Ambiguity and gender differences in financial decision making

an experimental examination of competence and confidence effects

Ambiguity and Gender Differences in Financial Decision Making: An Experimental Examination of Competence and Confidence Effects

Matthias Gysler, Jamie Brown Kruse and Renate Schubert*

May 2002

Abstract

This paper reports the results of an experiment that brings together psychological measures of competence and overconfidence with laboratory economic measures of individual valuations of uncertainty. We examine the valuations of risky and ambiguous lotteries in a financial decision context. The experiment can be viewed in two parts. The first part replicates an experimental design reported by Heath and Tversky (1991) but within a financial market context. This part produces two measures: 1) competence, the perception of feeling knowledgeable or competent in an area and 2) overconfidence, the well documented result that many individuals overestimate their ability. These measures, together with an indicator of objective knowledge, were used to explain elicited certainty equivalents in the second part of the experiment. Certainty equivalents were elicited for lotteries that were contingent on the price movements of real stock and bond funds, the price changes of simulated virtual funds, and pure risk lotteries. These represent three different levels of uncertainty: two-sided ambiguity, one-sided ambiguity and pure risk. Our results show a significant relationship between individual overconfidence and competence measures and elicited values of lotteries in a financial decision context. Further, the interaction of overconfidence, competence and knowledge measures with gender produce nearly opposite effects.

Key Words: risk, ambiguity, overconfidence, gender, financial decision making, economic experiments

---

*Financial support for this study was provided by Swiss Federal Institute of Technology and is gratefully acknowledged. Research was conducted while Professor Kruse was an academic visiter at the Center for Economic Research. Valuable help in conducting the experiment and comments on earlier drafts were provided by the research assistants and associates of the Center for Economic Research.

Gysler: Research Assistant, Swiss Federal Institute of Technology, Center for Economic Research, Weinbergstr. 35, 8092 Zürich, Switzerland
Phone: ++41 1 632 79 69, Fax: ++41 1 632 10 42
matthias.gysler @wif.gess.ethz.ch

Kruse: Professor, Texas Tech University, Department of Economics, Box 41014 Lubbock, TX 79409
Phone: ++1 806 742 2201 EXT 236
jamie.kruse@ ttu.edu

Schubert: Professor, Swiss Federal Institute of Technology, Center for Economic Research, Weinbergstr. 35, 8092 Zürich, Switzerland
Phone: ++41 1 632 47 17, Fax: ++41 1 632 10 42
schubert@wif.gess.ethz.ch

1. Introduction

A fundamental problem in the analysis of choices under uncertainty is the distinction between risk, where the probabilities are known, and ambiguity, where there is also uncertainty about the probability distribution. The emphasis on ambiguity stems from its relevance for the evaluation of real life decisions (Heath and Tversky, 1991). In financial markets a decision is normally based on knowledge about an investment as well as historical price patterns but lacking information about specific probabilities. Such a situation is obviously ambiguous. Additionally, empirical evidence shows that individuals deviate systematically from the predictions of standard economic theory that assumes the individual maximizes a stable (expected) utility function. Heath and Tversky (1991) propose that an individual's perception of his or her own competence could be an explanation of these deviations.

A tributary question of gender differences in investment behavior may also be considered in this context. There is some evidence for the existence of such differences (Jianakoplos and Bernasek, 1996, Barsky et.al., 1997, Powell and Ansic, 1997), but also against it (Schubert et.al., 1999). There is also strong evidence that men, on average, are more overconfident than women (Barber and Odean, 2001).

Therefore this paper presents the results of a laboratory experiment designed to deal with the question of ambiguity and whether measured overconfidence and competence influence an individual's willingness to pay for an investment under different formats of uncertainty. In addition, research is extended to examine whether overconfidence and competence may explain the contradictory evidence on gender differences. In order to separate effects resulting from different attitudes from effects resulting from different constraints (such as income, wealth, or professional carriers), we use the method of a controlled laboratory experiment. Measures of overconfidence and competence originating in the psychology literature are connected with laboratory decision-making in a financial setting. Therefore the design of the

experiment is partly based on previous approaches used to calibrate competence levels as well as measure overconfidence effects (Heath and Tversky, 1991). We then tested whether these measures have a significant influence on individual investment behavior under different formats of uncertainty that included pure risk and two levels of ambiguity.

The paper proceeds with a discussion of some of the relevant literature. The topics of ambiguity, the competence effect, overconfidence and gender related issues are briefly covered. We then state the testable hypotheses and follow with a description of the experimental design paying special attention to the key issues that arise in the statistical analysis of the data. Our discussion of results follows the design section and finally, we close with conclusions and suggestions for further research.

2. Relevant Literature

Ever since Ellsberg (1961) presented his famous paradox, researchers have been interested in modeling and understanding the distinction between risk and ambiguity. Camerer and Weber (1992) provide a review of empirical work and theoretical models of decisions under ambiguity.[1] Tversky and Kahneman (1992) describe ambiguity effects as preferences that differ with the source of uncertainty. Using the Tversky and Kahneman line of reasoning, in order to understand individual attitudes towards ambiguity one has to understand *source preferences* (what makes the individual prefer one source of uncertainty over another). Heath and Tversky (1991) offered perceived competence as one explanation for source preferences. According to their *competence hypothesis*, the willingness to accept ambiguity, depends on more than the judged probability of future outcomes and the information available. It also

[1]Recent literature in the modelling of ambiguity focuses on rank dependent models. A good literature review on that issue can be found in Diecidue and Wakker, (2001). For a list of annotated references on decisions and uncertainty by P. Wakker see http://www.fee.uva.nl/creed/wakker/refs/rfrncs.htm.

depends on the individual's assessment of his or her own ability to evaluate and process the information accurately in the relevant decision context. The Heath and Tversky (1991) measure of competence used bets on self-assessed accuracy of answers to knowledge-based questions. Heath and Tversky (1991) concluded that subjects were ambiguity seeking (averse) only in the contexts that they felt relatively more (less) knowledgeable and interpreted this positive relationship as a competence effect. The reason for the existence of such a competence effect may be that some individuals may attribute a bad (good) outcome of a decision as bad (good) luck whereas others attribute it to their capabilities in general. The attributions that different individuals would assign to the same outcome are referred to as "credit and blame" attributions (Heath and Tversky, 1991). Using a more general self-assessment of knowledge than the Heath and Tversky (1991) competence measure, Keppe and Weber (1995) achieved similar results for financial market decisions.

The aforementioned results provide evidence that ambiguity does not command a stable premium in addition to the risk premium. The competence hypothesis provides an explanation for the relationship between ambiguity and risk aversion. When individuals believe themselves to be competent they favor an ambiguous lottery over a risky one. The evidence for this over- or undervaluation seems to be caused by what the individual internally perceives as his or her competence level in the respective field.

Fox and Tversky (1995) find that ambiguity aversion is stimulated in a comparative setting and disappears in a noncomparative context.[2] Using the term "comparative ignorance", they propose that the individual will compare his or her limited knowledge in one context with superior knowledge in another context. A second kind of comparison could be with other

[2]Chow and Sarin (2001) partly replicated these findings. However, the preference for risk persists in their study. Fox and Weber (2002) replicated the result and extend it to the situation of familiar-unfamiliar situations.

individuals that are perceived to be more knowledgeable. In both cases, comparative ignorance influences behavior towards uncertainty and is strongly related to the competence effect mentioned above. When individuals feel competent, they may act ambiguity seeking. But in a comparative setting the feeling of competence may change, resulting in ambiguity averse behavior such as the well known Ellsberg paradox (Ellsberg, 1961).

The result that individuals are overconfident, i.e. overestimate their self-assessed knowledge, is perhaps the most robust finding in the psychology of judgement literature (DeBondt and Thaler, 1995). Recently, the concept has received increasing attention in economic literature. Overconfidence in financial decision-making has received much attention in analytical studies (Odean,1999; Gervais and Odean, 2001, Daniel et. al., 1998) as well as empirical studies (Kirchler and Maciejovsky, 2002, Camerer and Lovallo, 1999).[3] These studies use interpretations of overconfidence derived from the psychological literature (Laschke and Weber, 1999). In the psychological literature, calibration studies are used to describe overconfidence[4]. In such studies subjects are asked to answer a question and to state how sure they are about the correctness of their response by indicating a judged probability of correctness. These probability judgements may be interpreted as confidence levels. They are collected in categories and then compared with subjects' accuracy, i.e. percentage of correct answers. It turns out that most individuals are overconfident. A visual representation of overconfidence is identified when the corresponding points lay below the 45° line in a graph that plots the confidence levels (judged probabilities) against the accuracy (see for example Griffin and Tversky, 1992).

---

[3] For a survey of research on overconfidence see Laschke and Weber (1999) (in German).

[4] Calibration studies measure the absolute overrating of an individual's knowledge. There are also studies which measure the relative overrating such as Svennson (1981).

Basically overconfidence is then the overrating of the individual's own competence and thus the feeling of competence controls the action (Griffin and Tversky, 1992). When it comes to financial decisions, the question is what drives ambiguity seeking or ambiguity averse behavior? Do overconfidence and competence measure the same effect or is overconfidence independent of an individual's objective knowledge?

There is evidence that women are less overconfident when the domain is more male oriented (for example: Beyer and Bowden, 1997). Anecdotally, financial markets are populated by more men than women (Merrill Lynch, 1996). In addition, women seem to be perceived as more conservative investors and are offered less risky investments by brokers (Wang, 1994). An experiment by Eckel and Grosmann (2001) also provides supporting evidence that women are expected to be more risk averse by other women as well as by men. Therefore it may be possible, that the competence effect may be influenced by gender. Field evidence seems to support the conjecture that women and men approach financial decision-making differently. In general, women have portfolios with a lower degree of risk than men (Jianakoplos and Bernasek, 1996; Merrill Lynch, 1996). But if women perceive themselves as less knowledgeable in financial markets, competence effects as well as (over)confidence effects may play a role.

Taking these two effects together, gender specific portfolios with a varying degree of risk might result. Given the regularities in the field evidence (Jianakoplios and Bernasek, 1996, Sunden and Surette, 1997, Barber and Odean, 2001), can we identify similar gender-linked regularities in a laboratory financial decision context?

Eckel and Grossmann (2001) found significant gender differences in choices between several risky prospects with women indicating a preference for the less risky prospect. Also when asked about their attitudes towards financial risks, women seem to report a lower risk propensity than men (Barsky et.al., 1997). On the other hand, although Schubert et.al. (1999)

found gender differences in abstract gambling decisions, the differences disappeared with the introduction of an investment decision context. Kruse and Thompson (2002) also found no significant differences between men and women in low probability loss situations. For choices under ambiguity, Powell and Ansic (1998) found that women are more uncertainty averse than men irrespective of familiarity, framing or costs. In their experiment, individuals demonstrate ambiguity averse behavior in unfamiliar situations when compared to familiar ones. Schubert et al. (2000) found weak differences under two different formats of ambiguity but again no differences under risk.

We conjecture that these sometimes contradictory results within risk experiments as well as between risk and ambiguity experiments may be caused by second order characteristics that influence the behavior of men and women differently. We investigate the influence of individual characteristics on attitudes toward uncertainty including whether competence and/or overconfidence have a second order effect on gender differences.

3. Hypotheses and Experimental Design

3.1. Hypotheses

Referring to the aforementioned competence and overconfidence effects as well as to the discussion of gender differences, three main research hypotheses, each with an ancillary hypothesis, are stated below:

H1: There is a competence effect for financial decision-making.

H1.1: There are gender differences with respect to the competence effect.

H2: There is an overconfidence effect for financial decision-making.

H2.1: There are gender differences with respect to the overconfidence effect.

H3: The degree of ambiguity (none versus one-sided versus two-sided ambiguity) has a measurable influence on certainty equivalents for financial options. Further, certainty equivalents depend on competence and overconfidence effects.

H3.1: There are gender differences in the response to ambiguity. The relationship of competence and overconfidence with stated certainty equivalents exhibit a gender effect.

3.2. Experimental Design

This design was created to combine a standard method of calibration as described in the previous sections with an experiment constructed to elicit the value of ambiguous and risky lotteries. As such, it can be viewed in two parts, Part A and Part B, described below.

Part A: Sections A1 and A2 form a replication of an experiment reported in Heath and Tversky (1991). The complete instructions (in English) can be found in the appendix. In section A1, subjects answered twenty questions that relate to knowledge of financial markets and companies that are publicly traded. 16 out of 20 questions were true knowledge questions whereas the remaining 4 out of 20 were guessing questions – all related to financial markets. After choosing one of two answers as the correct one, subjects were instructed to state the probability that they believed their answer to be correct. The judged probability could range from 50% (purely a guess) to 100% (the correct answer with certainty). After collecting subjects' responses to the twenty questions, part A2 used the judged probabilities to construct lotteries. For each question subjects were offered the choice between betting on the correctness of their answer and betting on a lottery. The probability of a win on the lottery matched the subject's judged probability that her answer was correct. In both situations a win

paid 40 CHF and a loss paid 0 CHF.[5] Heath and Tversky (1991) describe this as a choice between a lottery with well-defined probabilities and an ambiguous lottery.[6] After completing both parts A1 and A2, one of the questions was randomly selected and played out to determine the subject's earnings. Subjects were given a receipt for their earnings plus a 10 CHF payment for showing up on time. They were instructed to bring their receipt to part B the following week to receive payment for both sessions in cash at the conclusion of part B.

Part B: The structure of part B was quite different from part A. We elicited subjects' certainty equivalents for a set of twelve lotteries. Each of the twelve lotteries was presented as a bet on a 0.5% daily increase in the market price of a fund. Note that this structure is similar to an option and restricts the uncertainty to a gain domain. Subjects were asked to choose between a certain amount of money and a bet on a 0.5% increase in the fund price.

There are three forms of uncertainty characterized on twelve decision sheets in part B. We asked for decisions on the outcome of four real funds, four virtual funds, and four funds with well defined probabilities. This structure allowed us to compare decisions by individuals facing two-sided ambiguity, one-sided ambiguity and pure risk. We controlled the probabilities in the virtual and pure-risk funds so that individuals were facing similar objective expectations. We will describe the funds more carefully below.

The first four decision sheets for real funds elicited certainty equivalents when there is two-sided ambiguity. The ambiguity was two-sided in that neither the experimenter nor the subject had precise knowledge of the underlying probability distribution. Decision sheets gave information for a particular fund issued by the Bank Hofmann. Bank Hofmann is a small

[5] 40 CHF are approximate 26 USD.

[6] An example of a knowledge question in part A1 and a decision sheet for part A2 can be found in the instructions.

Swiss bank specialized in the field of private banking. The funds were Swiss Stocks, Swiss Small Stocks, Euro Stocks, and Swiss Rent (a bond fund). We provided historical price information on the funds. Subjects had a chart of the fund price over the past year, a chart of price changes over the same period, and the price quotes for the ten trading days prior to the experiment. Hereafter, we will refer to this case of two-sided ambiguity as the real funds information (RFI) uncertainty format.

[Insert Figure 1]

Figure 1 shows an example of the information we provided. The resolution of uncertainty came with the fund price announcement at 3 pm just before the conclusion of the experiment. Subjects were given a website where they could verify all prices later if they wished.

Our four virtual funds with one-sided ambiguity bear a close resemblance to the real funds. We used each time series of real fund prices to create a virtual fund simulation. The mean and variance estimates of the first difference in daily prices were used to create a simulated price time series. Because the experimenter knew the underlying process that generated the time series, the virtual funds represent one-sided ambiguity on decision sheets numbered five through eight. We will refer to one-sided ambiguity as the virtual fund information (VFI) uncertainty format. Subjects were told which sheets gave information on real funds and which ones were virtual funds. The same stochastic process was used to draw forty representatives of the next price in the virtual price series. Subjects knew that they would draw one of these representatives to determine the daily price change and in so doing determine the outcome of their bet.

After the first eight sheets were completed, the last four sheets were distributed. These sheets gave both the subject and the experimenter the same information about the probability of the price change. The probabilities were represented numerically in a table and visually in a pie

chart on decision sheets nine through twelve.[7] This case is referred to as the pure risk uncertainty format.

To summarize, the twelve lotteries represented four approximate expected values (14 CHF, 12 CHF, 10 CHF, and less than 5 CHF) in three uncertainty formats (two-sided ambiguity, one-sided ambiguity, and pure risk). The structure of the twelve lotteries with frequencies or probabilities is shown in Table 1 below.

[Insert table 1]

We concluded both parts of the experiment with a questionnaire. The questionnaire for part A contained questions on age, sex, monthly income, experience with different types of financial options, and self-assessed knowledge on financial markets. The questionnaire for part B asked questions about house money effects, about the interpretation of a loss or gain from the experiment, and asked for a self report of the decision process.

4. Data

Subjects from several different major fields of study were recruited for the experiment from undergraduate courses at University of Zurich and Swiss Federal Institute of Technology. None of them had prior experience with economics experiments. In part A of the experiment, 55 subjects participated. For the part B, 52 subjects returned (3 subjects did not). We excluded 2 subjects from our analysis of the results, because we were unable to interpret their responses to part B. Therefore we report the results of decisions by 50 individuals that completed both part A and part B. The average payment per subject was CHF 82.50.[8]

---

[7] The example decision sheet from the instructions for a virtual fund as well as for a risky fund can be found in the appendix.

[8] 82.50 CHF are approximate 53 USD.

For the analysis of part A we used the first 15 pure knowledge questions. We excluded one of the knowledge questions, because doubts arose if all subjects understood the question properly.[9]

Our hypothesis tests are based on statistical analysis of 750 data points in part A and 600 data points in part B.

5. Results

Based on the aforementioned hypotheses, statistical analysis of the experimental data gives us the following results:

H1: There is a competence effect for financial decision-making.

In order to investigate the first hypothesis in a quantitative way, we used a measure for competence similar to the one proposed by Heath and Tversky (1991). We took a binary correlation coefficient that - for each subject - related the judged probability of the correctness of an answer to the choice of the ambiguous lottery.[10] We denote the binary correlation coefficient for an individual by COMP. If COMP is positive, this may be interpreted as evidence in support of the Competence Hypothesis. 82% of the subjects in our sample yielded positive correlation coefficients. The average correlation coefficient was 0.48. A t-test indicates that the correlation is significantly different from zero at the 1% level of significance. We conclude that for the given financial knowledge questions, a significant

[9] One third of all subjects stated in this question that they were 100% sure but were wrong whereas only 2 subjects with the same statement were right. The question asked if Switzerland or India has the higher GDP. We suppose that many subjects confused GDP with GDP per capita, attributing the higher GDP to Switzerland.

[10] The correlation coefficient was constructed in the following way. For each individual, the choice of the ambiguous or risky lottery was correlated with whether his/her judged probability was above or below the group median for each question.

overall competence effect was found. This replicates results from Heath and Tversky (1991) for the financial market context.

H1.1: There are gender differences with respect to the competence effect.

The second part of our Hypothesis 1 addresses whether there are gender differences in the competence effect.

[Insert Figure 2]

Figure 2 shows the relationship between the judged probability and the propensity to choose the ambiguous bet for men and women. A t-test indicates no significant difference in the proportion of women that choose the ambiguous lottery at each judged probability and the corresponding proportion of men. An evaluation of Part A in isolation would lead us to conclude that there are no significant differences in ambiguity aversion due to gender. However, we do find significant differences in the variances for men and women.[11] In order to explain gender differences in ambiguity seeking, other factors must be considered. We will describe the interaction of gender with other factors when we discuss our results on tests of hypotheses H3 and H3.1.

H2: There is an overconfidence effect for financial decision-making.

The second hypothesis deals with overconfidence. The calibration curve is a standard method of representing overconfidence graphically. In order to construct such a calibration curve one classifies all answers in Part A according to their judged probabilities. For each class of judged probabilities, the proportion of correct answers(accuracy), is calculated. The accuracy

[11]This is according to Levene's test for equality of variances. Additionally, a Kolmogorov-Smirnov test for differences in distributions does indicate there is a significant difference in the distribution of choices by males and females at the 5% level of significance.

is then represented as a function of the underlying judged probabilities. Overconfidence is indicated if the data points lie below the 45^{o} line in a graph with the correctness proportion (accuracy) on the vertical axis and the judged probabilities (confidence level) on the horizontal axis. Figure 3 contains two calibration curves, one for subjects with total objective knowledge scores above the median and one for subjects with a score below the median. Hereafter, we will refer to individuals belonging to either partition as high knowledge or low knowledge subjects.

[Insert Figure 3]

Examining this overconfidence effect in more detail we find that low knowledge people demonstrate a higher degree of overconfidence than high knowledge persons. This aspect of the high knowledge and low knowledge calibration curves is consistent with Heath and Tversky (1991). This result is also in line with previous calibration studies (Griffin and Tversky, 1992). In addition one sees that with increasing judged probabilities the proportion correct is also increasing. Our data seems to suggest the existence of overconfidence. Yet, of course, statistical significance cannot be determined using graphical analysis. Therefore, it is appropriate to construct an adequate measure in order to quantify the overconfidence effect.

In order to use overconfidence in our regressions for hypothesis H3, we need a measure that captures individual differences. Since the measure used for the graphical determination of overconfidence is not an individualized measure, a further indicator is needed. We calculate for each individual, the difference between the average judged probability of correctness and the average correctness proportion (over fifteen questions). Let us denote this overconfidence

measure by OC.[12] On the basis of this indicator, a t-test on our experimental data from Part A shows that there is a statistically significant overall overconfidence effect.

H2.1: There are gender differences with respect to the overconfidence effect.

To test for gender differences in the overconfidence measure, we use a Kolmogorov-Smirnov test for differences in distributions. For both high and low knowledge groups, we find that men are significantly more confident than women. In the low knowledge group, men are more *over*-confident. In the high knowledge group, men are fairly accurate in their self knowledge. High knowledge women, on the other hand are *under*-confident. In other words, high knowledge women state subjective probabilities that are below their knowledge-based accuracy.

H3: The degree of ambiguity has a measurable influence on certainty equivalents for financial options. Further, certainty equivalents depend on competence and overconfidence effects.

> *H3.1: There are gender differences in the response to ambiguity. The relationship of competence and overconfidence with stated certainty equivalents exhibit a gender effect.*

We used regression analysis in order to evaluate the transmission of competence and overconfidence to choice behavior in a financial context. We used the stated certainty equivalents (CEs) as the dependent variable with explanatory variables representing approximate expected value, measures of ambiguity, competence, overconfidence, objective

---

[12] In a similar way, one could have looked at the difference between the average correctness of answers (expressed in septiles) and the self-assessed knowledge according to the questionnaire from part A (expressed on a seven-digit scale). Due to the high correlation of 72% between judged probabilities and self-assessed knowledge there is a high correlation between the two overconfidence indicators. We have chosen OC to stay as close as possible to the concept of calibration.

knowledge and gender. Since the regressions integrate gender specific variables, it is reasonable to treat hypothesis H3 and H3.1 simultaneously.

[Insert Table 2]

Table 2 contains a description of the explanatory variables. In the following, these variables and their explanatory power are examined in detail. Recall that we present uncertainty in three formats. The first format used lotteries based on real funds information (RFI) and thus two-sided ambiguity. The second format used lotteries based on virtual funds information (VFI) with statistical properties similar to the real funds and represented one-sided ambiguity. The third format used pure risk lotteries.[13] Variables L1, L2, L3, and L4 denote lotteries grouped by approximate expected values. The lottery with the smallest approximate expected value (L3) served as the base case variable. Competence and overconfidence are represented by the measures COMP and OC that were constructed to test hypotheses H1 and H2. We also used a measure of objective knowledge, denoted by the variable KNOW, which indicates the absolute number of correct answers given by an individual.[14]

[Insert Table 3]

Table 3 summarizes the results of the regressions. Regression 1 includes knowledge, competence and overconfidence measures as well as gender, primary interaction terms and

[13] Both subject and experimenter had the same information and access to the random number generating process.

[14] A t-test does indicate a slight but significant difference in the number of correct answers between men and women (significance level 5%). On average males in our sample demonstrated more "objective knowledge" on financial markets than females.

secondary interaction terms. Due to repeated measures, we estimated a random effects model using generalized least squares.[15]

Our regression results indicate, first, that individuals were sensitive to the estimated expected values of the lotteries (L1, L2, L3, L4) regardless of the uncertainty format (RFI, VFI, Pure Risk). This is seen in the highly significant coefficients on the lottery variables all in the correct direction and of a magnitude consistent with differences in expected value. This effect was robust, producing highly significant coefficients to all specifications of the model we tested.

Secondly, we find that the real funds evoke a stronger response than the virtual funds. Ambiguity aversion leads to a significantly lower certainty equivalent in general for the real funds compared to the pure risk base case. With one-sided ambiguity although there are no significant direct effects, there are secondary effects that can be explained by overconfidence, competence and knowledge.

The effect of overconfidence - as measured in Part A of the experiment - on the certainty equivalents in Part B varies according to the uncertainty formats and to gender. For females, as expected, overconfidence manifests as a significant increase in risk seeking and ambiguity seeking behavior[16]. With one-sided ambiguity (VFI), the magnitude of the overconfidence effect is between that of the two other formats. We find that the influence of overconfidence is

---

[15] A Breusch Pagan Test favored a random effects model over the classical regression model at significance level less than 1%. The fixed effects model was collinear due to a separate constant for each individual in addition to the other variables. We also tested for several experimental effects, such as house money, gambling effect or isolation effect, with data from the questionnaire. None of these effects were significant.

[16] Rabin (1997) reports, that when the questions become more vague, overconfidence of high knowledge individuals increases disproportionally. However, we did not find that such an effect has an additional influence

strongest in the two sided ambiguity case. In contrast to females, male overconfidence leads to lower CEs in the pure risk case. The effect of overconfidence on CE's for one-sided ambiguity (VFI) is also negative whereas only in the two-sided ambiguity (RFI) case, higher overconfidence leads to higher CEs as expected. It seems that for males the existence of a probability distribution, known or unknown, dampens the propensity to seek risk or ambiguity.

The competence measure has no significant general effect. However, there is a significant effect when competence is allowed to interact with the ambiguous lottery formats. Competence tends to dampen the overconfidence effect for men in the two sided ambiguity (RFI) case. On the other hand, competence and overconfidence reinforce ambiguity seeking behavior in women facing the real fund (RFI) case.

The knowledge variable gives us some interesting results. For males, higher knowledge goes with less risk and ambiguity seeking. There is a smaller effect in the real fund case than in the virtual fund case. For females, however, higher knowledge leads to higher certainty equivalents, i.e. more risk and ambiguity seeking behavior. The variable, KNOW is an objective measure of a subject's knowledge and produces an opposite effect for men and women.

Due to the elicitation of CEs for different types of uncertainty within one experiment, "comparative ignorance" could become an important factor (Fox and Tversky, 1995). In our experiment different types of comparisons are possible. Virtual funds yield comparisons between the experimenter and the less informed participants. Additionally, there are comparisons between the information in the three formats of uncertainty (RFI, VFI and pure

---

on CE's. A detailed analysis of our results with respect to this evidence is available from the authors upon request.

risk) all within one experiment. One may presume that the sequencing of the different decision sheets matters with respect to the comparisons individuals make. Individuals evaluated first, the four real funds, thereafter four virtual funds and finally four risky funds. It seems plausible that individuals compared the funds as they followed each other. This means that the assessment of virtual funds will be influenced by the corresponding assessment of real funds and the assessment of risky funds will depend on the corresponding assessment of virtual funds. According to Fox and Tversky (1995) comparative ignorance should be measured by competence (COMP) and knowledge (KNOW). The comparison between different uncertainty formats should be captured by the interaction terms of COMP and KNOW with RFI and VFI as well as with FEMALE.[17]

When comparing risky funds to virtual funds, individuals seem to perceive them as similar. It turns out that only the coefficient of CompV (competence x virtual fund) is significant. Hence the comparison with the virtual fund lotteries seem to influence the certainty equivalents observed for pure risk lotteries. However, in spite of the significance, the average effect on the certainty equivalent is relatively small which implies low perceived differences between virtual funds and pure risk lotteries. In both cases the experimenter has knowledge about the distribution of future prices. For risky funds, the subjects have the same knowledge, whereas they lack the corresponding knowledge for the virtual funds. It seems that in the case of virtual funds subjects think themselves to be able to assess the relevant price distribution. These effects hold for men and women equally.

---

[17] Chow and Sarin (2001) explain "comparative ignorance" by an additional factor, the so-called "Evaluability Hypothesis" (Hsee et.al., 1999). This hypothesis says that ignorance is an implicit attribute of uncertain options, which is easier to evaluate in a comparative context. This effect should not be a problem in our experiment, because in the context of evaluabilty, we ordered the different uncertainty formats from difficult to easy.

When comparing virtual to real funds, quite different results are obtained. As the effect of real on virtual funds is the focus here, both interactions of COMP and KNOW with RFI and VFI are important when significant. For males the effect of COMPR (competence x real fund) is reinforced by COMPV (competence x virtual fund). Additionally the coefficient on KNOWR (knowledge x real fund) is significant. Taken together this indicates a rather large effect. For females there is an additional effect of FCOMPR (female x competence x real fund) such that the influence of comparative ignorance is even stronger. Both effects described above are in line with the predictions of Fox and Tversky (1995). We conclude that when evaluating different formats within the same experiment, comparative ignorance is important. However comparative ignorance does not explain all of the differences in behavior between risky and ambiguous lotteries--some of the differences are explained, in part, by overconfidence.

Lastly, to gain a better understanding of the importance of the interaction of gender with competence and overconfidence, we examined a specification that stripped out the interaction terms. This specification (regression 2 in table 2) with explanatory variables L1, L2, L4, RFI,VFI and a dummy variable FEMALE yields the observation that FEMALE is not significant. This is in marked contrast to regression 1 of table 2 with a totality of all gender effects significant at the 1%-level.[18] One may presume that the existence of positive *and* negative gender effects on CEs confound an overall gender effect in a regression that does not control for individual heterogeneity measured by competence and overconfidence.

[Table 4]

Table 4 collects and summarizes the direct and secondary effects on observed certainty equivalents. The gender specific constant for females is highly significant and *negative*

[18] The joint significance of the gender variables has been tested with a Wald test.

whereas other gender effects, calculated out of the interactions, *increase* the certainty equivalent. On the other hand, the constant, which represents the general effect for males in the lowest probability risky fund, is highly *positive.* Most of the male effects *decrease* the certainty equivalent from this point on. In Table 5 we report forecasted CEs for low and high knowledge males and females out of the regression. Note that the highest certainty equivalents are forecasted for low knowledge males whereas the lowest certainty equivalents are forecasted for low knowledge females. When we look additionally at the effect of the knowledge variable and its interaction with FEMALE one sees the high impact of these variables that work in different directions for men and women. It seems that the women evaluate the lotteries from "below" and respond with a higher certainty equivalent as knowledge increases. This result is consistent with the competence hypothesis suggested by Heath and Tversky (1991). On the other hand it seems that males evaluate certainty equivalents from "above" and become more cautioned with increasing knowledge which is in accordance with the regression hypothesis of Einhorn and Hogarth (1986). Moreover the effect of knowledge dominates both the overconfidence and the competence effects.

[Table 5]

6. Conclusions

This experiment was designed to identify the relationship between attitudes toward uncertainty and individual measures of overconfidence and competence in a financial decision context. We found that two variables are of special importance for the explanation of the willingness to pay for ambiguous or risky lotteries: overconfidence and objective knowledge. In addition, our results show that gender plays an important role in predicting choices when individuals are confronted with uncertainty.

The influence of overconfidence varies with different uncertainty formats. With respect to gender, the willingness to pay for lotteries in the form of elicited certainty equivalents is lower for women than for men in general. However, overconfidence and knowledge reduce the corresponding difference. The influence of overconfidence on the willingness to pay varies significantly between men and women. Controlling for comparative ignorance, subjects generally demonstrate ambiguity aversion when confronted with two-sided ambiguity. Given the importance of knowledge in the context of comparative ignorance, our results imply that comparisons have an effect on certainty equivalents elicited in both the pure risk and ambiguity cases.

For all uncertainty formats, with increasing objectively measured knowledge men become more risk or ambiguity averse whereas women become more risk or ambiguity prone. As a consequence, among low knowledge individuals, men are more risk or ambiguity prone. Among high knowledge individuals, women are more risk or ambiguity prone.

Our results imply that individual characteristics, like knowledge and overconfidence, may have effects that are idiosyncratic to group membership or social affiliation. Our study examines the interaction of individual characteristics with gender. Other affiliations such as religion, race, or culture could produce similar results. Studies that do not take into account the interaction of individual characteristics with group identities may produce misleading results.

Our results indicate that an increase in knowledge in a financial decision making context can create a near role reversal between men and women in attitudes toward uncertainty. It seems that the acquisition and rating of an individual's contextual knowledge may help explain some of the puzzles pertaining to gender differences in labor market and financial market outcomes. If the knowledge acquisition is a "learning-by-doing" process, low knowledge men will acquire the knowledge—sometimes by "hard knocks", whereas women will not learn the

same lessons from their more conservative approach. As a consequence, they will sustain risk or ambiguity averse behavior.

Yet, the way in which increased knowledge changes men's and women's attitudes toward uncertainty is not completely clear. Therefore, further research should concentrate on reasons why knowledge and overconfidence are important predictors for choice behavior and on the links between knowledge and overconfidence. It would be particularly interesting to conduct further experiments which are able to track down "credit and blame" effects. The hypothesis that credit and blame personality attributes have a gender effect could be consistent with our empirical result. This hypothesis, i.e. the hypothesis that credit and blame attributions interact with other group affiliations is fertile ground for future research.

Literature

Barber B. and T. Odean (2001) 'Boys will be Boys: Gender, Overconfidence, and Common Stock Investment,' *Quarterly Journal of Economics*, Vol. 116 (1), pp 261-292.

Beyer, S and E. Bowden (1997) 'Gender Differences in Self-Perceptions: Convergent Evidence from three measures of accuracy and bias,' *Personality and Social Psychology Bulletin*, 23, pp. 157-172.

Barsky, R., F. Juster, M. Kimball and M. Shapiro (1997) 'Preference Parameters and Behavioral Heterogeneity: An Experimental approach in the Health and Retirement Study,' *Quarterly Journal of Economics*, 112 (2), pp. 537-579.

Camerer, C. and M. Weber (1992) 'Recent developments in Modeling Preferences: Uncertainty and Ambiguity,' *Journal of Risk and Uncertainty*, 5 (4), pp. 325-370.

Camerer, C. and D. Lovallo (1999) 'Overconfidence and Excess Entry: An Experimental Approach,' *American Economic Review*, 89, 306-318.

Chow, C. and R. Sarin (2001) 'Comparative Ignorance and the Ellsberg Paradox,' *Journal of Risk and Uncertainty*, 22 (2), pp 129-139.

Eckel C. and P. Grossman (2001) 'Sex Differences and Stereotyping in Attitudes towards Financial Risks,' *Working Paper, Virginia Tech*, mimeo.

De Bondt, W.F.M. and R.H. Thaler (1995) 'Financial Decision-Making in Markets and Firms: A Behavioral Perspective,' In Jarrow, R., V. Maksimovic and W. Ziemba (eds), *Handbooks in Operations Research and Management Science: Finance*, Amsterdam: Elsevier, pp 385-410.

Daniel, K., D. Hirshleifer and A. Subrahmanyam (1998) 'Investor Psychology and Security Market under- and Overreactions,' *Journal of Finance*, 53 (6), pp. 1839-1885.

Diecidue E. and P. Wakker (2001) 'On the Intuition of Rank-Dependent Utility,' *Journal of Risk and Uncertainty*, 23 (3), pp. 281-298.

Einhorn, H. and R. Hogarth (1986) 'Decision Making under Ambiguity,' *Journal of Business*, 59, pp. 225-250.

Ellsberg, D. (1961) 'Risk, Ambiguity and the Savage Axioms,' *Quarterly Journal of Economics*, 75, pp. 643-669.

Fox, C. and A. Tversky (1995) 'Ambiguity Aversion and Comparative Ignorance,' *Quarterly Journal of Economics*, 110, pp 585-603.

Fox C. and M. Weber (2002) 'Ambiguity Aversion, Comparative Ignorance, and Decision Context,' *Organizational Behavior and Human Decision Processes*, forthcoming.

Frisch, D. and J. Baron (1988) 'Ambiguity and Rationality', *Journal of Behavioral Decision Making*, 1, 149-157.

Gervais, S and T. Odean (2001)' Learning to be Overconfident,' *Review of Financial Studies*, 14 (1), pp. 1-27.

Griffin, D. and A. Tversky (1992) 'The Weighting of Evidence and the Determinants of Confidence,' *Cognitive Psychology*, 24, pp. 411-435.

Heath, C. and A. Tversky (1991) 'Preference and Belief: Ambiguity and Competence in Choice under Uncertainty,' *Journal of Risk and Uncertainty*, IV, pp 5-28.

Hsee, C.G., G.F. Lowenstein, S. Blunt and M.H. Bazerman (1999) 'Preference Reversals between Joint and Separate Evaluations of Options: A Review and Theoretical Analysis,' *Psychological Bulletin*, 125, pp. 576-590.

Jianakoplos, N. and A. Bernasek (1996) **'**Are Women More Risk Averse?,' *Working Paper, Colorado State University*, March 1996.

Keppe, H. and M. Weber (1995) 'Judged Knowledge and Ambiguity Aversion,' *Theory and Decision*, pp 51-77

Kirchler, E. and B. Maciejowsky (2002) 'Simultaneous over- and underconfidence: Evidence from experimental asset markets,' *Journal of Risk and Uncertainty*, forthcoming.

Kruse, J. B. and M. A. Thompson (2003) 'Valuing Low Probability Risk: survey and experimental evidence,' *Journal of Economic Behavior and Organization*, forthcoming Vol 50, No. 4.

Laschke and Weber (1999) 'Der Overconfidence Bias und seine Konsequenzen in Finanzmärkten,' *Sonderforschungsbereich 504, Working Paper Series No. 99-63*.

Merril Lynch (1996) **'**You and your Money. A Financial Handbook for Women Investors', New York.

Odean, T. (1999) 'Do Investors Trade Too Much?,' *American Economic Review*, Vol. 89, December 1999, 1279-1298.

Powell, M. and D. Ansic (1997) 'Gender Differences in Risk Behavior in Financial Decision-Making: An Experimental Analysis,' *Journal of Economic Psychology*, 18 (6), 605-28.

Rabin, M. (1998) 'Psychology and Economics,' *Journal of Economic Literature*, Vol. XXXVI, pp. 11-46.

Schubert, R., M. Brown, M. Gysler and H. W. Brachinger (1999) 'Financial Decision-Making: Are Women Really More Risk-Averse?,' *American Economic Review (Papers and Proceedings)* 89 (2), 381-385.

Schubert, R., M. Gysler, M. Brown and H. W. Brachinger (2000) 'Gender Specific Attitudes Towards Risk and Ambiguity: An Experimental Investigation,' *Working Paper, Center for Economic Research, Swiss Federal Institute of Technology, Zurich.*

Sunden, A. and B. Surette (1998) 'Gender Differences in the Allocation of Assets in Retirement Savings Plans,' *American Economic Review*, 88 (2), pp. 207-211.

Svensson, O. (1981) 'Are we all less risky and more skillful than our fellow drivers?,' *Acta Psychologica*, 47, pp. 143-148.

Taylor, K. (1995) 'Testing Credit and Blame Attributions as Explanation for Choices under Ambiguity,' *Organizational Behavior and Human Decision Processes*, Vol. 64 (2), pp. 128-137.

Tversky, A. and D. Kahneman (1992) ‘Advances in Prospect Theory: Cumulative Representations of Uncertainty,’ *Journal of Risk and Uncertainty*, Vol. 5 (4), pp. 297-323.

Wang, P. (1994) ‘Brokers still treat Men better than Women,’ *Money*, 23 (6), pp. 108-10.