Changes of expectations and risk attitudes and their impact on risk taking behavior

Alen Nosić and Martin Weber *

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Abstract

We use data from a repeated survey panel that was run with real online broker customers in September 2008, December 2008, and March 2009. In all three surveys subjects' risk attitudes, risk expectations, return expectations, and risk taking behavior, i.e. the proportion of wealth they are willing to invest into the stock market compared to a risk free asset, were elicited. Using this unique dataset we analyze whether risk taking, risk attitudes, and expectations change from one quarter to the other and whether the latter two have an impact on risk taking behavior. Our results indicate that risk taking behavior decreases substantially from September to December and from December to March. Similarly, risk expectations and return expectations also change substantially from one survey to the next one. In contrast, various measures of risk attitudes are fairly stable over the time periods. Interestingly, observed changes in risk taking behavior can primarily be attributed to changes in risk and return expectations but not to changes in past performance or changes in risk attitudes. Moreover, our findings are valuable for practitioners - who are urged by MiFID (2006) to elicit their customers' risk profiles and risk preferences - since we show that risk attitudes remain fairly stable and that changes in investment behavior can mainly be attributed to changes in expectations. Lastly, we illustrate that overconfidence seems to be a fairly stable construct between September and December and tends to decrease slightly from December to March.

Keywords: Overconfidence, Risk Attitude, Risk Perception, Return Perception, Risk Taking, Extended Domain Specificity

JEL Classification Code: G1

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*Alen Nosić is from the Lehrstuhl für Bankbetriebslehre, Universität Mannheim, L 5, 2, 68131 Mannheim. E-Mail: nosic@bank.BWL.uni-mannheim.de. Martin Weber is from the Lehrstuhl für Bankbetriebslehre, Universität Mannheim, L 5, 2, 68131 Mannheim and CEPR, London. E-Mail: weber@bank.BWL.uni-mannheim.de. We would like to thank seminar participants at the University of Mannheim for helpful comments. We would also like to thank the behavioral finance team at *Barclays Wealth*, Pete Brooks, Greg Davies and Dan Egan for not only providing us with the data but also for very helpful comments, stimulating discussions, and help in designing the survey in collaboration with us. We are particularly grateful to Dan Egan for his invaluable help in collecting and collating the data and running the survey over multiple periods.

1 Introduction

Both investment firms and researchers are eager to learn more about factors that influence subjects' risk taking behavior. In classic portfolio theory (see e.g. Markowitz (1952)) risk taking is argued to depend mainly on individuals' risk attitudes with the risk and return of an investment being equated by historical returns and historical volatilities. However, more general risk-value frameworks (see Sarin and Weber (1993), Weber (1997), and Jia et al. (1999)) allow for heterogenous beliefs about the riskiness and the returns of an investment and model subjects' risk taking behavior as follows:

$$\textit{Risk Taking} \;=\; f\;(\textit{Return Expectations},\; \textit{Risk Attitude},\; \textit{Risk Expectations}) \qquad (1)$$

Hence, changes in risk taking behavior should be caused by changes in one or more of these determinants of risk taking. Trying to incorporate this into the above equation we reformulate equation 1 as follows:

$$\Delta \textit{Risk Taking} = f(\Delta_1\ \textit{Return Expectations}, \Delta_2\ \textit{Risk Attitude}, \Delta_3\ \textit{Risk Expectations}) \qquad (2)$$

Both researchers and practitioners argue that risk taking behavior varies substantially over time, i.e. from one point in time to the following. Commenting on the financial crisis in September 2008 the New York Times assessed: "investors around the world frantically moved their money into the safest investments, like Treasury bills". Researchers analyzing dynamics of risk taking behavior also argue that risk taking behavior can change substantially over time (see e.g. Staw (1976), Thaler and Johnson (1990), Weber and Zuchel (2005), and Malmendier and Nagel (2008)). However, it is still an unresolved question what actually drives changes in risk taking behavior. In more general risk-value frameworks, changes in risk taking can be due to changes in expectations or risk attitudes. Thus, the main goal of this study is to analyze whether *Return Expectations* (Δ_1), *Risk Attitudes* (Δ_2), or *Risk Expectations* (Δ_3) change over time and subsequently affect changes in *Risk Taking* (Δ).

Knowing more about changes in the determinants of risk taking behavior is in particular important because of the regulations of the Markets in Financial Instruments Directive (MiFID) by the European Parliament and the European Council (2004 and 2006). The MiFID 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 customers' "preferences regarding risk taking, his risk profile, and the purpose of the investment (Article 35, 4)." However, MiFID is not specific about how often investment advisors have to elicit risk preferences and risk profiles. To close this gap we analyze in the following whether risk attitudes or expectations of individuals change over time and whether these changes have an impact on risk taking behavior.

The main data were gathered via repeated internet surveys which were conducted in collaboration with the behavioral finance team at *Barclays Wealth* from September 2008 to March 2009. A big advantage of our study is that we use a unique dataset of real online broker customers that includes information on the customers' expectations, risk attitudes, and risk taking behavior.

Selected customers of *Barclays Wealth* were asked to participate repeatedly in a questionnaire survey. The survey was run on a quarterly basis from September 2008 to March 2009. Overall 617 subjects participated at least once in the three surveys. Of these 617 subjects, 287 participated once, 181 twice, and 149 thrice. In all three surveys we elicited amongst others financial risk taking by asking subjects to divide an amount of £100.000 either into the stock market (FTSE-All-Share) or into a risk free asset with a safe interest rate of 4%. We also elicited subjective risk attitudes using three questions of *Barclays Wealth*'s psychometrically validated risk attitude scale. In addition, we elicited risk and return expectations of subjects for their own portfolio and for the market (FTSE-All-Share).

Using survey data has some pros and cons. On the one hand, it has the disadvantage that we do not observe actual behavior of people and that there might be potential selection and response biases. On the other hand, a big advantage is that relevant variables can be elicited in a clean environment and do not need to be indirectly inferred from actions and that in contrast to choice data one does not need to maintain the strong assumption that decision makers have objectively correct (i.e. rational) expectations (for an overview of some pros and cons of survey data see Manski (2005)). Surveys asking for individuals' expectations and beliefs are very common[1] and are highly influential both in academia and practice.

Our results indicate that - consistent with evidence in the financial media and with findings in the literature - risk taking behavior in the financial domain is indeed varying over time. Risk taking is defined as the hypothetical amount subjects would invest into the stock market and a risk free asset, respectively. Subjects invest substantially less into risky assets in December than in September and also substantially less risky in March than in December. More specifically, the percentage invested into the risky asset drops from 56.02% in September to 52.77% in December and to 46.52% in March. Analyzing the main determinants of risk taking - risk attitudes as well as risk and return expectations - our findings are twofold. First, risk attitudes seem to remain fairly stable as the risk attitude score on a 7-point Likert scale changes from one survey to the other by more than 1 point only for approximately 20% of all subjects. Second Wilcoxon signed-rank tests show that risk and return expectations vary significantly from one survey to the other. Moreover, we show that changes in risk taking can mainly be attributed to changes in risk and return expectations and not to changes in risk attitudes. This result remains stable even if we control for individual past performance. Finally, we compare changes in risk expectations in relation to changes in actual risk, which is a measure of overconfidence. We show that this measure of overconfidence seems to be fairly stable initially and decreases in the long run.

These findings are important for practitioners in two ways: first, we show that risk attitudes are stable individual constructs that do not need to be elicited on a quarterly basis. Note that this line of argument cannot be generalized to all risk attitude measures currently used by practitioners. In particular inappropriate measures such as the ones that confound risk attitudes and expectations do not need to be stable over time. Second, we illustrate that subjective expectations are important determinants of risk taking behav-

[1]A non exclusive list of such surveys in the U.S. are the University of Michigan Health and Retirement Study (HRS) survey `http://hrsonline.isr.umich.edu/index.php?p=qnaires`, the Survey of Economic Expectations `http://www.disc.wisc.edu/econexpect/Index.html`, the University of Michigan Survey of Consumers `http://www.sca.isr.umich.edu`, the UBS/Gallup survey `http://www.ropercenter.uconn.edu/data_access/data/datasets/ubs_investor.html`, and the Duke/CFO Business Outlook survey `http://www.cfosurvey.org/duke`. Two examples from Germany are 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`. Findings in some of these surveys are going to be discussed in section 2.

ior and that it might be worthwhile for practitioners to elicit their clients' expectations regularly.

Our study extends findings in the empirical and experimental literature. Up to now, there is no study documenting whether changes in expectations and/or changes in risk attitudes drive changes in risk taking behavior. However, there are several papers analyzing whether risk taking behavior actually changes over time. Malmendier and Nagel (2008) use real world data to show that individuals' personal experiences of macroeconomic shocks have long-lasting effects on their risk taking behavior. In the experimental literature Staw (1976) and Thaler and Johnson (1990) show that risk taking behavior can depend on individual prior gains and losses. But both empirical and experimental studies are not able to disentangle the channel through which individual risk taking behavior changes over time; i.e. they are not able to analyze whether changes in risk taking behavior can be attributed to changes in risk attitudes or expectations or both. In contrast, our data basis allow us to explicitly analyze this issue for a sample of real bank customers.

Furthermore, most studies analyzing changes in expectations and risk attitudes investigate either changes in risk expectations (e.g. Weber and Milliman (1997)) or changes in return expectations (e.g. Shiller et al. (1996)) or changes in risk attitudes (e.g. Sahm (2007) and Klos (2008)) separately but not in one single study. Moreover, most of these studies are not able to relate changes in expectations and risk attitudes to changes in risk taking. Vissing-Jorgensen (2003) and Dominitz and Manski (2007) analyze the relation between the probability of holding stocks and expected equity returns. Using large scale survey data, they find that the probability of holding stocks is higher the higher expected returns are. We extend their findings in two ways: first, they do not analyze changes in expectations and consequently their influence on changes in risk taking behavior. Second, they proxy for risk taking by the probability of holding stocks whereas we analyze asset allocation decisions.

Another important advantage of our study is that the surveys we use in our paper were conducted in early September 2008 (6-20), December 2008 (6-20), and March 2009 (21-30). This unique dataset allows us to test if the turmoil on financial markets during this period such as the collapse of Lehman Brothers had substantial effects on risk attitudes, expectations, and risk taking behavior. In addition, using repeated survey data on real online broker customers to analyze changes in risk attitudes adds to the literature which often relies on student populations (see e.g. Baucells and Villasis (2006) or Harrison et al. (2005)) and offers substantial advantages. For example, we are able to control if differences in past portfolio performance or changes in market conditions drive changes in risk attitudes, expectations or risk taking behavior.

This paper proceeds as follows: in section 2 we provide a literature review and formulate our hypotheses. Section 3 presents information on survey respondents and on the survey design. The main results are reported in section 4 while the last section provides a discussion of our results and a short conclusion.

2 Related Literature and Hypotheses

Anecdotal evidence suggests that risk taking behavior of investors, i.e. their division of wealth between risky and risk free assets, can substantially vary over time and does not need to be perfectly stable. According to the Deutsche Aktieninstitut in the year 2000, at the height of the internet boom, 6.2 million people in Germany held part of their wealth in stocks. By 2008, in the course of the financial crisis, this number had dropped to only 3.5 million. In a similar vein, the Wall Street Journal (2008) reports in an article 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.

Thus, individuals risk taking behavior, i.e. their choice between risky and risk free assets, seems not to be perfectly stable over time. This temporal instability can be due to various factors: first, subjects do not need to exhibit the same level of risk aversion over time. Second, individual risk expectations and return expectations do not need to be stable and might be shaped by personal experiences. Third, important personal aspects such as income and wealth might change over time. All these factors can individually or jointly lead to changes in risk taking behavior over time. In the following we are going to illustrate general findings in the literature on the stability or non-stability of risk taking behavior. Subsequently, we are going to present more recent studies analyzing changes in risk attitudes and expectations over time, before we pick up the question why changes in risk taking over time occur.

Earlier studies in decision analysis on the stability of risk preferences or risky choices seem to confirm the anecdotal evidence. Camerer (1989) and Hey and Orme (1994) investigate the short term temporal reliability and stability of risky choices. Both studies confront subjects with the same set of choices at two points in time (less than 10 days apart). Their results indicate that individuals change their risk taking behavior in 25%-30% of all cases. However, these studies do not explicitly analyze the role of prior gains or losses on subsequent risk taking behavior.

Staw (1976) analyzes exactly this and shows that risk taking behavior does not need to be stable and substantially depends on prior personal outcomes. He illustrates that subjects take significantly more risks following a loss than following a gain and terms this "escalation of commitment". The "escalation of commitment" hypothesis is also in line with findings in the literature on the disposition effect (see e.g. Odean (1998) and Weber and Camerer (1998)). On the other hand, Thaler and Johnson (1990) argue that it is difficult to make generalizations about risk taking preferences. They show a reverse effect, i.e. enhanced risk taking in the gain domain, in two stage gambles which they term the "house money effect". Weber and Zuchel (2005) conduct an in-depth analysis of the two conflicting effects "escalation of commitment" and "house money effect" and show that the framing of the situation is important when analyzing changes in risk taking behavior. On the one hand, the "house money effect" is prevalent if a situation is framed as a lottery, on the other hand, the "escalation of commitment" effect is predominant if the situation resembles a portfolio investment.

These studies show that the personal experience of gains or losses in the past can influence subsequent risk taking behavior. In a slightly related context Malmendier and Nagel (2008) show that personal macroeconomic experiences seem to have a great impact on personal decisions and on the risk taking behavior of individuals. They illustrate that subjects who have experienced high inflation and bad market-returns throughout their lives invest substantially less risky than subjects who have experienced excellent market-returns in the course of their lives. However, they do explicitly state that their goal is not to analyze whether changes in beliefs or in risk aversion or a mix of both drive observed differences in risk taking behavior.

Overall, the presented evidence suggests that subjects need not take constant levels of risks in their investment decisions. Various factors such as changes in personal macroeconomic experiences or gains and losses in own investments might affect risk taking behavior in a dynamic setting. In a first step, we simply want to find evidence for the well-established claim that risk taking behavior does not need to be stable in our survey for the sample period September 2008 to March 2009. Consistent with the aforementioned anecdotal evidence and findings in the literature we formulate hypothesis 1 as follows:

Hypothesis 1: Financial risk taking behavior varies over time

One important explanation for varying risk taking behavior over time often brought forward are changes in income or wealth. The fact that an increase in wealth should result in a higher level of risk taking or a decrease in relative risk aversion is a key implication of various difference habits models. Brunnermeier and Nagel (2008) use microdata to analyze this key implication of difference-habit models empirically. They show that wealth changes affect the decision to participate in stock markets but that they have hardly any effect on asset allocation decisions, i.e. on the proportion a household invests in risky and risk free assets, respectively. In a similar vein, Guiso et al. (2003) analyze stock ownership in major European countries and illustrate that the share of wealth invested in the stock market is independent of investors' wealth. Thus, both papers show that wealth effects cannot explain observed changes in risk taking behavior over time.

In more general risk-value frameworks variations in financial risk taking behavior over time can mainly be attributed to changes in risk and return expectations and/or changes in risk attitudes (see equation 1 and 2). In the following, we will review some more recent findings in the empirical and experimental literature on long run changes in risk attitudes and changes in expectations over time.

Changes in risk attitudes:

Studies analyzing long term changes in risk attitudes by confronting the same set of subjects with the same set of questions can be roughly classified into two groups. First, studies using data from large scale panel surveys such as the Socio-Economic Panel (SOEP) or the Michigan Health and Retirement Survey (HRS) which mostly use self-assessment tasks with answer possibilities on Likert-scales. Second, laboratory and field experiments using lottery related tasks to elicit risk attitudes and subsequently, changes in risk attitudes.

Using data from simple 11-point self-assessment tasks from the SOEP waves in 2004 and 2006, Klos (2008) analyzes the temporal stability of risk attitude measures. He shows that individual risk attitudes tend to be fairly stable over time and that the effect is in particular strong for those subjects that indicated the central category. Similarly, Sahm (2007) finds evidence for persistent differences between individuals but relatively high stability of risk attitudes within individuals over time using the HRS panel data set with more than 12,000 observations.

Andersen et al. (2008) use a field experiment with a representative sample of the Danish population and Harrison et al. (2005) a laboratory study with students to analyze the temporal stability of risk attitudes. Both studies obtain subjects' risk aversion measures using a multiple price list approach (see e.g. Holt and Laury (2002)). They find only slight variation of risk attitudes over time and conclude that risk attitudes seem to be a stable construct. In addition, Baucells and Villasis (2006) find similar results in a laboratory study in which they elicit risk attitudes using binary lottery choice tasks. They also find only small deviations in risk attitudes over time and argue that most of these changes disappear if one introduces noise.

Overall, evidence in research implies that risk attitudes seem not to change too much over the course of time and that observed changes can mainly be attributed to errors. Hence, our hypothesis is the following:

Hypothesis 2: Risk attitudes are fairly stable over time

Changes in risk and return expectations:

The original formulation of the capital asset pricing model (CAPM) is a static one-period model that assumes homogenous expectations (see e.g. Sharpe (1964) and Lintner (1965)). Subsequent studies extended these assumptions by considering heterogenous beliefs, time-varying expectations, and a dynamic investment problem of rational investors (see e.g. Merton (1973) and Miller (1977)). In contrast, behavioral approaches argue that some subjects misinterpret the informational content of a new signal and adjust their expectations inappropriately. Consequently, they over- or underreact to new information because of their biased expectations (see for an overview DeBondt (2000)). Both rational and behavioral studies agree that risk and return expectations can vary between subjects and also within subjects over time when new information comes into the market.

Changes in return expectations have been analyzed extensively in the empirical and experimental literature, mostly with repeatedly carried out large scale surveys. Dominitz and Manski (2005) analyze the dynamics of expectations in the Survey of Economic Expectations (1999-2001) and in the Michigan Survey of Consumers (2002-2004). They find that expectations are not perfectly stable over time but that differences between persons are larger than differences within persons over time.

Using a series of cross-section UBS/Gallup surveys, Fisher and Statman (2002) and Vissing-Jorgensen (2003) show that subjects' long and short term expectations change substantially over the course of time. Taking data from the 1998-2003 surveys, Vissing-Jorgensen (2003) illustrates that average 1-year expectations vary substantially from a high of 15.8% in January 2000 to a low of around 6% at the end of 2002. She argues that expectations and actual returns almost seem to move together. Analyzing the crash in the Japanese stock market Shiller et al. (1996) illustrate that a sharp drop in expectations for long run earnings growth could be observed for the period 1989-1994. They argue that changes in expectations probably have substantial economic effects but do not provide direct and unambiguous evidence on this issue.

Using a between-subjects design, Glaser and Weber (2005) demonstrate that return expectations after September 11 and the following market downturn are significantly higher than return expectations before the event indicating that subjects did believe in some sort of mean reversion. However, they note that there is no unambiguous ex ante prediction whether subjects will expect mean reversion or trend continuation in stock prices in response to such a dramatic event.

Risk perception or risk expectations are also often argued to be based on individuals' past experiences of a similar event or situation (see e.g. Ricciardi (2004)). In a similar vein, Loewenstein et al. (2001) hypothesize that decisions are evaluated at an emotional level and that prior outcomes, good as well as bad ones, influence this emotional level and the way individuals perceive the risk of a situation.

Consistent with these hypotheses, Weber and Milliman (1997) and Mellers et al. (1997) experimentally show that risk perceptions change significantly over time after subjects have experienced either good or bad outcomes. More precisely, they show that risk attitudes are almost perfectly stable if one controls for changes in risk perceptions. Similarly, Glaser and Weber (2005) find that volatility estimates are significantly higher after the terror attacks of September 11 than before.

Overall, the evidence in the literature indicates that both risk and return expectations can vary substantially over time as they can e.g. be influenced by macroeconomic developments or individually experienced gains and losses. However, to come up with a general hypothesis whether risk and return expectations should rise or fall in response to the dramatic events in late 2008 is difficult. Hence, hypothesis 3 follows:

Hypothesis 3: Expectations vary over time

On the one hand, the presented evidence at the start of this section indicates that financial risk taking behavior does not need to be constant over the course of time and may vary given prior gains and losses or given macroeconomic changes. On the other hand, risk and return expectations - two major determinants of risk taking in risk-value models - have also been shown to vary over time, whereas risk attitudes seem to be fairly stable. Our data allow us to test explicitly what actually drives changes in risk taking. Consistent with the previously presented literature we assume that changes in risk taking over time are mainly driven by changes in risk and return expectations and not by changes in risk attitudes or past performance.[2]

[2]Note that the goal of this study is not to test whether changes in risk and return expectations are based on rational motives or whether they are due to irrational motives such as misreaction to new information.

3 Data

3.1 Survey Respondents

Our analysis is based on a repeated questionnaire study that was run as part of a joint collaborative research project with the behavioral finance team at *Barclays Wealth* in September 2008, December 2008, and March 2009. About 90% of all subjects in the September sample completed the survey before September 12, i.e. before the bankruptcy of Lehman Brothers and the subsequent downturn on financial markets. Unfortunately, we do not have explicit information on the specific date each individual has completed the survey.

Before the September wave, a stratified sample of *Barclays Stockbrokers*' client base was drawn. To accomplish stratification, we grouped subjects according to their *Age*, *Number of deals per year*, *Number of holdings*, and *Portfolio value* into non-overlapping subgroups, so called strata. This procedure was used to improve the representativeness of the sample and in order to take care of our collaborating bank's desire to undersample subjects who trade very little (*Number of deals per year*≤1) or have a relatively low portfolio value (*Portfolio value*< £1,000). Thus, in all strata in which subjects were included that traded less than once a year or had a portfolio value of less than £1,000 a lower percentage of subjects were invited to participate in the survey than in the remaining strata. Note that although we did undersample, we did not exclude these subjects totally as still more than 16% of all approached individuals had a portfolio value below £1,000.

Overall, 19,251 clients were emailed and invited to participate in a repeated survey. This equals approximately 5% of all customers. Of the 19,251 individuals that were approached by email in late August/early September 2008 about 4,520 (23%) opened the email. Of those that opened the email, 849 (20%) went to the website and in the end, 479 out of these 849 subjects completed the survey in September. The response rate is slightly lower but still in the same ballpark as in similar studies by Dorn and Huberman (2005, 4%) and Glaser and Weber (2007, 7%). Both studies also sent an email to customers of an online broker and asked them to participate in an online questionnaire. It took subjects on average 24 minutes to answer the survey.

The 479 subjects who participated in September were contacted again by email in late November/early December 2008 and invited to participate in a shorter version of the questionnaire.[3] Overall, 240 of the 479 subjects participated for a second time in December. In addition, *Barclays Wealth* sent out an email to further 700 customers that had not been contacted yet, in order to increase the number of subjects in future surveys.[4] This resulted in an additional 138 subjects joining the panel in December. These 138 subjects received the same questionnaire that was filled out by the 479 subjects in September and not the shorter December version. In March 2009, all 617 subjects that had previously participated in at least one round were contacted again and invited to participate in a further study. This time all subjects received the same, shorter version of the questionnaire. Overall, 287 subjects participated only once (214 in September and 73 in December) and 149 subjects participated in all three surveys. Of the remaining 181 subjects who participated twice, 91 participated in September and December, 65 in December and March, and 25 in September and March.

The main goal of the study is to analyze whether risk taking behavior, risk attitudes, and expectations change from September to December and from December to March and what might drive these changes. To analyze this we want to compare on an individual level subjects' responses to survey questions at the three points in time. In contrast to previous studies using one-time survey responses from online broker customers (see e.g. Dorn and Huberman (2005) and Glaser and Weber (2007)) our dataset consists of repeated observations and allows us to analyze changes in the main variables. However, an analysis of individual changes in the main variables is only possible for subjects that took part at least in two consecutive surveys, i.e. in September and in December or in December and March or in all three surveys. 240 subjects participated both in September and December and 214 subjects participated both in December and March. In addition, 149 subjects participated in all three surveys.

To address a potential selection bias we compare the overall adult British population with

[3]In contrast to the second version of the questionnaire we elicited in the first, longer version demographics, further individual characteristics and various behavioral client profiling questions. These questions are psychometrically validated and used by *Barclays Wealth* within the advisory process.

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

survey participants and we also compare subjects who participated once with those that participated twice and thrice, respectively. Table 1 illustrates mean scores of demographics and further characteristics for various groups. The first two columns illustrate mean scores for all participants of our study (Group^{all}) and for the adult British population (GB^{all}), respectively. The next three columns illustrate the same scores separately for subjects that participated only once (Group^{once}, N=287), twice (Group^{twice}, N=181), and subjects that participated in all three surveys (Group^{thrice}, N=149).

The average age of all survey participants is 51.65 with two thirds of the subjects aged between 40 and 66; four years older than the average British adult. In addition, subjects in our sample are more likely to be married (0.65 vs. 0.52) or male (0.93 vs 0.49) compared to the British average. *Gross income* is highly skewed with an overall mean of £76,615.73 and an overall median of £55,000 and substantially larger than for the average Briton (£30,000). Clearly, our subjects are not likely to be representative of the typical British adult. However, we find a considerable variation in subject's answers which allows us to test our hypotheses. In addition, our finding that respondents to this kind of survey are predominately male and have a substantially larger gross income than the overall population is consistent with Dorn and Huberman (2005).

Comparing subjects that participated once (Group^{once}), twice (Group^{twice}), and thrice (Group^{thrice}), respectively, we find hardly any differences for the three subgroups. Only for the level of investable wealth that is measured in 9 categories from 1 (£0 - £10,000) to 9 (> £ 1 million) we find significant differences between the subgroups. Subjects that participated only once in the survey have a substantially lower investable wealth than subjects who participated thrice. Moreover subjects who participated thrice indicate higher wealth levels than those who participated twice. Since the main goal of our study is to analyze changes in various variables on an individual level over time, differences in wealth between the three subgroups should not be problematic.

After having introduced the main variables in the following subsection, we are going to analyze whether the three groups of subjects (Group^{once}, Group^{twice}, and Group^{thrice}) differ in their response behavior in subsection 3.3.

Insert table 1 here

3.2 Survey Design

This subsection presents the main variables that were elicited repeatedly within the surveys. All surveys were designed in close collaboration with the behavioral finance team at *Barclays Wealth* in order to get a better understanding of investors' behavior. Besides demographics and further individual characteristics that were described above and collected only in the first survey in which a subject participated we elicited the following variables repeatedly. The main variables are summarized in table 2.

(Financial) Risk taking: In the hypothetical risk taking task subjects were asked to invest an amount of £100.000 either into the stock market (FTSE-All-Share) or into a risk free asset with a safe interest rate of 4%. The higher the amount subjects allocate to the stock market the more risk are they willing to take in this hypothetical task. A big disadvantage of real transaction data 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. Thus, although hypothetical risk taking is only an indirect proxy of risk taking behavior it is a measure for which we have all necessary information.

Risk attitudes: In the September and December surveys we use three questions from *Barclays Wealth*'s 8-question psychometric scale to assess subjects' risk attitudes. Brooks et al. (2008) show that this scale efficiently differentiates individuals from low risk tolerance to high risk tolerance and that the scale has high levels of reliability and validity. The three questions used in our study can be found in table 2. For all three questions we used a 7-point Likert scale with the endpoints "1 = Strongly Disagree" and "7 = Strongly Agree".[5] In the March survey only one of these three risk attitude measures was elicited (*Risk Attitude 2*). We do not elicit risk attitudes from lotteries because of the extended domain specificity result in Nosić and Weber (2007) who show that risk attitudes inferred from lotteries are not related to investment behavior in stocks.

[5]Amongst others Bollen and Barb (1981), Cicchetti et al. (1985), Preston and Colman (2000), Alwin and Krosnick (1991), and Weng (2004) show that reliability, validity, and discriminating power increases up to 7-point scales and that after this additional effects can hardly be observed. Moreover, Viswanathan et al. (2004) argue that the number of categories should be picked such that it is as close as possible to a natural number of categories for a specific question and that one shouldn't use too many scales as this overburdens subjects and is too hard of a cognitive task for them. Hence, using 7-point Likert scales seems to be the best trade-off between understandability and reliability for our sample of *Barclays Wealth* customers.

Expected return and expected risk: Since we have argued in sections 1 and 2 that subjective risk and return expectations are important determinants of risk taking behavior, we tried to elicit them extensively in the questionnaire. To do this we elicited subjects three months expectations for their own portfolio as well as for the overall stock market (FTSE-All-Share). We chose the three months forecasting period because the survey panel is also conducted on a quarterly basis. Since Nosić and Weber (2007) have shown that risk expectations elicited on a purely subjective scale need not to coincide with risk expectations elicited via confidence intervals, we utilize both qualitative and numeric approaches to measure subjects' expectations.

To measure risk and return expectations numerically we asked individuals to state a best guess (mean estimate) for the three month return as well as upper and lower bounds for 90% confidence intervals for the return in three months. More precisely, we asked them to submit what they consider to be lower and upper bounds so that there is only a 5% chance that the return in three months will be below the lower bound and a 5% chance that it will be higher than the upper bound. Numeric return expectations for the market (*Market-Return-Num.*) or for a subject's own portfolio (*Own-Return-Num.*) are simply equal to the best guess for the return of the market and for the own portfolio, respectively. However, to obtain a measure of numeric risk expectations is not as straightforward. We use the two point approximation suggested in Keefer and Bodily (1983) which transforms stated confidence intervals into volatility estimates and has been widely used in the empirical literature (e.g. Graham and Harvey (2005), Ben-David et al. (2007), and Glaser et al. (2007)). This transformation gives us the two risk expectation measures *Market-Risk-Num.* and *Own-Risk-Num.*

To get the two qualitative measures of return expectations (*Market-Return-Subj.* and *Own-Return-Subj.*) we ask subjects to classify both expected market and own portfolio returns on a 7-point Likert scale with the endpoints "1 = Extremely bad return" and "7 = Extremely good return". Similarly, the qualitative measures of risk expectations (*Market-Risk-Subj.* and *Own-Risk-Subj.*) are obtained by asking subjects to classify both expected market and own portfolio risk on a 7-point Likert scale with the endpoints "1 = Not risky at all" and "7 = Extremely risky".

Past performance: We use the following approach to control for the possibility that past investment returns affect changes in risk taking behavior. We elicit individuals' subjective estimates of past performance, both past stock markets performance (FTSE-All-Share) and past own portfolio performance within the last three months on a repeated basis. Similar to expectations we use two elicitation methods. First, we ask subjects to give us a numerical estimate of their own past returns or the stock markets past return in percent. Second, we ask subjects to judge past returns on 7-point Likert scales with the endpoints "1 = Extremely bad return" and "7 = Extremely good return". In addition, we also ask subjects to indicate their past performance at other online brokers, if applicable.

Insert table 2 here

3.3 Differences in Groups

In the following, we analyze the selection bias problem and in this connection in particular the question if subjects that participated once, twice, and thrice, respectively, differ in their response style to the repeatedly elicited variables. Overall, we have 17 repeatedly elicited variables in September and December (and 15 in March): $1 \cdot$ risk taking, $3 \cdot$ risk attitude ($1 \cdot$ risk attitude in March), $8 \cdot$ expectations, and $5 \cdot$ past performance. The mean and median values for all variables in a given month are very similar between the three groups of subjects: Group^{once}, Group^{twice}, and Group^{thrice}.

We use a series of Mann-Whitney rank-sum tests to analyze whether the response behavior in the separate groups differs significantly. Comparing responses of Group^{once} subjects in September and December with those of subjects that participated repeatedly (Group^{twice} and Group^{thrice}) we find that only for 3 out of 34 variables there are statistically significant differences. Similarly, comparing subjects that participated twice with those that participated thrice, we only find significant differences for 3 out of 49 variables.[6] In addition, the few significant differences are scattered over various variables with no clear-cut uniform effect. Hence, we argue that there is no indication that subjects who participated once differ substantially in their response behavior from those that participated twice or thrice. In addition, the same seems to be true if we compare subjects that participated

[6] We compare response behavior of subjects that participated twice and thrice, respectively, for 17 variables in September, 17 variables in December, and 15 variables in March. This gives us a total of 49 comparisons.

twice and thrice directly.

4 Results

4.1 On the stability of risk taking, risk attitudes and expectations

This subsection analyzes if risk taking, risk attitude, expectations, and past performance are stable individual traits or whether they change over our three observation periods. Thus, we compare the response behavior in September with the one in December and the one in December with the one in March. Table 3 reports mean scores of all repeatedly elicited variables in our sample, separately for the three months. We report mean values in each of the three months only for subjects that participated at least twice in the survey, however, our results are essentially the same if we compute the numbers for all 617 subjects or for the 149 subjects that participated thrice. The last two columns in table 3 report results of Wilcoxon signed-rank tests analyzing whether the difference between the two respective months is significant. To avoid the problem that differences in repeatedly elicited variables are driven by the fact that different subjects participated in separate months, we run these tests only for those subjects that participated in the two respective months.

For *Risk-Taking* we observe, consistent with hypothesis 1, that the share subjects are willing to invest into the market (FTSE-All-Share) varies substantially. It decreases from 56.02% in September to 52.77% in December to 46.52% in March. All differences are highly significant at the 1% level.

Changes in risk attitudes are hardly observable for all three risk attitude measures. *Risk Attitude 2* and *Risk Attitude 7* are virtually the same in September and in December. *Risk Attitude 6* rises slightly from 4.43 to 4.61 from September to December. This difference is significant at the 5% level. However, this rise indicates that subjects seem to be less risk averse in December than in September which is seemingly at odds with our previous finding on lower levels of risk taking behavior in December. Since we only elicited *Risk Attitude 2* in March we can just analyze the change of this risk attitude measure from December to March. Table 3 shows that *Risk Attitude 2* decreased slightly from 3.63 to

3.55 in this time period with the decrease being not significant. In addition, analyzing the stability of risk attitudes on an individual level, we find that around 40% of all subjects do not change self-reported risk attitudes at all and that around 80% of all subjects do not change their self-reported risk attitude score by more than one point on the 7-point Likert scales. This stability of risk attitudes is consistent with findings in Sahm (2007) and Baucells and Villasis (2006) as well as with hypothesis 2.

Risk expectations or risk perceptions on the other hand, seem to change considerably over time. On the one hand, all four risk expectation measures *Market-Risk-Num.*, *Market-Risk-Subj.*, *Own-Risk-Num.*, and *Own-Risk-Subj.* are substantially higher in December than in September. On the other hand, *Own-Risk-Num.* is substantially lower in March than in December. All differences are highly significant on the 1% level. More precisely, both numerical risk measures or three month volatility estimates (*Market-Risk-Num.* and *Own-Risk-Num.*) rise from approximately 0.05 in September to 0.075 in December and drop slightly to around 0.07 in March.[7] The extreme rise of volatility estimates from September to December is consistent with Glaser and Weber (2005) who show in a between-subjects design that volatility estimates before 9/11 were substantially lower than after 9/11. In a similar vein, subjective risk expectations also rise substantially from September to December and remain almost stable from December to March. These findings indicate that subjects perceived both their own investments and investments into the market to be riskier in December than in September and that they perceived *Own-Risk-Num.* to be lower in March than in December. These changes in risk expectations are also in line with hypothesis 3.

For return expectations a similar picture emerges. For all return expectations measures (*Market-Return-Num.*, *Market-Return-Subj.*, *Own-Return-Num.*, and *Own-Return-Subj.*) subjects expect on average higher returns in December than in September. The same is true if we compare return expectations in March and in December, indicating that subjects became more and more optimistic over the three time periods. Wilcoxon signed-rank tests show that four of eight return expectations turn out to rise significantly ($p < 0.01$) from one quarter to the other. Overall, consistent with Vissing-Jorgensen (2003) and Shiller et al. (1996) as well as with hypothesis 3, we show that return expectations do vary substantially

[7] We will compare this change in volatility estimates with actual changes in market risk in subsection 4.3 in more detail.

over time. More specifically, in our sample subjects get more and more optimistic over time.

Analyzing changes in past performance, we obtain a simple result. Most subjects judge past performance, be it their own or the markets' performance, from June to August and from December to March to be substantially higher than the performance in the time span September to December. This result is not surprising considering the fact that stock markets took a severe downturn in the last quarter of 2008. The performance of the FTSE-All-Share from September to December was approximately -20% and thus substantially worse than the performance in the time periods June to September (-10%) and December to March (-7%). Two interesting findings on subjects self-assessed past performance emerge: first, subjects numerical estimates of past market performance are not too far-off real market returns. Second, subjects judge their own past performance to be lower than the market performance, although they do not expect their own portfolio to be more risky than the market.

Our main findings are in line with previous findings in the literature and with our hypotheses 1 - 3. Risk taking behavior (see Malmendier and Nagel (2008)), risk expectations (see Glaser and Weber (2005)), and return expectations (see Vissing-Jorgensen (2003)) seem to vary over time whereas risk attitudes tend to be fairly stable (see Sahm (2007)). Moreover, our results remain stable if we analyze differences only for those subjects that participated thrice or if we include all observations at each point of time.

Insert table 3 here

4.2 What Drives Changes in Risk Taking?

Having provided evidence for changes in risk taking behavior and expectations as well as evidence for relative high stability of risk attitudes we want to analyze what actually influences changes in risk taking behavior over time. As a first test of the functional relationship in equation 1 and 2 we analyze whether subjects' behavior is in accordance with the model propositions. Hence, we study whether subjects that take more risks in December (March) than in September (December) (Δ R.T.$^+$) become less risk averse, expect higher returns and/or perceive the risk of an investment in the market to be lower. And for subjects that take less risks in December (March) than in September (December) (Δ R.T.$^-$) we analyze whether they become more risk averse, expect lower returns and/or perceive the risk of an investment in the market to be higher.

A simple sign test indicates that 74 subjects in the period September to December and 99 subjects in the period December to March take less (more) risks over time although they become less (more) risk averse. We also find that 77 [64] subjects take more (less) risks although they expect numerical and subjective market returns to be lower (higher) in December than in September [in March than in December]. Finally, our results also indicate that 55 [67] subjects take more (less) risks although they perceive the riskiness of the market (numerical and subjective) to be higher (lower) in December than in September [in March than in December].

However, these numbers do not indicate that subjects behave not according to the model. It might well be that subjects who are less risk averse in December than in September [in March than in December] take a substantially lower level of risks because of lower return expectations and/or higher risk expectations. Hence, only those subjects that take more (less) risks although they are more (less) risk averse, expect lower (higher) returns and perceive the risk to be higher (lower) in December than in September [in March than in December] do not behave in accordance with the functional form.

Our results indicate that subjects do not behave in accordance with the functional form and thus violate some sort of dominance concept in less than 8.8% of all cases. If we assume that the probability to submit non intuitively correct risk attitude, risk expectations, and return expectations to be $\frac{1}{2}$, respectively, then about 12.5% ($\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2}$) of all subjects should not behave in accordance with the functional form. Since our results indicate this to be slightly lower, we interpret our findings as a first hint for the usefulness of more general risk-value frameworks (see Sarin and Weber (1993) and Jia et al. (1999)).

Admittedly, the previous test is a weak test of model consistency and doesn't allow us to make inferences about what actually drives changes in risk taking behavior. To improve on this we analyze in table 4 the value of all risk attitude, expectation, and past performance measures separately for the two time periods September to December (left panel) and

December to March (right panel). In each panel we report mean values of all variables for two distinct groups of subjects: first, subjects who take more risks from one survey to the next one (Δ R.T.$^+$) and second, subjects who take less risks from one survey to the next one (Δ R.T.$^-$). The last column in each panel reports results on Mann-Whitney rank-sum tests comparing the two groups Δ R.T.$^+$ and Δ R.T.$^-$.

Comparing changes in risk attitudes between the two groups shows hardly any differences for both panels.[8] Mann-Whitney rank-sum tests indicate that there is no significant relation between the way subjects adjust their risk attitude scores over time and changes in their risk taking behavior over time.

In addition, analyzing whether there are any differences in the way subjects update their own portfolio expectations between the two groups we mostly find no significant differences as changes in own portfolio expectations are fairly similar for both groups (Δ R.T.$^+$ and Δ R.T.$^-$). The only significant difference between the two groups of subjects can be observed for *Diff. Own-Risk-Num.* in the December to March panel. Subjects who take more risks in March than in December (Δ R.T.$^+$) expect their own portfolio returns to be higher in March than in December whereas subjects that take less risks in March than in December (Δ R.T.$^-$) expect their own portfolio returns to be lower in March than in December. This result is not highly significant and gets insignificant if we only analyze the subgroup of subjects that has participated in all three surveys.

Interestingly, there are no significant differences between the two groups (Δ R.T.$^+$ and Δ R.T.$^-$) for *Diff. Market-Return-Num.* and *Diff. Market-Risk-Num.* in both panels. *Diff. Market-Return-Num.* is simply the numerical return estimate in December (March) minus the one in September (December) and positive in both groups and panels. Our results are the same if we calculate the numerical variables not as simple differences but as percentage changes. A similar picture emerges if we analyze *Diff. Market-Risk-Num.*

However, for subjective market risk and market return expectations we find substantial and stable differences between the two groups. Subjects who take more risks from one survey to the next one (Δ R.T.$^+$) expect subjective market returns (*Diff. Market-Return-*

[8] Note that *Diff. Risk Attitude 6* and *Diff. Risk Attitude 7* were not elicited in March. Therefore, we cannot analyze changes in these variables from December to March.

Subj.) to become substantially higher over time and grow by on average 0.395 and 0.509, respectively. Whereas subjects who take less risks in December than in September or less risks in March compared to December (Δ R.T.$^{-}$) expect subjective market returns to stay fairly stable over time. Differences in differences between the two groups are significant in both panels as indicated by z-scores of 2.024 and 2.468 and a first indication that changes in subjective market return expectations seem to be related to changes in investment behavior. This result remains stable even if re-run the analysis only for subjects that participated in all three surveys.

We find a reverse pattern for subjective market risk expectations: subjects in the group Δ R.T.$^{-}$ expect *Diff. Market-Risk-Subj.* to be positive on average (0.555 and 0.02) whereas subjects in the group Δ R.T.$^{+}$ expect it to be negative on average (-0.052 and -0.2). The difference in differences in the September to December panel is highly significant with a z-score of -3.35. In contrast, the difference in differences in the December to March panel is in the right direction but not significant. Moreover, table 4 also shows that changes in past performance estimates are hardly related to changes in risk taking behavior as only *Diff. Past Perf. Self Subj.* is significantly different for both groups.

These findings are first indications that changes in subjective market return and market risk expectations seem to be related to changes in investment behavior in markets. However, one problem of the previous analyses is that we can only apply it to subjects who take more or less risks from one period to the other. Thus, we omit all subjects that take the same level of risk in two subsequent periods. The following analyses try to alleviate this problem.

Insert table 4 here

In order to investigate the question what drives changes in risk taking behavior in more depth we use multivariate tobit regressions. We use tobit since our variables are censored from below (-100) and from above (+100). In table 5 we report results of clustered tobit regressions of changes in risk taking, from one point in time to the next one. Since we use both changes from September to December and changes from December to March in these analyses we need to drop *Diff. Risk Attitude 6* and *Diff. Risk Attitude 7* as they were not elicited in March. In addition, we also need to take into account that our observations do not need to be independent as 149 subjects participated in all three surveys and appear repeatedly in our sample of differences. We control for this by clustering our regressions over subjects.

The results in the first regression of table 5 indicate that *Diff. Risk Attitude 2* cannot explain changes in risk taking behavior. Interestingly, our results hold even if we re-run the regressions and exclude subjects that report the same risk attitude in September and in December or the same risk attitude in December and March.

Column 2 of table 5 illustrates that in contrast to changes in risk attitudes, changes in subjective expectations can explain changes in risk taking behavior. More precisely, the positive coefficient of 2.348 indicates a positive relation between *Diff. Market-Return-Subj.* and *Diff. Risk Taking*. The larger the market return expectations in December (March) are compared to September (December), the larger is the level of risk taking in December (March) compared to September (December). For changes in subjective market risk expectations (*Diff. Market-Risk-Subj.*) we find a reverse effect, indicated by the significantly negative coefficient of -2.208. Hence, the higher subjects' perceive the risk of the market in December (March) in comparison to September (December) the less risky they invest in December (March) compared to September (December). Our results remain essentially the same if we further require that *Diff. Risk Attitude 2* is not equal to zero.

In additional robustness tests we check whether our results also hold for the numerical risk and return expectations. Running the same regressions with numerical expectations instead of ordinal ones, we find that changes in numerical expectations cannot explain changes in risk taking behavior. This result remains stable even if we check for robustness by e.g. running the regressions separately for subjects that participated twice and thrice, respectively, or for those subjects that indicated certain levels of income or wealth, or for those that stated positive expected returns. This finding is consistent with first results in table 4 and in contrast to Nosić and Weber (2007) who show in their experiment with business and economics students that risk taking behavior can be heavily influenced by subjective numerical risk and return expectations.

We can only hypothesize why we do not find a significant effect for the numerical variables in our dataset: first, in numerical values outliers such as an expected market return of 143% in three months which we actually observe in our dataset could affect our results.[9] Second, practitioners argue that ordinal ratings are more feasible and that most individuals with no specific background in economics seem to understand subjective ordinal ratings better than numerical ones. Thus, e.g. all rating agencies transform default probabilities or expected losses into ordinal scales. Since subjects in our study do not necessarily have a background in finance or economics this argument might be relevant for our dataset. Third, scanning the personal comments that subjects could submit after the March survey we find that many subjects regard the numerical questions to be too technical and confusing to answer. A further indication that subjects had problems stating numerical risk and return expectations is the fact that almost 23% (September), 24% (December), and 17% (March) of all subjects expect three month market (FTSE-All-Share) returns to be negative. Similarly, 9% (September), 13% (December), and 6% (March) of all subjects expect their own portfolio to generate negative returns. Although they expect negative market returns, most of these subjects allocate a positive amount of their money in the hypothetical risk taking task into the market.[10]

The third regression tests whether our findings prevail if we analyze changes in subjective market expectations and *Diff. Risk Attitude 2* as independent variables jointly. Our main results remain stable. In the fourth and fifth column we include numerical expectations, past market performance, and various demographics as additional independent variables. Multicollinearity is no issue for the numerical expectations since the correlation between numerical and subjective risk and return expectations is relatively low, consistent with findings in Nosić and Weber (2007). However, multicollinearity becomes an issue if we try to include both past market performance measures at the same time. To avoid this problem we include *Diff. Past Perf. Market Num.* in regression four and *Diff. Past Perf. Market Subj.* in regression five, separately. Our main results with regard to expectations remain stable as both *Diff. Market-Risk-Subj.* and *Diff. Market-Return-Subj.* are still significant determinants of *Diff. Risk Taking.*

[9] Note that this reasoning alone cannot explain the entire finding as it remains stable, even if we winsorize the data.

[10] An in depth analysis of why some subjects state negative expected returns and still invest into a portfolio is certainly interesting but not the scope of the present study.

In addition, we find a slightly significant effect for *Diff. Past Perf. Market-Num.* in regression 4 if we run the regressions for all subjects. However, this result is not very stable as *Diff. Past Perf. Market-Num.* is not a significant determinant of *Diff. Risk Taking* if we re-run the regression only for those subjects that participated in all three surveys.

Insert table 5 here

After having analyzed which factors drive changes in risk taking behavior from September to December and from December to March jointly, we turn to analyze this question separately for the two time periods. Table 6 reports results of simple tobit regression of changes in risk taking (*Diff. Risk Taking*) on various independent variables. All odd numbered models run the regressions for all difference variables in the time period September to December, whereas all even numbered models run the regressions for all difference variables in the time period December to March. We run the regressions only for those subjects that participated in all three surveys, i.e. for subjects for that we have an observation in both time periods.

Our finding that changes in *Diff. Risk Attitude 2* cannot explain changes in risk taking remains stable. In addition, for regressions which rely on data that were collected in September and December 2008 (1, 5, 7, and 9) we can also include *Diff. Risk Attitude 6* and *Diff. Risk Attitude 7* as additional independent variables. Both measures are also not able to explain changes in risk taking. These results remain stable even if we run the regressions for each risk attitude measure individually.

Interestingly, our result that changes in subjective market risk and return expectations can best explain *Diff. Risk Taking* remains fairly stable even if we run the analyses for the two subsample of observations separately. The coefficients for *Diff. Market-Return-Subj.* are almost stable and between 2.7 and 3.7 and mostly significant. Lower levels of significance can be driven by a lower number of observations. The results for *Diff. Market-Risk-Subj.* are not as clear-cut. *Diff. Market-Risk-Subj.* is always negative, however, only significant in odd-numbered regressions.

Why can changes in subjective risk expectations explain changes in risk taking only for the period September to December but not for the one from December to March? We can only speculate about this. A possible explanation could be that changes in risk expectations and subsequently changes in risk taking behavior are smaller and hardly existent in the second period from December to March, whereas they are existent in the period September to December, i.e. the period of large turmoils on financial markets.

Overall, all coefficients for *Diff. Market-Return-Subj.* and *Diff. Market-Risk-Subj.* point into the correct direction, however, the significance of our results is lower than in table 5. A possible explanation for the lower significance are a lower number of observations in the separated analyses.

Insert table 6 here

4.3 Overconfidence over Time

Besides changes in risk and return expectations there is also a large strand of literature analyzing changes in the level of overconfidence over time. Gervais and Odean (2001) illustrate in a theoretical model that investors often attribute success to their own acumen while attributing failure to chance and term this "learning to be overconfident". This self-serving attribution bias results in subjects getting more overconfident after investment success and subsequently taking more risky actions but not more underconfident after investment failure. In the long run, however, frequent feedback lowers the self attribution bias and subjects get less overconfident. In line with the self attribution hypothesis, Barber and Odean (2002) and Statman et al. (2006) show that overconfidence varies with prior past performance.

Experimental evidence on the evolution of overconfidence is equivocal. Deaves et al. (2005) find evidence for the "learning to be overconfident" hypothesis whereas Jonsson and Allwood (2003) find evidence for individual stability of overconfidence over time. To analyze the question whether overconfidence is stable or varies over time in more depth we compare the level of overconfidence (miscalibration) on an individual level in September, December, and March with each other using a confidence interval approach. Following the two-point approximation methodology suggested by Keefer and Bodily (1983) we transform estimates of confidence intervals, i.e. upper and lower bounds, into volatility estimates. To get a measure of overconfidence we simply compare the estimated volatility with a volatility benchmark: Overconfidence $= -\frac{Estimated\ volatility}{Volatility\ of\ the\ benchmark}$. This overconfidence measure enables us to analyze to what degree subjects adjusted their risk expectations in reaction to changes on financial markets and is thus related to our analyses in the previous subsections. Since we cannot calculate a volatility benchmark for each subject's portfolio we can only analyze individual overconfidence with regard to the market.

Our measure for estimated volatility is simply *Market-Risk-Num.* To obtain an adequate measure for the volatility of the benchmark, the FTSE-All-Share we can use two approaches. First, we can try to calculate historical volatilities for the FTSE-All-Share and relate these to the estimated volatilities (*Market-Risk-Num.*). However, one big disadvantage of historical volatilities is that the results heavily depend upon the time span that is used to calculate the historical volatility. This disadvantage is in particular severe due to the extreme turmoils that financial markets around the world have been experiencing between September and December. Second, we can use a measure of the implied volatility of the British stock market embedded in prices of out of the money index call and put options. However, there is no implied volatility index that is calculated for the FTSE-All-Share but only one for the FTSE-100 (VFTSE-100). Since the correlation between FTSE-All-Share and FTSE-100 is almost 1 ($\rho > 0.99$) we use the average VFTSE-100 levels for September 6-20 (0.15), December 6-20 (0.22), and March 21-30 (0.18) as our volatility benchmarks. Thus, subjects who end up with an overconfidence score above -1 are overconfident whereas subjects with a score below -1 are underconfident.

As we have seen in table 3 our measure of estimated volatility (*Market-Risk-Num.*) in September is substantially smaller than in December and March implying that subjects adjusted their volatility estimates upwards. However, this adjustment of volatilities might be perfectly rational as subjects correctly incorporated that markets became substantially more risky over time. Our overconfidence measures which are simply the estimated volatilities inferred from the bounds divided by the average implied volatility in September, December, and March and normalized by minus one control for possible changes in the riskiness of the benchmark. We find mean overconfidence in September to be -0.36 (median=-0.31), mean overconfidence in December to be -0.34 (median=-0.28), and mean overconfidence in March to be -0.4 (median=-0.38). All scores are significantly larger than

-1 indicating that subjects tend to set too tight bounds and thus underestimate volatilities.

Testing for differences in the degree of overconfidence between the September and the December wave we find no statistically significant difference using a Wilcoxon signed-rank test (p=0.28). Subjects correctly adjusted their volatility estimates upwards in reaction to the dramatic changes on financial markets. A similar result has been indirectly observed by Glaser and Weber (2005) in their analyses of DAX volatility forecasts before and after 9/11. However, analyzing the differences in the degree of overconfidence between March and December we find a significantly lower level of overconfidence in March than in December (p=0.002). Our results do not change if we control for subjects' past performance in the analyses.

Hence, the level of overconfidence remains fairly stable from September to December, i.e. in the phase of a huge downturn, and gets smaller from December to March. Why can we not find evidence for a self-serving attribution bias and thus initial increases in overconfidence after investment success and later on a reduction in overconfidence as subjects gain experience as proposed in the model of Gervais and Odean (2001)? The reason might simply be the fact that there is hardly any investment success in the first period from September to December. More than 87% of all investors state they did not have a positive portfolio return between September and December. Thus, overconfidence remains fairly stable initially before a slight learning effect sets in. However, to analyze the dynamics of overconfidence in more depth we would need more observations over time.

5 Conclusion

Based on a repeated survey study that was run in collaboration with *Barclays Wealth* we document that real online broker customers' risk taking or investment behavior changes substantially from one quarter to the other. According to more general risk-value models these changes can be attributed to changes in expectations or changes in risk attitudes or both. We show that expectations vary substantially over time whereas risk attitudes seem to be fairly stable and do not vary too much over time. Furthermore, we show that changes in risk taking behavior seem to be mainly driven by changes in expectations and not changes in attitudes. This result is stable even if we control for past performance and demographics. Lastly, we provide evidence that overconfidence (miscalibration) of real investors seems to be relatively stable from September to December 2008 and tends to decrease slightly thereafter.

We extend previous findings in the literature on changes in risk taking, expectations, and risk attitudes as follows: first, our unique dataset allows us to analyze changes in risk taking, expectations, and risk attitudes of real online broker customers. Second, previous studies in the literature analyze only changes in risk taking (see e.g. Malmendier and Nagel (2008)) or only changes in expectations (see e.g. Vissing-Jorgensen (2003)) or only changes in risk attitudes (see e.g. Sahm (2007)) individually but not jointly. Thus, in contrast to our study they are not able to disentangle the channel through which risk taking behavior changes over time or they are not able to observe changes in risk taking behavior at all. Third, a major advantage of our survey is that the first round of surveys was conducted in the beginning of September 2008, i.e. just before the extreme turmoils recently experienced 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 and during the crisis using the same panel of investors. Fourth, our dataset is the first one that allows us to test predictions in the study by Gervais and Odean (2001) on the stability of overconfidence with real investors where one is able to control for previous investment success.

Our findings should be valuable for practitioners in banking. We show that risk attitudes - if measured correctly and without confounding effects - seem to be fairly stable and that changes in risk taking behavior seem to be caused by changes in expectations and not by changes in risk attitudes or changes in past performance. Thus, practitioners who are urged by MiFID (2006) to elicit their customers' risk profiles and risk preferences can argue that elicitation of risk attitudes needs not to be carried out on a quarterly basis. Moreover, our results indicate that it might be worthwhile for practitioners to elicit their clients' expectations as they seem to underestimate the volatility of the market substantially and as this underestimation seems to persist over time.

Future research could combine repeatedly elicited survey data with data on portfolio holdings and trading activity and thus extend findings in previous studies who analyze the relationship between trading data and a one-time survey (see Dorn and Huberman

(2005) and Glaser and Weber (2007)). Moreover, it seems interesting to analyze whether the extreme events in financial markets in recent months have long-lasting effects on risk attitudes and expectations as well as on the actual asset allocations of economic agents.

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Table 1: Demographic characteristics and descriptive statistics

The first two columns of this table report mean values of various demographics and descriptive statistics for participants of our study (Group^{all}) and for the adult British population (GB^{all}) (GB^{all} data are supplied through the Office for National Statistics). The next three columns report mean values of various demographics and descriptive statistics for a subset of participants that took part in all three surveys only once (Group^{once}), only twice (Group^{twice}) or in all three surveys (Group^{thrice}), separately. *Age*, *Number of dependants*, and *Gross income* are self-explanatory. *Gender* and *Marital status* are two dummy variables that take the value 1 if the subject is male and married, respectively. Investable wealth is measured in 9 categories from 1 (£0 - £10,000) to 9 (> £ 1 million). The last three columns report z-scores of Mann-Whitney rank-sum tests or binomial tests (for the two dummy variables) which test whether subjects that participated once, twice or thrice differ from the respective subgroup of subjects. * indicates significance at the 5% level and ** indicates significance at the 1% level.

	Group^{all}	GB^{all}	Group^{once}	Group^{twice}	Group^{thrice}	Diff.$^{twice-once}$	Diff.$^{thrice-once}$	Diff.$^{thrice-twice}$
Age	51.65	47.66	51.69	50.52	52.96	-0.667	1.082	1.595
Number of dependents	1.14	-	1.17	1.13	1.08	-0.328	-0.309	0.056
Gender	0.93	0.49	0.92	0.93	0.95	0.674	0.238	0.453
Gross income	76,615.73	30,000	71,446.59	85,718.92	76,631.4	1.157	0.902	-0.207
Marital status	0.65	0.52	0.67	0.65	0.62	0.647	0.314	0.601
Investable wealth	4.80	-	4.58	4.52	5.55	1.082	3.660**	3.488**

Table 2: Definition of dynamic variables

This table summarizes and defines variables that were elicited repeatedly. Note that *Risk Attitude 6* and *Risk Attitude 7* were not elicited in the March survey.

Variable	Question / Description
Risk Taking	
Risk Taking	Measures, on a percentages basis, 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 by 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	
Perf.-External	What do you think the return of your investments held at other banks over the past 3 months was?
Perf.-Market-Num.	"What is your best estimate of the return of the UK stock market (FTSE-All-Share) over the past 3 months?"
Perf.-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)
Perf.-Own-Num.	"What do you think the return of your own portfolio over the past 3 months was?"
Perf.-Own-Subj.	"How would you rate the returns of your own portfolio over the past 3 months?" (1 = Extremely bad ... 7 = Extremely good)

Table 3: Differences in repeatedly elicited variables between rounds

This table reports mean values of all repeatedly elicited variables broken down by the month they were elicited for all subjects that took part in the survey at least twice. The last two columns indicate z-statistics of Wilcoxon signed-rank tests that test whether scores in December are significantly different from scores in September (Difference$^{Dec-Sept}$) or whether scores in March are significantly different from scores in December (Difference$^{March-Dec}$). Wilcoxon signed-rank tests are only carried out if a subjects has participated in the two respective months. * indicates significance at the 5% level and ** indicates significance at the 1% level.

	Sept. (N=265)	Dec. (N=305)	March (N=239)	Difference$^{Dec-Sept}$ z-score	Difference$^{March-Dec}$ z-score
Risk Taking					
Risk-Taking (Hypoth.)	56.02	52.77	46.52	-2.586**	-3.90**
Risk Attitude					
Risk Attitude 2	3.34	3.63	3.55	1.889	-0.731
Risk Attitude 6	4.43	4.61	-	2.511*	-
Risk Attitude 7	5.04	5.06	-	0.388	-
Expectations					
Market-Return-Num.	1.57	3.57	5.42	1.661	3.311**
Market-Risk-Num.	0.052	0.075	0.072	7.289**	-0.568
Market-Return-Subj.	3.5	3.67	3.84	1.089	-0.478
Market-Risk-Subj.	4.76	5.17	5.15	4.596**	1.533
Own-Return-Num.	4.38	6.23	8.18	2.941**	3.324**
Own-Risk-Num.	0.053	0.078	0.067	6.737**	-2.562**
Own-Return-Subj.	3.89	3.91	4.17	-1.092	2.599**
Own-Risk-Subj.	4.2	4.45	4.53	3.680**	1.287
Past Performance					
Perf-Ext.	-2.14	-12.57	-3.19	-7.406**	3.618**
Perf-Market-Num.	-8.2	-16.79	-6.96	-8.198**	7.782**
Perf-Market-Subj.	2.32	1.82	2.42	-7.426**	4.641**
Perf-Own-Num.	-7.7	-18.51	-8.48	-9.521**	7.03**
Perf-Own-Subj.	2.95	2.33	2.92	-7.256**	4.261**

Table 4: Changes in risk taking I

This table reports mean values of changes in risk attitudes, expectations and past performance separately for subjects who take more (less) risks in December compared to September in the left panel and for subjects who take more (less) risks in March compared to December in the right panel: Δ R.T.$^{+}$ (Δ R.T.$^{-}$). All change or differences variables are calculated for each subject separately simply as the value in December minus the value in September in the left panel and as the value in March minus the value in December in the right panel. The last column in each panel reports z-scores of a Mann-Whitney rank-sum test comparing the two groups of subjects. * indicates significance at the 5% level and ** indicates significance at the 1% level.

	September to December			**December to March**		
	Δ R.T.$^{+}$	Δ R.T.$^{-}$	Difference in differences	Δ R.T.$^{+}$	Δ R.T.$^{-}$	Difference in differences
Risk Attitude						
Diff. Risk Attitude 2	0.182	0.009	0.542	0.037	-0.093	1.192
Diff. Risk Attitude 6	-0.013	0.218	-1.232	-	-	-
Diff. Risk Attitude 7	0.026	-0.037	0.217	-	-	-
Expectations						
Diff. Market-Return-Num.	0.937	3.945	-0.072	3.129	0.523	1.395
Diff. Market-Risk-Num.	0.022	0.029	-0.621	0.004	-0.008	1.565
Diff. Market-Return-Subj.	0.395	-0.027	2.024*	0.509	0.052	2.468*
Diff. Market-Risk-Subj.	-0.052	0.555	-3.35**	-0.200	0.020	-1.21
Diff. Own-Return-Num.	2.980	3.252	0.245	3.148	3.414	0.556
Diff. Own-Risk-Num.	0.034	0.019	0.929	0.002	-0.015	2.092*
Diff. Own-Return-Subj.	-0.067	-0.018	0.041	0.296	0.021	1.332
Diff. Own-Risk-Subj.	0.240	0.321	-0.77	0.463	0.062	1.265
Past Performance						
Diff. Past Perf. External	-8.994	-14.83	0.556	5.571	4.467	0.152
Diff. Past Perf. Market Num.	-11.835	-5.880	-1.418	9.037	10.097	-0.702
Diff. Past Perf. Market Subj.	-0.697	-0.670	-0.174	0.352	0.680	-1.178
Diff. Past Perf. Self Num.	-13.000	-12.893	0.596	11.602	8.908	0.403
Diff. Past Perf. Self Subj.	-0.558	-0.873	1.482	0.741	0.144	2.375*

Table 5: Changes in risk taking II

This table reports results of clustered tobit regressions where standard errors take clustering over subjects into account. 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 change or differences variables are calculated for each subject separately simply as the value in December (March) minus the value in September (December). p-values are reported in parentheses. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

	(1)	(2)	(3)	(4)	(5)
Risk Attitude					
Diff. Risk Attitude 2	0.936		1.071	1.001	0.933
	(0.220)		(0.149)	(0.216)	(0.252)
Expectations					
Diff. Market-Return-Num.				0.151	0.038
				(0.256)	(0.714)
Diff. Market-Risk-Num.				4.451	5.349
				(0.870)	(0.846)
Diff. Market-Return-Subj.		2.348	2.327	1.934	2.013
		(0.017)**	(0.018)**	(0.049)**	(0.046)**
Diff. Market-Risk-Subj.		-2.208	-2.303	-2.529	-2.631
		(0.016)**	(0.015)**	(0.010)**	(0.009)***
Past Performance					
Diff. Past Perf. Market Num.				-0.164	
				(0.056)*	
Diff. Past Perf. Market Subj.					0.137
					(0.872)
Demographics	No	No	No	Yes	Yes
Dummy-Period	-2.124	-3.441	-2.978	-0.464	-3.489
	(0.470)	(0.242)	(0.312)	(0.886)	(0.283)
Constant	-4.366	-3.601	-3.803	4.694	5.478
	(0.021)**	(0.069)*	(0.054)*	(0.524)	(0.468)
Observations	434	435	431	396	396

Table 6: Changes in risk taking III

This table reports results of tobit regressions of changes in risk taking (*Diff. Risk Taking*) on changes in risk attitude, expectations, and past performance as well as demographic variables, separately for the two time periods *September-December* and *December-March.* All change or differences variables in regressions 1, 3, 5, 7, and 9 are calculated for all subjects that participated in September and December simply as the value in December minus the value in September. All change or differences variables in regressions 2, 4, 6, 8, and 10 are calculated for all subjects that participated in December and March simply as the value in March minus the value in December. Subjects are only included in the analyses if they participated in all three surveys. p-values are reported in parentheses. * indicates significance at the 10% level, ** indicates significance at the 5% level, and *** indicates significance at the 1% level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Diff. Risk Attitude 2	0.760	-0.462			1.412	-0.321	1.586	-0.846	1.260	-0.921
	(0.606)	(0.728)			(0.387)	(0.810)	(0.345)	(0.520)	(0.483)	(0.486)
Diff. Risk Attitude 6	0.469				1.900		2.011		2.043	
	(0.833)				(0.348)		(0.397)		(0.389)	
Diff. Risk Attitude 7	1.433				1.150		0.959		1.083	
	(0.332)				(0.471)		(0.575)		(0.525)	
Diff. Market-Return-Num.							-0.019	0.280	-0.075	0.165
							(0.913)	(0.253)	(0.455)	(0.449)
Diff. Market-Risk-Num.							-48.940	41.831	-52.745	42.404
							(0.407)	(0.284)	(0.377)	(0.276)
Diff. Market-Return-Subj.			2.832	3.794	2.937	3.725	3.153	2.716	2.871	2.941
			(0.108)	(0.014)**	(0.054)*	(0.019)**	(0.094)*	(0.071)*	(0.135)	(0.048)**
Diff. Market-Risk-Subj.			-4.497	-0.534	-4.883	-0.537	-4.465	-0.867	-4.503	-1.019
			(0.005)***	(0.716)	(0.004)***	(0.746)	(0.007)***	(0.617)	(0.008)***	(0.557)
Diff. Past Perf. Market Num.							-0.066	-0.156		
							(0.643)	(0.257)		
Diff. Past Perf. Market Subj.									1.549	-0.308
									(0.344)	(0.804)
Demographics	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Constant	-3.313	-5.966	-1.423	-7.326	-2.184	-7.062	0.339	-3.516	2.377	-6.518
	(0.163)	(0.006)***	(0.575)	(0.000)***	(0.366)	(0.001)***	(0.983)	(0.770)	(0.881)	(0.592)
Observations	149	140	149	141	149	140	140	130	140	130