Hindsight Bias and Individual Risk Attitude within the Context of Experimental Asset Markets*

Tarek El-Sehity[a], Hans Haumer[b],

Christian Helmenstein[c], Erich Kirchler[d], Boris Maciejovsky[e]

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Abstract

This paper investigates (i) the robustness of hindsight bias in experimental asset markets, (ii) the time invariance of the different experimental risk elicitation methods of certainty equivalents and binary lottery choices, and (iii) their correspondence. The results of our within-subjects approach with 133 traders do not support the conjecture that hindsight bias is a general phenomenon. Furthermore, our findings challenge the presumption of time-stable risk preferences and of procedural invariance with respect to different experimental risk elicitation methods.

Keywords: Hindsight bias; Risk attitude; Financial markets; Experimental economics; Behavioral finance

JEL-Classification: C90; G10; D81

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a University of Vienna, Department of Psychology, Unit of Economic Psychology, Universitätsstrasse 7, A-1010 Vienna, Austria. E-mail: el-sehity@mail.com

b Wealth Architecture, Schömergasse 28, A-3400 Klosterneuburg, Austria. E-mail: office@wealtharchitecture.com

c Institute for Advanced Studies, Stumpergasse 56, A-1060 Vienna, and ESCE Economic and Social Research, Technology Center, A-7000 Eisenstadt, Austria. E-mail: helmen@ihs.ac.at

d University of Vienna, Department of Psychology, Unit of Economic Psychology, Universitätsstrasse 7, A-1010 Vienna, Austria. E-mail: erich.kirchler@univie.ac.at

e Max Planck Institute for Research into Economic Systems. Strategic Interaction Group, Kahlaische Strasse 10, D-07745 Jena, Germany. E-mail: maciejovsky@mpiew-jena.mpg.de

1 Introduction

"Financial economics is, perhaps, the least behavioural of the various subdisciplines of economics" (DeBondt and Thaler 1995, p.385).

Standard finance theory is based on expected utility theory and rational expectations (encompassing Bayesian updating), leading to a picture of market participants whose individual investment decisions are solely driven by the expected utility of returns. It is assumed that investors are able to identify relevant information (and discriminate against irrelevant information) as well as weight and process it accurately according to expected states.

Experimental evidence, however, indicates that actual investment decisions seldom follow these restrictive assumptions. Objectively irrelevant (Kirchler et al. 2001) and selectively presented information (Dittrich et al. 2002) are shown to influence individual trading behavior on an experimental asset market. In a wider behavioral context, phenomena such as endowment-framing (Weber et al. 2000), the disposition effect (Shefrin and Statman 1985, Weber and Camerer 1998), overconfidence (Kirchler and Maciejovsky forthcoming, Odean 1998a), and loss aversion (Myagkov and Plott 1997, Odean 1998b) weaken the predictive power of standard finance theory.

While the use of standard finance theory for the purpose of characterizing optimal behavior is undisputed, the validity of using it to describe *actual* behavior is not. "The representative investor is assumed to understand the economy and the process determining asset prices; the individual investor frequently does not" (Brennan 1995, p.61). A promising approach to describe and, possibly, explain financial decision making may be the explicit consideration of psychological factors. In particular, heuristics and biases need to be integrated.

In this paper we (i) investigate whether hindsight bias, as a specific decision bias which has been extensively studied by psychologists, is a robust phenomenon not only in individual decision making but also in market environments, drawing upon a within-subjects approach. Furthermore, we (ii) analyze the time stability of individual risk attitudes, as inferred from certainty equivalents and binary lottery choices, as well as (iii) the correspondence of these experimental risk elicitation methods, that is whether different methods yield identical classifications.

The results of our within-subjects approach question the hindsight bias as a general phenomenon. Rather, it is moderated by the specific methodological approach used. In addition, our findings challenge the presumption of time stable risk preferences and of procedural invariance with respect to different experimental risk elicitation methods.

The paper is organized as follows: The remainder to this section reviews research related to hindsight bias and experimental risk elicitation methods. Section 2 describes our experimental set-up, and in section 3 we report our main results. Finally, section 4 discusses and concludes our findings.

1.1 Hindsight bias

Hindsight bias is based on empirical evidence indicating that individuals, after receiving outcome information, claim to have "known it all along" (Fischhoff 1975). Moreover, individuals who have received such outcome information are largely unaware of its effect on their judgment. Once past, events seem more comprehensible and also more predictable than before.

Most experimental studies investigating hindsight bias apply between-subjects designs. Subjects are randomly split into two groups; the "foresight"- and the "hindsight"-group. The first group is asked to predict the likelihood of certain events, whereas the latter group is told the "correct" outcome and is asked to predict the likelihood of the events as if they had not received the outcome information. If individuals are prone to hindsight bias, then the "hindsight"-group who is informed of a given outcome is expected to assign that outcome a higher probability than the "foresight"-group. Empirical findings support this conjecture, emphasizing that those people who are actually asked to predict an event do not find the prediction as easy as hindsight subjects claim it is (Fischhoff 1975).

Hindsight bias has been demonstrated in a large variety of fields, including general knowledge tasks (Wood 1978), and most relevant to our study also in employee evaluation (Mitchell and Kalb 1981), accounting (Helleloid 1988), and business decisions (Bukszar and Connolly 1998, Connolly and Bukszar 1990). However, in a meta-analysis of data from 122 independent experiments (Christensen-Szalanski and Willham 1991), hindsight bias was found to be three times larger for studies using almanac questions compared to other domains.

Hindsight bias has been explained by motivational factors (e.g., Campbell and Tesser 1983, Pennington et al. 1980, Verplanken and Pieters 1988) as well as by cognitive factors (e.g., Beckerian and Bowers 1983, Hawkins and Hastie 1990), such as memory impairments and reconstruction biases (e.g., Erdfelder and Buchner 1998, Hell et al. 1988) report an interaction effect for motivation: With high motivation to recall accurately, the point in time of outcome information had no effect on judgments. Generally, cognitive factors are held more important in explaining hindsight bias than motivational factors (e.g., Christensen-Szalanski and Willham 1991). Also, neither the instruction to "try harder" (Fischhoff 1977, Leary 1981, 1982, Synodinos 1986) or to ignore the feedback information (Bukszar and Connolly 1998, Fischhoff 1975, Hennessey and Edgell 1991) nor monetary incentives (Camerer et al. 1989, Tversky and Kahneman 1974) are capable to reduce hindsight bias.

Recent empirical evidence, more fundamentally, questions the robustness of hindsight bias and emphasizes the relevance of moderating variables. For instance, feedback information (Hoch and Loewenstein 1989) as well as the self-relevance of an event (Mark and Mellor 1991) reduce hindsight bias. Also, the extent of cognitive effort during choice (Creyer and Ross 1993), individual attitudes (Hölzl et al. forthcoming), the information made available to subjects (Stahlberg, Eller and Frey 1993), and the plausibility of additional information (Pohl 1998) systematically influence the strength of the bias. Introducing randomly selected items (Winman 1997) eliminates the hindsight bias, and very surprising outcomes even reverse the effect (Ofir and Mazursky 1997). Hindsight bias has also been found to be slightly attenuated in groups (Stahlberg et al. 1995).

Also, basic experimental design features, such as the between- versus within-subjects approach, seem to moderate the hindsight bias. Wendt (1993) studied the robustness of the bias within the context of the 1988 and 1992 parliamentary elections in the German province of Schleswig-Holstein. One week before the elections, subjects were asked to predict the election outcomes, and one week after the elections, they were asked to remember their predictions. The results did not support hindsight bias. Also, Stahlberg, Eller, Romahn and Frey (1993) found no hindsight bias with respect to remembering subjects' test scores in a within-subjects sample as well as Winman (1997) who only reports the hindsight phenomenon in between-subjects designs, but not in within-subjects designs. By contrast, Bryant and Brockway (1997) confirmed hindsight bias for a within-subjects sample: The probability estimates of conviction made two hours before the not-guilty verdict in the O. J. Simpson criminal trial were higher than estimates of prior probability made two days after the verdict.

In this study we aim to shed some light on the robustness of the hindsight bias in an experimental asset market environment using a within-subjects design. More precisely, we investigate whether traders in an experimental asset market are prone to hindsight bias with respect to remembering their price predictions. We therefore do not only focus on individual decision behavior in one-shot situations, but also capture the dynamics of personal experience over multiple trading periods, allowing for feedback about individual market earnings. At the beginning of each trading period, participants were asked to predict next period's average trading prices. On the basis of these predictions the *objective* outcome average price predictions were computed. Upon market closing, participants were asked to *subjectively* estimate their total average price predictions across all trading periods Four weeks later, participants were confronted with their outcome average price predictions, and were asked to remember their initial estimates. If participants are prone to hindsight bias, then their remembered estimates should deviate from their initial estimates in the direction of the outcome average price predictions.

1.2 Experimental risk elicitation methods

According to standard theory, different procedures to infer risk attitude should nevertheless yield the same outcome. Empirical evidence, however, indicates that the results differ across methods, violating the assumption of procedural invariance. Fellner and Maciejovsky (2002) study the relationship between individual risk attitudes, as inferred by the procedures of certainty equivalents and lottery choices, and market behavior on an experimental asset market. As the results of elicitation methods are not positively correlated with each other, the two methods yield no unambiguous classifications. Kirchler et al. (2001) report findings of an experimental asset market showing that the higher the degree of risk aversion, the lower the total number of contracts concluded, irrespective of the risk elicitation method. In general, the correspondence of certainty equivalents and binary lottery choices was weak, however. Exploring the effect of the binary lottery procedure in an auction, Rietz (1993) shows that observed behavior does not follow the predictions of expected utility theory. Davis and Holt (1993), Roth (1995) and Krahnen et al. (1997b) conclude that experimental approaches to infer risk attitude have severe short-comings. Particularly, Krahnen et al. (1997a) doubt the usefulness of individual certainty equivalents as meaningful indicators of individual risk attitude, and Selten et al. (1999) call into question the usefulness of the binary lottery mechanism to induce risk neutrality. While money appears to be ineffective in inducing risk neutrality, binary lotteries perform even worse in this respect.[1]

In the present study we examine (i) the stability of individual risk attitude over a time horizon of four weeks and (ii) the correspondence of different experimental risk elicitation methods.

1 More critique on the binary lottery mechanism as a means to induce risk neutrality is put forward by Cox et al. (1985) and Walker et al. (1990). Note, however, that in strategic settings it is probably the only way of inducing commonly known idiosyncratic risk attitudes. For an application of the binary lottery mechanism in an investment experiment see Dittrich et al. (2001).

2 The experiment

2.1 Participants

Overall, 133 students at the University of Vienna and the Vienna University of Economics and Business Administration participated in the study. Fifty-three subjects participated in an experiment in which one risky asset was traded, whereas the remaining 80 subjects participated in an experiment in which two risky assets were traded. Four weeks after the experiments had been conducted participants obtained their payoff, which on average amounted to €14.45 with a standard deviation of €15.35. Forty-one females and 92 males, aged 18 to 43 ($M = 22.31, SD = 3.53$), participated in the study. Ninety-seven participants were students of economics, whereas the remaining 36 participants were enrolled in other social science disciplines.

2.2 Experimental design and procedure

Subjects participated on asset markets, which were conducted using computers and the software z-Tree (Zurich Toolbox for Ready-made Economic Experiments, Fischbacher (1999)). The sequence of events in the experiment is shown in Figure 1. Each market lasted for at least 13 and at most 18 trading periods, with each trading period lasting 180 seconds. The exact number of trading periods was randomly determined with equal probabilities.

Before the asset markets opened, participants were asked (i) to reveal their certainty equivalent for a lottery that offers a payoff of 100 Experimental Guilders[2] with a probability of $p = .50$, and zero Experimental Guilders otherwise, and (ii) to make seven decisions among risky lotteries. The payoffs of the lotteries are listed in Table 1. For controlling position effects, the lotteries were systematically varied with respect to a_1 (highest possible payoff) and a_2 (lowest possible payoff) as well as to A (certain payoff) and to the sequence of a_1/a_2 (risky payoffs).

The certainty equivalent allows the experimenter to infer participants' attitude towards risk. More precisely, it allows discriminating between risk aversion, risk neutrality, and risk seeking behavior. A certainty equivalent that is lower than the expected value of the lottery, which is 50 Experimental Guilders, indicates risk aversion, a certainty equivalent equal to the expected value indicates risk neutrality, and finally, a certainty equivalent above the expected value indicates risk seeking behavior. Also, the seven decisions among lotteries can be used to infer risk attitude. However, since each lottery

2 One hundred Experimental Guilders equal €7.27.

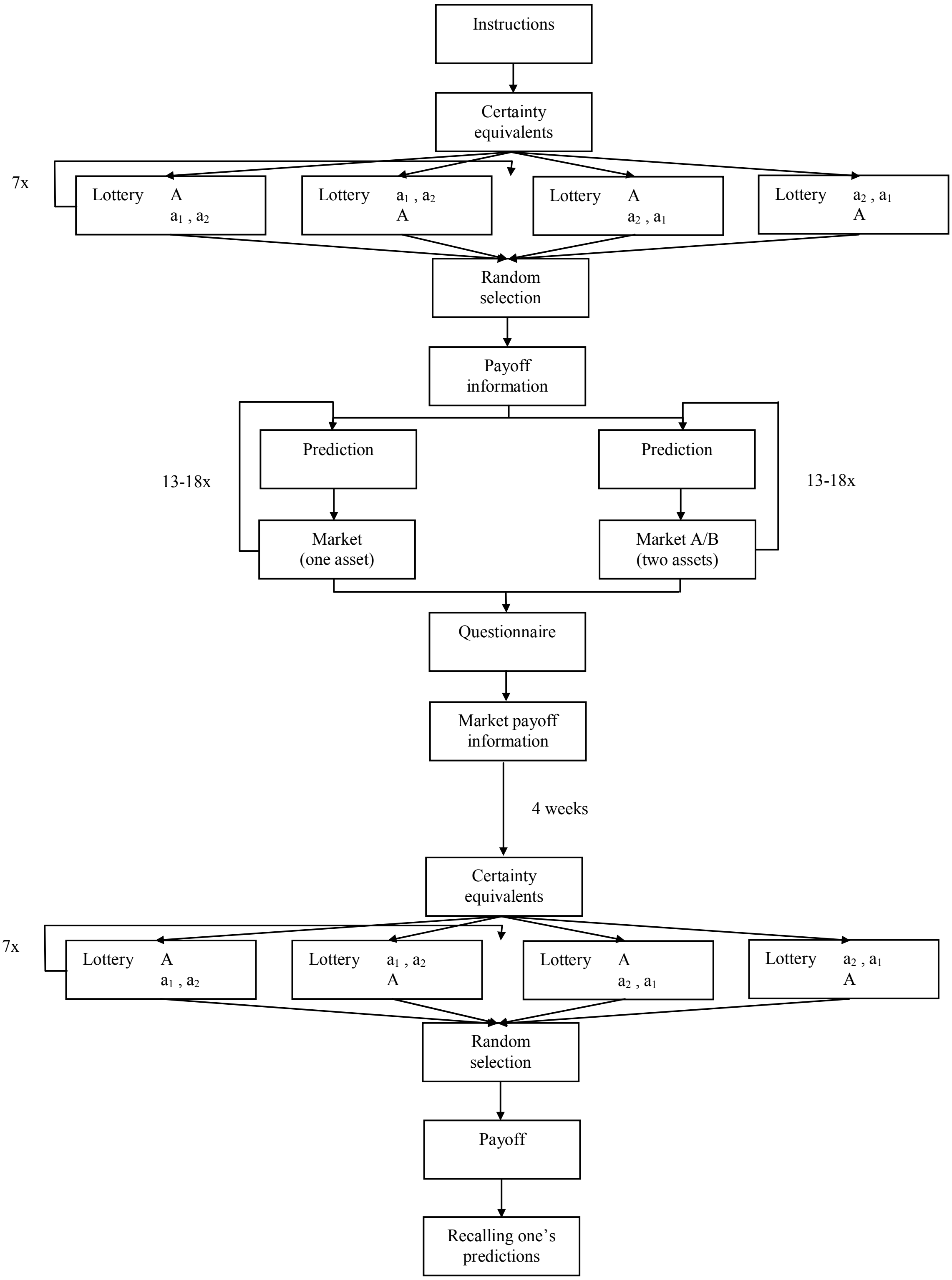

Figure 1: The sequence of events in the experiment

Table 1: Lottery payoffs in Experimental Guilders

Lottery		Payoff	p	Expected value
1	a_1	160	.20	88
	a_2	70	.80	
	A	88	1.00	88
2	a_1	150	.32	99
	a_2	75	.68	
	A	99	1.00	99
3	a_1	178	.28	106
	a_2	78	.72	
	A	106	1.00	106
4	a_1	140	.35	101
	a_2	80	.65	
	A	101	1.00	101
5	a_1	135	.40	105
	a_2	85	.60	
	A	105	1.00	105
6	a_1	188	.25	98
	a_2	68	.75	
	A	98	1.00	98
7	a_1	130	.30	102
	a_2	90	.70	
	A	102	1.00	102

Note: A denotes the certain payoff, whereas a_1 and a_2 denote the risky payoff of the lottery.

has the same expected value in each of its two components, namely the certain payoff and the risky payoff, the design only allows to distinguish between risk aversion (certain payoff) and risk neutrality (risky payoff).

One of the seven decisions was randomly selected in order to determine the individual payoff. Conversely, the revealed certainty equivalents did not translate into individual monetary payoffs. The payoff from the lotteries was added to the total payoff from the market. Four weeks after the experiments were conducted, participants again were asked to (i) reveal their certainty equivalent for a lottery offering a payoff of 100 Experimental Guilders with a probability of $p = .50$ and zero Guilders otherwise; and (ii) to make seven decisions among lotteries.

Subjects participated either on a market in which just one risky asset was traded or on a market in which two risky assets were traded. On the latter market, the assets were separately traded on two independent markets, whereby the sequence of the markets was determined randomly. In Figure 1 the markets on which two different assets were traded are referred to as markets A and B.

At the beginning of each trading period, participants were asked to predict the next period's average trading price of the asset(s).[3] On the basis of these predictions the outcome average price predictions (p_o) were computed as the individual average of price predictions across all periods.[4]

The outcome average price predictions served as the individual objective outcome information, with which participants were confronted four weeks later. Directly after market closing, in a post-experimental questionnaire participants were asked to estimate their total average price predictions across all trading periods (p_s), that is to subjectively "compute" the average of all their price predictions. Note, that both p_o and p_s actually relate to the same reference value, namely the individual average price predictions across trading periods. However, while p_o refers to the objective average value, p_s reflects the subjective estimate of it. Despite the fact that participants were not paid according to the accuracy of their predictions, the high correlation between individual predictions and actual average trading prices across all trading periods indicates that subjects made their decisions very carefully and also accurately ($r(133) = .82, p < .001$).[5]

3 Recall that if two assets are traded, subjects predicted the next period's trading prices separately for both assets.

4 In those experiments in which more than one asset was traded this was done separately for the two assets.

5 The correlation coefficients across trading periods ranged from $r(133) = .26$ in the 3rd period ($p < .001$) to $r(133) = .89$ in the 12th period ($p < .001$).

Four weeks later, participants obtained their payoff from the asset market experiments. Subjects were confronted with their *outcome* average price predictions (p_o), and were asked to remember their initial subjective estimates (p_s). These estimates are henceforth referred to as $\hat{p_s}$. Recall that if traders were prone to hindsight bias, then their remembered estimates should deviate from their initial estimates in the direction of the outcome average price predictions ($\mid p_o - \hat{p_s} \mid < \mid p_s - \hat{p_s} \mid$). Put differently, participants are expected to orient their responses to the exogenously presented information (p_o) rather than to the direction of their initial predictions (p_s).

3 Experimental results

3.1 Hindsight bias

If traders on an experimental asset market were prone to hindsight bias, then their remembered price estimates should deviate from their initial estimates in the direction of the outcome average price predictions, with which they were confronted.

The results did not confirm this conjecture, indicating that traders on our experimental asset market were not generally prone to hindsight bias. Only about half of the subjects (26 out of 53) who participated in an experimental asset market in which just one risky asset had been traded displayed the expected behavior and were prone to hindsight bias ($\chi^2 = 0.20, p = .81$). On the market in which two risky assets had been traded, 32 out of 80 participants were prone to hindsight bias with respect to the first asset ($\chi^2 = 1.61, p = .20$) and 38 out of 80 with respect to the second asset traded ($\chi^2 = 0.03, p = .89$). Overall, only 19 out of 80 participants were classified as constantly being prone to hindsight bias for both assets traded.

If instead of the frequency, the mean of the difference between outcome average price predictions p_o and remembered price estimates $\hat{p_s}$ is compared to the mean of the difference between initial price estimates p_s and remembered price estimates $\hat{p_s}$, no statistically significantly difference can be observed between the two means, neither for those cases in which only one asset was traded, nor for the cases in which two assets were traded (see Table 2). In conclusion, the existence of hindsight bias on an experimental asset market is neither supported with respect to the frequency of its presence nor with respect to the size of the bias.

Table 2: Means and standard deviations for the differences between average outcome predictions and remembered average price estimates and for differences between initial average price estimates and remembered average price estimates

Number of assets traded		M	SD	t-value	p-value
One asset	$\mid p_o - \hat{p_s} \mid$	47.82	72.97	0.004	.99
	$\mid p_s - \hat{p_s} \mid$	47.79	85.42		
Two assets	$\mid p_o - \hat{p_s} \mid$	65.23	81.97	−0.22	.83
	$\mid p_s - \hat{p_s} \mid$	68.12	118.35		

Note: p_o denotes the average outcome predictions, p_s the initial average price estimates, and $\hat{p_s}$ the remembered average price estimates.

3.2 Individual risk attitude

We investigate (i) the stability of individual risk attitudes as elicited by the experimental methods of certainty equivalents and binary lottery choices and (ii) the correspondence between these two methods.

The average certainty equivalent of participants amounted to 43.15 ($SD = 30.30$) before the asset markets were opened and to 40.31 ($SD = 25.49$) directly before participants received their payoff four weeks later. Thus, the results indicate a slight increase in individual risk aversion, although the difference is not statistically significant ($t = 0.98, p = .33$). If the revealed individual certainty equivalents are pooled to risk aversion (certainty equivalents < 50), risk neutrality (certainty equivalents $= 50$), and risk seeking behavior (certainty equivalents > 50), it can be observed that the frequency of risk averse certainty equivalents slightly decreased from $t = 0$ to $t = 1$, whereas the frequency of risk seeking behavior dramatically dropped by 50% ($\chi^2 = 30.60, p < .001$). Thus, our results indicate that directly before subjects knowingly obtained their payoff their readiness to engage in risky lottery choices substantially decreased. Figure 2 displays the frequency of risk averse, risk neutral, and risk seeking certainty equivalents for $t = 0$ and $t = 1$.

An index for risk attitude ranging from 0 = risk neutrality to 7 = risk aversion was computed out of the seven decisions among binary lotteries. Participants' average risk attitude before the asset markets were opened amounted to 3.51 ($SD = 2.03$), indicating that in 3.51 of the seven cases the secure rather than the risky alternative was chosen, and to 3.99 ($SD = 2.17$) directly before participants received their payoff four weeks later. Our findings indicate that individual risk aversion significantly increased

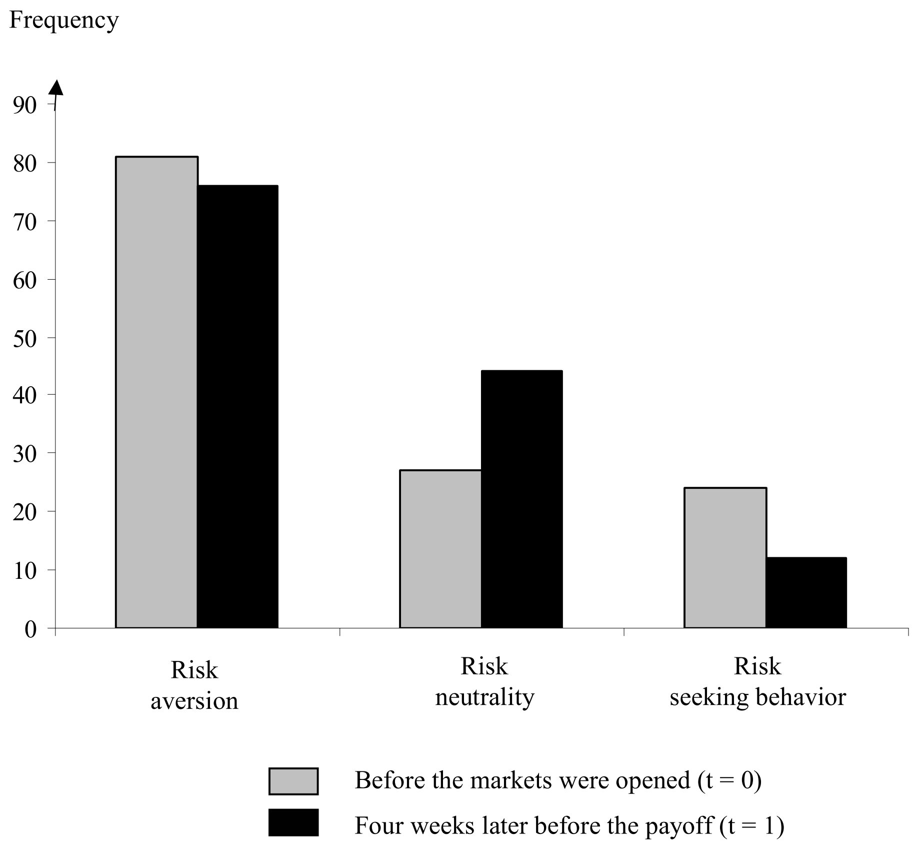

Figure 2: Frequency of individual risk attitudes inferred by certainty equivalents for $\mathtt{t} = 0$ and $\mathtt{t} = 1$

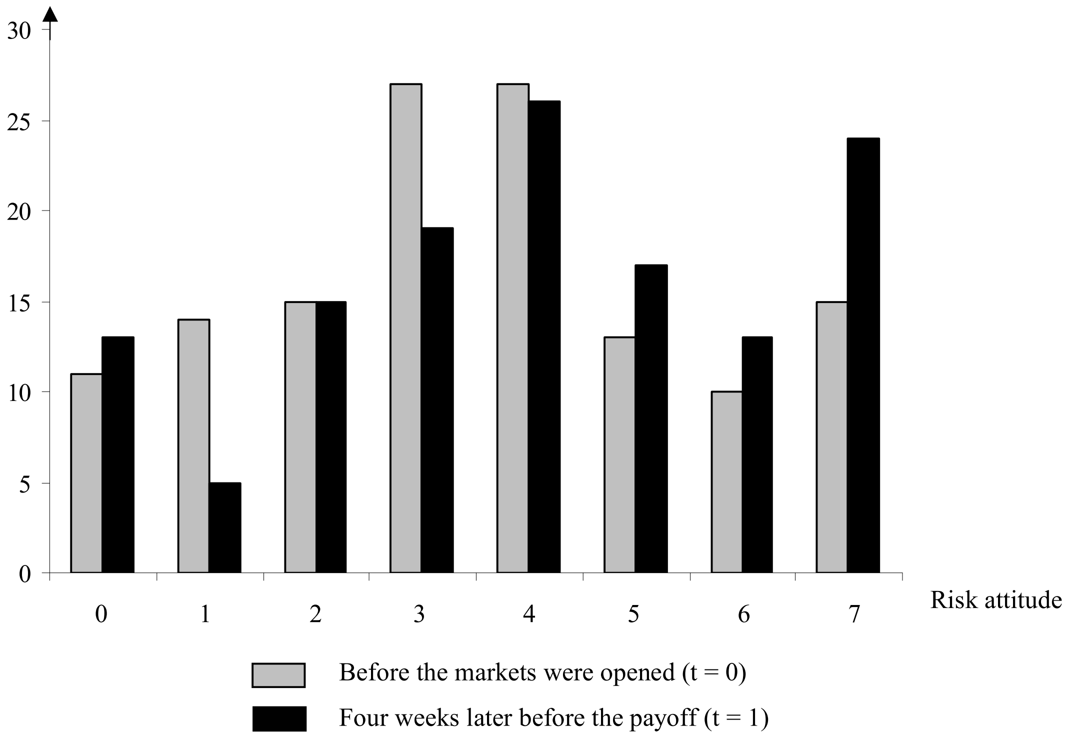

Figure 3: Frequency of individual risk attitudes inferred by lottery choices for $\mathtt{t} = 0$ and $\mathtt{t} = 1$

($t = -1.80, p = .075$), right before participants obtained their payoff. Figure 3 shows that the frequency of risk averse lottery choices (i.e., a risk index of 7) significantly increased at $t = 1$, whereas less risk averse lottery choices (i.e., indices of 1 or 3) decreased ($\chi^2 = 3.57, p = .059$). Thus, prior to the payoff participants were less inclined to engage in risky choices with respect to the certainty equivalent, whereas they were more inclined to engage in risk averse lottery choices with respect to the binary lottery method.

On an individual level, risk attitude as elicited by certainty equivalents ($\chi^2 = 65.03, p < .001$) and by binary lottery choices ($\chi^2 = 15.23, p < .001$) was found to be unstable between the two points of time. Only 30.30% of all individual risk patterns with respect to certainty equivalents and 15.15% with respect to lottery choices remained constant over the four weeks of investigation. By far the most stable pattern observed was a certainty equivalent of 50, displaying risk neutrality (12.12%).

In a further step, the correspondence of different experimental risk elicitation methods, more precisely between certainty equivalents and binary lottery choices, was studied. The results indicate that the two methods were not positively correlated with each other, neither before the asset markets were opened ($r(109) = -.04, p = .70$) nor directly before the payoff four weeks later ($r(120) = -.06, p = .51$).[6] In fact, no relation whatsoever was observed between these two methods. This is also true when extreme cases are analyzed: No correspondence resulted between risk attitudes as measured by the method of certainty equivalents and the method of lottery decisions for extreme cases, that is a certainty equivalent of 0 (complete risk aversion) and 50 (risk neutrality), as well as for a risk index computed from the lottery decisions of 0 (complete risk neutrality) and a value of 7 (complete risk aversion; Table 3).

4 Discussion and conclusion

The scope of the present paper is threefold. First, to study the robustness of hindsight bias on an experimental market applying a within-subjects design and allowing for multi-trading periods and individual earnings feedback. Second, to investigate time stability between the two different experimental risk elicitation methods of certainty equivalents and binary lottery choices. Third, to test for the correspondence between these two methods.

6 Only those certainty equivalents were used which discriminated between risk aversion and risk neutrality, since the lotteries were also designed in a way that allows one to discriminate only between risk aversion and risk neutrality.

Table 3: Correspondence between certainty equivalents and lottery decisions for extreme cases

Risk attitude	Certainty equivalent			Lottery decisions		
	Time	Frequency of correspondence (with lottery choices)	N	Time	Frequency of correspondence (with certainty equivalents	N
Risk neutrality	t = 0	4	27	t = 0	4	11
	t = 1	4	44	t = 1	5	13
Risk aversion	t = 0	0	0	t = 0	0	15
	t = 1	0	2	t = 1	0	24

Our results do not lend support to the conjecture that traders on an experimental asset market are prone to hindsight bias in remembering their price predictions. Moreover, the results indicate that hindsight bias does not appear to be generally present; rather it was found to be moderated by the methodology in use. This result may be content-specific. Whereas in studies with almanac questions hindsight bias seems to be a robust phenomenon, in our experimental approach personal experience and feedback on financial performance may crowd out the bias.

Another explanation for our finding may be the within-subjects design itself, relating to an asymmetry in the possibility to draw upon prior information. By repeated participation in the experiment, the within-subjects design enables subjects to remember their estimates, whereas under the between-subjects design each participant starts afresh from an informational point of view, and the subjects in the group with information may use that information as an anchor for individual judgments.

More general, in the light of our results the cognitive approach may be more conducive to explain the presence of hindsight bias than the motivational approach. The former approach rests upon the presence of a strong directional anchor, favoring a biased estimate, while the latter approach - bare of a directional anchor - leads to a random outcome independent of the particular experimental design.

In a different domain, our results challenge the assumption of time-invariant risk attitudes. Both on the individual as well as on the aggregate level, experimentally inferred risk attitudes are not identical between the two points of investigation. With decreasing distance to payoff, participants are less inclined to engage in risk-seeking behavior as measured by certainty equivalents but more inclined to exhibit risk-averse behavior as measured by lottery choices. Thus, in experiments with delayed or no payoffs at all an increasing degree of "gambling behavior" can be expected to occur, possibly generating misleading inferences about risk preferences if generalized.

Even more fundamentally, our results suggest that there is almost no correspondence between the two risk elicitation methods of certainty equivalents and lottery choices, indicating that different elicitation methods yield different risk classifications. This does not only violate the procedural invariance axiom of normative theory, but also questions the general validity of measuring attitudes towards risk. If so, empirical findings concerning risk behavior may suffer from the shortcoming of being moderated by the method employed.

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