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Which measures predict risk taking in a multi-stage controlled investment decision process?

Kremena Bachmann[a], Thorsten Hens[b,c,e]*, Remo Stössel[d]

[a]*Department of Banking and Finance, University of Zurich, Plattenstrasse 32, 8032 Zürich, Switzerland*
[b]*Department of Banking and Finance, University of Zurich, Plattenstrasse 32, 8032 Zürich, Switzerland and*
[c]*Department of Finance, Norwegian School of Economics, NHH, Bergen*
[d]*Department of Banking and Finance, University of Zurich, Plattenstrasse 32, 8032 Zürich, Switzerland*
[e]*Department of Economics, University of Lucerne, Switzerland*

Abstract

We assess the ability of different risk profiling measures to predict risk taking along a multistage process that reflects individuals' discovery of their willingness to take risks. We find that the individual willingness to take risks varies along the process, but its level is always related to a composite measure of the individual risk tolerance. Assessment of the risk tolerance cannot be substituted by a simulated experience, although the latter can improve the perception of the risk and reward potential of the investment and motivate higher risk taking. The risk tolerance measure addresses different notions of risk, but we found that the individual loss aversion is the most powerful predictor of risk taking at all stages of the discovery process. By contrast, we found that neither the self-assessed risk tolerance measures nor the investment experience are suitable for consistently predicting risk taking at different stages of the process.

JEL classification: D81; G11

Keywords: Risk profiling; Risk tolerance; Risk attitude; Risk preferences; Risk taking; Experience sampling

1. Introduction

An essential task in investment management is determining the amount of risk an investor should take. In principle, investors can identify their willingness to bear risks through investment in the financial market, but this approach is costly because a considerable amount

* Corresponding author. Tel.: +41 44 634 48 22.
E-mail address: kremena.bachmann@bf.uzh.ch (K. Bachmann)

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of wealth can be lost because of inconsistent decisions during the learning process. To assist investors and justify their recommendations as required by regulators, financial professionals use various techniques to determine the level of risk that their clients should take.

In this study, we evaluate the suitability of such risk profiling techniques based on their power to explain and predict individual risk-taking behavior. More important, we believe that the relationship between the assessed risk profile and the subsequent risk taking may not be stable if individuals are still in the process of identifying their willingness to take risks. The involvement in such a process is likely because individuals are not always able to correctly anticipate their emotional reactions to possible outcomes (Kahneman, 2009).

To shed some light on this issue, we conduct an experimental study on whether an individual's risk taking changes over different stages of a process along which private investors are expected to correct misperceptions and discover their true willingness to take risks. We then analyze how the predictability of risk profiling questions varies over the stages of such a process. The goal of the study is to identify risk profiling measures that consistently explain and predict risk taking at all stages of the discovery process. This consistency is important because investment advisors usually do not know which stages of the process their clients have completed. Using a risk profiler that is suitable only if clients have completed certain stages of the discovery process can lead to inappropriate advice being given.

To determine the relevant stages of the discovery process, we consider evidence from previous studies reporting that individual risk taking varies with certain characteristics of the decision setting, such as ambiguity, personal experience, and feedback. We use these features to design a multistage discovery process that reflects the investment experience of a typical private investor. For simplicity, investors only decide between one risky asset and cash. At the beginning of this process, it is assumed that investors decide within an ambiguous situation, that is, they know the return of holding cash, but they do not know anything about the return distribution of the risky asset. Afterwards, the ambiguity is revealed while investors can choose its presentation format. In the third stage, the investors are asked to answer some risk profiling questions. In the next stage of the process, they experience the risk-return characteristics of different asset allocations based on simulations. In the fifth stage, the investors learn which return they have made, and in the last stage, they are able to reconsider their investment decision using a three-day break. We analyze whether individual risk taking changes over the different stages of the process, that is, whether investors are involved in a process of discovering their willingness to take risks. We then analyze the ability of different risk profiling questions to consistently predict risk taking over the different stages of the process.

Nobre and Grable (2015) suggest that risk profiling questions should consist of questions assessing the risk need (the amount of risk required to meet a particular financial goal), the risk capacity (the client's ability to absorb a possible financial loss resulting from the financial risk taken) and the financial risk tolerance (an individual's willingness to accept uncertainty related to the outcome of a financial decision). Carr (2014) analyses the optimal weighting of these dimensions. In this study, we focus on the assessment of the investors' risk tolerance, which is a psychological concept. The assessment of the risk need and the risk capacity are purely financial issues that can be managed with financial planning tools. In our study, we use a broad definition of risk tolerance that

refers to losses as an additional notion of risk. Moreover, we use different formats to state the questions, that is, some questions use lotteries and others use verbal alternatives; we also consider questions based on a self-assessment. Additionally, we consider other factors that may affect risk taking, such as investment experience outside of the study and the investors' risk awareness as reflected in the misperception of the true risk-reward profile of their investments. We also analyze whether simulated experience can substitute for risk profiling based on questions.

We find that some aspects of an individual's risk tolerance explain risk taking at all stages of the decision process, while the risk awareness and the self-stated investment experience cannot. Moreover, although simulated experience improves risk awareness and supports risk taking, it cannot be used as a substitute for the assessment of individual risk tolerance when explaining and predicting risk taking. While risk tolerance can be measured in many ways, we find that the individuals' loss aversion is the most suitable measure because it most accurately predicts the risk-taking behavior of investors involved in a process of discovering their willingness to take risks. Of interest, we find that self-assessed risk tolerance measures are not suitable for predicting risk taking at any stage of the decision process. If individuals' risk tolerance cannot be assessed and one must rely on socioeconomic characteristics, then only gender can be used as a predictor of risk taking.

The results of our study have important policy implications. Regulators in most developed countries acknowledge the importance of using risk profilers, and professional advisors use various risk profiling methods to justify their recommendations. However, it is not clear whether the risk profilers used in practice are suitable for determining the optimal level of risk taking (Brayman, Finke, Grable, and Griffin, 2017). Their external validity is sometimes tested based on real asset allocation decisions (Corter and Chen, 2006; Gilliam, Chatterjee, and Grable, 2010; Grable and Lytton, 2003; M. Guillemette, Finke, and Gilliam, 2012; Wärneryd, 1996). However, it is unclear whether an asset allocation at a certain point of time is a good assessment criterion because clients may still be involved in the process of discovering their willingness to take risks. Our analysis explicitly considers the impact of this discovery process on the suitability of different risk profiling measures. We identify measures that consistently predict risk taking at every stage of the process. This is important for advisors because they usually do not know which stages of the discovery process their clients have already passed. Using questions that consistently predict risk taking at all stages of the discovering process increases the probability that clients remain satisfied with the recommendations. At the same time, making recommendations based on questions that consistently predict risk taking at all stages of the discovery process should support the advisors' confidence that these recommendations match the clients' risk tolerance and do not encourage misperceptions that are corrected over time.

2. Literature review and research hypotheses

Using different measures of individual risk tolerance, previous studies have found that these measures are related to individual investment risk taking. For example, Barsky and Juster (1997) find that risk tolerance revealed in a hypothetical choice between uncertain

income streams predict stock ownership. Yook and Everett (2003) find a significant positive correlation between the total score of several risk tolerance measures and the percentage of actual stock holdings in portfolios. Corter and Chen (2006) propose another risk tolerance measure and show that it is positively correlated with the riskiness of the actual investment portfolios chosen. Wärneryd (1996) finds a significant relationship between the individual investment attitude based on risk-return considerations and the risk in portfolios of Dutch households. Gilliam et al. (2010) find a significant positive association between broadly used risk tolerance measures and equity ownership.

While these studies show that the evaluation of the individual risk tolerance is important for explaining investment risk taking, it remains unclear whether the explanatory power remains stable over time because individuals change their risk-taking behavior. For this reason, we designed a controlled laboratory experiment that stays close to the advisory processes found in praxis so that the setting is not too artificial.

We also consider information- and experience-driven changes in investment risk taking. At the beginning, investors are expected to make investment decisions under ambiguity, that is, they may not know the exact risk-return characteristics of the alternatives that they consider for investment. Frisch and Baron (1988) argue that ambiguity arises from the perception of missing information relevant for a probability judgment, which supports the normative status of utility theory. From a theoretical perspective, ambiguity is important because it motivates lower stock market participation compared with the basic expected utility model (see, e.g., Epstein and Schneider, 2010 among others). Antoniou et al. (2015) confirm the prediction of the theoretical ambiguity literature. In particular, they find that an increase in ambiguity is associated with reductions in capital flows into equity mutual funds. Hence, providing information that makes probability judgments easier can increase risk taking. Based on this literature, we conjecture that our participants take less risk under ambiguity, that is, in the first stage, than in later stages of our experiment.

In the second stage of our experiment, the participants can acquire three different descriptions of the returns of the risky asset. Previous studies have shown that even if individuals are provided with identical information, the presentation format can influence the utilization of information. In a classic demonstration of this phenomenon, Slovic et al. (1978) observe that the presentation of formally equivalent statistics influences risk-taking behavior. Similar types of framing effects have been reported in the literature on decision-making (Tversky and Kahneman, 1981). Framing effects have been extensively used to modify risk-relevant behavior, facilitate cooperative conflict resolutions and advance knowledge or attitudes (see Rohrmann, 1992 for an overview). We focus on the last aspect and hypothesize that individuals have different abilities to utilize information in different formats, which may influence their risk-taking behavior.

In the third stage of our experiment, the participants are asked to answer questions regarding their risk tolerance and investment experience. The effect, wherein individuals change their behavior in response to being monitored, has been widely discussed in health economics (Parsons, 1974) and consumer behavior research (Fitzsimons and Williams, 2000). In our study, we consider the existence of assessment effects in the context of investment risk taking.

In the fourth stage of our experiment, the participants can experience the return distribution by drawing samples from it before they can decide how to invest. Converging findings show that there are systematic differences between decisions based on experience and decisions based on description (Hertwig and Erev, 2009), particularly in the context of decisions involving rare events (Hertwig et al., 2004). Kaufmann et al. (2013) show that communicating risk with the help of experience sampling and graphical displays leads to higher risk taking. Goldstein et al. (2008) suggest that using interactive methods allowing individuals to explore the probability distributions of potential outcomes can be beneficial for inferring preferences and predicting subsequent risk-taking behavior. In line with this research, we hypothesize that experience sampling influences risk taking. In particular, we analyze whether experience sampling can substitute the assessment of individual risk tolerance in explaining and predicting risk-taking behavior.

In the next stage of our experiment, the participants have a break of three days in which they can carefully study the design of the experiment and what they have done so far. Previous research suggests that decision-makers switch to simpler strategies if decisions have to be made under time pressure, which can explain preference reversals (Ordonez and Benson, 1997). In negotiations, for example, individuals appear to reach higher-quality agreement after a break because the latter allows them to assess strategies and behavior (Harinck and De Dreu, 2008). We hypothesize that giving individuals time to re-evaluate the decision problem may have an impact on their subsequent risk taking.

In the last stage of our experiment, the participants learn the outcomes of their previous investments and decide for the last time whether and how to revise them. Given that all relevant information is available before a decision is made, the outcome of a decision should not be used to improve subsequent decisions. However, Fischhoff (1975) demonstrates the existence of a hindsight bias, an effect of the outcome information on the judged probability for different outcomes. His explanation for observing this bias is that outcome information calls attention to information that would make a decision good or bad. For example, bad outcomes call attention to the risks associated with the decision as an argument against taking the decision. We hypothesize that the information on the outcomes of previous decisions may affect the subsequent risk taking and take the effect into account when assessing the suitability of risk profiling questions.

3. Survey design

Our study consists of six stages, which differ either in the information that individuals receive or in the tasks they have been asked to perform. Table 1 provides an overview of all stages. It specifies the information that is also provided at every stage and the tasks that the individuals were asked to perform after receiving the new information.

A common task at every stage is an investment decision. At each stage, individuals were given financial wealth expressed in Experimental Currency Units (ECU) and asked to split the wealth between a risky and a riskless asset. The amount in ECU varied between individuals dependent on their true financial situation, which was assessed in advance

Table 1 Survey structure

	New information provided	Tasks after receiving new information
Stage 1: Ambiguity	Information on the return of the riskless asset	Make an investment decision
Stage 2: Return information	Return distribution of the risky asset (described by graphics, scenarios, and statistics)	Make an investment decision
Stage 3: Profile estimation		1. Answer questions assessing risk tolerance, financial knowledge, and experience 2. Make an investment decision 3. Answer risk awareness questions (1st time)
Stage 4: Simulated experience	Experience the risk-return profile of different asset allocations through simulations	1. Answer risk awareness questions (2nd time) 2. Make an investment decision
Stage 5: Time break	Three days break	Make an investment decision
Stage 6: Feedback	Receive report of returns with all previous investment decisions	1. State satisfaction/expectations 2. Make an investment decision

together with other demographic and socio-economic characteristics. The monetary value of all ECU endowments was 10 Euros. The investment decisions between stages were independent. The individuals were informed that one of their investment decisions would be relevant for their final payment and that the relevant decision would be determined randomly at the end.

In the first stage, individuals were asked to make an investment decision under ambiguity, that is, the individuals knew only the return of the riskless asset but did not have any information about the return distribution of the risky asset. The latter was provided in the second stage using different formats. The graphical format used histograms, the verbal format was based on scenarios, and the statistical format used descriptive statistics (see Appendix D). The individuals could use the format that they considered most helpful. Acquiring information was not mandatory. Subsequently, individuals were asked to make an investment decision for a second time. In the next stage, no new information was provided. Instead, individuals were asked questions about their risk tolerance, financial knowledge and investment experience. Because asking such questions may change the individual risk-taking behavior, we asked individuals to make a third investment decision. Afterwards, individuals were asked questions assessing their risk awareness, that is, their understanding of the risks and rewards associated with different investment decisions.

In the fourth stage, individuals received the opportunity to experience the risk of investment in the risky asset. Our experience sampling tool is based on the same idea as the tool used by Kaufmann et al. (2013), that is, individuals draw different scenarios on the realization of the risky asset and observe how the return distribution of different asset allocations

emerge. To make asset allocations comparable, we allowed individuals to simultaneously observe the final outcomes of two different asset allocations side-by-side (see Figure A-1 in the Appendix). Both asset allocations use the same return realization of the risky asset and the same investment horizon of 1 year. The simulations were restarted with every change in the asset allocation. To avoid framing effects, both return distributions were scaled in the same way. After observing the final outcomes of at least two hundred scenarios (this required at least 10 drawings), the individuals were asked to answer our risk awareness questions for the second time and to make an investment decision. The payoff of the participants depended on this investment decision but not on the decisions made while drawing outcomes of different asset allocations.

In the fifth stage, the individuals were informed that they would have a three-day break. In reality, the clients received factsheets with investment information. Similarly, individuals were given the option to download the description of the assets for further reference. After a three-day break, the individuals were asked to make their fifth investment decision. They were also asked to state which investment decision they consider the best one, that is, which investment decision they would consider relevant for their payment.

In the sixth stage, individuals received a report on the realized returns with each of their five investment decisions. For each decision, the individuals were asked to state to what degree they are satisfied and to what degree they are positively or negatively surprised. Afterwards, the individuals were asked to make a final investment choice.

3.1. Incentives

The participants received a base payment of 13.25 Euros and a payoff based on one of the five investment decisions. The relevant decision was selected randomly. The payoff in the selected decisions depended on the preferred exposure to the risky asset and the return of the risky asset, which was drawn from the previously communicated distribution of the risky asset. Additionally, the participants could gain or lose 2% (20 cents) of their initial endowment with every correct (incorrect) answer to the risk awareness questions. All questions that were relevant for the final payment were marked in red, and the instructions stated that this indicates payoff relevance. The median completion time was 27 min, excluding the three-day break. The total payments varied between 21.75 and 27.65 Euros with an average of 26.20 Euros.

3.2. Participants

The survey was conducted online[1] in January 2014 with 439 Germans aged between 18 and 65. The sample was provided by a professional market research agency and included individuals from a national panel of over 200,000 Germans. Socioeconomic questions were used to apply a quota sampling procedure for selecting participants from the general population to ensure the representativeness of the sample.

We used the time those individuals took to read the instructions and answer the questions to exclude those that are most likely to provide random answers.[2] The filtered sample includes 320 individuals. A summary of their socioeconomic profiles is provided in Table B-1 in the Appendix. Most of the individuals have no children, have a high school degree,

work as employees without supervisory responsibilities, have a monthly net income between 1,300 to 2,600 Euros and have a financial wealth of between 2,500 to 10,000 Euros.

3.3. Definitions

The *risk profiler* is a composite of several measures that predicts investment risk taking. Nobre and Grable (2015) suggest that risk profiling questions should consist of questions assessing the risk need (the amount of risk required to meet a particular financial goal), the risk capacity (the client's ability to absorb a possible financial loss resulting from the financial risk taken) and the financial risk tolerance (the individual's willingness to accept uncertainty related to the outcome of a financial decision). We focus on the assessment of the risk tolerance since the first two concepts are purely financial issues that can be managed with financial planning tools. In our setting, the investor's *risk tolerance* is a multidimensional construct that reflects an investor's attitude toward risk. We use different notions of risk that refer to the uncertainty of payoffs and to payoffs below a certain reference point. The attitude toward uncertainty is usually called risk aversion. The attitude toward payoffs below a certain reference point is called loss aversion. We consider the investor's *risk awareness* as an additional driver of risk taking. It measures the discrepancy between the perceived and the true risk-reward characteristics of the chosen investment.

3.4. Questions design

The questions used in our survey assess an individual's risk tolerance, risk awareness and investment experience, along with socio-economic and demographic characteristics as potential drivers of financial risk taking. The questions are provided in the Appendix.

The questions assessing an investor's risk tolerance address different notions of risk. In line with the results of Morrison and Oxoby (2014), who find that loss aversion influences decisions involving risk beyond the effects of risk aversion, we assess risk aversion and loss aversion as separate descriptions of an individual's risk tolerance. The estimation of individual's risk aversion is based on self-assessments. An individual's loss aversion is estimated with a price table task, which is similar to the one used by Holt and Laury (2002). In this task, the individuals were asked to make eight binary comparisons. In each comparison, they were asked to select either the safe option or the risky option. A control question describing the individual's choice asks individuals to confirm or revise their decision.

The question assessing individual risk awareness aimed to evaluate an investor's understanding of the return distribution of the risky asset. We used multiple choice questions with individually randomized answers. In addition to answering the questions, we asked individuals to state their confidence in the correctness of their answers.

To compare the different question types, we apply the same seven-point Likert scale to all questions.[3] For three questions, it was not appropriate to use a Likert scale. In these cases, we ensured that the questions had seven answer options with equal psychological distance, that is, we used numbers such as years for the financial experience questions, which precisely defined the steps between the answers. In the empirical analysis, we treated the answers as an interval-based numerical dataset.[4]

Table 2 Risk taking revisions

	Percentage of individuals changing risk taking	Risk taking revisions			
		Mean (in%)	SD (in%)	Min (in%)	Max (in%)
Stage2-Stage1 (after ambiguity reduction)	55.9%	−0.067	14.43	−57	50
Stage3-Stage2 (after risk profiling questions)	46.3%	0.214	12.39	−55	55
Stage4-Stage3 (after experience sampling)	61.3%	4.019	16.07	−90	65
Stage5-Stage4 (after break)	54.1%	−1.299	13.09	−60	50
Stage6-Stage5 (after outcome feedback)	56.2%	0.189	12.87	−50	55

4. Results

4.1. Risk taking along the discovery process

Our experimental design is based on the idea that individuals facing investment decisions are involved in a process of discovery of their willingness to take risks. To test this conjecture, we first consider the individual changes in risk taking between two subsequent stages of the decision process. Because participants had to allocate their wealth between a risky and a risk-free asset, we take the percentage allocated in the risky asset as the measure of risk taking. The summary statistics reported in Table 2 suggest that at all stages, about half of all individuals change their risk-taking behavior. Except in the stage after the experience sampling, where individuals increase their risk taking by 4% on average, risk-taking revisions do not have a clear direction.

Next, we test whether the risk-taking revisions are associated with individual characteristics observable in the corresponding stages. The relevant characteristics of the stages that differ among individuals are linked to (1) the demand for information on the risky asset, (2) an improvement in the risk awareness after the experience sampling, and (3) the average portfolio return with past investment decisions, expectations and satisfaction with these returns. Table 3 reports summary statistics on risk-taking revisions between two subsequent decisions. It also includes the results of independent tests on the association of individual characteristics observed in different stages of the decision process and the risk-taking revisions.

We observe that individuals acquiring information on the risky asset are more likely to change their risk taking. Additional Kruskal-Wallis tests, which are not reported here, suggest that the description type (verbal, graphical, and statistical) is not associated with either the risk-taking revisions or with the level of risk taking in the second stage. Furthermore, we observe that individuals who improve their awareness of extreme outcomes and extreme positive outcomes after the experience sampling take more risks on average. Finally, we observe that individuals change risk taking after receiving information on the outcomes of previous decisions. In particular, individuals who receive a bad (nonpositive) outcome on average reduce their risk taking, while individuals who receive a good (positive) outcome with previous decisions take more risks on average. Significantly more individuals change their risk taking after bad outcomes than individuals who change their risk taking after good

Table 3 Risk taking revisions and individual characteristics

	Level of risk taking revisions						
	Mean (in%)	SD (in%)	Min (in%)	Max (in%)	Kruskal-Wallis Test (p-value)	Individuals changing risk taking	Pearson χ^2-Test (p-value)
Acquire information							
No	−0.48	14.56	−50	50		0.47	
Yes	0.08	14.42	−57	50	0.510	0.59	0.036
Risk awareness							
q1 (extreme returns)							
Deterioration	−2.78	17.06	−48	30		0.65	
No change	4.03	16.22	−90	65		0.62	
Improvement	6.33	14.75	−30	53	0.070	0.57	0.665
q2 (low returns)							
Deterioration	4.53	13.72	−20	30		0.68	
No change	4.10	15.95	−90	65		0.61	
Improvement	3.19	18.28	−48	65	0.872	0.62	0.790
q3 (extreme low returns)							
Deterioration	4.05	12.61	−30	35		0.59	
No change	4.82	15.59	−40	65		0.61	
Improvement	−6.95	24.41	−90	10	0.351	0.63	0.959
q4 (extreme high returns)							
Deterioration	6.60	15.05	−20	50		0.76	
No change	3.16	15.68	−90	65		0.59	
Improvement	9.26	19.24	−30	65	0.068	0.65	0.249
q5 (volatility)							
Deterioration	4.32	14.60	−48	35		0.66	
No change	4.21	16.08	−90	65		0.61	
Improvement	2.41	17.96	−40	60	0.420	0.56	0.690
q6 (average return)							
Deterioration	8.27	16.39	−15	63		0.63	
No change	3.73	16.32	−90	65		0.61	
Improvement	2.57	11.69	−30	35	0.464	0.65	0.874
Average outcome							
Non-positive	−17.94	14.52	−50	0		0.89	
Positive	1.27	11.95	−50	55	0.000	0.54	0.003
Expectations							
Comforted	1.61	11.24	−50	45		0.52	
Disappointed	−2.68	15.30	−50	55	0.001	0.65	0.016
Satisfaction							
Comforted	1.58	12.60	−50	55		0.54	
Disappointed	−3.22	12.94	−48	30	0.002	0.61	0.149

The table presents summary statistics of risk taking revisions as well as the percentage of individuals changing risk taking over two subsequent decisions. It also reports the results of independent tests on the association between risk taking revisions and individuals' characteristics in different stages. In the case of variables with two categories, the Pearson χ^2-Test is equivalent to the one-sides Fisher exact test.

outcomes. Similarly, individuals disappointed by their previous returns tend to reduce their risk taking, while individuals pleased with their previous returns tend to increase their risk taking.

So far, we find that the stages of the decision process under consideration are associated with significant changes in individual risk taking. However, do individuals learn something about their willingness to take risks by going through the various stages? To answer this question, we asked individuals to state which investment decision they consider the best one. To avoid outcome bias, we asked this question just before the outcomes of their investment decisions were revealed to them. Approximately 30% of the participants who revised their risk taking stated that their best decision was the last one. Moreover, the association between risk-taking revisions and choosing the last decision as the best one is statistically significant (Fisher exact test, p value: 0.02). We conclude that the provided decision stages were helpful for participants involved in a process of discovering their willingness to take risks.

Overall, we find that individual risk taking changes significantly after receiving information on the risky asset, while the direction of risk taking depends on individual risk tolerance. Moreover, the individual risk taking increases significantly after improving risk awareness in the experience sampling task. Although the outcome of previous decisions should not change risk taking because outcomes cannot be accumulated over stages, there are significant differences in the risk-taking revisions of individuals experiencing good or bad outcomes on average with their previous decisions. Finally, we find that individuals involved in discovering their willingness to take risks learn successfully over the different stages of the decision process.

4.2. Explaining risk taking

In this section, we analyze the importance of individual risk tolerance, risk awareness and financial experience as drivers of investment risk taking. The evaluation of these factors is based on a factor analysis. The analysis shows that the answers to the twenty questions evaluating individuals' risk tolerance, risk awareness and financial experience can be summarized by three different factors, which are not correlated with each other (see Appendix C for more details).

In the following, we use these factors in ordinary least square regressions to test whether they can explain risk taking as expressed by the amount of wealth that individuals invest in the risky asset at each stage. Previous research suggests that demographic and socioeconomic characteristics influence an individual's risk tolerance and risk taking (see, e.g., Grable and Lytton, 2003; Sundén and Surette, 1998; Xiao, 1996). To take this into account, we use age, gender, number of children, education, job position, income, and wealth as controls in each regression. As an additional independent variable, we include an indicator variable that captures whether the individual acquires information on the risky asset. In the last decision, we include the average return of the previous investment decisions as a further independent variable. The estimation results are reported in Table 4.

We observe that among the three factors capturing the individuals' risk tolerance, risk awareness and financial experience, only the risk tolerance factor explains risk-taking

Table 4 Risk taking drivers

	Investment in the risky asset (0–100)							
Decision 1								
Risk tolerance	8.628***	9.651***					8.623***	9.622***
	(1.198204)	(1.095)					(1.209)	(1.098)
Risk awareness			−1.166	0.514			−0.396	0.759
			(1.492)	(1.434)			(1.384)	(1.289)
Financial experience					−0.451	1.555	0.347	0.985
					(1.6044)	(1.331)	(1.486)	(1.201)
Acquire	9.159***	10.201***	9.652***	9.761***	8.849**	10.349***	9.486***	9.738***
Information	(2.490)	(2.304)	(2.839)	(2.796)	(2.743)	(2.570)	(2.652)	(2.519)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Adjusted R^2	0.2506	0.2297	0.1166	0.04133	0.115	0.04505	0.2457	0.2274
Decision 2								
Risk tolerance	9.353***	10.228***					9.464***	10.218***
	(1.2338)	(1.137)					(1.244)	(1.139)
Risk awareness			−0.1056	1.349			0.759	1.612
			(1.551)	(1.494)			(1.4244)	(1.337)
Financial experience					0.04716	1.651	0.971	1.005
					(1.665)	(1.388)	(1.529)	(1.245)
Acquire	10.295***	10.761***	10.157***	9.676**	10.108***	10.919***	10.127***	9.645***
Information	(2.564)	(2.392)	(2.951)	(2.913)	(2.848)	(2.680)	(2.728)	(2.611)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Adjusted R^2	0.27	0.2368	0.1234	0.04445	0.1234	0.04625	0.2666	0.2373
Decision 3								
Risk tolerance	9.398***	10.172***					9.402***	10.196***
	(1.2339)	(1.140)					(1.245)	(1.145)
Risk awareness			−1.138	0.231			−0.298	0.565
			(1.5512)	(1.497)			(1.425)	(1.344)
Financial experience					−0.487	0.344	0.389	−0.247
					(1.667)	(1.392)	(1.531)	(1.252)
Acquire	10.7677***	10.739***	11.2282***	10.515***	10.430***	10.735***	11.049***	10.273***
Information	(2.565)	(2.398)	(2.951)	(2.920)	(2.850)	(2.687)	(2.731)	(2.626)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Adjusted R^2	0.271	0.2341	0.1248	0.04179	0.1234	0.0419	0.2662	0.2297
Decision 4								
Risk tolerance	9.635***	10.719***					9.857***	10.67***
	(1.3872)	(1.248)					(1.3926)	(1.245)

(continued on next page)

Table 4 (Continued)

	Investment in the risky asset (0–100)							
Risk awareness			1.283	2.741			2.0013	2.686
			(1.680)	(1.600)			(1.5607)	(1.443)
Financial experience					0.7789	1.722	1.9091	1.146
					(1.8448)	(1.504)	(1.7153)	(1.354)
Acquire	12.646***	13.157***	11.31***	10.772***	12.154***	12.677***	12.137***	11.559***
Information	(2.882)	(2.628)	(3.224)	(3.076)	(3.1483)	(2.914)	(3.0074)	(2.778)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Adjusted R^2	0.2279	0.2284	0.09951	0.05763	0.09824	0.05283	0.2298	0.2339
Decision 5								
Risk tolerance	9.176***	10.137***					9.087***	10.153***
	(1.262)	(1.144)					(1.272)	(1.147)
Risk awareness			−0.993	0.880			−0.503	0.873
			(1.5404)	(1.4811)			(1.426)	(1.330)
Financial experience					−1.837	0.093	−0.974	−0.41
					(1.687)	(1.389)	(1.567)	(1.248)
Acquire	10.414***	11.54***	10.258***	10.371***	9.291**	10.938***	10.414***	10.947***
Information	(2.623)	(2.408)	(2.9557)	(2.847)	(2.880)	(2.692)	(2.747)	(2.561)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Adjusted R^2	0.2431	0.2335	0.1046	0.04461	0.107	0.04356	0.2391	0.2299
Decision 6								
Risk tolerance	9.4223***	10.143***					9.3997***	10.1586***
	(1.3302)	(1.184)					(1.341)	(1.186)
Risk awareness			−0.099	1.437			0.428	1.430
			(1.617)	(1.522)			(1.502)	(1.375)
Financial experience					−1.625	0.076	−0.660	−0.441
					(1.772)	(1.428)	(1.651)	(1.2905)
Acquire	9.992***	10.346***	9.368**	8.824**	8.905**	9.743***	9.607**	9.397***
Information	(2.763)	(2.492)	(3.103)	(2.925)	(3.024)	(2.768)	(2.896)	(2.647)
Average return	2.862***	2.911***	3.215***	3.371***	3.204***	3.379***	2.869***	2.899***
	(0.352)	(0.331)	(0.374)	(0.356)	(0.373)	(0.355)	(0.354)	(0.333)
Controls	Yes	No	Yes	No	Yes	No	Yes	No
Adjusted R^2	0.1957	0.2137	0.0545	0.0342	0.0573	0.0315	0.1908	0.2116

The table reports the estimation results of ordinary least square regressions with the percentage of wealth invested in the risky asset (0–100) as a dependent variable in each regression. Standards errors are given in parentheses. Age, gender, number of children, education, job position, income, and wealth are used as controls. ***, **, and *indicate significance levels of 1%, 5%, and 10%, respectively.

behavior at each stage. Its impact on risk taking is stable over different decision modes and is robust to demographic and socio-economic characteristics used as controls. The influence of the factors capturing individuals' risk awareness and financial experience on risk taking is statistically not significant. Interestingly, we observe significant and robust differences in the risk taking associated with the demand for information on the risky asset. Individuals who acquire information on the risky assets invest approximately 10% more in the risky asset than individuals who do not acquire information on the risky asset. Although individuals cannot accumulate returns of subsequent investment decisions, their risk taking in the last stage changes with the average outcome of their previous investment decisions.

4.3. Predicting risk taking

In the following, we analyze which combination of single questions has the strongest predictive power for risk-taking behavior. We apply a cross-validation analysis.[5] Table 5 reports the estimated coefficients of the variables with significant predicting power. The risk awareness assessed before (after) the experience sampling is used to predict the first (last) three investment decisions. The average return on past investment decisions is used only in the prediction of the last decision.

We observe that risk taking at all stages is best predicted by individuals' loss aversion. Its assessment is, however, critical. While a general loss aversion formulation is not helpful in predicting risk taking, a verbal question specifying returns and a quantitative version based on a lottery question are able to predict risk taking in all decision modes. By contrast, risk aversion measures based on self-assessment cannot be used to predict risk taking. Another important predictor of risk taking is the returns of past decisions. Although the odds of the outcomes do not change over time and returns cannot be accumulated, the participants take significantly more (less) risks after observing positive (negative) average returns with their past investment decisions.

In the context of the assessed risk tolerance, demographic and socio-economic characteristics have limited predictive power. To shed some light on them, we repeat the cross-validation analysis while excluding the risk tolerance and the investment experience questions. Table 6 reports the estimation results.

We observe that among the demographic and socioeconomic characteristics, gender is the most reliable variable in predicting risk taking. Females are less willing to take risks. As in the previous analysis, age can be a good predictor of risk taking but only in certain situations, while income loses predicting power. The effect of previous returns on subsequent risk-taking remains strong.

We conclude that assessed individuals' loss aversion is the most powerful predictor of risk taking at all stages and in the context of all other questions that we use with a potential impact on risk taking. We find that self-assessed knowledge, experience, and risk aversion are not useful in predicting individual risk taking. Finally, recommending less risky investment can be optimal for female individuals if there is no option to assess their risk tolerance.

Table 5 Predicting power of single questions

	Decision 1	Decision 2	Decision 3	Decision 4	Decision 5	Decision 6
General risk taking						3.5532* (1.3725)
General financial risk taking						
Current financial risk taking						
Past financial risk taking						
General financial loss aversion						
Verbal financial loss aversion	6.525*** (1.082)	6.438*** (1.115)	6.375*** (1.102)	7.537*** (1.204)	8.334*** (1.125)	5.040*** (1.268)
Quant. financial loss aversion	5.632*** (1.096)	5.088*** (1.108)	7.905*** (1.102)	8.04*** (1.204)	4.317*** (1.140)	3.941*** (1.086)
Financial investing for thrill						
Professional experience in finance						
Consumption of financial news						
Financial knowledge						
Statistical knowledge						
Financial trading experience						
Trading frequency		3.539*** (1.064)				3.576** (1.174)
Risk awareness 1						
Risk awareness 2						
Risk awareness 3						
Risk awareness 4						
Age class		−2.754** (0.998)				
Female						
Number of children						
Education						
Professional status						
Monthly income		2.674** (1.009)				
Wealth						
Average past return						8.137*** (0.971)
Acquire information	3.956*** (1.011)	4.316*** (1.007)			4.637*** (1.051)	2.745** (1.042)
Adjusted R^2	0.2789	0.3491	0.2995	0.2978	0.2889	0.4363

The table reports the estimates of cross-validation analysis with the percentage of wealth invested in the risky asset (0–100) as a dependent variable in each regression. Standards errors are given in parentheses. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

Table 6 Predicting power of demographic and socioeconomic characteristics

	Decision 1	Decision 2	Decision 3	Decision 4	Decision 5	Decision 6
Age class		−3.416** (1.161)			−2.921* (1.162)	
Female	−3.044** (1.145)	−3.843** (1.160)	−3.772** (1.171)		−4.173*** (1.165)	−3.401** (1.078)
Number of children						
Education						
Professional status						
Monthly income						
Wealth	−2.703* (1.201)					
Average past return						10.463*** (1.078)
Acquire information		4.739*** (1.160)	4.995*** (1.171)	5.535*** (1.288)	4.861*** (1.170)	
Adjusted R^2	0.035	0.092	0.072	0.052		0.252

The table reports the estimates of cross-validation analysis with the percentage of wealth invested in the risky asset (0–100) as a dependent variable in each regression. Standards errors are given in parentheses. ***, **, and * indicate significance levels of 1%, 5%, and 10%, respectively.

5. Discussion and implications

We found strong evidence that individuals' risk tolerance is a more powerful predictor of risk taking than investors' self-assessed investment experience or risk awareness. More important, we found that the association between risk tolerance and risk-taking remains significant over different decision stages related to reduced ambiguity, extended experience and feedback on previous decisions.

With respect to the impact of these decision stages on risk taking, we find that reduced ambiguity influences risk taking, but it does not necessary increase it, as documented by Antoniou et al. (2015). However, we find that extending experience with the risky asset through simulations increases risk taking, which is in line with the results of Kaufmann et al. (2013) and Bradbury et al. (2014). Furthermore, we observe that the average return of previous decisions influences the subsequent risk taking, although the odds of the possible outcomes remain the same and returns cannot be accumulated. As suggested by Fischhoff (1975), this behavior can be explained with a stronger focus on the risks (returns) after negative (positive) returns. It is also possible that individuals use outcomes to judge the quality of their previous decisions, as suggested by Baron and Hershey (1988). In this case, positive (negative) outcomes would increase (decrease) the confidence in the decision quality and individuals would increase (decrease) subsequent risk taking, as we observe in our experiment.

Risk tolerance measures are usually multidimensional, and the components can be correlated (Guillemette et al., 2015). We analyzed the predicting power of the components and found that an individual's loss aversion is the most powerful predictor of risk taking in all decision modes. This supports previous findings that loss aversion measures are more powerful in explaining risk taking than the Arrow-Pratt measures (Guillemette et al., 2012). Moreover, we found that self-assessed risk tolerance has no predicting power. Among the questions assessing investment experience, we found that only the question related to the trading frequency can predict risk taking in some decision modes. Overall, we do not find a positive relationship between investment experience and risk taking, which is in contrast to the results of Corter and Chen (2006). This can be explained with differences in the measures. While Corter and Chen (2006) ask individuals to evaluate their investment experience relative to other individual investors, our measures are based on individual trading experience.

Several studies suggest that risky asset ownership can be explained by demographic and socioeconomic variables (see for example Grable and Lytton, 2003; Sundén and Surette, 1998; Xiao, 1996). We found that among the assessed demographic and socioeconomic characteristics, only gender can predict risk taking in most decision modes but only if the individual risk tolerance cannot be assessed. If the risk tolerance is assessed, gender loses its predicting power. This observation is in line with the results of Wärneryd (1996) and Grable and Lytton (2003).

Our results have important implications for the design of risk profilers. To predict risk taking, the latter should include questions assessing the individual risk tolerance, which should include a question on the investor's loss aversion. Gender is a useful predictor of risk taking only if the risk tolerance cannot be assessed. By contrast, self-assessed investment experience is not a reliable predictor of risk taking, but the stated trading frequency can be used as a proxy for investment experience when predicting risk taking.

Another important predictor of risk taking is the past investment return. The latter influences the desired risk taking beyond the level based on the assessed risk tolerance. Hence, in addition to assessing an individual's risk tolerance, a risk profiler should either consider an investor's misperception of risk, or the latter should be corrected through additional measures. Otherwise, investors will be willing to revise their risk taking for no good reason.

6. Conclusions

The optimal amount of risk an investor should take is one of the most important issues in wealth management. Since answering this question through real-life investment experience can be costly, several studies suggest risk profiling measures and prove their suitability by showing that they can explain risk taking.

This article studied whether and how the suitability of different risk profiling measures varies if individuals are involved in a process of discovering their willingness to take risks. This process included situations with reduced ambiguity, extended experience and feedback on the outcomes of previous decisions, which reflect the experience of private investors. The results show that private investors are often involved in the process of discovering their willingness to take risks. The average risk-taking behavior changes over the different stages of the learning process, but it is always associated with a composite measure of the individual's risk tolerance. Overall, we did not find any significant association between risk taking and investment experience outside of the study, although sometimes the self-reported trading frequency can predict risk taking. Letting investors experience the riskiness of different asset allocations through simulations reduces biases in the risk-reward perception of the investors, but the investors' risk tolerance and loss aversion in particular remains a significant predictor of the individual risk-taking behavior at all stages of the decision process. By contrast, self-assessed risk tolerance measures appear to not be suitable for predicting risk taking at any stage of the decision process.

These results suggest that risk profiling measures should be selected carefully. When investors are involved in a process of discovering their willingness to take risks, some measures are more stable predictors of risk taking than others and should not be missed by risk profilers. By contrast, other measures may predict risk taking in only some or none of the stages, which limits their suitability. Using measures that predict risk taking at all stages of the discovery process increases the probability that clients remain satisfied with the derived recommendations. At the same time, making recommendations based on questions that consistently predict risk taking at all stages of the discovery process should support the advisors' confidence that these recommendations match the clients' risk tolerance and do not create misperceptions that are corrected over time.

Notes

1 Online studies allow effective access to a sample of the general population. Moreover, they allow tracking of the time individuals spend on each question.
2 We excluded all individuals who needed less than one and a half minutes to read the instructions and less than 15 minutes to finish the survey.

3 For the quantitative financial loss aversion question, we presented eight answer options. The last two possibilities were merged because only three individuals used the seventh possibility in their choices. The results of a robustness test with the combined answer possibilities shows that the results remain stable.
4 According to the literature, Likert scales can be considered an interval-based measure, that is, parametric analysis is appropriate (Carifio and Perla, 2007; Norman, 2010; Pell, 2005).
5 The analysis uses recursive feature elimination that removes the least important predictors of a model step-by-step. First, a model with all predictors is trained on a training set. The model is then used to predict the test set. The least important predictor is then removed from the model, and the whole procedure is repeated for all the subsequent subsets of predictors. To avoid any selection bias (e.g., over-fitting predictors and samples), the train and test data sets are resampled with a 10-fold cross-validation. After the resampling iterations, the most appropriate number of predictors is determined based on the resampling output. The predictors with the best rankings across all the resampling iterations are then used to fit the final model.

Appendix

A Experience sampling

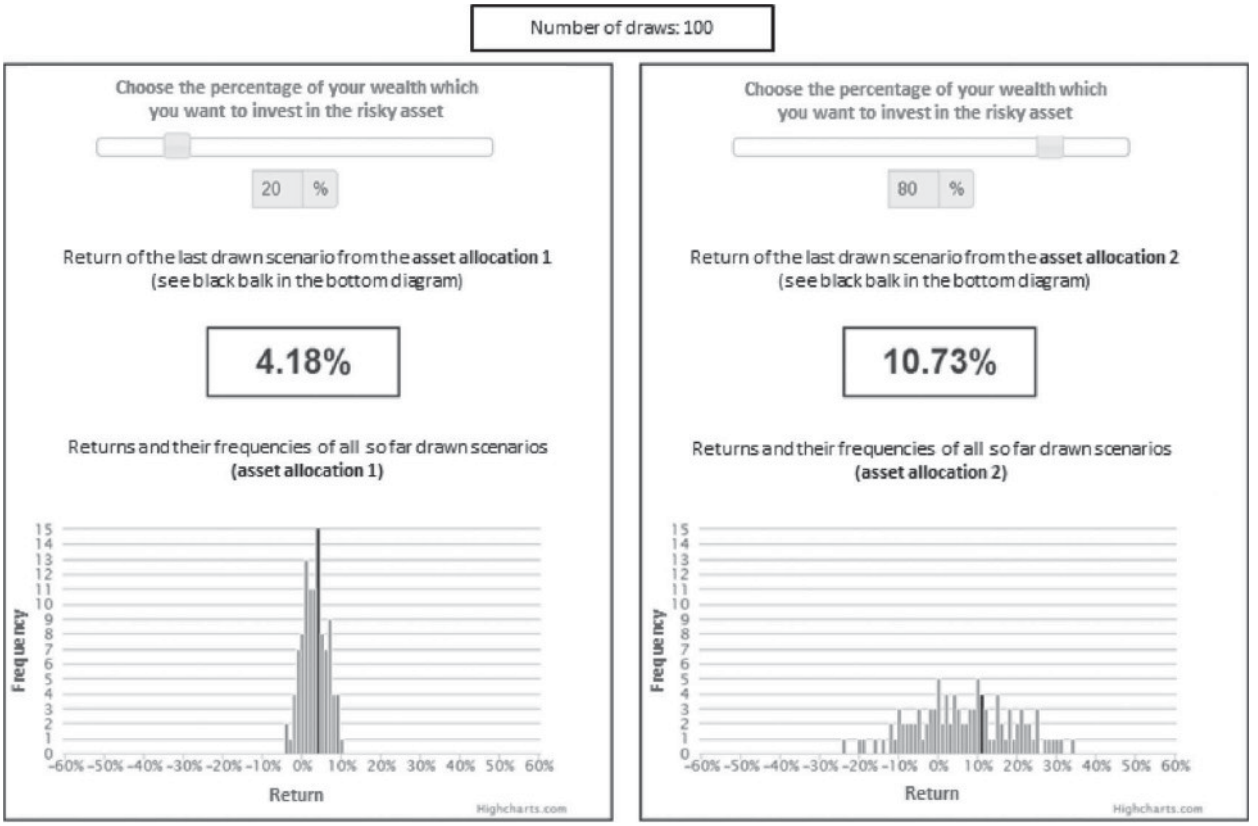

Fig. A-1: Illustration of the experience sampling.

B Socioeconomic and demographic characteristics

Table B-1: Sample description

	N	Percentage	Variable type
Age			Categorical variable
18–24	54	16.88%	0
25–34	44	13.75%	1
35–44	70	21.88%	2
45–54	82	25.63%	3
55–64	70	21.88%	4
Gender			Indicator variable
Male	147	45.94%	0
Female	173	54.06%	1
Number of children			Ordinal variable
0	201	62.81%	0
1	62	19.38%	1
2	43	13.44%	2
3	10	3.13%	3
4	4	1.25%	4
Education			Categorical variable
Primary school	10	3.13%	0
Secondary school	65	20.31%	1
High school	96	30.00%	2
Bachelor	39	12.19%	4
Master	45	14.06%	5
PhD	11	3.44%	6
Other education	53	16.56%	7
No education	1	0.31%	8
Professional status			Categorical variable
Self-employed/in family business	37	11.56%	0
Employee in top management	18	5.63%	1
Employee with leadership position	65	20.31%	2
Employee without leadership position	108	33.75%	3
Apprentice	47	14.69%	4
Unemployed	45	14.06%	5
Monthly income			Categorical variable
0–1,300 Euro	60	18.75%	0
1,300–2,600 Euro	94	29.38%	1
2,600–3,600 Euro	74	23.13%	2
3,600–5,000 Euro	54	16.88%	3
5,000–18,000 Euro	11	3.44%	4
$>$ 18,000 Euro	1	0.31%	5
No answer	26	8.13%	
Wealth			Categorical variable
0–500 Euro	47	14.69%	0
500–2,500 Euro	44	13.75%	1
2,500–10,000 Euro	59	18.44%	2
10,000–30,000 Euro	46	14.38%	3
30,000–65,000 Euro	32	10.00%	4
65,000–175,000 Euro	30	9.38%	5
175,000 Euro	11	3.44%	6
No answer	51	15.94%	

C Factor analysis

Table C-1: Factor loadings with a varimax rotation

	Factors (before experience sampling)			Factors (after experience sampling)		
	Risk tolerance	Financial experience	Risk awareness	Risk tolerance	Financial experience	Risk awareness
General risk taking	**0.73**	0.18	−0.11	**0.73**	0.19	−0.11
General financial risk taking	**0.87**	0.29	−0.09	**0.87**	0.29	−0.04
Current financial risk taking	**0.65**	0.15	−0.01	**0.65**	0.15	−0.02
Past financial risk taking	**0.56**	0.34	−0.16	**0.56**	0.34	−0.17
General loss aversion	**0.4**	0.16	0.03	**0.4**	0.16	0.05
Verbal loss aversion	**0.74**	0.11	−0.16	**0.75**	0.11	−0.09
Quantitative loss aversion	**0.49**	0.11	0.13	**0.5**	0.11	0.17
Financial investing for thrill	**0.6**	0.49	−0.12	**0.61**	0.48	−0.08
Professional experience in finance	0.07	**0.59**	−0.14	0.08	**0.58**	−0.14
Consumption of financial news	0.3	**0.67**	−0.02	0.3	**0.66**	−0.01
Financial knowledge	0.33	**0.74**	0.01	0.32	**0.75**	−0.02
Statistical knowledge	0.16	**0.47**	0.27	0.15	**0.48**	0.18
Trading experience	0.15	**0.74**	0.14	0.14	**0.75**	0.13
Trading frequency	0.44	**0.63**	0.02	0.43	**0.64**	0.01
Risk awareness 1	0	0.07	**0.72**	0	0.09	**0.77**
Risk awareness 2	−0.16	0	**0.73**	−0.1	0.02	**0.68**
Risk awareness 3	−0.08	−0.03	**0.62**	−0.12	−0.08	**0.75**
Risk awareness 4	0.05	0.02	**0.89**	0.14	0.04	**0.88**
SS loadings	3.81	3.05	2.45	3.82	3.08	2.55
Proportion variance	0.21	0.17	0.14	0.21	0.17	0.14
Cumulative variance	0.21	0.38	0.52	0.21	0.38	0.53
Proportion explained	0.41	0.33	0.26	0.4	0.33	0.27
Cumulative proportion	0.41	0.74	1	0.4	0.73	1

D Questions

The following questions are assessed on a seven-point scale ranging from “not true at all” to “absolutely true.”

General risk tolerance: In general, I am a risk loving person.

General financial risk tolerance: My risk tolerance when I am investing money is generally high.

Current financial risk tolerance: My current willingness to take risk in financial decisions is low.

Past financial risk tolerance: My risk tolerance in financial decisions was high in the past.

General financial loss aversion: When I am confronted with an important financial decision then I do concern more with the possible losses than with the possible gains.

Verbal financial loss aversion: For a 50-percent chance to earn a high amount of money with a financial investment I would be willing to risk an equal amount of money.

Financial investing for thrill: I already invested very often money because of the thrill if its value will go up or down.

Professional experience in finance: I collected the big part of my professional experience in the financial sector (investment advisory, insurance, asset management, trustee, tax counseling, auditing, and accounting).

Consumption of financial news: I am very interest in economic news.

Financial knowledge: I can explain to a friend very well at which things he or she has to look after in the case of risky financial assets.

Statistical knowledge: I can explain to a friend very well what a probability distribution is.

Quantitative financial loss aversion: You have the choice to invest 500 ECU in a risky or in a risk-free asset. The wealth will be invested for one year. With an equal probability (each with 50%) the risky asset will result in a positive return of 50% p.a. (i.e., 250 ECU) or in a negative return. The risk-free asset will result in a positive return of 2% p.a. (i.e., 10 ECU).

Risky asset		Decision		Risk-free asset
50% probability to get a return of	50% probability to get a return of	I prefer the risky asset	I prefer the risk-free asset	100% probability to get a return of
50% p.a. (250 ECU)	−8% p.a. (−40 ECU)			2% p.a. (10 ECU)
50% p.a. (250 ECU)	−15% p.a. (−75 ECU)			2% p.a. (10 ECU)
50% p.a. (250 ECU)	−22% p.a. (−110 ECU)			2% p.a. (10 ECU)
50% p.a. (250 ECU)	−29% p.a. (−145 ECU)			2% p.a. (10 ECU)
50% p.a. (250 ECU)	−36% p.a. (−180 ECU)			2% p.a. (10 ECU)
50% p.a. (250 ECU)	−43% p.a. (−215 ECU)			2% p.a. (10 ECU)
50% p.a. (250 ECU)	−50% p.a. (−250 ECU)			2% p.a. (10 ECU)

Are you sure? In comparison to the risk-free asset (2%) you prefer the risky asset (50% chance to get a return of 50% p.a. [i.e., 250 ECU]) if the possible negative return is not higher than −8%. p.a; beginning at a possible negative return of −15% p.a. you prefer the risk-free asset. Is this really your final decision?

Financial trading experience

Since how many years do you trade financial asset by yourself?

- I have never traded financial assets by myself.
- I buy and sell financial assets since about 1 to 3 years.
- I buy and sell financial assets since about 4 to 6 years.
- I buy and sell financial assets since about 7 to 9 years.

- I buy and sell financial assets since about 10 to 12 years.
- I buy and sell financial assets since about 13 to 15 years.
- I buy and sell financial assets since more than 15 years.

Trading frequency

How many times do you reallocate your financial assets, that is, how often do you buy and sell financial assets?

- Not at all
- About every second year
- About once a year
- About twice a year
- About four times a year
- About every month
- At least once a week

Risk awareness 1

The asset allocation with the highest probability for a strong negative and a strong positive return is:

- 10% risk-free asset/90% risky asset
- 40% risk-free asset/60% risky asset
- 80% risk-free asset/20% risky asset
- 35% risk-free asset/65% risky asset

How confident are you with your answer?: Not sure at all 1-2-3-4-5-6-7 Absolutely sure.

Risk awareness 2

Which asset allocation does not allow you to get a return higher than 2%?

- 5% risk-free asset/95% risky asset
- 0% risk-free asset/100% risky asset
- 100% risk-free asset/0% risky asset
- 75% risk-free asset/25% risky asset

How confident are you with your answer?: Not sure at all 1-2-3-4-5-6-7 Absolutely sure.

Risk awareness 3

The asset allocation with the greatest risk for negative return in the worst out of 100 cases is:

- 50% risk-free asset/50% risky asset
- 40% risk-free asset/60% risky asset
- 10% risk-free asset/90% risky asset
- 45% risk-free asset/55% risky asset

How confident are you with your answer?: Not sure at all 1-2-3-4-5-6-7 Absolutely sure.

Risk awareness 4

The asset allocation with the greatest potential for positive returns in the best out of 100 cases is:

- 60% risk-free asset/40% risky asset
- 20% risk-free asset/80% risky asset
- 5% risk-free asset/95% risky asset
- 15% risk-free asset/85% risky asset

How confident are you with your answer? Not sure at all 1-2-3-4-5-6-7 Absolutely sure.

Risk awareness 5

The asset allocation with the smallest variation of returns is:

- 20% risk-free asset/80% risky asset
- 45% risk-free asset/55% risky asset
- 80% risk-free asset/20% risky asset
- 30% risk-free asset/70% risky asset

How confident are you with your answer? Not sure at all 1-2-3-4-5-6-7 Absolutely sure.

Risk awareness 6

The asset allocation with the highest expected return is:

- 5% risk-free asset/95% risky asset
- 10% risk-free asset/90% risky asset
- 40% risk-free asset/60% risky asset
- 25% risk-free asset/75% risky asset

How confident are you with your answer? Not sure at all 1-2-3-4-5-6-7 Absolutely sure.

Descriptions on the risky asset

- Graphical description

In the following graphic, you see the realized returns and their frequencies of 280 randomly drawn scenarios for the risky asset. Higher bars mean higher frequencies.

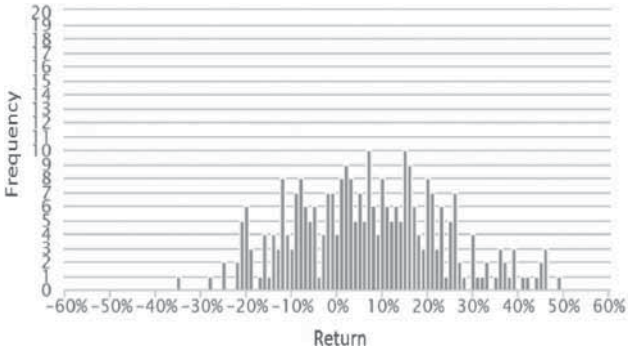

Fig. D-1: Example of a return distribution used in the graphical description of the risky asset.

- Verbal description

The average return for the risky asset over all possible scenarios is 7% per annum. In 70 out of 100 scenarios one can expect that the return falls between −10% and 24% per annum, and in 30 out of 100 scenarios the return is lower than −10% and higher than 24% per annum.

The positive or negative deviation from the average return is the same, and has the same probability. For example, a return of −3% has the same probability as a return of 17%.

- Statistical description

The returns are normally distributed with a mean of 7% and a SD of 16%. The normal distribution has the property that returns close to 7% are more probable than those further away, and that the probability of a return of −3% has the same probability as a return of 17%.

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References

Antoniou, C., Harris, R. D. F., & Zhang, R. (2015). Ambiguity aversion and stock market participation: An empirical analysis. *Journal of Banking & Finance, 58,* 57–70.

Baron, J., & Hershey, J. C. (1988). Outcome bias in decision evaluation. *Journal of Personality and Social Psychology, 54,* 569–579.

Barsky, R., & Juster, F. (1997). Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study. *The Quarterly Journal of Economics, 112,* 537–579.

Bradbury, M. A. S., Hens, T., & Zeisberger, S. (2014). Improving investment decisions with simulated experience. *Review of Finance, 19,* 1–34.

Brayman, S., Finke, M., Grable, J., & Griffin, P. (2017). Current practices for risk profiling in Canada and review of global best practices. *Journal of Financial Service Professionals, 71,* 71–81.

Carifio, J., & Perla, R. J. (2007). Ten common misunderstandings, misconceptions, persistent myths and urban legends about Likert scales and Likert response formats and their antidotes. *Journal of Social Sciences, 3,* 106–116.

Carr, N. (2014). Reassessing the assessment: Exploring the factors that contribute to comprehensive financial risk evaluation. Unpublished doctoral dissertation. Kansas State University, Manhattan, Kansas.

Corter, J. E., & Chen, Y. J. (2006). Do investment risk tolerance attitudes predict portfolio risk? *Journal of Business and Psychology, 20,* 369–381.

Epstein, L. G., & Schneider, M. (2010). Ambiguity and asset markets. *Annual Review of Financial Economics, 2,* 315–346.

Fischhoff, B. (1975). Hindsight ≠ foresight: The effect of outcome knowledge on judgment under uncertainty. *Journal of Experimental Psychology: Human Perception and Performance, 1,* 288–299.

Fitzsimons, G. J., & Williams, P. (2000). Asking questions can change choice behavior: Does it do so automatically or effortfully? *Journal of Experimental Psychology: Applied, 6,* 195–206.

Frisch, D., & Baron, J. (1988). Ambiguity and rationality. *Journal of Behavioural Decision Making, 1,* 149–157.

Gilliam, J., Chatterjee, S., & Grable, J. (2010). Measuring the perception of financial risk tolerance: A tale of two measures. *Journal of Financial Counseling and Planning, 21,* 30–43.

Goldstein, D. G., Johnson, E. J., & Sharpe, W. F. (2008). Choosing outcomes versus choosing products: Consumer-focused retirement investment advice. *Journal of Consumer Research, 35,* 440–456.

Grable, J. E., & Lytton, R. H. (2003). The development of a risk assessment instrument: A follow-up study. *Financial Services Review, 12,* 257–274.

Guillemette, M. A., Yao, R., & Iii, R. N. J. (2015). An analysis of risk assessment questions based on loss- averse preferences. *Journal of Financial Counseling and Planning, 26,* 17–29.

Guillemette, M., Finke, M., & Gilliam, J. (2012). Risk tolerance questions to best determine client portfolio. *Journal of Financial Planning, 25,* 36–44.

Harinck, F., & De Dreu, C. K. W. (2008). Take a break! or not? The impact of mindsets during breaks on negotiation processes and outcomes. *Journal of Experimental Social Psychology, 44,* 397–404.

Hertwig, R., Barron, G., Weber, E. U., & Erev, I. (2004). Decisions from experience and the effect of rare events. *Psychological Science, 15,* 534–539.

Hertwig, R., & Erev, I. (2009). The description-experience gap in risky choice. *Trends in Cognitive Sciences, 13,* 517–523.

Holt, C., & Laury, S. (2002). Risk aversion and incentive effects. *The American Economic Review, 92,* 1644–1655.

Kahneman, D. (2009). The myth of risk attitudes. *Journal of Portfolio Management, 36,* 1. (available at http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=45267051&site=ehost-live)

Kaufmann, C., Weber, M., & Haisley, E. (2013). The role of experience sampling and graphical displays on one's investment risk appetite. *Management Science, 59,* 323–340.

Morrison, W., & Oxoby, R. (2014). *Loss Aversion in the Laboratory*. IZA discussion papers, 8309.

Nobre, L. H. N., & Grable, J. E. (2015). The role of risk profiles and risk tolerance in shaping client investment decisions. *Journal of Financial Service Professionals, 69,* 18–21.

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in Health Sciences Education, 15,* 625–632.

Ordonez, L., & Benson, L. I. (1997). Decisions under time pressure: How time constraint affects risky decision making. *Organizational Behavior and Human Decision Processes, 71,* 121–140.

Parsons, H. (1974). What happened at Hawthorne? *Science, 183,* 922–932.
Pell, G. (2005). Use and misuse of Likert scales. *Medical Education, 39,* 970.
Rohrmann, B. (1992). The evaluation of risk communication effectiveness. *Acta Psychologica, 81,* 169–192.
Slovic, P., Fischhoff, B., & Lichtenstein, S. (1978). Accident probabilities and seat belt usage: A psychological perspective. *Accident Analysis and Prevention, 10,* 281–285.
Sundén, A. E., & Surette, B. J. (1998). Gender differences in the allocation of assets in retirement savings plans. *American Economic Review, 88,* 207–211.
Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science, 211,* 453–458.
Wärneryd, K.-E. (1996). Risk attitudes and risky behavior. *Journal of Economic Psychology, 17,* 749–770.
Xiao, J. J. (1996). Effects of family income and life cycle stages on financial asset ownership. *Financial Counseling and Planning, 7,* 21–30.
Yook, K., & Everett, R. (2003). Assessing risk tolerance: Questioning the questionnaire method. *Journal of Financial Planning,* 48–55.