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INVESTORS' BEHAVIOUR AND PERFORMANCE IN VARIOUS RISK ENVIRONMENTS: RESULTS OF A CLASSROOM EXPERIMENT

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Abstract. Investor's behaviour, his or her risk tolerance and risk aversion depending on the level of risk in investment environment and his or her emotional condition is a very interesting field of financial research. There is a vast amount of literature on decision-making in the conditions of uncertainty and risk, also how emotions affect investment decisions. Using data from an originally designed classroom experiment, investors' behavioural patterns, their investment performance in risk-free and risky environments are studied. Also the differences between male and female investment behaviour and financial performance, and the effect of the amount of the initial endowment are considered.

Keywords: behavioural finance, financial experiments, risk, investment performance, investment decision-making.

JEL classification: C91, G02, G11.

1. Introduction

Investment behaviour under risk or uncertainty has been a widely researched topic in behavioural finance, and various effects and impact factors affecting decision-making process have been studied. All investors want to make sound, unbiased decisions, and not take excessive risks without additional gains. A better understanding of our behaviour in an investment setting may provide grounds for better decisions.

The aim of this paper is to clarify the difference in the performance of individuals' investment behaviour in different risk settings. In order to construct various risk environments the author designed an original classroom experiment that formed the basis for the current research. An additional focused attention is paid to the difference in the investment performance by males and females since gender differences in investing are a continuously intriguing issue.

During the last decades economic games and classroom experiments have become increasingly popular in teaching a wide range of topics, from international economics (e.g. Johnson 2010) to management accounting (e.g. Schwartz *et al.* 2007). Of course, experiments and games are now inseparable from teaching principles of microeconomics and macroeconomics; hereby it is appropriate to refer to Chamberlin (1948) as a first market experiment published in an academic journal. The experiment introduced in this paper was not elaborated as a part of a syllabus of a course on investments. However, as participants affirmed, it was pretty useful, and could be considered as edutainment.

The paper is structured in the following manner. In section 2 a review of the literature relevant to this topic is provided; the author discusses several streams of research. Next, a description of the experiment design is provided with some discussion on potential limitations and problems. After that, the author presents the results, and the paper is finalized with conclusive remarks. The format of this paper presupposes that some information and descriptions have to be present in a contracted form; only the key aspects are paid attention to.

2. Literature review

As the topic under consideration in this paper is multifaceted, it would be appropriate to provide a literature review of three different research directions: risk-taking behaviour in the process of investment decision-making, gender differences in an investment setting and risk-taking behaviour, and an experimental approach to study the investor's behaviour.

There is a substantial amount of research related to risk-taking behaviour in an economic context, as well as investment decision making under risk and uncertainty. Hereby it is apt to mention seminal works by Slovic (1964) where issues of risk taking measurement were discussed. The rela-

tionship between risk and decision-making was given a new dimension in fundamental papers by Tversky, Kahneman (1974), Kahneman, Tversky (1979) in which it was showed that judgments under uncertainty are affected by heuristics; risk preference depends on a decision-maker's prospect, whether a decision-maker faces gain or loss. Later these works were developed into Tversky, Kahneman (1981), Tversky, Kahneman (1992). Prior to works by A. Tversky and D. Kahneman, P. Slovic analyzed the investment decision process of stockbrokers and discussed implications of judgment for investment decision making (Slovic 1969; Slovic 1972). Differences in risk tolerance and risk taking in an international context were examined in Kantšukov, Linnas (2013) who assessed and compared risk propensity of chief financial officers in Sweden, Estonia and Ukraine. However, the sample in the latter study was too small to make extended generalizations.

The role of emotions in investment decision-making process has been largely discussed in academic literature. Emotions, such as fear or euphoria, may have negative or positive effects on an individual's readiness to take risks or trade actively. Some of the recent papers on the relationship between emotions and investing include Moreno *et al*. (2002), Levy, Galili (2006); Daniel *et al*. (2002) provide extensive evidence on how investors' psychological biases affect their behaviour and asset prices. In Shiv *et al*. (2005) it was found that patients with stable focal injuries related to emotion made more advantageous investment decisions than those who had had stable focal injuries unrelated to emotions. All in all, emotional condition of an investor may affect his or her investment behaviour and decision-making that in turn affects his or her investment performance.

Regarding research devoted to gender differences in investment behaviour, risk-taking and risk perception in investment framework one can bring out several remarkable studies.

Hudgens, Fatkin (1985), using an experimental approach found that males exhibit greater risk-taking than females. Powell, Ansic (1997) examined gender differences in financial decision-making strategy and risk propensity; according to results, females were less risk-seeking than males irrespective of many factors. Barber, Odean (2001) found that investment portfolios of female investors tended to perform better compared with portfolios of male investors albeit men traded more actively with securities than women.

Dwyer *et al*. (2002), using a large dataset on mutual fund investors, found that female investors tend to take less risk than male investors in their mutual fund investments; however, this difference diminishes once accounted for financial knowledge. Results by Dwyer *et al*. (2002) refute earlier results by Hudgens, Fatkin (1985). Atkinson *et al*. (2003) found that male and female mutual fund managers did not differ significantly in terms of performance and risk, however gender influenced the decision-making.

Talpsepp (2010) studied disposition's effect on an example of investors in the Estonian stock market; his results confirmed earlier results by Barber, Odean (2001). Additionally the relationship between age and portfolio management performance was studied: it was concluded that older investors had had better investment performance vis-à-vis younger investors. A recent large-sample based study by Liersch (2013) from Merrill Lynch did not find a significant difference between men and women in their approach to investing, although the statement about females' greater risk-aversion was not also debunked. A study by Sapienza *et al*. (2009) provides an explanation for the reason of gender differences in financial risk aversion – risk aversion is affected by testosterone although this relationship is not linear Based on the results of studies of this stream of research it is possible to claim the difference between male and female approach to investing which may influence the investment performance.

Using an experimental approach to study investors' decision-making is not something new. One can find descriptions of many experiments and investment games both in academic as well as educational literature. Many experiments can be presented as examples. Barua, Srinivasan (1991) studied investors' behaviour using experimental data; their main focus was on investors' risk perception and utility function.

Berg *et al*. (1995) designed an experiment to study the presence of reciprocity and trust in an investment setting; later it was presented in a simpler format by Chaudhuri (2001). A very comprehensive list of classroom experiments and games in economics can be found in Brauer (1994); they are also represented in a more convenient way on the website of professors Greg Delemeester and Jurgen Brauer 'Games Economists Play' (Games Economists Play…). Of course, the impact of various inputs and factors on investment decisions was studied using an experimental approach already several decades ago, e.g. Elias (1972), Teoh, Shiu (1988), Hill, Viceisza (2010). Cipriani, Guarino (2009) studied herd behaviour in an artificial financial market on the example of financial market professionals. One of the latest is the study by Putri, Arofah (2013) where the authors studied the impact of risk information reports on investment analysts' decision-making.

The author of the present research contributes to the topic of investment decision-making by constructing the experimental model of a securities market where participants unknowingly compete between each other for the highest gain. In the present study previously observed streams of research are amalgamated by combining topics of investment decision-making under risk, experimental analysis, and gender differences in financial behaviour.

3. Empirical analysis

3.1. Experiment design

In order to compare investment behaviour of individuals in environments with risk and without risk, also to document their emotional conditions it was decided to conduct an experiment as other approaches seemed unfeasible.

The experiment was designed solely by the author of this paper; the data collection process was assisted by a couple of undergraduate students from the Faculty of Economics and Business Administration (FEBA), at the University of Tartu. The idea behind the experiment was to simulate interaction between participants of a stock market, observe their investment behaviour, e.g. whether participants were taking low, modest, high risk, diversified portfolios etc. In some sense the framework of the experiment resembles that of Bell (1993) although the author was not aware of Bell (1993) paper at the time the experiment described further was developed.

The experiment was conducted in groups of three. In total there were 60 participants and 20 groups. Also, at the beginning three pilot experiments were conducted that revealed some errors in the underlying model; and thus the results of these treatments were not included into the analysis. The author's desire was to monitor the difference between male and female investment behaviour. That is why groups were either all-male or all-female. There were 10 all-male and 10 all-female groups. Participants were invited on a voluntary basis, and the majority of them were students of the FEBA of the University of Tartu. The experiment also took place in the FEBA rooms. Female participants' median age was 23 years (with median absolute deviation of 1 year), male participants' median age was also 23 years (with median absolute deviation of 1 year). As the experimental framework was pretty sophisticated, participants were requested to bring their notebooks so that they could use MS Excel file to document their transactions. These files were later collected, and they formed the basis of empirical analysis. In parallel, experimenters had the master MS Excel file that helped to keep track and double-check transactions of all the participants in the group. This double-checking was implemented to prevent possible errors that could alter actual results.

The experiment was conducted before Estonia joined the euro zone, that's why we operated with Estonian currency, Kroon, as a monetary unit. (Estonian Kroon was pegged to the euro at a fixed exchange rate of 15.6466 = 1 euro.) Each participant was endowed a certain amount of (virtual) money, either 75 EEK (≈ 4.79 EUR), 100 EEK (≈ 6.39 EUR) or 125 EEK (≈ 7.99 EUR). The different amounts of endowment were introduced in order to test the relationship between the amount of the initial endowment and a final portfolio value, i.e. whether participants who had a larger amount of the initial capital could increase the value of their capital more than those with a lower amount of the initial capital. It is also important to add that each participant was endowed the same amount of the initial capital during the risky and risk-free series; this allowed observing how well the participant handled his/her money in various risk contexts

Endowed capital could be invested into hypothetical securities X, Y and Z. with initial prices 20, 15, and 10 Estonian Kroons respectively (equivalently ≈ 1.27, ≈ 0.96 and ≈ 0.64 euros). There were dividend payments on each security to be made at the end of each session of a series:

- security X paid 5 Kroons (≈ 0.32 euros) per share with 100% probability,
- security Y paid 2.5 Kroons (≈ 0.16 euros) with probability of 50% and 5 Kroons with probability of 50%,
- security Z paid 5 Kroons with probability of 50% and nil with probability of 50%.

Thus, the initial expected dividend yield for all the securities at the beginning of the session was 25%; however, participants could select securities according to their risk tolerance.

The experiment consisted of two series, risk-free and risky; each series consisted of 5 sessions. The difference between risky and risk-free series was very simple: by the end of the fifth session of a risky series one of the randomly selected securities was defaulted (by the roll of a dice), i.e. the value of this security dropped to zero. In the context of the present research every participant faced the risk of default. Ignoring a possible default of a security (which can be compared to the bankruptcy of an underlying company in a real life) could result in a significant decrease of portfolio value. It is possible to claim that the core of this experiment was in the difference of participants' investment

behaviour and performance during risk-free and risky series.

In each session of a series participants had to make investment decisions regarding the purchase or sale of securities. For the sake of simplicity it was not possible to lend securities or sell them short; also it was not possible to borrow money to buy securities. During the first session of each series participants could only buy or keep the cash. In the end of each session there were dividend payments made; as dividends on securities Y and Z were random then the amount of dividends on these securities was determined using a random mechanism (the toss of a coin). At the beginning of the next session participants had to make new decisions regarding the sale and purchase of securities – this way it worked till the end of a series. At the end of a series the total value of each participant's portfolio (securities plus cash) was calculated. The second series proceeded on the same basis.

The price mechanism was developed to assure that prices of securities changed from session to session. The formula of the price was elaborated by the author in a manner that the price would depend on the number of sold-purchased securities. If there were more securities bought than sold (sold than bought) then the price would increase (decrease). The formula itself looks as follows:

$$P_{j,t} = P_{j,t-1} \cdot \left[1 + \ln\left(1 + \frac{N^{+}_{j,t} - N^{-}_{j,t}}{P_{t-1}} \right) \right], \quad (1)$$

where:

$P_{j,t}$ – price of a security j in session t (j = 1…3, t = 1…5),

$N^{+}_{j,t}$ – total amount of security j purchased by participants during session t,

$N^{-}_{j,t}$ – total amount of security j sold by participants during session t,

For example, if the last price of a security was 16 EEK, and during the current session one of the participant's buys 3 securities, the second one buys 1, and the third one sells 2 securities, then the difference between number of purchased and sold securities is 2, then the new price is ≈ 17.88 EEK. If during the session there were 4 securities sold and one security purchased then the difference would be -3, and the new price ≈ 12.68 EEK. If a number of purchased and sold securities was the same, the price would not change.

People involved in the experiment directly influenced price movement, and they could pump up the volatility, i.e. significantly increase or decrease prices. Participants were not told about the formula; also they were not told about how new prices were configured. In a room where the experiment took place, participants were placed so that they could not communicate with each other or exchange information on transactions.

The winner of the experiment was the person whose average return over sessions of risk-free and risky series was the highest. In order to stimulate participants activeness, at the beginning of the experiment it was announced that the winner would receive 25% of the average of final portfolio values – over risky and risk-free series – in hard cash (actually, when enrolling students for the experiment, each participant was promised to be compensated in the case he or she will win).

The design of the previously described experiment is far from flawless both formally and practically. For instance, the fact that for each experimental group different securities were defaulted aggravates the comparison of participants' performance. This is also true for random dividend payments – as in each session of a series dividend payments were allocated according to a random mechanism then dividend payment patterns distort the comparison of investment performance. Also one can question adequacy of the price mechanism formula.

A separate issue is associated with the choice of participants. As the overwhelming majority were students of economics and business, this potentially creates some bias and space for criticism (e.g. students are not "real people" in the sense that they lack employment and investment experience, sample of students may be not representative from the points of view of education, age, social status). In addition some of the participants were not interested in investing or financial markets; additional explanations regarding the mechanism of purchase and sale of securities, and dividend payments were needed. On the contrary, there were participants with the level of knowledge about financial markets and investments above the average, who were experienced in stock trading (or gambling). Hereby it is appropriate to refer to the opinion of a recognized behavioural economist Dan Ariely who remarks that when testing core behaviour, e.g. when making decisions about buying or selling something, students do not differentiate much from other people (Ariely, Real-world endowment).

The experiment also involved the questionnaire on state-trait anxiety inventory (STAI) developed by C. Spielberger, R. L. Gorusch and R. E. Lushene. This was done in order to observe changes in participants' anxiety during the experiment and relationship between the level of anxiety and investment performance. Every participant

had to fill the questionnaire three times: before the first series, after the first series (before the second one), and at the end of the experiment. This part of the analysis helped to establish the connection between each participant's emotional and his/her investment performance.

3.2. Results

Results of the experiment were largely in accordance with preliminary expectations and results of previous research. Although statistical testing was not planned for this study, some results of statistical testing are reported on a selective basis. The author was interested primarily in differences in the performance of male and female participants, and differences in performance during risk-free vis-à-vis risky series. However, one should keep in mind the relatively small sample size and participants' heterogeneous (education and experience with investing first of all) background when making conclusions and generalizations.

First of all, participants' average return per session in a risk-free series was higher than average return per session in a risky series, 27.1% versus 17.7%, and this difference was statistically significant at $\alpha = 0.05$. At the same time, the difference between volatilities of return was not that remarkable: it was 10.3% during session in a risk-free series and 9.2% during session in a risky series. The volatility was measured as the standard deviation of price return.

At this point it has to be mentioned that the sequence of series (risk-free first, risky second or vice versa) did not play a role as in every group average return in a risk-free series was higher than average return in a series with risk. The next two figures demonstrate that. Groups' average returns are ranked from minimal till maximal based on the group average return during the first series.

As one can see no group earned higher return during the risk containing series compared with the risk-free series, regardless of the sequence of series. However, this result is pretty much trivial; orders of series were changed from group to group to measure difference in participants' levels of anxiety, and exclude the impact of sequence of a series on outcomes of the experiment.

During the risk-free series participants invested on average 149.3 Kroons (9.54 EUR), whereas during the series with risk, the average invested amount was only 71.3 Kroons (4.56 EUR). This difference was also statistically significant (Prob. = 0.0000); on the basis of this it is possible to conclude that during the risky series participants practiced more risk-averse investment behaviour. Consequently portfolio value by the end of a risk-free series was on average higher than portfolio value by the end of a series with risk (347.2 EEK, or 22.2 EUR versus 236.2 EEK, or 15.1 EUR). This difference was also statistically significant (Prob. = 0.0000).

The picture of investment performance becomes more interesting when results are broken down by gender. Below there is a table that contains data on average, maximal and minimal return and return volatility for all groups, and male and female groups separately.

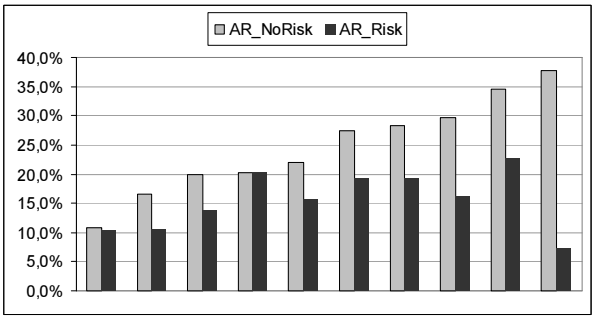

Fig. 1. Average return per risk-free session (AR_NoRisk) and average return per risky session (AR_Risk) for groups with risk-free series as a first (Source: composed by the author)

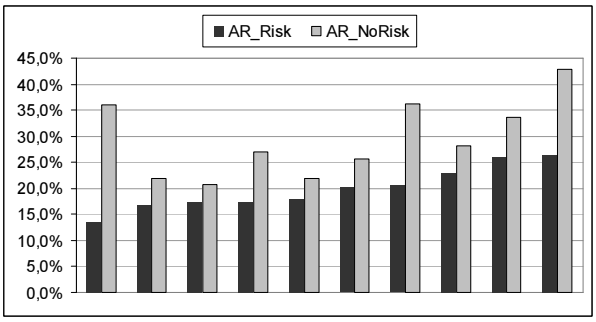

Fig. 2. Average return per risk-free session (AR_NoRisk) and average return per risky session (AR_Risk) for groups with risky series as a first (Source: composed by the author)

The third column, 'with risk', marked with an asterisk, contains data on returns on the condition that securities did not default. It shows which return would be earned by participants over all, male and female groups if no securities were defaulted. Obviously, this adjustment does not change values of maximal returns but alters values of average and minimal returns, and also volatility. This way it is possible to compare participants' investment performance during risk-free and risky series net of influence of chance.

As one can notice, males' average return per session was higher than females' both in the case of risk-free and risky series. This difference be-

tween males' and females' performance is significant in the case of risk-free series (t-stat. = 4.027, Prob. < 0.05), in the case of risky series this difference is not statistically significant (t-stat. = 1.202, Prob. > 0.05). However, it is remarkable that maximum return in the risky series was demonstrated by a female participant. Also, negative (minimal) return of the risk containing series was larger in absolute terms for male groups (the situation changes if one is to neglect default of securities in the risky series).

Table 1. Average, minimal and maximal returns on participants' investments in the experiment (compiled by the author)

	Participants' return per session of a series		
	risk-free	with risk	with risk*
All			
Average	27.05%	17.75%	21.62%
Max	62.67%	41.19%	41.19%
Min	9.77%	-16.97%	4.79%
Volatility	10.32%	9.18%	7.03%
Male			
Average	31.84%	19.17%	21.42%
Max	62.67%	33.03%	33.03%
Min	15.44%	-16.97%	9.76%
Volatility	11.25%	9.58%	6.25%
Female			
Average	22.27%	16.33%	20.84%
Max	36.04%	41.19%	41.19%
Min	9.77%	-12.29%	4.79%
Volatility	6.54%	8.69%	7.77%

When thinking of a possible optimal investment strategy during the series with risk, especially if a participant has no clue about how prices change, then probably obvious choices would be either exiting all the positions in the fifth (last) session or diversification of holdings. Of course, particular behaviour and financial decisions largely depend on one's risk aversion but in a game-theoretical setting, when you have to compete with other participants for real cash, it would be more rational to sell all the securities.

An analysis of participants' investment behaviour during the risky series revealed that among 60 participants 31 would have the same return on their investment if no security was defaulted. This means that those participants either exited all the positions they had or they were simply lucky in a sense that they did not hold a defaulted security in their portfolio by the end of fifth session. Of these 31 participants roughly half (16, or 26.7%) were those who sold all the securities, and the other half (15, or 25%) were lucky. Also it is remarkable that out of 20 experimental cases, the same persons were the winners of a risk-free and a risky series 12 times; in male groups it occurred 8 times and in female groups 4 times. Of course, there is too thin ground to make a conclusion that the proportion of investors who can outperform others in any risk environment is higher among men than women, but in the author's opinion this result is worthy of further inquiry.

An additional issue is connected to the relationship between the amount of the initial endowment and participant's final portfolio value by the end of a series. This relationship was studied by correlating the amount of the initial endowment with portfolio value at the end of risk-free and risky series. Plus, the relationship between the initial endowment and a final portfolio value was analyzed separately for male and female group. Results are presented in the following Table 2.

Table 2. Correlation between participant's initial endowment and portfolio's final value (compiled by the author)

	Spearman's ρ	Prob.
Asset value by the end of a risk-free series		
All	0.380	0.0028
Male	0.217	0.2495
Female	0.590	0.0006
Asset value by the end of a risky series		
All	0.463	0.0002
Male	0.443	0.0141
Female	0.481	0.0071

As it turned out, on a general level the relationship between the amount of the initial endowment and the final portfolio value at the end of a risk-free series was positive and statistically significant. However, when looking separately at men and women, the correlation between male participants' initial endowment and portfolio's final value was not statistically significant; in the case of female participants this relationship was strongly positive and statistically significant. This may lead to the possible conclusion that in the absence of risk the amount of the initial endowment is not so crucial for male investors; final results could be largely determined by skills and knowledge. At the same time, the relationship between the amount of the initial endowment and portfolio's final value during the risky session was both remarkably positive and statistically significant for male and female participants.

Regarding real cash paid to the winners during all the experiments, the total amount was 120 euros. Of this amount 50.17 euros were received by the female winners and 69.83 euros by the male winners.

An analysis of the STAI questionnaire demonstrated that participants' pre-experiment anxiety level was significantly higher than after the risk-free series (Prob. = 0.0015), and anxiety level before the experiment was not statistically different from anxiety level after the risky series (Prob. = 0.5067). Also there was found no statistically significant relationship between participant's gender and the (trait and state) anxiety scores (Prob. > 0.05).

It is also important to note that the state anxiety score after risky series was significantly higher than the state anxiety score after risk-free series (t-stat. = -2.818, Prob. = 0.0065) which can support the conclusion that emotionality is higher in the situation with risk. However, this difference (the state anxiety score at the end of a risk-free series minus the state anxiety score at the end of a series with risk) was in a weak negative (-0.269) but significant correlation (Prob. = 0.0376) with series order (risk-free series first and then risky, or vice versa), i.e. the state anxiety score by the end of a risk-free series tended to be higher than the state anxiety score by the end of the risky series if the first series was risk-free, and contrariwise.

It was interesting that for all the participants the correlation between the state anxiety score after the risk-free series and session average rate of return during the risk-free series was not significant (Prob. > 0.05), whereas the correlation between the state anxiety score at the end the risky series and session average return during the risky series was negative (–0.395) and significant (Prob. = 0.0018). However, for male groups this correlation was not significant (Prob. = 0.0652) but for female participants it was (Prob. = 0.0051). This may raise a hypothesis that women's investment behaviour and performance are influenced by emotions more than that of men's but it needs more profound scrutiny, especially for causality of this relationship.

4. Conclusions

The classroom experiment described in this paper allows various aspects of investment behaviour to be studied: the difference between male and female investors, behaviour patterns and investment strategies under different risk conditions, the relationship between the amount of the initial endowment and investment performance. One can also measure participants' anxiety level in order to understand investors' emotions before and after the experiment, and also check the relationship between participants' anxiety and their investment performance.

All the participants demonstrated more conservative investment behaviour during the risky series that was in line with expectations: if there is a danger of losing the money one does not risk so much compared to the situation where such a danger is absent. During the risky series not all the participants exited their positions or followed diversification strategy which demonstrates either risk-seeking behaviour or lack of understanding of the essence and impact of risk. In contrast to previous findings by Barber, Odean (2001), Talpsepp (2010), male participants' investment performance during the experiment was better than female participants' performance. Also there can be made cautious conclusions that for male investors the amount of the initial endowment is not correlated with their investment performance in a risk-free environment; in the case of female investors their anxiety is negatively correlated with return on investment in a risky investment setting.

This difference was not controlled for participants' knowledge of financial markets and investment skills, i.e. participants were not asked about their investment experience and educational background. The relatively small sample size may also undermine the reliability of the results.

Despite the findings the author sees his main contribution in the educational aspect of the experiment (e.g. when teaching concepts of risk and diversification in the investments class). As it was shown, for instance, by Frank (1997), Durham *et al*. (2007) experiments can be beneficial for students in their study process improving students' performance; teaching economics via using classroom experiments is discussed in Holt (1999). Of course, there are potentially several shortcomings in the experiment itself as well as limitations in implementing it (duration, availability of computers etc.). One must not forget the problem of incentives for participants in an experiment as it is discussed in Dickie (2006).

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