# Risk Attitude and Market Behavior: Evidence from Experimental Asset Markets*

Gerlinde Fellner[a], Boris Maciejovsky[b]

September 2002

**Abstract**

In this paper we relate individual risk attitude as elicited by binary lotteries and certainty equivalents to market behavior. By analyzing 26 independent markets with a total of 280 participants we show that binary lottery choices and certainty equivalents are poorly correlated. Only lottery choices are related to market behavior: the higher the degree of risk aversion the lower the observed market activity. Females are more risk averse than males according to binary lotteries, submit fewer offers and engage less often in trades.

Keywords: Individual risk attitude, Gender differences, Binary lottery choices, Certainty equivalents, Experimental economics

JEL-Classification: C91; C92; D40; D80; G10

* The authors acknowledge financial support by the University of Vienna under the project title "600 Jahre Universität Wien". We are indebted to Tarek El-Sehity, Eva Hofmann and Herbert Schwarzenberger for their research assistance. Valuable comments by Werner Güth are gratefully acknowledged.

a Max Planck Institute for Research into Economic Systems, Strategic Interaction Group, Kahlaische Str. 10, D-07745 Jena, Germany. Tel.: +49/3641/686 643, Fax: +49/3641/686 623, E-mail: fellner@mpiew-jena.mpg.de

b Max Planck Institute for Research into Economic Systems, Strategic Interaction Group, Kahlaische Str. 10, D-07745 Jena, Germany. Tel.: +49/3641/686 626, Fax: +49/3641/686 623, E-mail: maciejovsky@mpiew-jena.mpg.de

## 1 Introduction

The assessment of individual risk attitude is important for various domains of managerial and financial decision making, both in theory and practice. Predictions derived from standard finance theory, such as portfolio theory, are based on assumptions concerning individual risk attitudes. For instance, the separation theorem of the CAPM assumes that individual risk aversion in the from of $\mu, \sigma$-preferences determines individual diversification with respect to risky and risk-less assets. From a managerial perspective the assessment of risk attitude is important in terms of legal matters and in terms of performance and success. Investment consultants, for instance, are legally obliged to inform investors about the potential risk of their investments, thereby usually relying on risk classifications. Other important domains, in which risk assessment is central, are training, personnel selection, and placement.

Risk attitude is usually measured either by drawing upon cardinal utilities or by psychometric approaches, such as scales and questionnaires. Cardinal utilities reflect preferences over lotteries with known probability distribution, and capture risk attitude by the curvature of the utility function.[1] Psychometric approaches directly attempt to measure risk attitude by asking respondents to indicate how much they agree with a set of statements. Both approaches implicitly assume that individual risk attitude is a stable personality trait.

Previous empirical studies have primarily focussed on relating risk attitude to individual decision making, e.g. entrepreneurial decisions (Brockhaus 1980), acquisitions (Pablo et al. 1996), and asset allocation (Riley and Chow 1992). Only a few studies have explicitly explored the relation between risk attitude and market behavior.

In this paper we (i) investigate whether two measures of risk attitude, binary lotteries and certainty equivalents, yield identical classifications, (ii) relate these measures to market behavior on experimental asset markets, and (iii) investigate whether risk attitude and trading behavior differs between females and males. Overall, we study 26 independent markets with a total of 280 subjects.

Our results indicate that the two measures of risk preference, binary lottery choices and certainty equivalents, are poorly correlated. However, the higher the

1 A recent paper by Rabin (2000) challenges this assumption by showing that expected utility theory is not able to provide plausible account of risk aversion over moderate stakes. Rubinstein (2001), however, stresses that this critique only holds if preferences depend on the final level of wealth. General developments in modelling preferences under risk are discussed by Weber and Camerer (1987).

degree of risk aversion, according to the binary lottery choices, the lower the observed market activity. Certainty equivalents, on the contrary, are not related to market behavior. According to their lottery choices females are more risk averse than males. Again, we do not observe a similar pattern with respect to certainty equivalents. However, females generally show less market activity than males.

The paper proceeds with a discussion of some of the relevant literature. In section 3 our experimental setup is presented. Section 4 covers our results and finally section 5 discusses our main findings.

## 2 Related literature

According to expected utility theory, different procedures to infer risk attitude should yield identical outcomes. Empirical evidence, however, indicates that the results differ across methods (MacCrimmon and Wehrung 1990, Slovic 1964), violating the assumption of procedural invariance. Lichtenstein and Slovic (1971) report systematic differences between lottery choices and bids in gambling decisions (preference reversals), Schoemaker and Hershey (1992) find that certainty and probability equivalents do not yield the same risk classification, and Kirchler et al. (2001) report findings of an experimental asset market showing that the two elicitation methods of binary lottery choices and certainty equivalents are poorly correlated.

Risk attitude not only differs across assessment methods, but also varies within the same method used (Krahnen et al. 1997, MacCrimmon and Wehrung 1986, Payne et al. 1980, Schoemaker 1993). Well-known examples are the favorite long-shot bias (Hausch et al. 1981, McGlothlin 1956), or the house money effect (Thaler and Johnson 1990). El-Sehity et al. (forthcoming) investigate the time constancy of binary lottery choices and certainty equivalents by comparing individual risk attitude at the time the experiment was conducted to four weeks later when subjects obtained their payoff. Close before receiving their payoffs, participants are less inclined to engage in risk-seeking behavior as measured by certainty equivalents and are more inclined to exhibit risk-averse behavior as measured by lottery choices. These findings question the asserted stability of risk preferences.

As an alternative to "objective" measures of risk, based on the expected utility framework, concepts of subjective risk perception have been proposed in the literature (Coombs and Lehner 1981, Pollatsek and Tversky 1970, Sitkin and Pablo 1992). Weber and Milliman (2000) report that different definitions of risk attitude measure different underlying constructs. Risk attitudes derived from the expected utility framework, for instance, describes choice behavior, whereas other constructs, such as relative risk attitudes (Dyer and Sarin 1982) or perceived risk attitudes capture different behavioral aspects.

Aside from the debate on risk assessment methods, there is a substantial body of literature investigating individual differences in risk attitude; e.g. whether females are more risk averse than males. Some empirical findings suggest that women hold larger proportions of wealth in financial assets with lower volatility (Chow and Riley 1992, Cohn et al. 1975, Jianakoplos and Bernasek 1998) and that female professional investors weigh risk attributes more heavily than their male colleagues (Olen and Cox 2001). However, there is also evidence casting doubt on the assertion that females generally avoid risk more strongly than males (Johnson and Powell 1994, Schubert et al. 1999). In a recent paper, Gysler et al. (2002) show that an increase in knowledge in a financial decision making context balances gender differences in risk attitude.

Empirical studies on risk attitude have not only focussed on individual decision making but also on market behavior. Ang and Schwarz (1985) compare two markets, in which subjects differ with respect to elicited risk attitude, and find that the less risk averse market converges quicker. Güth et al. (1997) report the result of an experimental study showing that individual risk attitudes do not explain final portfolio holdings, and Wärneryd (1996) analyzes Panel-data of Dutch households and finds that hypothetical lottery choices are only weakly linked to individual portfolio decisions. Comparing the risk attitude measures based on expected utility theory and on psychometric approaches, Pennings and Smidts (2000) find that there is some degree of convergence, however risk attitude as inferred from lotteries is superior in predicting market behavior. The authors, however, did not observe market behavior directly, but inferred it from responses to a questionnaire. Generally, the relation between individual risk attitude and market behavior remains largely unexplored; the few studies so far allow no clear conclusion.

This paper contributes to the existing literature by investigating the correspondence of two measures of risk attitude within the context of experimental asset markets. More precisely, we study the consistency of binary lottery choices and certainty equivalents, and relate these measures to market behavior. The focus of our analysis rests on market activity, i.e. the number of bids and asks submitted to the market as well as trading volume.

## 3 The experiment

### 3.1 Participants

Overall, 280 students at the University of Vienna and the Vienna University of Economics and Business Administration participated on 26 different markets. The participants' earnings were contingent on their decisions and amounted, on average, to €16.10 with a standard deviation of €15.50. One-hundred-eight females and 172 males, aged 18 to 43 ($M = 22.15, SD = 3.12$), participated in the study.

### 3.2 Experimental procedure

Subjects participated in computerized asset markets, using the software z-Tree (Fischbacher 1999, Zurich Toolbox for Ready-made Economic Experiments). A schematic sequence of events on the markets is shown in Figure 1. Six markets consisted of 13 trading periods, whereas the remaining 20 markets consisted of 18 trading periods. Each period lasted 180 seconds.

[Figure 1 about here.]

Before the asset markets had been opened, participants were asked (i) to reveal their certainty equivalent for a lottery that offers a payoff of 100 Experimental Currency Units (ECU)[2] with a probability of $p = .50$, and zero ECU 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).

[Table 1 about here.]

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 ECU, 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

2 One hundred ECU equal €7.27.

each 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.

After receiving instructions about the experimental asset market, subjects participated in two trial periods of six minutes each in order to become familiar with the selling and buying procedures on the market. After the trial periods, the asset market was opened. Overall, 26 sessions were run with eight sessions consisting of eight subjects and 18 sessions consisting of 12 subjects. The markets differed with respect to the number of periods, the number of subjects per market, and with respect to the initial asset and cash endowments (see Table 2). Markets with identical characteristics are referred to as blocks. We used a continuous anonymous double auction, whereby subjects could submit bids and asks, accept standing bids and asks, or remain aloof. Bids and asks were automatically ranked, indicating the most favorable offer. Information about trading history, provided as a chronological list of contracts, was displayed throughout the trading periods.

[Table 2 about here.]

## 4 Results

In order to ensure comparability between the four blocks of experiments, we calibrate the data of block 1 to account for the lower number of trading periods in these markets. All analyses reported in this section are based on aggregated market data. Overall, participants submitted on average 93.96 offers (47.8 bids and 46.16 asks) across the trading periods, resulting in 51.04 contracts.

This section proceeds with a correlation analysis of the two risk elicitation methods; binary lottery choices and certainty equivalents. We then relate individual risk attitude to market behavior, particularly to market activity, as inferred by the number of bids and asks submitted to the market and the overall trading volume. Furthermore, we study whether risk attitudes systematically differ between females and males. Finally, our experimental design allows to investigate whether different market characteristics, i.e. differences in initial cash and asset holdings as well as differences in the size of the market, affect trading behavior.

Observation 1 *Risk attitude inferred by binary lotteries is not related to risk attitude inferred by certainty equivalents.*

Evidence for this observation is provided by the results of a Spearman correlation. For this analysis an index is computed out of the seven lottery decisions made by subjects, ranging from 0=risk aversion to 7=risk neutrality. The participants' average risk index amounts to 3.42 ($SD = 2.01$). Thus, according to the lottery choices participants exhibit a slight degree of risk aversion. The average certainty equivalent that was revealed by subjects is 41.94 ($SD = 31.87$), indicating as well moderate risk aversion. For the correlation analysis, only those certainty equivalents are analyzed, which discriminate between risk aversion and risk neutrality ($\leq 50$), since the lotteries are also designed in a way that allows only to discriminate between risk aversion and risk neutrality. Despite the fact that both measures indicate a slight degree of risk aversion, they are not positively correlated (Spearman's $\rho = .012, p = .85$), casting doubt on the assumption of procedural invariance.[3] This result is illustrated by a bubble-plot with binary lottery choices at the axis of abscissae and certainty equivalents at the axis of ordinates. The size of the bubbles reflect the total number of observations with respect to a certain data combination (see Figure 2).

[Figure 2 about here.]

In a next step we investigate the relation of individual risk attitude and gender to market behavior. To ensure comparability between the 26 markets, we ran multiple comparisons of the different markets using the Dunnett T3-Test. The results indicate that markets do not differ significantly with respect to (i) total market activity (total number of submitted bids and asks, irrespective whether or not they resulted in contracts), (ii) market activity based on the number of trades (number of bids and asks that resulted in contracts), and (iii) market activity based on the number of bids and asks, which did not lead to trades. Since markets do not differ systematically, we run analyses on aggregated markets.

3 Empirical evidence on preference reversals arrives at similar conclusions; when individuals choose between a gamble offering a high probability of winning a modest sum and a low probability of winning a large amount, they usually prefer the former. However, when asked to state their minimum selling price for the two gambles, they state a higher one for the latter (Lichtenstein and Slovic 1971).

Observation 2 *The lower the degree of risk aversion, inferred by binary lotteries, the higher the total market activity and the higher the number of trades. Risk attitude, inferred by certainty equivalents, however, is not related to market behavior.*

Evidence for this observation is provided by the results of Least square-Regressions (LS) with total market activity, i.e. the sum of bids and asks, irrespective whether or not they led to trades, and the number of trades as dependent variables, and binary lottery choices, certainty equivalents, initial cash and asset holdings, gender (0=female, 1=male), age, and the number of market participants (0=12 subjects, 1=8 subjects) as independent variables.

The results indicate that the more risk averse subjects are according to binary lotteries, the less they engage in market activities; they submit a lower number of bids and asks (see Table 3) and are also less likely to conclude trades (see Table 4). Contrary, certainty equivalents are not related to market activity; they neither predict the number of offers submitted to the market nor do they predict the number of trades concluded. Our findings thus reflect those reported in Observation 1: Binary lotteries and certainty equivalents do not seem to capture the same dimension of risk attitude. Only binary lotteries contribute to explain market behavior.

[Table 3 about here.]

[Table 4 about here.]

Analyzing the number of concluded trades separately for buying and selling activities reveals that for higher risk aversion, as inferred by binary lotteries, the number of submitted bids and asks, resulting in trades, is lower. For this analysis a median-split with respect to binary lotteries is performed, dichotomizing risk aversion into a lower and a higher degree. In a next step, we run a MANOVA with four dependent variables, i.e. the number of submitted bids and asks resulting in trades as well as the number of accepted standing bids and asks, and with dichotomized risk aversion as independent factor. Our findings indicate that higher risk aversion leads to a lower number of submitted bids as well as to a lower number of submitted asks. However, this result only holds for submitted offers, and not for the acceptance of standing bids and asks (see Table 5).

[Table 5 about here.]

Breaking down concluded trades into buying and selling activity reveals that even on the fundamental level of bids and asks differences with respect to risk attitude materialize. At both sides of the market, i.e. buying and selling, higher risk aversion implies more chary market behavior. However, we observe an asymmetric trading pattern with respect to the submission and the acceptance of offers. Risk aversion is crucial in predicting trading behavior only in the former case: Market participants with high risk aversion submit fewer bids and asks, but do not accept fewer standing offers.

OBSERVATION 3 *Females show less market activity and conclude fewer trades than males.*

This observation is supported by the results of LS-Regressions reported in Tables 3 and 4. Females submit a lower number of bids and asks to the market and also conclude less contracts than males.[4] In order to analyze trading behavior separately for submitted offers and accepted standing offers, we run a MANOVA with four dependent variables, i.e. the number of submitted bids and asks resulting in trades as well as the number of accepted standing bids and asks, and with gender as independent factor. Our results indicate that gender differences are only evident for submitted bids and asks. These findings should be interpreted cautiously, however, since the proposed pattern is almost reversed in the case of accepted standing offers (see Table 6).

[Table 6 about here.]

OBSERVATION 4 *According to the binary lottery choices females are more risk averse than males. With respect to the certainty equivalents, however, we only observe an attenuated gender difference.*

Evidence for this observation is provided by LS-Regressions with binary lotteries and certainty equivalents as dependent variables and gender (0=female, 1=male) and age as independent variables. The results with respect to the binary lottery choices are displayed in Table 7 and those with respect to the certainty equivalents in Table 8. For the latter analysis only the choices of those participants are considered which reveal certainty equivalents lower equal 50, revealing risk attitude ranging from risk aversion to risk neutrality.

4 The distribution of females and males does not significantly differ across endowment conditions ($\chi^2 = 1.00, p = .32$). However, females, classified as being more risk averse, achieve lower final earnings than males ($t = -4.51, p < .01$).

[Table 7 about here.]

[Table 8 about here.]

The results indicate that females are more risk averse than males according to the binary lottery choices, however, only an abated gender difference is observed for the certainty equivalents. Losing the restriction of exclusively analyzing subjects' choices which reveal risk aversion or risk neutrality, indicates that the latter gender difference is not robust. Taking also risk seeking behavior into account erases the observed gender difference completely. The same holds true for the alleged impact of age on risk attitude with respect to certainty equivalents (see Table 8). Focusing solely on risk aversion and risk neutrality delusively indicates that age is negatively related to certainty equivalents, i.e. the higher one's age the more likely it is to reveal a lower certainty equivalent. However, this result proves to be fragile and disappears when the complete set of choices is analyzed.

Since we allow for different market characteristics we can study the impact of cash and asset endowments as well as market size on trading behavior. Table 2 displays the market characteristics; initial cash holdings amount either to 250 or 300 ECU, initial asset holdings are 5, 6 or 8, and markets include either 8 or 12 participants.

Observation 5 *Higher initial cash holdings lead to lower market activity as well as to a lower number of concluded trades. Initial asset holdings as well as market size, however, do not influence trading behavior.*

This observation is supported by the results of LS-Regressions, reported in Tables 3 and 4. Subjects endowed with higher amounts of initial cash show less market activity; they submit a fewer number of bids and asks, and also conclude less trades. However, we do not find that initial asset holdings as well as market size affect trading behavior. Breaking down the unit of analysis by focusing on submitted offers resulting in trades and accepted standing offers separately reveals that initial cash holdings matter for both, submitted offers and accepted standing offers, whereas initial asset holdings have no impact on either.

## 5 Discussion

Empirical studies on the relation between elicited risk attitudes and individual decision making allow for no clear cut interpretation; some studies suggest that risk attitude is related to observed behavior, whereas others describe risk attitude as only loosely connected to actual choices. Previous empirical work has been mostly concerned with relating risk attitude to individual choices, paying little attention to market behavior.

We are trying to fill this empirical gap by studying how elicited risk attitude is related to behavior on experimental asset markets, whereby risk attitude is inferred by binary lottery choices and certainty equivalents. Overall, we study 26 independent markets with a total of 280 subjects. Market characteristics vary systematically with respect to the number of trading periods, initial cash as well as asset endowments, and market size. Our research questions concern (i) the correspondence of binary lottery choices and certainty equivalents, (ii) the relation of elicited risk attitudes to market behavior, and (iii) alleged gender differences in inferred risk attitudes as well as in market behavior.

Our results indicate that the two independent risk elicitation measures yield different classifications; binary lottery choices and certainty equivalents are uncorrelated, violating the invariance assumption of expected utility theory.[5] Relating elicited risk attitude to market behavior indicates that only binary lottery choices have explanatory power in predicting trading activity; the lower the degree of risk aversion the higher the number of bids and asks as well as the number of trades. Risk attitude inferred from certainty equivalents, however, is unrelated to market behavior.

When studying the relation between risk attitude and market behavior, results seem to crucially depend on the assessment method. While our findings suggest that market behavior can only be predicted by one of the two methods considered, other studies arrive at different results. Ang and Schwarz (1985), for instance, compare trading behavior on two distinct experimental asset markets, populated by more or less risk averse traders, whereby risk attitude is inferred by personality inventories. Contrary to our findings, their results indicate that trading volume does not differ across markets. The two studies, however, are distinct with respect to the risk elicitation method and the market composition; we elicit risk attitude by drawing upon the expected utility theory framework and allow for interaction of traders with different risk attitude within one market. A recent paper by Pennings and Smidts (2000)

5 In our experimental setup only binary lottery choices yielded monetary payoffs for subjects. Previous empirical evidence on the persistence of preference reversals, however, suggests that the provision of monetary payoffs is unlikely to reduce the occurrence of preference reversals (Grether and Plott 1979), even for high stakes (Pommerehne et al. 1982). Therefore, we feel confident that our results would be robust, even if subjects had been paid for revealing their certainty equivalents.

compares lottery choices and psychometric scales for predicting trading behavior in slaughter hog markets. Their findings suggest that lottery choices are better predictors of market behavior. However, in contrast to our study, the authors rely on questionnaire data and cannot observe market behavior directly.

Since our markets vary in different respects, we can also investigate the impact of cash and asset endowments as well as market size on trading behavior. Our results indicate that higher initial cash holdings lead to lower market activity as well as to a lower number of concluded trades, suggesting more conservative trading behavior. Initial asset holdings as well as market size, however, do not affect market behavior.

A substantial body of literature is concerned with gender differences in risk attitude, hypothesizing that females are more risk averse than males. The results of our study seem to support this conjecture. However, gender differences are only confirmed with respect to binary lottery choices and not with respect to certainty equivalents. Generally, we find that females show less market activity than males. They submit fewer bids and asks and conclude less contracts. A recent stream of papers, however, suggests to be cautious in attributing such findings solely to gender; risk attitude might be moderated by second order characteristics, e.g. attitude towards ambiguity, competence or overconfidence (see Gysler et al. 2002, for a discussion).

Evidence of our experimental asset markets suggests that certainty equivalents are not linked to trading behavior and are thus inferior to lottery choices in eliciting risk classifications. In managerial decision making one should therefore rather rely on binary lotteries in inferring individual risk attitude. Supplementary future research is needed to investigate whether the course of trading, i.e. dividend payments, realized gains and losses, wealth accumulation etc., has a recursive impact on individual risk attitude. In addition, market behavior could be studied in the context of second order characteristics and personality traits jointly with elicited risk attitude.

## References


Ang, J. S. and Schwarz, T.: 1985, Risk aversion and information structure: An experimental study of price variability in the securities markets, *Journal of Finance* **40**, 825–844.

Brockhaus, R. H.: 1980, Risk-taking propensity of entrepreneurs, *Academy of Management Journal* **23**, 509–520.

Chow, V. K. and Riley, W.: 1992, Asset allocation and individual risk aversion, *Financial Analysts Journal* **48**, 32–37.

Cohn, R. A., Lewellen, W. G., Lease, R. C. and Schlarbaum, G. G.: 1975, Individual investor risk aversion and investment portfolio composition, *Journal of Finance* **30**, 605–620.

Coombs, C. H. and Lehner, P. E.: 1981, A valuation of two alternative models for a theory of risk: Part I. Are moments of the distributions useful in assessing risks?, *Journal of Experimental Psychology: Human Perception and Performance* **78**, 1110–1023.

Dyer, J. S. and Sarin, R. K.: 1982, Relative risk aversion, *Management Science* **28**, 875–886.

El-Sehity, T., Haumer, H., Helmenstein, C., Kirchler, E. and Maciejovsky, B.: forthcoming, Hindsight bias and individual risk attitude within the context of experimental asset markets, *Journal of Psychology and Financial Markets* .

Fischbacher, U.: 1999, z-Tree: Zurich toolbox for readymade economic experiments: Experimenter's manual, *Working Paper* **21**. Institute for Empirical Research in Economics at the University of Zurich.

Grether, D. M. and Plott, C. R.: 1979, Economic theory of choice and the preference reversal phenomenon, *American Economic Review* **69**, 623–638.

Güth, W., Krahnen, J. P. and Rieck, C.: 1997, Financial markets with asymmetric information: A pilot study focusing on insider advantages, *Journal of Economic Psychology* **18**, 235–257.

Gysler, M., Kruse, J. B. and Schubert, R.: 2002, Ambiguity and gender differences in financial decision making: An experimental examination of competence and confidence effects, *Mimeo* . Center for Economic Research, Swiss Federal Institute of Technology.

Hausch, D. B., Ziemba, W. T. and Rubinstein, M.: 1981, Efficiency of the market for racetrack betting, *Management Science* **27**, 1435–1452.

Jianakoplos, N. A. and Bernasek, A.: 1998, Are women more risk averse?, *Economic Inquiry* **36**, 620–630.

Johnson, J. E. V. and Powell, P. L.: 1994, Decision making, risk and gender: Are managers different?, *British Journal of Management* **5**, 123–138.

Kirchler, E., Maciejovsky, B. and Weber, M.: 2001, Framing effects on asset markets: An experimental analysis, *Working Paper* **181**. Department of Economics, Humboldt-University of Berlin.

Krahnen, J. P., Rieck, C. and Theissen, E.: 1997, Inferring risk attitudes from certainty equivalents: Some lessons from an experimental study, *Journal of Economic Psychology* **18**, 469–486.

Lichtenstein, S. and Slovic, P.: 1971, Reversals of preference between bids and choices in gambling decisions, *Journal of Experimental Psychology* **89**, 46–55.

MacCrimmon, K. R. and Wehrung, D. A.: 1986, *Taking risks: The management of uncertainty*, Free Press, New York.

MacCrimmon, K. R. and Wehrung, D. A.: 1990, Characteristics of risk taking executives, *Management Science* **36**, 422–435.

McGlothlin, W. H.: 1956, Stability of choices among uncertain alternatives, *American Journal of Psychology* **69**, 604–615.

Olen, R. A. and Cox, C. M.: 2001, The influence of gender on the perception and the response to investment risk: The case of professional investors, *Journal of Psychology and Financial Markets* **2**, 29–36.

Pablo, A. L., Sitkin, S. B. and Jemison, D. B.: 1996, Acquisition decision-making processes: The central role of risk, *Journal of Management* **22**, 723–746.

Payne, J. W., Laughhann, D. J. and Crum, R. L.: 1980, Translation of gambles and aspiration effects in risky choice behavior, *Management Science* **26**, 1039–1060.

Pennings, J. M. E. and Smidts, A.: 2000, Assessing the construct validity of risk attitude, *Management Science* **46**, 1337–1348.

Pollatsek, A. and Tversky, A.: 1970, A theory of risk, *Journal of Mathematical Psychology* **7**, 540–553.

Pommerehne, W. W., Schneider, F. and Zweifel, P.: 1982, Economic theory of choice and the preference reversal phenomenon: A re-examination, *American Economic Review* **72**, 569–574.

Rabin, M.: 2000, Risk aversion and expected utility theory: A calibration theorem, *Econometrica* **68**, 1281–1292.

Riley, W. B. and Chow, K. V.: 1992, Asset allocation and individual risk aversion, *Financial Analysts Journal* **48**, 32–37.

Rubinstein, A.: 2001, Comments on the risk and time preferences in economics, *Mimeo* . School of Economics, Tel Aviv University.

Schoemaker, P. J. H.: 1993, Determinants of risk-taking: Behavioral and economic views, *Journal of Risk and Uncertainty* **6**, 49–73.

Schoemaker, P. J. H. and Hershey, J. C.: 1992, Utility measurement: Signal, noise, and bias, *Organizational Behavior and Human Decision Processes* **52**, 397–424.

Schubert, R., Brown, M., Gysler, M. and Brachinger, H. W.: 1999, Financial decision-making: Are women really more risk-averse?, *American Economic Review: Papers and Proceedings* **89**, 381–385.

Sitkin, S. B. and Pablo, A. L.: 1992, Reconceptualizing the determinants of risk behavior, *Academy of Management Review* **17**, 9–38.

Slovic, P.: 1964, Assessment of risk taking behavior, *Psychological Bulletin* **61**, 330–333.

Thaler, R. H. and Johnson, E. J.: 1990, Gambling with the house money and trying to break even: Effects of prior outcomes on risky choice, *Management Science* **36**, 643–660.

Weber, E. U. and Milliman, R. A.: 2000, Perceived risk attitudes: Relating risk perception to risky choice, *Management Science* **43**, 123–144.

Weber, M. and Camerer, C.: 1987, Recent developments in modelling preferences under risk, *OR Spektrum* **9**, 129–151.

Wärneryd, K.-E.: 1996, Risk attitudes and risky behavior, *Journal of Economic Psychology* **17**, 749–770.

Figure 1: Sequence of events in the experiment

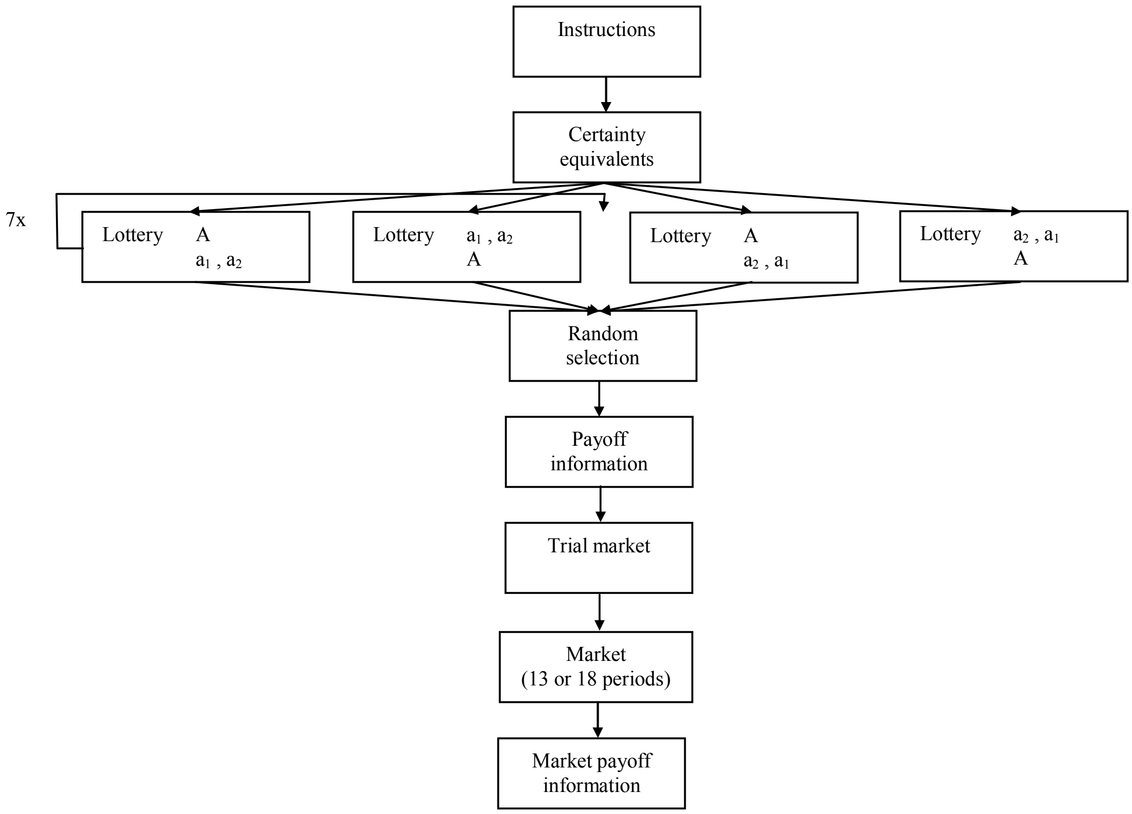

Figure 2: Bubble plot on binary lotteries and certainty equivalents

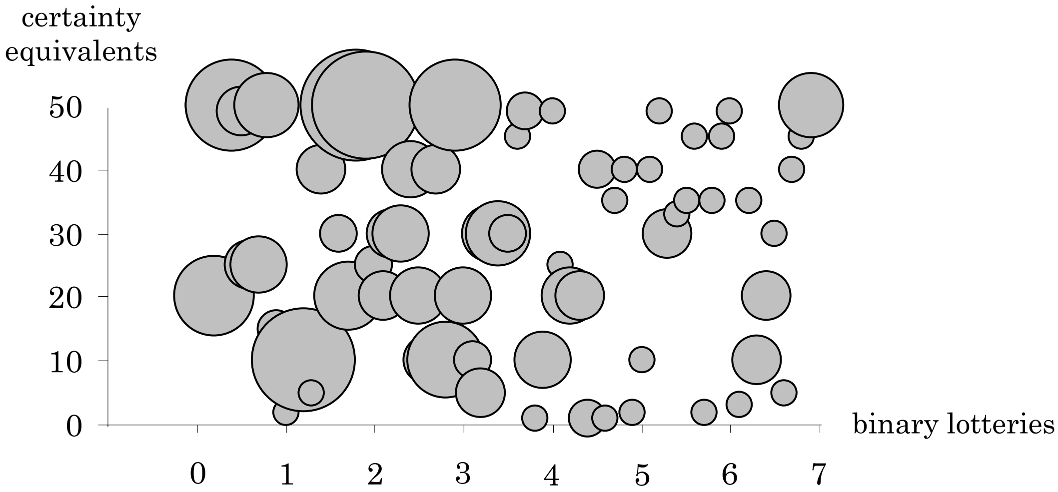

Table 1: Lottery payoffs in Experimental Currency Units

| 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.

Table 2: Composition of the asset markets

| Block | Number of markets | Number of periods | Subjects per market | Initial assets | Initial cash in ECU |
|---|---|---|---|---|---|
| 1 | 6 | 13 | 12 | 5 | 250 |
| 2 | 6 | 18 | 12 | 6 | 250 |
| 3 | 8 | 18 | 8 | 8 | 250 |
| 4 | 6 | 18 | 12 | 5 | 300 |

Table 3: Least squares regression on total market activity

| Dependent Variable: Total market activity<br>Method: Least squares<br>Newey-West HAC standard errors and covariance (lag truncation = 5) | | | | |
|---|---|---|---|---|
| Variable | Coefficient | Std.Error | t-Statistic | Prob. |
| Constant | 313.268400 | 119.383300 | 2.624055 | 0.0092 |
| Binary lotteries | 5.506759 | 2.600536 | 2.117548 | 0.0351* |
| Certainty equivalents | −0.026788 | 0.115465 | −0.231999 | 0.8167 |
| Initial cash | −0.813223 | 0.233261 | −3.486317 | 0.0006** |
| Initial assets | −3.858532 | 12.930400 | −0.298408 | 0.7656 |
| Gender | 34.239220 | 8.959151 | 3.821703 | 0.0002** |
| Age | −1.127843 | 1.530654 | −0.736837 | 0.4619 |
| Number of subjects | 15.711320 | 34.697860 | 0.452804 | 0.6511 |
| $R^2$ | 0.115047 | Mean dependent var | | 93.95962 |
| Adjusted $R^2$ | 0.092273 | S.D. dependent var | | 81.73169 |
| Durbin-Watson stat | 1.939235 | S.E. of regression | | 77.86965 |
| F-statistic | 5.051572 | Prob(F-statistic) | | 0.00002 |

Note: * denotes significance at the 5 % level, and ** at the 1 % level.

Table 4: Least squares regression on the total number of trades

| | | | | |
|---|---|---|---|---|
| Dependent Variable: Total number of trades | | | | |
| Method: Least squares | | | | |
| Newey-West HAC standard errors and covariance (lag truncation = 5) | | | | |
| Variable | Coefficient | Std.Error | t-Statistic | Prob. |
| Constant | 327.434700 | 88.376260 | 3.705007 | 0.0003 |
| Binary lotteries | 2.951982 | 1.496010 | 1.973237 | 0.0495* |
| Certainty equivalents | −0.031623 | 0.072914 | −0.433704 | 0.6648 |
| Initial cash | −0.800319 | 0.167782 | −4.769981 | 0.0000** |
| Initial assets | −15.978350 | 9.030766 | −1.769324 | 0.0780 |
| Gender | 16.408020 | 6.176823 | 2.656384 | 0.0084** |
| Age | 0.179116 | 1.047169 | 0.171047 | 0.8643 |
| Number of subjects | 26.699270 | 22.068400 | 1.209842 | 0.2274 |
| $R^2$ | 0.121114 | Mean dependent var | | 51.04121 |
| Adjusted $R^2$ | 0.098496 | S.D. dependent var | | 49.54758 |
| Durbin-Watson stat | 1.921990 | S.E. of regression | | 47.04423 |
| F-statistic | 5.354683 | Prob(F-statistic) | | 0.00009 |

Note: * denotes significance at the 5 % level, and ** at the 1 % level.

Table 5: MANOVA results on the number of trades with respect to low and high risk aversion inferred from binary lotteries

| | Risk aversion | Mean | Standard deviation | n | F(1; 278) | p |
|---|---|---|---|---|---|---|
| Submitted bids | high | 18.24 | 19.62 | 88 | 4.44 | .036* |
| | low | 25.17 | 27.86 | 192 | | |
| Submitted asks | high | 23.08 | 21.68 | 88 | 4.80 | .029* |
| | low | 30.33 | 27.33 | 192 | | |
| Accepted bids | high | 22.13 | 24.43 | 88 | 0.17 | .678 |
| | low | 23.39 | 22.92 | 192 | | |
| Accepted asks | high | 25.96 | 25.84 | 88 | 0.91 | .341 |
| | low | 29.01 | 24.31 | 192 | | |

Note: * denotes significance at the 5% level.

Table 6: MANOVA results on the number of trades with respect to gender

| | Gender | Mean | Standard deviation | n | F(1; 278) | p |
|---|---|---|---|---|---|---|
| Submitted bids | female | 17.45 | 22.38 | 108 | 8.37 | .004** |
| | male | 26.47 | 27.10 | 172 | | |
| Submitted asks | female | 24.22 | 24.08 | 108 | 3.89 | .049* |
| | male | 30.45 | 26.72 | 172 | | |
| Accepted bids | female | 24.81 | 27.61 | 108 | 1.06 | .303 |
| | male | 21.85 | 20.25 | 172 | | |
| Accepted asks | female | 31.68 | 30.48 | 108 | 3.80 | .052 |
| | male | 25.77 | 20.21 | 172 | | |

Note: * denotes significance at the 5% level, and ** at the 1% level.

Table 7: Least squares regression on binary lottery choices

| | | | | |
|---|---|---|---|---|
| Dependent Variable: Binary lottery choices | | | | |
| Method: Least squares | | | | |
| Variable | Coefficient | Std.Error | t-Statistic | Prob. |
| Constant | 4.207439 | 0.851400 | 4.941789 | 0.0000 |
| Gender | 0.715726 | 0.244572 | 2.926442 | 0.0037** |
| Age | −0.055183 | 0.038217 | −1.443921 | 0.1499 |
| $R^2$ | 0.034294 | Mean dependent var | | 3.425000 |
| Adjusted $R^2$ | 0.027321 | S.D. dependent var | | 2.007535 |
| Durbin-Watson stat | 2.120631 | S.E. of regression | | 1.979921 |
| F-statistic | 4.918355 | Prob(F-statistic) | | 0.007962 |

Note: ** denotes significance at the 1 % level.

Table 8: Least squares regression on certainty equivalents

| | | | | |
|---|---|---|---|---|
| Dependent Variable: Certainty equivalents | | | | |
| Method: Least squares | | | | |
| Sample: If certainty equivalent $\leq 50$ | | | | |
| Variable | Coefficient | Std.Error | t-Statistic | Prob. |
| Constant | 42.87894 | 7.407726 | 5.788407 | 0.0000 |
| Gender | 4.075358 | 2.240974 | 1.818565 | 0.0703 |
| Age | −0.662123 | 0.333302 | −1.986555 | 0.0481* |
| $R^2$ | 0.026965 | Mean dependent var | | 30.79149 |
| Adjusted $R^2$ | 0.018577 | S.D. dependent var | | 16.60460 |
| Durbin-Watson stat | 1.823867 | S.E. of regression | | 16.44965 |
| F-statistic | 3.214597 | Prob(F-statistic) | | 0.04197 |

Note: * denotes significance at the 5 % level.