey participants were more likely to be male (0.93 versus 0.49) compared with the British average. Gross income was highly skewed with a mean of £76,616 and a median of £60,000 and substantially larger than the median British income of £30,000. Clearly, our respondents were not representative of the typical British adult. However, being predominantly male and having a substantially larger gross income than the overall population makes them similar to the German private investor population sampled by Dorn and Huberman (2005).

There are hardly any differences between the investor subgroups who participated once, twice, three, or four times, respectively. Only the level of investable wealth, measured in nine categories from 1 (£0–£10,000) to 9 (>£1 million), differs significantly. Investors who participated only once had substantially lower investable wealth than investors who participated more frequently.[7] Since the main goal of our study is to analyze changes in different variables at an individual level over time, differences in wealth between the four subgroups should not be problematic. Investor wealth was also included as a control variable. We conducted a similar analysis not reported here comparing demographics as well as expectations for

[7] We deliberately gave subjects the option not to answer the questions about income and wealth. Nevertheless, both questions were answered by slightly above 80% of the subjects.

those who participated in each subsequent round versus those who did not participate in the next round and found no significant differences.

3.2 SURVEY DESIGN

Besides demographics and other individual characteristics described above and collected only in the first survey in which respondents participated, the following variables, summarized in Table II, were elicited every 3 months. The Table AI in appendix presents the exact wording of the questions as well as the order in which the questions were posed.

3.2.A Financial risk taking

Participants were asked to invest £100,000 either into the UK stock market (FTSE-All-Share) or into a risk-free asset with a guaranteed interest rate of 4%, with a greater percentage allocated to the stock market indicating greater risk taking. Using hypothetical choices versus transaction data has advantages and disadvantages. A disadvantage of using real transaction data to make inferences about risk taking in portfolio allocations is that it is hardly possible to obtain complete information on total asset holdings of individuals at all banks at which they have an account. We also know that real transactions are subject to investor inertia and temporary practical constraints that may not be constant from period to period. Hypothetical risk taking with a new stake of equal size provided at each time period does not have these constraints and thus offers a cleaner measure of the effect of changes in risk and return expectations or changes in risk attitude. However, hypothetical actions are hypothetical, and some might argue that such data reflect cheap talk. As outlined in the introduction, such survey data should be seen as an additional and complementary source of data to understand determinants of changes in investor risk taking.

3.2.B Risk attitudes

In the September 08 and December 08 surveys, we used the three questions shown in Table II from *Barclays'* eight-question psychometric scale of investors' risk attitude. Brooks *et al.* (2008) show that this scale differentiates individuals with low-risk tolerance from those with high-risk tolerance and that it has high reliability. All three questions were answered on a seven-point Likert scale with the endpoints "1 = Strongly Disagree" and "7 = Strongly Agree".[8] In the March and June survey, only the most

[8] Bollen and Barb (1981) and Alwin and Krosnick (1991) have shown that reliability, validity, and discriminating power increases up to seven-point scales and that, after this,

Table II. Definition of survey variables

Variable	Question/Description
Risk Taking	
Risk Taking	Measures the (hypothetical) amount of money an individual is willing to invest into the FTSE-All-Share compared to a risk-free asset with a 4% return (0 = invest everything into the risk free asset; 100 = invest everything into the risky stock market)
Risk Attitude	
Risk Attitude 2	"It is likely I would invest a significant sum in a high-risk investment." (1 = Strongly disagree... 7 = Strongly agree)
Risk Attitude 6	"I am a financial risk taker." (1 = Strongly disagree... 7 = Strongly agree)
Risk Attitude 7	"Even if I experienced a significant loss on an investment, I would still consider making risky investments." (1 = Strongly disagree... 7 = Strongly agree)
Expectations	
Market-Return-Num.	Measures individuals' return expectations for the FTSE-All-Share in 3 months in percent
Market-Risk-Num.	Measures individuals' volatility expectations for the FTSE-All-Share in 3 months by transforming estimates of bounds into volatility estimates.
Market-Return-Subj.	"How would you rate the returns you expect from an investment in the UK stock market (FTSE-All- Share) over the next 3 months?" (1 = Extremely bad... 7 = Extremely good)
Market-Risk-Subj.	"Over the next 3 months, how risky do you think the UK stock market (FTSE-All- Share) is?" (1 = Not risky at all... 7 = Extremely risky)
Own-Return-Num.	Measures individuals' return expectations for the own portfolio at the bank in 3 months in percent
Own-Risk-Num.	Measures individuals' volatility expectations for the own portfolio at the bank in 3 months transforming estimates of bounds into volatility estimates
Own-Return-Subj.	"How would you rate the returns you expect from your own portfolio over the next 3 months?" (1 = Extremely bad... 7 = Extremely good)
Own-Risk-Subj.	"Over the next 3 months, how risky do you think the investments in your own portfolio are?" (1 = Not risky at all... 7 = Extremely risky)
Past Performance	
PastPerf.-External	"What do you think the return of your investments held at other banks over the past 3 months was?"
PastPerf.-Market-Num.	"What is your best estimate of the return of the UK stock market (FTSE-All-Share) over the past 3 months?"
PastPerf.-Market-Subj.	"How would you rate the returns of the UK stock markets (FTSE-All-Share) over the past 3 months?" (1 = Extremely bad... 7 = Extremely good)
PastPerf.-Own-Num.	"What do you think the return of your own portfolio over the past 3 months was?"
PastPerf.-Own-Subj.	"How would you rate the returns of your own portfolio over the past 3 months?" (1 = Extremely bad... 7 = Extremely good)

diagnostic of these three risk attitude measures was elicited, i.e., Risk Attitude 2: "It is likely I would invest a significant sum in a high risk investment."

3.2.C Expected return and expected risk

As described above, risk and return expectations were elicited in two different ways, one quantitative/numeric, the other qualitative/subjective. Crossed with that, we also asked investors for their risk and return expectations over the next 3 months for (i) the UK market portfolio (FTSE-All-Share) and (ii) for their own investment portfolio at the bank. To get respondents' quantitative/numeric risk and return expectations, we asked them to state their best guess (median estimate) for the 3-month percentage return, followed by a lower and upper bound on the 3-month percentage return they had provided, such that there would only be a 5% chance that the return in 3 months would be below the lower bound and a 5% chance that it would be higher than the upper bound. Numeric return expectations for the market (Market-Return-Num.) or for an investor's own portfolio (Own-Return-Num.) are equal to the best guess for the market and own portfolio return, respectively. To obtain numeric risk expectations, we used the two point approximation to the variance of outcomes suggested by Keefer and Bodily (1983), which transforms stated upper and lower bounds into volatility estimates and has been widely used in the empirical literature (e.g., Graham and Harvey, 2005 and Glaser *et al.*, 2007).[9] This provided us with the two numeric risk expectation measures Market-Risk-Num. and Own-Risk-Num.

For the two qualitative/subjective measures of return expectations (Market-Return-Subj. and Own-Return-Subj.), respondents were asked how they would rate the returns they expected from the market and their own portfolio over the next 3 months, on a seven-point Likert scale ranging from "1 = Extremely bad return" to "7 = Extremely good return". Similarly, the qualitative/subjective measures of risk expectations (Market-Risk-Subj. and Own-Risk-Subj.) were obtained as judgments of expected market risk

additional effects can hardly be observed. Moreover, Viswanathan et al. (2004) argue that the number of response categories should be as close as possible to a natural number of categories for a specific question, and that one should not overburden respondents with too hard a task.

[9] For the two point approximation of variance we use:

$$\text{variance} = \left[\frac{\text{return}_{\text{num}}(0.95) - \text{return}_{\text{num}}(0.05)}{3.25}\right]^2,$$

see Keefer and Bodily (1983, p. 597).

and expected own portfolio risk over the next 3 months, on a seven-point Likert scale ranging from "1 = Not risky at all" to "7 = Extremely risky".

3.2.D Past performance

We elicited participants' memories of past performance, both of the UK stock market in general (FTSE-All-Share) and of their own portfolio over the last 3 months, using two elicitation methods: (i) as a numeric (percentage return) estimate (PastPerf.Own-Num and PastPerf.Market-Num) and (ii) as a qualitative subjective judgment on seven-point Likert scales with the endpoints "1 = Extremely bad return" and "7 = Extremely good return" (PastPerf.Own-Subj. and PastPerf.Market-Subj.). In addition, we also asked respondents for their numeric (percentage) estimates of past 3-month returns of their personal investments held at other banks (PastPerf.External).

3.3 DIFFERENCES IN RESPONSES BETWEEN GROUPS WITH DIFFERENT RESPONSE RATES

To test for any selection bias in our data, i.e., the question whether participants who completed one, two, three or four surveys provided different answers on any of the above variables, we conducted a series of Mann–Whitney rank-sum tests. We found a very small number of significant differences not more than can be expected by chance alone, scattered over different variables with no discernable pattern, suggesting that there were no differences on these variables between these groups of respondents. As mentioned earlier, we did a similar analysis for those who answered in the following round versus those who did not answer, which also showed no significant differences.

4. Results

4.1 RISK TAKING, RISK ATTITUDE, AND RISK AND RETURN EXPECTATIONS ACROSS TIME

Table III reports the means of all repeatedly elicited variables in our study, for the four assessed periods.[10] The last three columns in Table III report Wilcoxon signed-rank test statistics that indicate whether the difference in

[10] Table III includes values only for respondents who participated in at least two of the four surveys, but results are essentially the same if we either include the data for all 617 investors or restrict ourselves to the 89 investors who participated four times.

Table III. Survey responses across time periods

This table reports mean responses on indicated variables by time of elicitation. The last three columns provide *z*-statistics of Wilcoxon signed-rank tests of differences between successive time periods, for those investors who participated in both time periods. *Significant at the 5% level; **significant at the 1% level.

	Mean				Difference December–September	Difference March–December	Difference June–March
	September ($N=265$)	December ($N=305$)	March ($N=239$)	June ($N=188$)	*z*-score	*z*-score	*z*-score
Risk-Taking	56.02	52.77	46.52	53.47	−2.59**	−3.90**	3.86**
Risk Attitude 2	3.34	3.63	3.55	3.55	1.89	−0.73	0.46
Risk Attitude 6	4.43	4.61	–	–	2.51*	–	
Risk Attitude 7	5.04	5.06	–	–	0.39	–	
Market-Return-Num	1.57	3.57	5.42	4.25	1.66	3.31**	−1.11
Market-Risk-Num	0.052	0.075	0.072	0.090	7.29**	−0.57	2.54**
Market-Return-Subj	3.50	3.67	3.84	4.20	1.09	−0.48	2.52**
Market-Risk-Subj	4.76	5.17	5.15	4.52	4.60**	1.53	−6.21**
Own-Return-Num	4.38	6.23	8.18	5.98	2.94**	3.32**	−0.59
Own-Risk-Num	0.053	0.078	0.067	0.087	6.74**	−2.56**	3.59**
Own-Return-Subj	3.89	3.91	4.17	4.42	−1.09	2.60**	2.53**
Own-Risk-Subj	4.20	4.45	4.53	4.34	3.68**	1.29	−2.32**
PastPerf-Ext	−2.14	−12.57	−3.19	11.83	−7.41**	3.62**	7.05**
PastPerf-Market-Num	−8.20	−16.79	−6.96	13.86	−8.20**	7.78**	10.09**
PastPerf-Market-Subj	2.32	1.82	2.42	5.27	−7.43**	4.64**	9.99**
PastPerf-Own-Num	−7.70	−18.51	−8.48	13.14	−9.52**	7.03**	9.20**
PastPerf-Own-Subj	2.95	2.33	2.92	4.66	−7.26**	4.26**	8.20**

value for that variable is significant between two successive survey administrations. These tests only use data from respondents who participated in the two respective surveys, i.e., use only within-subject data.

For Risk-Taking we observe, consistent with Hypothesis 1(a), that the percentage of the £100,000 stake that investors are willing to place into the market (FTSE-All-Share) varies substantially. As shown in Figure 2 and Table III, risk taking decreases from 56.0% in September 08 to 52.8% in December 08 and further to 46.5% in March 09, and then increases again to 53.5% in June 09. All differences are significant at the 1% level.

In contrast, there are hardly any changes in self-reported risk attitudes over the four time periods. Risk Attitude 2 ("It is likely I would invest a significant sum in a high risk investment") and Risk Attitude 7 ("Even if I

experienced a significant loss on an investment, I would still consider making risky investments") are virtually the same in September 08 and in December 08. Risk Attitude 6 ("I am a financial risk taker") rises slightly from 4.43 to 4.61 from September 08 to December 08, a difference significant at the 5% level, but in a direction that is inconsistent with the observed declines in risk taking over that time period. From March 09 onward, we only elicited Risk Attitude 2, the single most diagnostic measure from *Barclays'* eight-question scale, with a distribution of responses that covered the full range of values across investors, as shown in Figure 3, but which, as Table III shows, did not change across time periods. There were only minor variations at the individual-subject level, and over 56% of those participating in all four rounds did not change their self-reported risk attitude scores across that time period by more than a single point on the seven-point Likert scale. This stability of risk attitudes across time is in line with findings in Sahm (2007) and Baucells and Villasis (2010) and supports Hypothesis 1(b).

As in Hypothesis 1(c), risk expectations changed considerably over time, in ways mostly consistent with market events. Thus, all four risk expectation measures (Market-Risk-Num., Market-Risk-Subj., Own-Risk-Num., and Own-Risk-Subj.) were significantly higher in December 08 than September 08, following the Lehman Brothers collapse and subsequent market decline and volatility increase, as shown in Table III. The numeric volatility estimates of risk stayed steady or increased from December 08 to March 09 and June 09. In contrast, subjective risk expectations that are likely more affect- than analysis-based stayed steady from December 08 to March 09, but then significantly decreased by June 09, indicating perhaps some habituation to the continuing volatility, i.e., a decrease in worry or concern.

Return expectations were similarly variable over time, consistent with Hypothesis 1(c), though less so than risk expectations. As shown in Table III, both the numeric and the subjective return expectations were positive (numeric) or slightly positive (subjective) from September 08 to June 09.[11] This suggests that for the first three survey rounds respondents expected some form of market correction for subsequent periods. Also shown in Table III, investors' numeric estimates of past market performance were not too far off actual market returns. The performance of the FTSE-All-Share for the 3-month period before the questionnaire was distributed was approximately −12% for September 08, −25% for December 08, −8% for March 09, and +14% for June 09.

[11] The only exception is a slight, but non-significant decrease in the numeric return expectation from March 09 to June 09.

In summary, our results are consistent with Hypotheses 1(a) to (c). Moreover, our results are robust, i.e., remain essentially the same if we analyze differences only for those investors who participated three or four times or if we include all observations at each point of time.

4.2 DIFFERENCES BETWEEN NUMERIC AND SUBJECTIVE ASSESSMENTS OF RISK AND RETURN EXPECTATIONS FOR MARKET PORTFOLIO AND OWN PORTFOLIO

Table IV(a) Panel A shows the correlations between the numeric and the subjective measure of the four solicited expectations (returns and risks, for market and own portfolio, respectively), for each of the four survey rounds. The pattern of correlations is truly consistent across time periods. While all correlations are significant at the 0.05 level or higher, there are much higher correlations between the numeric and the subjective elicitation value for return expectations than for risk expectations (Wilcoxon signed-rank test $z = 2.52$; $p < 0.02$). The same pattern also holds for the correlation of changes, Table IV(a) Panel B, which are generally lower, significant for return and not significant for risk. This is consistent with prior studies that have found much closer correspondence between subjective return expectations and normative values such as the expected value of past returns of investment options than between subjective risk expectations and normative values such as the variance or standard deviation of past returns (Weber and Hsee, 1998; Weber *et al.*, 2005).

Table IV(b) Panel A shows that there are reasonably high correlations (from 0.48 to 0.64) between investors' risk and return expectations for the market and their own portfolios when the expectations are assessed numerically. This is also true for return expectations assessed subjectively (from 0.45 to 0.64), but the correlations are much reduced for subjectively assessed risk expectations (from 0.27 to 0.37). While investors on average exhibit some optimism or "better than average" bias, as shown in Table III, where subjective return estimates are better ($t = 7.92$, $p < 0.00001$) and subjective risk estimates lower ($t = -13.25$; $p < 0.00001$) for own portfolios than for the market portfolio, it is possible that different feelings influence the subjective risk expectations of different investors for their own portfolios (for some perhaps hope, while for others fear), thus lowering the correlation between this estimate and their subjective risk expectation for the market. Again the results are remarkably consistent across the four time periods. The correlations of changes (Panel B) again show the same pattern as in Panel A, with most correlation coefficients being somewhat lower.

Table IV. Correlations between return and risk expectation measures for market and own portfolio

This table reports the Pearson's correlation coefficients between (a) numeric and subjective measures of return and risk expectations for market and own portfolios, respectively; (b) assessments for market portfolio and own portfolio of return and risk expectations, assessed either numerically or subjectively, respectively; and (c) risk and return expectations assessed either for market or own portfolio, numerically or subjectively, respectively. Panel A presents the analysis for absolute levels of variables, Panel B for changes in those variables from the previous time period to the indicated time period. All correlations are significant at the 5%-level or higher (unless stated n.s. = not significant).

Panel A: correlations of absolute levels of variables

(a) Numeric–subjective correlation

	Return		Risk	
DATE	Market portfolio	Own portfolio	Market portfolio	Own portfolio
"Sept 08"	0.49	0.4	0.18	0.26
"Dec 08"	0.49	0.49	0.18	0.26
"March 09"	0.49	0.49	0.22	0.32
"June 09"	0.64	0.55	0.3	0.18

(b) Market–own correlation

	Return		Risk	
DATE	Numeric	Subjective	Numeric	Subjective
"Sept 08"	0.48	0.47	0.63	0.27
"Dec 08"	0.56	0.51	0.63	0.37
"March 09"	0.64	0.45	0.58	0.31
"June 09"	0.61	0.64	0.59	0.37

(c) Risk–return correlation

	Market Portfolio		Own Portfolio	
DATE	Numeric	Subjective	Numeric	Subjective
"Sept 08"	−0.05 (n.s.)	−0.26	0.21	0.1
"Dec 08"	−0.02 (n.s.)	−0.31	0.3	−0.04 (n.s.)
"March 09"	0.12 (n.s.)	−0.32	0.29	−0.01 (n.s.)
"June 09"	−0.01 (n.s.)	−0.21	0.11 (n.s.)	0.01 (n.s.)

Panel B: correlations of changes in variables from previous to indicated time period

(a) Numeric–subjective correlation

	Return		Risk	
DATE	Market portfolio	Own portfolio	Market portfolio	Own portfolio
"Sept 08"	–	–	–	–
"Dec 08"	0.22	0.30	−0.02 (n.s.)	−0.06 (n.s.)
"March 09"	0.18	0.25	0.07 (n.s.)	0.07 (n.s.)
"June 09"	0.49	0.36	0.15	0.05 (n.s.)

(b) Market–own correlation

	Return		Risk	
DATE	Numeric	Subjective	Numeric	Subjective
"Sept 08"	–	–	–	–
"Dec 08"	0.58	0.42	0.48	0.14
"March 09"	0.51	0.22	0.39	0.22
"June 09"	0.34	0.33	0.74	0.07 (n.s.)

(continued)

Table IV. Continued

(c) Risk–return correlation				
	Market portfolio		Own portfolio	
DATE	Numeric	Subjective	Numeric	Subjective
"Sept 08"	–	–	–	–
"Dec 08"	0.02 (n.s.)	−0.22	0.05 (n.s.)	−0.04 (n.s.)
"March 09"	0.19	−0.09 (n.s.)	0.11 (n.s.)	−0.06 (n.s.)
"June 09"	−0.00 (n.s.)	−0.12 (n.s.)	0.02 (n.s.)	0.01 (n.s.)

Table IV(c) Panel A provides some results indicative of investors' financial sophistication. Finucane *et al.* (2000) observed that people's risk and return expectations often show a negative relationship, i.e., options with higher return expectations are being perceived as carrying lower risks, contrary to the actual positive relationship between risks and returns between assets in efficient markets. This negative relation can be seen as evidence that people use their affect toward an investment to judge both its expected risk and return, with more positive-feeling choice options being seen as less risky and as yielding greater returns. Table IV(c) shows that, different from studies using university students, the investors in our study did not show such a negative relationship in their numeric judgments about their own portfolio. In an analysis across subjects, their numeric judgments correctly implied a positive relationship between risk and return expectations for their own portfolios.[12] However, for the more qualitative /subjective judgments of expectations, even this set of relatively prosperous and experienced personal investors showed significant negative correlations between what they expected for risks and returns for the market portfolio, and much smaller positive or zero correlation for their own portfolio, suggesting that subjective feelings can affect the perceptions and actions of even financially sophisticated investors, as also shown by Holtgrave and Weber (1993). Panel B shows that there is essentially no relationship between changes in risk expectations and changes in return expectations in our data.

4.3 WHAT PREDICTS RISK TAKING AND DRIVES CHANGES IN RISK TAKING?

Although we are mostly interested in the relationship between changes in different variables (Equation (3)), we first present an analysis testing Equation (2), the more general risk–return framework. Table V Column 1

[12] Within investors the picture is inconclusive, some show positive others negative correlations over time.

Table V. Predictors of risk taking

This table reports regression coefficients of clustered Tobit regressions where standard errors take clustering over subjects into account. The dependent variable in each model is risk taking. Independent variables are: risk attitude, expectations, and past performance as well as demographic variables. The regressions include round dummies with round one as the baseline. Columns are explained in the text. *Significant at the 10% level, **significant at the 5% level, and ***significant at the 1% level. Decider is a dummy variable that takes the value 1 if the investor is the person primarily responsible for financial decisions in the household. Financial literacy is assessed using four questions. Each correct answer gives one point, i.e., the variable ranges from 0 to 4, with 0 (4) indicating low (high) financial literacy. Questions are taken from Van Rooij et al. (2011). For the exact wording of these questions see Table A1 in Appendix.

Type of variable		1	2	3	4	5	6
Why?	Risk Attitude 2	3.47***	3.30***	3.27***	3.03***	3.30***	2.91***
Why?	Market-Return-Num		0.24**	0.29***	0.38***	0.31***	0.34***
Why?	Market-Risk-Num		−19.25	−19.07	−45.20**	−21.81	−61.82**
Why?	Market-Return-Subj		5.75***	5.33***	5.40***	5.06***	5.01***
Why?	Market-Risk-Subj		−4.27***	−4.13***	−2.95***	−4.06***	−3.12***
Why?	Own-Return-Num						0.13
Why?	Own-Risk-Num						18.84
Why?	Own-Return-Subj						0.64
Why?	Own-Risk-Subj						0.32
Why?	Past Perf. Market Num			−0.11		−0.08	
Why?	Past Perf. Market Subj			0.87**		1.26	
Why?	Past Perf. Own Num					−0.11	
Why?	Past Perf. Own Subj					1.53*	
Who?	Age				0.04		0.05
Who?	Gender				9.47*		9.05*
Who?	Dependents				1.67*		1.62*
Who?	Decider				−10.17		−9.71
Who?	Marital status				−5.00		−4.06
Who?	Financial literacy				0.62		1.00
Who?	Income (categorical)				0.19		0.27
Who?	Wealth				0.59		0.64
When?	Round 2	−4.33**	−3.47*	−3.76*	−4.41*	−3.99*	−4.37*
When?	Round 3	−10.28***	−10.94***	−10.97***	−10.46***	−10.97***	−10.02***
When?	Round 4	−2.83	−8.59***	−10.95***	−6.27**	−10.57***	−6.68**
	Constant	44.77***	46.11***	41.89***	38.00***	38.80***	32.83***
	Observations	1264	1219	1216	876	1216	858

shows that risk taking significantly depends on risk attitude. As proposed by the framework Column 2 shows that risk taking also depends on subjective market risk and return expectations and also on numeric return expectation (though less significantly so) but not on numeric risk expectation which

turns out to be significant in Column 4 where demographic control variables are included. Numbers in Table V are coefficients in a Tobit model, i.e., cannot interpreted directly. Taking the coefficient "3.30" for risk attitude (Column 2) marginal effects show that a higher risk tolerance of one step results in a 2.82% higher investment in the risky asset.[13]

Column 3 shows that higher past performance measured on a subjective scale results in higher risk taking. Including demographics (Column 4), we find that being male and having a larger number of dependents leads to marginally significant more risk taking. All other variables show no effect. Columns 5 and 6 also include estimates about investors' own portfolio. We find hardly any significant effect for these variables, whereas the results for the other variables remain stable.

The analysis underlying Table V allows us to test Hypothesis 2. We ran two Tobit regressions including round dummies with risk taking as the dependent variable. Predictor variables are market estimates: either numeric expectations for return and risk or subjective expectations for return and risk. Consistent with Hypothesis 2, we find the R^2 to be higher for subjective factors (0.0171 versus 0.0056), the *t*-statistics to be larger (return: subjective 8.79 versus numeric 3.52; risk: subjective –4.85 versus numeric –1.10) and the F-value to be larger for the regression with subjective factors (31.16 versus 8.08).

In addition to the direct influence of past performance variables on risk taking shown in Table V, there seems to be an indirect effect. Table VI shows that past return variables are related to both numeric and subjective return expectations. We find that past performance better explains subjective return expectations than numeric return expectations as R^2 are larger for regressions with subjective variables as dependent variables than with numeric variables. Subjective numeric return expectations are significantly related to subjective numeric past performance measures. Especially for subjective return predictions, all four regression coefficients are positive, i.e., higher past returns estimations imply higher future return predictions.

Table VII shows the same variables as listed in Table III, now separated for investors whose risk taking either increased or decreased between two successive time periods (Δ RiskTaking >0; Δ RiskTaking <0) for the three comparison time periods (September 08–December 08; December 08–March 09; March 09–June 09). The last column for each time comparison shows the results of Mann–Whitney rank-sum tests.

[13] For the Market variables the marginal effects are as follows: 0.20, −16.40, 4.90, and –3.64, e.g., a 10% points higher return expectation (Market-Return-Numeric) leads to 2% points increase in investment in the risky asset.

Table VI. Regression coefficients for effects of past performance variables on numeric and subjective return expectations for market and personal portfolio

This tables reports linear regression coefficients for the effect of past performance variables on numeric and subjective return expectations for market and personal portfolio. We include round dummies and individual fixed effects. *Significant at 5%; **significant at 1% level; ***significant at 0.1% level.

	Numeric return predictions		Subjective return predictions	
Predictors	Market portfolio $n = 1163$	Own portfolio $n = 1163$	Market portfolio $n = 1160$	Own portfolio $n = 1163$
PastPerf-Ext-Num	−0.025	−0.051**	−0.004	−0.000
PastPerf-Market-Num	0.256***	0.171***	0.001	0.003
PastPerf-Market-Subj	−0.878**	0.035	0.110**	0.111***
PastPerf-Own-Num	−0.008	−0.052*	−0.001	−0.002
PastPerf-Own-Subj	−0.012	0.081	0.128***	0.085**
Round 2	4.098***	1.321	0.362***	0.146
Round 3	3.732***	3.596***	0.366***	0.171*
Round 4	0.817	−0.130	0.159	−0.043
Constant	5.430***	5.042***	2.843***	3.393***
R^2	0.072	0.020	0.109	0.118

Variables that differ between these two groups of respondents are potential predictors of risk taking. Table VII shows that this rules out measures of risk attitudes, which hardly show any difference between the two groups for all three transitions in time.[14] Changes in investors' risk and return expectations for their own portfolios mostly also do not differ significantly between the two groups (Δ R.T.$^{+}$ and Δ R.T.$^{-}$). The same is true for changes in their numeric risk and return expectations for the market portfolio, Diff. Market-Return-Num. and Diff. Market-Risk-Num. However, for changes in subjective/qualitative risk and return expectations for the market portfolio we find differences between the two groups. Investors who take more risks from one time period to the next (Δ R.T.$^{+}$) expect market returns (Diff. Market-Return-Subj.) to be substantially higher over the next 3 months, whereas investors who take less risk (Δ R.T.$^{-}$) expect market returns to stay fairly stable over time. Differences in changes in subjective market return expectations between the two groups are significant for all three time periods, suggesting that changes in subjective market return expectations are related to changes in risk taking. This result remains stable

[14] Note that Diff. Risk Attitude 6 and Diff. Risk Attitude 7 were not elicited in March and June.

Table VII. Changes in risk attitudes, expectations, and past performance

Mean changes in reported risk attitudes, expectations, and past performance across time periods, separately for investors who took more risk or less risk in the second time period. Variables as listed in Table III. The Mann–Whitney rank-sum test statistic indicates whether the change in the row variable is different for these two groups. *Significant at 5%; **significant at 1% level.

	September–December			December–March			March–June		
	Δ Risk Taking >0	Δ Risk Taking <0	*z*-score	Δ Risk Taking >0	Δ Risk Taking <0	*z*-score	Δ Risk Taking >0	Δ Risk Taking <0	*z*-score
Diff. Risk Attitude 2	0.18	0.01	0.54	0.04	-0.09	1.19	0.14	0.12	0.60
Diff. Risk Attitude 6	−0.01	0.22	−1.23	–	–	–	–	–	–
Diff. Risk Attitude 7	0.03	−0.04	0.22	–	–	–	–	–	–
Diff. Market-Return-Num	0.94	3.94	−0.07	3.13	0.52	1.40	−0.14	−2.39	1.45
Diff. Market-Risk-Num	0.02	0.03	−0.62	0.00	−0.01	1.57	0.02	0.02	0.35
Diff. Market-Return-Subj	0.40	−0.03	2.02*	0.51	0.05	2.47*	0.58	−0.18	2.31*
Diff. Market-Risk-Subj	−0.05	0.56	−3.35**	−0.20	−0.02	−1.21	−0.69	−1.12	1.19
Diff. Own-Return-Num	2.98	3.25	−0.25	3.15	3.41	−0.56	0.73	−0.15	1.36
Diff. Own-Risk-Num	0.03	0.02	0.93	0.00	−0.02	2.09*	0.02	0.02	−0.43
Diff. Own-Return-Subj	−0.07	−0.02	−0.04	0.30	0.02	1.33	0.59	−0.03	2.07*
Diff. Own-Risk-Subj	0.24	0.32	−0.77	0.46	0.06	1.27	−0.25	−0.18	−0.32
Diff. Past Perf. External	−8.99	−14.83	0.56	5.57	4.47	0.15	16.37	18.71	−1.52
Diff. Past Perf. Market Num	−11.84	−5.88	−1.42	9.04	10.10	−0.70	25.40	20.70	0.87
Diff. Past Perf. Market Subj	−0.70	−0.67	−0.17	0.35	0.68	−1.18	2.96	2.91	0.07
Diff. Past Perf. Own Num	−13.00	−12.89	0.60	11.60	8.91	0.40	22.71	19.11	0.94
Diff. PastPerf. Own Sub	−0.55	−0.87	1.54	0.80	0.14	2.54**	2.07	1.70	0.20

when we rerun the analysis only for investors who participated in all four surveys. The reverse is true for subjective market risk expectations (Diff. Market-Risk-Subj.): investors who take less risk from one time period to the next (Δ R.T.$^{-}$) expect market risk to increase for the next period, whereas investors who take more risk (Δ R.T.$^{+}$) expect it to decrease. Table VII finally shows that changes in past performance estimates are not related to changes in risk taking, as only Diff. Past Perf. Own Subj. is significantly different for the two groups for one period.

We use Tobit regressions to determine what combinations of factors drive changes in risk taking, since the dependent measure "Change in percentage of £100,000 invested into the market" is censored from below (−100) and from above (+100). Table VIII reports the results of multivariate Tobit regressions with clustered standard errors of changes in risk taking from one time period to the next.[15]

Column 1 of Table VIII shows that changes in self-reported risk attitude (Diff. Risk Attitude 2) do not explain changes in risk taking, but the coefficients are in the right direction. This result still holds when we rerun the regression while excluding investors who reported the same risk attitude in two subsequent time periods. Column 2 shows that, in contrast to changes in risk attitude, changes in subjective risk and return expectations do explain changes in risk taking. The larger subjective market return expectations are in the current survey round compared with the previous round, the more risk is taken in the current round compared with the previous round. The greater the perceived level of risk of the market in the current round, the less risk is taken in the current round. The same regression with numeric instead of subjective estimates of expectations (Column 3) shows that changes in numeric expectations cannot explain changes in risk taking, confirming Hypothesis 2. The regression in Column 4 shows that changes in subjective market risk and return expectations continue to predict changes in risk taking even when numeric predictions variables are included, though changes in self-reported risk attitude also become marginally significant predictors. Marginal effects are almost identical to the regression coefficients.

Finally, we added demographic variables (Column 5) and numeric and subjective judgments about past market performance (Column 6) as predictors of changes in risk taking.[16] As shown in Columns 5 and 6, neither group of variables predicts changes in risk taking, and neither do changes in

[15] Since Diff. Risk Attitude 6 and Diff. Risk Attitude 7 were not elicited at all time periods, they were not included in the analyses. We took into account that most investors participated in more than one survey by clustering our regressions over respondents.

[16] We did not add income and wealth as those variables were less frequently available.

Table VIII. Predictors of changes in risk taking

This table reports regression coefficients of Tobit regressions where standard errors take clustering over subjects into account. The dependent variable in each model is changes in risk taking (Diff. Risk Taking). Independent variables are changes in: risk attitude, expectations, and past performance as well as demographic variables. All changes or differences variables are calculated for each person separately, as the value on the current survey minus the value on the previous survey. Columns are explained in the text. *Significant at the 10% level, **significant at the 5% level, and ***significant at the 1% level.

	1	2	3	4	5	6
Diff. Risk Attitude 2	0.93	0.98	1.23*	1.30*	1.23*	1.20*
Diff. Market-Return-Num			0.28	0.17	0.24	0.26
Diff. Market-Risk-Num			1.47	1.95	1.83	3.05
Diff. Market-Return-Subj		2.62***		2.03**	1.91**	2.09**
Diff. Market-Risk-Subj		−1.45*		−1.44*	−1.44*	−1.53*
Diff. Past Perf. Market Num						−0.05
Diff. Past Perf. Market Subj						0.48
Age					−0.09	−0.08
Gender					5.56	2.92
Dependents					−0.17	−0.10
Decider					7.10	6.97
Marital status					2.04	1.74
Financial literacy					−0.58	−0.70
Dummy-Period 2-1	−12.36	−10.26***	−12.58***	−10.24***	−10.47***	−10.49**
Dummy-Period 3-2	−14.48***	−12.89***	−15.92***	−13.78***	−13.81***	−13.36***
Constant	7.99***	6.09***	8.10***	6.05***	−0.34	1.79
Observations	572	569	532	529	526	519

numeric market risk and return expectations. The only two variables that consistently and reliably predict changes in risk taking are changes in investors' subjective expectations of market risks and returns.[17]

Support for Hypothesis 1(d) that changes in risk taking are mediated by changes in risk and return expectations is provided by the results of a mediation analysis (e.g., Shrout and Bolger, 2002), summarized in Figure 4. For each of the three transitions in time (September 08 to December 08 to March 09 to June 09), we regressed risk taking in the two subsequent periods on a time dummy. As discussed earlier and shown by the significant regression coefficients for the direct link between time and risk taking in the bottom

[17] As a robustness check we redid the analysis of Table VIII excluding extreme values for numeric changes. We define those by Diff. Market-Return-Num and Diff Post Perf. Market Num being larger than 50% and Diff.-Risk-Num being larger than 0.5. In regression 3, 5, and 6 we loose 4, 8, and 4 observations. The number 50% might look pretty large but there was a three month period where the real market return was about −25%. The results basically do not change.

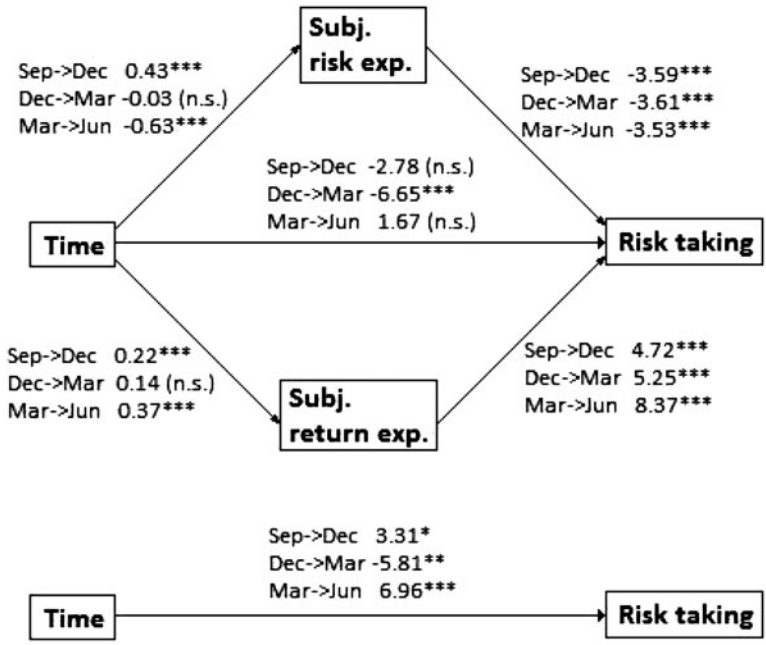

Figure 4. Results of mediation analysis. *Significant at the 10% level, **significant at the 5% level, and ***significant at the 1% level.

part of Figure 4, risk taking differed significantly between the two time periods for all three transitions. We next tested the precondition for possible mediation of changes in risk taking by changes in subjective risk and return expectations, namely whether risk and return expectations significantly differed between time periods. As shown by the coefficients for the links between time and either risk or return expectations on the left side of the top portion of Figure 4, this precondition was satisfied for two of the three time transitions. As shown by the coefficients for the links between both risk or return expectations and risk taking on the right side of the top portion of Figure 4, risk taking was significantly predicted by risk and return expectations across time periods. Most importantly, when risk and return expectations are added to the time dummy to predict risk taking, the time predictor is no longer significant for the two time transitions for which the precondition for mediation was satisfied (i.e., September 08 to December 08, and March 09 to June 09). The difference in magnitude and significance level of the indirect effect of time on risk taking, shown by the coefficients for that link in the top part of Figure 4, and the direct effect in the bottom part of Figure 4 provide evidence that changes in risk and return expectations successful mediate observed changes in risk taking over time.

5. Conclusion

In repeated surveys conducted between September 08 and June 09, a sample of *Barclays* online brokerage personal investors showed substantial changes in risk taking over time. Using risk-value models that allow for individual and situational differences in risk and return expectations as well as differences in self-reported risk attitude, we tie these changes in risk taking to changes in subjective expectations of risk and return, whereas risk attitudes remain remarkably stable over time, as one would expect from a psychological trait. Any existing small changes in self-reported risk attitude predict changes in risk taking only at marginal levels of significance. These results are stable when we control for past investment performance and demographics.

Consistent with previous work on risk expectations (Weber *et al.*, 2005), we find that qualitative subjective judgments of expected market risk and return predict risk taking, but that investors' quantitative estimates of market returns and volatility, far closer to the traditional finance risk–return model, fail to predict observed changes in risk taking. Subjective judgments of risk and return expectation continue to be significant predictors of risk taking even when investors' quantitative estimates of expected market returns and their volatility are included in the regression, suggesting that it is the more emotion-based components of these judgments that drive changes in risk taking.

In summary, our study extends previous findings in the literature on changes in risk taking, expectations, and risk attitudes in multiple important ways. First, our unique dataset allows us to analyze changes in risk taking, expectations, and risk attitudes of online broker customers. The personal investors in our sample are affluent and frequently trade in stocks and other securities, and are financially sophisticated. They do not show myopia in information use, in the sense that they do not use/substitute subjective risk and return expectations for their own personal portfolios when they make risky decisions involving the market portfolio. They also do not show any halo effect in their numeric risk and return predictions,[18] and their risk taking is not directly influenced by recent investment gains or losses. Thus, it is fair to say that our results probably place a lower bound of the degree and type of irrationality that one might expect to see in a broader sample of personal investors.

Whereas previous studies in the literature analyzed only changes in risk taking (see e.g., Malmendier and Nagel, 2011), in expectations (see e.g.,

[18] Though they do show one for their subjective judgments of expected risks and returns.

Vissing-Jorgensen, 2003), or in risk attitude (see e.g., Sahm, 2007), our study examined the relationship between these variables. This allowed us to examine the mechanism or channel by which risk taking might change over time. Another fortuitous feature of our study is the fact that the first survey was conducted in the early part of September 08, i.e., just before extreme turmoil in financial markets. Hence, we are able to analyze the effect of substantial stock price drops on risk attitudes and expectations by comparing the expectations and attitudes shortly before the crisis to those during and after the crisis, using the same panel of investors. While only a direct manipulation of risk and return expectations would allow us to conclusively establish their causal role in changing risk taking, our within-subject repeated measures design and the results of the mediation analysis strongly suggest that observed changes in risk taking over the survey period were the result of changes in subjective feelings about future market risk and return, and not the result of changes in risk attitude.

We observed one significant change in self-reported risk attitude. Risk Attitude 6 ("I am a financial risk taker") showed a significant increase (from 4.43 to 4.61) from September 08 to December 08, but in a direction inconsistent with the observed decline in risk taking over that time period. Investors who we know had been losing money in the stock market between September 08 and December 08, might have concluded that they must be greater risk taker than they had previously thought, in light of these losses. No such changes in self-reports of risk attitudes were observed for the more diagnostic self-report measure Risk Attitude 2.

Our findings should be valuable for banking practitioners. We show that risk attitudes—if measured correctly and without confounding effects—seem to be fairly stable and that changes in risk taking seem to be triggered by changes in risk and return expectations. Thus, practitioners urged, e.g., by the MiFID of the European Union (2006), to elicit their customers' risk profiles and risk preferences can argue that risk attitudes need not to elicited on a quarterly basis. Instead our results show that investors hold risk and return expectations that change significantly over time and seem to guide their investment behavior. Our data also show that these changing risk and return expectations are influenced by recent events, in a number of ways not consistent with rational theory, providing ample opportunity for investor education.

Future research should investigate which other variables drive risk taking behavior. We know from previous studies that overconfidence and optimism (Nosic and Weber, 2010) as well as the anticipation of optimism on the part of others (Egan *et al.*, 2011) lead to higher risk taking. There are most likely other psychological factors as well.

Our results indicate that it would be worthwhile for practitioners to elicit their clients' risk and return expectations more frequently and to provide some corrective feedback at the end of regular time periods, e.g., at the end of each calendar year, as investors seem to persistently underestimate and subjectively underappreciate the volatility of the market, putting hope over fear.

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Appendix

Table AI. Variables and wording of survey questions

[a] *Financial Literacy* and other demographic variables were only assessed once, i.e., in the first round.

Variable (Order)	Exact wording of survey questions
Risk Taking	
Risk Taking (3) (3) = Third question	"Now imagine you have an overall wealth of £100,000 and you could invest this amount either in a risk-free investment with a safe interest rate of 4% or into the UK stock market (FTSE all-share). How much would you invest in the in the UK stock market (FTSE all-share)?" (0 = invest everything into the risk free asset; 100 = invest everything into the risky stock market).
Risk Attitude	
Risk Attitude 2 (7)	"It is likely I would invest a significant sum in a high risk investment." (1 = Strongly disagree... 7 = Strongly agree)
Risk Attitude 6 (8)	"I am a financial risk taker." (1 = Strongly disagree... 7 = Strongly agree)
Risk Attitude 7 (9)	"Even if I experienced a significant loss on an investment, I would still consider making risky investments." (1 = Strongly disagree... 7 = Strongly agree)
Expectations	
Market-Return-Num. Market-Risk-Num(4).	"In the next questions, we would like you to make three estimates of future stock market returns. * Your middle estimate should be your best guess (as likely be above the actual value as below it); * Your high estimate should be lower than the actual value very rarely (about once in 20 estimates); * Your low estimate should be above the actual value very rarely (about once in 20 estimates); Please enter your response as a percent, i.e. a rise as X%, or a fall as -X%. The return of the **UK stock market (FTSE all-share)** in **3 months**:" For Market-Return-Num. the middle estimate is used. For Market-Risk-Num. the implicit expected volatility is calculated from the high and low estimates using the two-point approximation by Keefer and Bodily (1983).
Market-Return-Subj.(1)	"How would you rate the returns you expect from an investment in the UK stock market (FTSE-All- Share) over the next 3 months?" (1 = Extremely bad... 7 = Extremely good)
Market-Risk-Subj.(2)	"Over the next 3 months, how risky do you think the UK stock market (FTSE-All- Share) is?" (1 = Not risky at all... 7 = Extremely risky)
Own-Return-Num. Own-Risk-Num. (12)	"In the next questions, we would like you to make three estimates of future returns on investments held with us. * Your middle estimate should be your best guess (as likely be above the actual value as below it);

(continued)

Table AI. Continued

Variable (Order)	Exact wording of survey questions
	* Your high estimate should be lower than the actual value very rarely (about once in 20 estimates); * Your low estimate should be above the actual value very rarely (about once in 20 estimates); Please enter your response as a percent, i.e. a rise as X%, or a fall as -X%. The return of **your portfolio held with us** in **3 months** time:" For Own-Return-Num. the middle estimate is used. For Own-Risk-Num. the implicit expected volatility is calculated from the high and low estimates using the two-point approximation by Keefer and Bodily (1983).
Own-Return-Subj.(13)	"How would you rate the returns you expect from your own portfolio over the next 3 months?" (1 = Extremely bad... 7 = Extremely good)
Own-Risk-Subj.(14)	"Over the next 3 months, how risky do you think the investments in your own portfolio are?" (1 = Not risky at all... 7 = Extremely risky)
Past Performance	
PastPerf.-External (15)	"What do you think your return (percentage change) of investments held elsewhere over the past three months was? If you hold all of your investable assets with us, enter zero. Please enter your response as a percent change, i.e. a rise as X%, or a fall as -X%."
PastPerf.-Market-Num. (10)	"What do you think the UK stock market (FTSE all-share) return (percentage change) over past three months was? Please enter your response as a percent change, i.e. a rise as X%, or a fall as -X%."
PastPerf.-Market-Subj (11).	"How would you rate the returns of the UK stock markets (FTSE-All-Share) over the past 3 months?" (1 = Extremely bad... 7 = Extremely good)
PastPerf.-Own-Num.(5)	"What do you think your return (percentage change) with us over past three months was? Please enter your response as a percent change, i.e. a rise as X%, or a fall as -X%."
PastPerf.-Own-Subj.(6)	"How would you rate the returns of your portfolio (all investments held with us) over the past three months?" (1 = Extremely bad... 7 = Extremely good)
Other variable[a]	
Financial LIteracy	"Suppose you had £100 in a savings account, the interest rate was 10% per year and you never withdraw the money or the interest payments. After 5 years, how much do you think you would have in the account in total?" More than £150/Exactly £150/Less than £150/Do not know "Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?" More than today /Exactly the same/Less than today/Do not know

(continued)

Table AI. Continued

Variable (Order)	Exact wording of survey questions
	"When an investor spreads money among different assets, does the risk of losing money" Increase/Decrease/Stay the same/Do not know "If the interest rate rises, what should happen to bond prices?" Rise/Fall/Stay the same/Do not know
Decider	"Are you the person in the household primarily responsible for financial decisions in the household?" (0 = no, 1 = yes)