The Motivated Beliefs of Investors Under Limited Liability*

Steffen Ahrens†
Ciril Bosch-Rosa‡

October 2, 2019

Abstract

We demonstrate that experimental subjects form motivated beliefs to self-justify any "excessive risk-taking" under limited liability. Using a new experimental design, we compare the risk assessment that experimental subjects make when a) they invest their own endowment or b) they invest someone else's. In control blocks, all subjects are responsible for their investments and reap all accruing gains or losses. In treatment blocks, banker subjects invest the endowment of client subjects. If the outcome of such investment is positive, then the gains are split between both of them. On the other hand, if the outcome is negative, then client absorbs all losses. Our results show that, in such treatment, for the same investment opportunity, banker subjects both invest more and expect higher returns to their investments. This suggests the existence of cognitive biases in financial decision-making and gives support to the recent literature on the formation of motivated beliefs to maintain a positive self-image.

Keywords Moral Hazard · Cognitive Dissonance · Motivated Beliefs

JEL Classification C91 · D84 · G11 · G41

*Corresponding author: cirilbosch@gmail.com. The authors would like to thank Dirk Engelmann, Jana Friedrichsen, Daniel Gietl, Anna Gumpert, Frank Heinemann, Peiran Jiao, Shyam Sunder, and Roel van Veldhuizen for their useful comments. We also thank Juan Dominguez Morán for the programming of experimental software and the testing support. Additionally, the authors gratefully acknowledge financial support from the Deutsche Forschungsgemeinschaft (DFG) though the CRC TRR 190 "Rationality and Competition." All remaining errors are ours.

†Technische Universität Berlin, Universität Konstanz

‡Technische Universität Berlin

1 Introduction

Most people hold certain moral beliefs and will strive to uphold them to maintain a positive self-view (Festinger, 1962; Epley and Gilovich, 2016). Yet, quite often they are confronted with situations in which their actions are in conflict with such principles. This creates a psychological discomfort that psychologists refer to as "cognitive dissonance" (Festinger, 1962). A common way to deal with such tension is to modify one's beliefs by, for example, shifting appropriately the likelihood of an outcome to justify a selfish action (Haisley and Weber, 2010; Gino et al., 2016) by selectively overweighting information that is supportive of the selfish action (Zimmermann, forthcoming; Eil and Rao, 2011). In other words, when our actions are not aligned with our views we might form motivated beliefs in a trade-off between holding accurate or desirable beliefs (Bénabou and Tirole, 2016).

In finance, the formation of such motivated beliefs can lead investors to stay in low performing investments (Goetzmann and Peles, 1997; Cheng et al., 2014), induce the disposition effect (Chang et al., 2016), and give rise to excessive risk-taking under limited liability (Barberis, 2015). Concerning the latter, (Barberis, 2015) argues that, because of limited liability, investors might inadvertently bias downwards the risk perception of their investments to maintain a positive self-image while still profiting from their excessive investments.[1]

In this paper we use experimental methods to test whether limited liability induces motivated beliefs on investors. Using a novel experimental design we compare the risk assessment and investments that subjects do under full and limited liability. In control rounds, subjects evaluate different assets and decide how much to invest in each of them. Because there is full liability, subjects reaping all gains but also absorbing any losses. In treatment rounds, on the other hand, subjects are divided into bankers and clients. Clients are passive spectators while Bankers evaluate the different assets and decide how much of the clients' endowment to invest in each of them. If the investment results in gains, then the profits are split between banker and client. If there are losses, then the

[1] Note that while this phenomenon holds a strong resemblance to what Bénabou et al. (2018) call "absolving narratives," the motivated beliefs in Barberis (2015) and Bénabou (2015) are fundamentally different as they are not formed after the realization of the investment, but rather at the moment of making the investment. In other words, the type of motivated beliefs we are interested in are *decision-related*, not *outcome-related*.

client absorbs all of them leaving the banker with no gains nor losses. Our design allows us to isolate any change in beliefs that might come from the sudden change in the trade-off between accurate and desirable beliefs arising from the limited liability.

We are the first to study the effect of limited liability on the motivated beliefs of financial investors. The results are clear: under limited liability bankers take higher risks and expect significantly higher returns than they do for the same investment under full liability. Such result points towards the presence of motivated beliefs as predicted by Barberis (2015), Bénabou (2015), and Bénabou and Tirole (2016).

This paper is part of a trend in behavioral finance which aims to understand how investors form beliefs and make decisions in financial markets using experimens (e.g., Nosić and Weber (2010); Bosch-Rosa et al. (2018); Weber et al. (2018)). More precisely, we are part of the literature that investigates cognitive biases in financial environments. Some previous work in this area that is close to our research are Chang et al. (2016) and Mayraz (2017). While the first investigates the effects of delegation on the disposition effect, the second studies the effects of "wishful thinking" on investors.

Our contribution is to analyze whether limited liability affects the beliefs of investors, and by extension, their actions. This is relevant as A) it contributes to the growing literature on "motivated beliefs" (Bénabou and Tirole, 2011, 2016; Bénabou, 2015; Gino et al., 2016) by shedding light on the effects that incentives have on the beliefs of financial investors and B) it clarifies the channels through which limited liability induces excessive risk-taking by financial investors.

The paper is organized as follows. Section 2 presents our experimental design. Section 3 presents the results of the experiment. Finally, Section 4 concludes.

2 Experimental Design

The core of our experiment is divided into two blocks of three rounds. In each round we present subjects with a graph showing the daily prices of a stock from the DAX30[2] for eleven consecutive years (see Figure 1). Subjects know that the data comes from the DAX30, but are neither told the exact years of the data nor the name of the company. Additionally, they are told that all time-series have been shifted such that the price at

[2] Germany's prime blue chip stock market index.

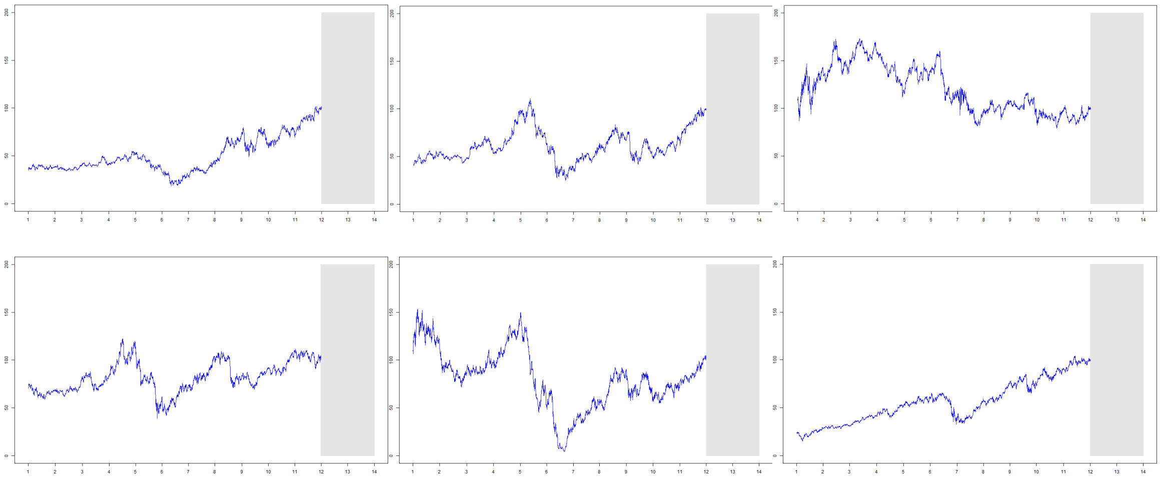


Figure 1: The six graphs presented to subjects (from left to right and from top to bottom): (1) Bayerische Motoren Werke AG, 27-Jun-03 – 27-Jun-16; (2) Daimler AG, 20-Jun-03 – 20-Jun-16; (3) Deutsche Telekom AG, 10-Sep-02 – 10-Sep-15; (4) Siemens AG, 05-Jan-04 – 05-Jan-17; (5) Infineon Technologies AG, 08-Jul-03 – 08-Jul-16; (6) Linde AG, 18-Dec-02 – 18-Dec-15. All data are downloaded from Google Finance

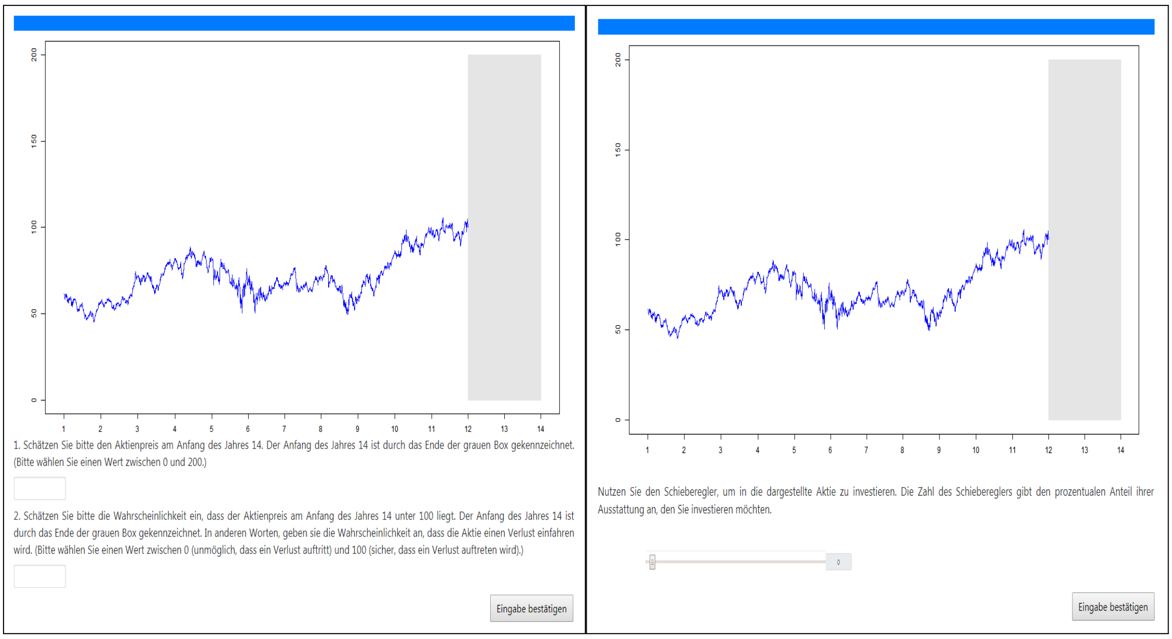
the beginning of the 12th year is always € 100. Additionally, they know that they will not get any feedback until the end of the experiment, and that the specific instructions for each block will be read immediately before it starts.

2.1 Belief Elicitation and Investment

In each round, after seeing an animation representing the evolution of prices for the anonymous stock, subjects are presented with the Assessment Screen (see left panel of Figure 2). In this screen they are asked to assess the probability that the price of the stock will be below € 100 by the beginning of the 14th year (i.e., the likelihood of a loss), and to guess the price of the stock at that point. Once this is done they move to the Investment Screen.

For each Investment Screen (see right panel of Figure 2) subjects are endowed with € 10 and asked to invest as much as they want of this endowment into the stock they just assessed. The return (Π_i) to the investment (I_i) of subject i will be the difference between the price at the beginning of the 12th year (€ 100) and the price at the beginning of the 14th year ($price_{t=14}$). Any amount that the subject does not invest in the stock is assumed to go into a risk-free asset with no returns. This leaves the payoff for the investment phase as:

$$\Pi_i = I_i * \frac{price_{t=14}}{100} + €10 - I_i. \tag{1}$$



(a) First Screen (b) Second Screen

Figure 2: Screen for the belief elicitation phase. Subjects are asked for the probability that the price of this stock will be below 100 at the beginning of the fourteenth year, and for an exact estimate of this price. Notice that the graph presented in this screen is one of the randomly generated graphs used during practice rounds. For more details on practice rounds see the instructions in Appendix B.

After making their investment decisions subjects immediately move to the next round where they are presented with a new Assessment Screen containing a different graph to asses. This process is repeated three times, after which the instructions for the second block of three rounds are read aloud.

Eliciting beliefs prior to the investment decision allows us to measure cleanly the effect of the change in the mindset on the motivated beliefs, free of other behavioral biases such as wishful thinking. This approach assumes that cognitive dissonance is an explicit contributor to the decision making process (e.g. Rabin, 1994; Konow, 2000; Oxoby, 2004). Alternatively, cognitive dissonance may arise in retrospect in order to self-justify (the outcomes of) past decisions (e.g. Akerlof and Dickens, 1982; Goetzmann and Peles, 1997; Chang et al., 2016). Such a view is approximated by changing the order of belief and investment elicitation in our experimental design. Note, however, that investing first allows for wishful thinking to enter the motivated beliefs.

2.2 Control and Treatment

In each session one of the blocks is a Control block and the other is a Treatment Block. The difference between the Treatment and Control blocks is that before the start of Treatment blocks half of our subjects are assigned the role of "Bankers" while the other half are "Clients." Subjects are aware of their specific type before the the block starts, and they know they will keep the type for the whole block. The structure and tasks in Treatment blocks are identical to those of Control, except for the investment part. In this part, Bankers will be making investment decisions (I_i^B) not over their endowment, but over the endowment of clients (j). So while both get € 10 in each round, Bankers are assumed to invest their whole endowment in the risk-free asset, while deciding how much to invest of client j's endowment. If the investment is profitable (i.e., $price_{t=14} \geq$100), then the Banker and Client split the gains. On the other hand, if the investment turns out sour (i.e., $price_{t=14} < 100$), then the Client absorbs the whole loss.[3] Therefore, the payoff for Banker i in Treatment rounds is:

$$\Pi_i^B = \begin{cases} \left(I_i^B * \dfrac{price_{t=14}}{100} - I_i^B\right) * 0.5 + €10, & \text{if } p_{t=14} \geq 100 \\ €10, & \text{if } p_{t=14} < 100 \end{cases} \tag{2}$$

Analogously, the payoffs for Client j, who is paired with Banker i, are:

$$\Pi_j^i = \begin{cases} \left(I_i^B * \dfrac{price_{t=14}}{100} - I_i^B\right) * 0.5 + €10, & \text{if } p_{t=14} \geq 100 \\ I_i^B * \dfrac{price_{t=14}}{100} + €10 - I_i^B, & \text{if } p_{t=14} < 100 \end{cases} \tag{3}$$

The payoff structure and investment opportunities in our experiment seem well suited to study the effects of cognitive dissonance in financial markets. To see this, consider the example used by Barberis (2015) of traders on the mortgage desk of banks: because subprime products were usually complex, there was scope for traders to manipulate their beliefs (as a self-justification for excessive risk-taking), as it would be hard to argue against any assessment they had made. Similarly, the ambiguity of the products offered to Bankers in our experiment lends itself particularly well to belief manipulation, allowing us to study the effects of limited liability on the risk assessment of Bankers.

[3] We acknowledge that incurring in losses might have a reputational cost for bankers. Yet, for the sake of simplicity, and to make moral hazard most salient, we decided that bankers incur a zero cost in case of a failed investment.

2.3 Details on payoffs

In total, across both blocks, we elicit six times the probability that the stock will suffer a loss, the expected price, and the investment decision for each subject. To incentivize the choices in the Assesment Screen we used the binarized scoring rule (Hossain and Okui, 2013), where subjects' payoff is either 0€ or 5€. The binarized scoring rule is incentive compatible and robust to any risk preferences subjects might have. Additionally, to avoid any hedging, subjects were paid for only one of their six choices for the loss assessments, price predictions, and investment (be it in the Control or Treatment block). The payoff relevant decisions were randomly and independently chosen by the computer, so a subject might get paid for her price prediction in round three, her investment in round four, and the accuracy of the assessed loss likelihood in round six. This payoff structure makes the moral hazard effect even more salient since the (unique) payoff for the investment decision was equally likely to come from the Control or Treatment block.

2.4 Personality Traits

Finally, subjects take part in a third block in which we elicit their personality traits. This block includes tests for risk, ambiguity, and loss aversion through a modification of the multiple price lists used in Rubin et al. (2017). Additionally, to measure their cognitive ability, subjects answer the CRT (Frederick, 2005), CRT2 (Thomson and Oppenheimer, 2016) and eCRT (Toplak et al., 2014) questions. Subjects also answer the short version of the Big Five personality traits suggested by Rammstedt and John (2007), as well as the three questions on financial literacy that we borrow from Lusardi and Mitchell (2011). At the end of the block they are asked to state their gender, field of study, and age.

3 Results

A total of 218 subjects were recruited through ORSEE (Greiner, 2004). All sessions lasted two hours and were run at the Experimental Economics Laboratory of the Technische Universität Berlin. Subjects made on average 23.04€, and the experiment was programmed and conducted using O-Tree (Chen et al., 2016).

We ran three types of sessions: Type 1 sessions ran first the Control Block presenting subjects with graphs 1-3 and then the Treatment Block using graphs 4-6. Type 2 sessions started with the Treatment block using graphs 4-6 and followed by the Control Block using graphs 1-3. This allows us to control for the ordering effects of each block. Type 3 sessions, on the other hand, have the same ordering as Type 1 sessions (Control then Treatment), but with inverted graph order, so in Control subjects are presented with graphs 4-6 and in Treatment graphs 1-3. To account for order effects of belief elicitation and investment decision, we additionally ran Type 1 and two of Type 2 sessions in which we flipped the order of the screens in Figure 2.

Table 1 presents the median value across all subjects for the expected price (Price-Exp), the expected probability of a loss (ProbLoss), and the share of the endowment invested in the stock (Investment). The table is divided by types of session (rows) and graph (columns). Note that across all three session types Control always has twice as many observations as Treatment does. This is because we use only the data of Bankers in Treatment blocks (109 observations) while for Control blocks we use the data of all participants (218 observations).

It is clear from Table 1 that beliefs and investment decisions differ substantially across graphs. These difference are (in most cases) statistically significant (see Table 3 in Appendix A for pairwise comparisons), and go in the direction one would expect from looking at the graphs. For example, subjects expect Graph 1, with a clear upward trend, to be (almost) half as likely to result in losses than Graph 2, which has a less clear upward trend. Additionally, there is a clear correlation between the expected price and the probability of losses, the more likely a loss is, the lower the expected price. All of this leads us to believe that our graphical interface is understood by our subjects, and that their beliefs respond to the graphs we present them.

3.1 The Effects of Limited Liability on Beliefs and Investment Behavior

The left (right) panel of Figure 3 presents the expected pricec (probabilities that subjects assign to a loss) for each of the six graphs presented to subjects. The light-shaded columns are the elicited beliefs of all subjects in Control, while the dark-shaded columns only include the beliefs of Bankers in Treatment. Analogously Figure 4 presents the investment decisions of all subjects in Control (light-shaded bar) and Bankers in Treatment (dark-shaded bar) for each of the six graphs.

	Control			Treatment		
	Graph 1	Graph 2	Graph 3	Graph 4	Graph 5	Graph 6
Session type 1 (N=86):						
PriceExp	120.0	89.5	107.0	105.0	117.5	116.0
ProbLoss	35.0	60.0	50	50.0	40.0	35.0
Investment	40.0	17.5	25.0	47.5	60.0	73.0
Session type 2 (N=88):						
PriceExp	119.0	90.0	100.0	95.0	110.5	110.0
ProbLoss	35.0	60.0	50.0	56.5	40.0	40.0
Investment	55.0	24.5	50.0	30.0	50.0	60.0
	Treatment			**Control**		
	Graph 1	Graph 2	Graph 3	Graph 4	Graph 5	Graph 6
Session type 3 (N=44):						
PriceExp	120.0	90.0	105.0	100.0	116.0	115.0
ProbLoss	30.0	56	50.0	50.0	45.0	35.0
Investment	71.5	30.0	46.0	16.5	30.0	39.5

Table 1: The upper part of the table shows the median values of price expectation, loss probability, and investment for each of the six graphs in each of the three session types. For Treatment cases only the data of Bankers is taken into consideration considered. Since we do not see significant differences across any of the three measures depending on the screen order, we pool together the data of both orders.

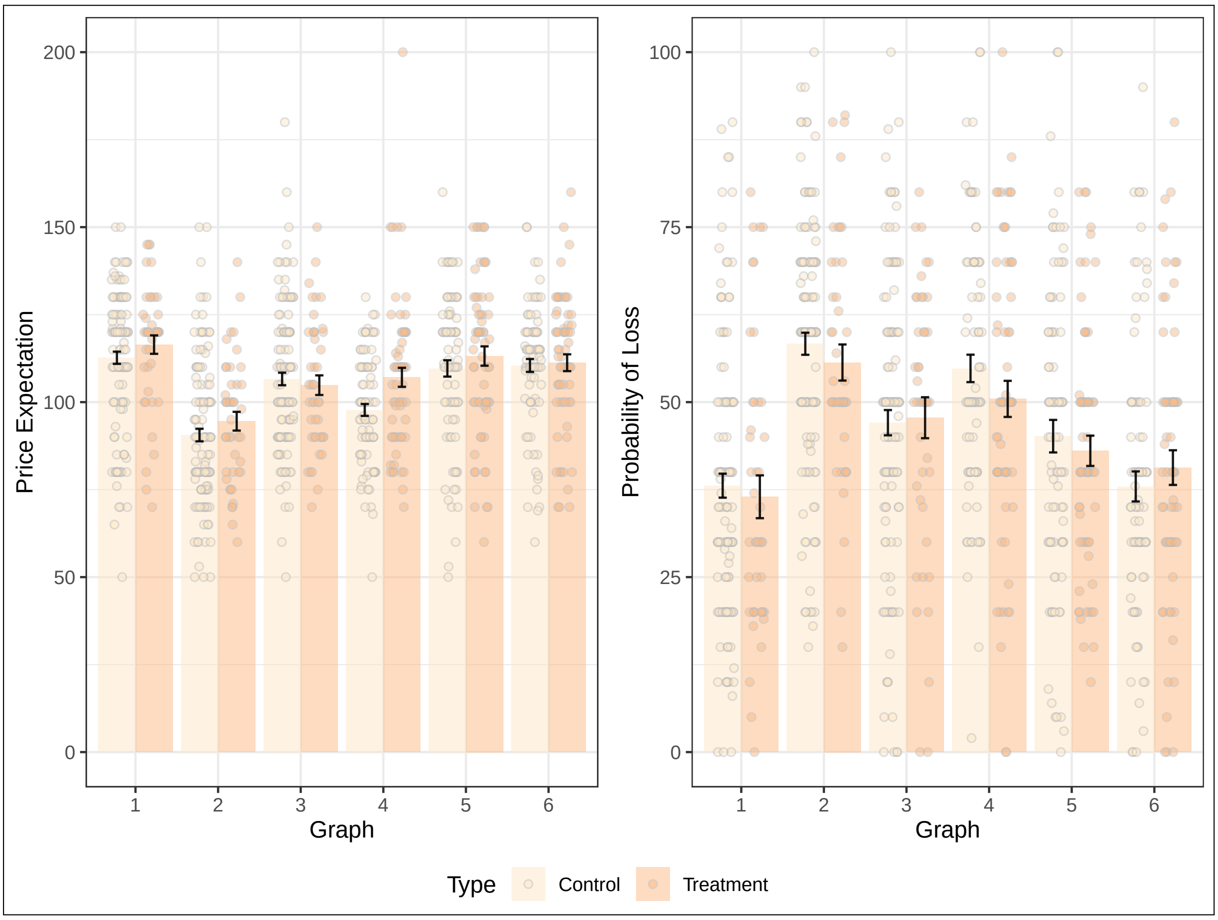


Figure 3: In the vertical axis we plot the subjects' stated price expectations (left panel) and loss probabilities (right panel). In the horizontal axis we separate by graph. The bars represent the average belief, the black error bar represents the standard error. Each dot is an individual belief. Light-shaded columns collect beliefs of all subjects in Control blocks, dark-shaded columns collect beliefs of Bankers only in Treatment blocks.

In the following, we analyze a between-subject design; i.e. for each graph we compare the beliefs (investment) of bankers in treatment sessions to the beliefs (investment) of all subjects in control sessions. Figure 3 shows that, in general, subjects in treatment blocks hold higher expected prices than those in control and that they assign lower loss probabilities in treatment than in control blocks. At the same time, Figure 4 shows that, for the same graph, subjects invest substantially more in treatment blocks than in control blocks. Using a series of Wilcoxon rank-sum tests, the differences in investment are highly significant, whereas the differences in beliefs are not (see Table 4 in Appendix A). These results change, once we control for personal traits and order effects.

To do so, in Table 2 we run a series of linear models where the dependent variable is either (1) the expected stock price (ExpPrice), (2) the probability that subjects assign to a loss (ProbLoss), or (3) the investment share in the stock (Investment). Our main

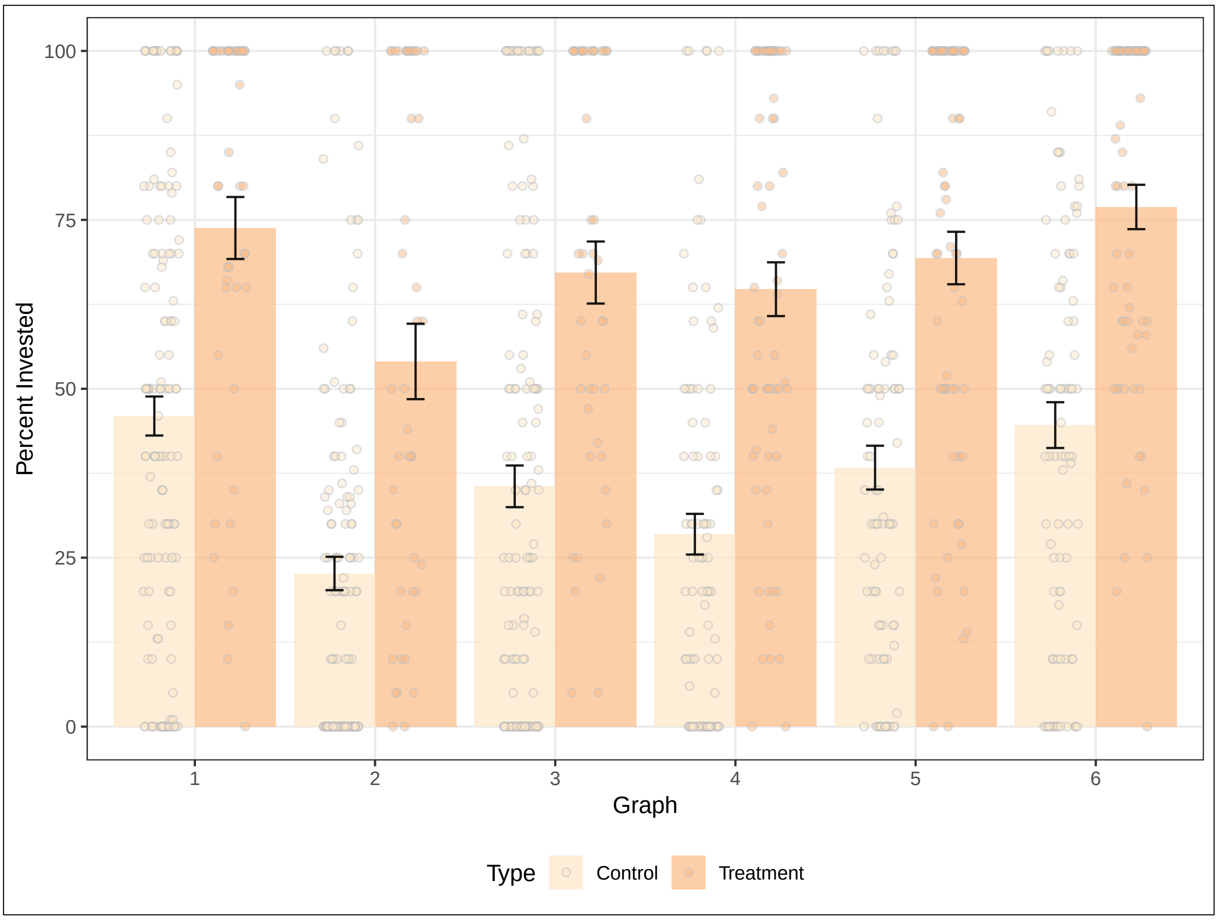


Figure 4: In the vertical axis we plot the percent of endowment invested. In the horizontal axis we separate by graph. The bars represent the average investment, the black error bar represents the standard error. Each dot is an individual investment decision. Light-shaded columns collect investments of all subjects in Control blocks, dark-shaded columns collect investments of Bankers only in Treatment blocks. The vertical black bars report the standard errors.

explanatory variable is “Treatment” which takes value unity if the observation is from a Banker in a Treatment round, or zero if it comes from a Control round. Additionally, we control for gender, graph-, screen- and treatment order, risk-, ambiguity-, and loss aversion, cognitive ability, and various other personality traits, and cluster all standard errors at the subject level.

Columns [1] through [3] have as dependent variable the expected price at $t = 14$, while columns [4] through [6] have the expected probability of a loss, respectively. Table 2 shows a strong effect of limited liability on the price expectations of the subjects. Subjects investing under limited liability form significantly higher return expectations. This result is robust to the introduction of ProbLoss as an explanatory variable (column [3]). Therefore, it is clear from Table 2 that, once we control for personality traits, we observe how investors form motivated beliefs to self-justify their excessive risk-taking.

Therefore we state:

Result 1: *In the presence of limited liability subjects modify their beliefs to maintain a positive self-image. For the same investment opportunity, subjects investing third-party funds under limited liability report higher expected returns.*

Notice that we detect motivated beliefs only on price expectations and not on probability of losses (Columns [4] through [6]). This might be because stating the probability that a stock holds losses in the future might be a harder concept to grasp for subjects than stating a future price expectation. This results in a very noisy estimate for loss probabilities, but not for price expectations as is clear in Figure 3. There we can see how, for each investment, the individual dots for beliefs span the whole support, while those for price expectations are concentrated around the median (additionally, see Table 5 in Appendix A for interquartile distances for each graph graphs).

It is also clear that our treatment has a large effect on the investment decision of subjects (columns [7] to [10] in Table 2). These differences are also obvious in Figure 4, where we see that the mean investment is clearly higher under treatment than under control. In fact, many subjects invest all of the client's endowment to take full advantage of the limited liability. Again, the result is robust to the introduction of regressors with high explanatory power such as ExpPrice or ProbLoss.

Result 2: *For the same investment opportunity, subjects make significantly larger investment under limited liability than under full liability.*

Interestingly, the investment decision is also affected by the order of which the screens are shown. Subjects who first saw the investment screen (i.e. "Screen Order" takes value unity) invest significantly more than subjects who first saw the belief elicitation screen. This is in line with our priors: If a subjects is asked to think about the losses of an investment, then they are more conservative in their investments. By contrast, the screen order is without effect on beliefs. Intuitively, this means that there is no effect of wishful thinking (after the investment has taken place) on the beliefs of the subjects. The abscence of wishful thinking is in line with the experimental evidence of Mayraz (2017) and Sun (2018).

Finally, note that with the exception of a weak, negative effect of loss aversion on the subjects' investment decisions, personality traits have no significant effects either on subject's beliefs or on their behavior.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
		ExpPrice			ProbLoss			Investment		
Treatment	3.320***	3.344***	2.469**	-1.228	-1.250	1.001	31.89***	31.85***	29.48***	31.04***
	(1.268)	(1.269)	(0.984)	(1.154)	(1.158)	(0.908)	(2.814)	(2.815)	(2.798)	(2.813)
Female	-1.223	-1.125	-0.0300	1.653	1.564	0.806	-2.163	-2.292	-1.494	-1.270
	(1.971)	(1.934)	(1.534)	(1.876)	(1.853)	(1.468)	(3.305)	(3.286)	(3.052)	(3.079)
Ambiguity Aversion	-0.380	-0.386	-0.0311	0.501*	0.507*	0.247	-0.850	-0.841	-0.567	-0.510
	(0.258)	(0.254)	(0.221)	(0.275)	(0.280)	(0.239)	(0.598)	(0.590)	(0.580)	(0.575)
Risk Aversion	-0.238	-0.255	-0.304	-0.0858	-0.0695	-0.241	-1.084	-1.061	-0.880	-1.106
	(0.287)	(0.286)	(0.253)	(0.293)	(0.300)	(0.260)	(0.819)	(0.796)	(0.802)	(0.756)
Loss Aversion	0.0625	0.115	0.0886	0.0104	-0.0378	0.0396	-1.235*	-1.304*	-1.386**	-1.329**
	(0.283)	(0.280)	(0.239)	(0.257)	(0.248)	(0.219)	(0.720)	(0.708)	(0.659)	(0.651)
Correct CRT	0.375	0.418	-0.0406	-0.615*	-0.656*	-0.374	0.313	0.256	-0.0409	-0.173
	(0.379)	(0.372)	(0.288)	(0.336)	(0.339)	(0.268)	(0.670)	(0.663)	(0.619)	(0.611)
Screen Order		-3.314**	-1.186		3.040*	0.809		4.365	6.713**	6.351*
		(1.582)	(1.325)		(1.644)	(1.326)		(3.436)	(3.077)	(3.240)
ExpPrice						-0.673***			0.709***	
						(0.0303)			(0.0512)	
ProbLoss			-0.700***							-0.654***
			(0.0398)							(0.0542)
Constant	112.2***	111.9***	137.2***	35.79***	36.02***	111.4***	76.77***	77.09***	-2.228	100.6***
	(8.261)	(8.196)	(6.434)	(6.264)	(6.239)	(6.370)	(17.51)	(17.32)	(17.34)	(16.29)
N	981	981	981	981	981	981	981	981	981	981
adj. R^2	0.131	0.135	0.542	0.135	0.138	0.544	0.272	0.274	0.426	0.398
Big Five	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Order dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Graph dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Graph Joint Significance	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: Three linear models and ten specifications. The first two columns study the effect of limited liability on expected prices and the probability of the stock having a loss, respectively. The third and fourth columns study the effect of limited liability on investment decisions.

4 Conclusion

Cognitive dissonance is the psychological discomfort that arises when one cannot rationalize two conflicting views or actions. A common way to deal with this tension is to form motivated beliefs (Festinger, 1962). An example of this would be to smoke and to believe that smoking is not that harmful (McMaster and Lee, 1991), to selectively recall only positive feedback on own performance (Zimmermann, forthcoming; Eil and Rao, 2011), or to convince oneself that those out-of-reach grapes are certainly sour (Æsop, 1914).

In finance, a recent strand in literature points to motivated beliefs as one of the reasons behind the excessive risk-taking that took place before the recent financial crisis (Barberis, 2015; Bénabou, 2015; Bénabou et al., 2018). In this case, investors (inadvertently) biased downwards their risk perception to maintain a positive self-image while profiting from their excessive risk-taking.

To study the formation of such motivated beliefs we run an experiment in which subjects make investment decisions both under full and limited liability. Under full liability investors respond for all of their losses, while under limited liability a neutral third-party (a client) absorbs any losses derived from the investment. Because we elicit the risk assessment of investors for the same investment under full and limited liability, our design allows us to detect whether limited liability leads to "excessive risk-taking" and motivated results.

The results are clear: for the same investment, limited liability leads investors to large increases in investment and, at the same time, for larger expected returns. Because beliefs are elicited in an incentive compatible way, any increase in expected gains can be interpret as an indication of motivated beliefs where the desirability of beliefs wins over their accuracy.

One of the implications of our results is that limited liability not only leads to excessive risk-taking through the abuse of moral hazard (Gropp et al., 2013), but also by (inadvertently) biasing upwards the expected profits of investors. Such bias can be extremely costly both for individual investors and firms (Bénabou, 2015), but are especially dangerous if such bias is collectively shared by the financial sector as these biased beliefs might reinforce bubble formation or trigger a new crisis (Bénabou and Tirole, 2016).

Finally, it is important to keep in mind that our experiment uses a pool of undergraduate students. This means that our results do not automatically imply the presence of motivated beliefs in professional financial investors, yet given the recent literature that lab and field results are both qualitatively and quantitatively similar (e.g., Herbst and Mas (2015), Fréchette (2015)), and given the robustness of our results, we believe that our results are strong enough to raise some concern about the effects of motivated beliefs in the financial industry. This highlights the need to incorporate behavioral insights into financial regulation.

References

Æsop (1914): "Æsop. Fables, retold by Joseph Jacobs," in *The Harvard Classics*, ed. by C. W. Eliot, P.F. Collier & Son, Vol. XVII, Part 1. Cited on page 13.

Akerlof, G. A. and W. T. Dickens (1982): "The economic consequences of cognitive dissonance," *The American economic review*, 72, 307–319. Cited on page 5.

Barberis, N. (2015): "Psychology and the Financial Crisis of 2007-2008," in *Financial innovation: too much or too little*, ed. by M. Haliassos, Cambridge, MA: MIT Press, 15–28. Cited on pages 2, 3, 6, and 14.

Bénabou, R. (2015): "The economics of motivated beliefs," *Revue d'économie politique*, 125, 665–685. Cited on pages 2, 3, and 14.

Bénabou, R., A. Falk, and J. Tirole (2018): "Narratives, Imperatives and Moral Reasoning," Tech. rep., Working Paper. Cited on pages 2 and 14.

Bénabou, R. and J. Tirole (2011): "Identity, Morals, and Taboos: Beliefs as Assets," *The Quarterly Journal of Economics*, 126, 805–855. Cited on page 3.

——— (2016): "Mindful economics: The production, consumption, and value of beliefs," *Journal of Economic Perspectives*, 30, 141–64. Cited on pages 2, 3, and 14.

Bosch-Rosa, C., T. Meissner, and A. Bosch-Domènech (2018): "Cognitive bubbles," *Experimental Economics*, 21, 132–153. Cited on page 3.

Chang, T. Y., D. H. Solomon, and M. M. Westerfield (2016): "Looking for someone to blame: Delegation, cognitive dissonance, and the disposition effect," *The Journal of Finance*, 71, 267–302. Cited on pages 2, 3, and 5.

Chen, D. L., M. Schonger, and C. Wickens (2016): "oTree - An open-source platform for laboratory, online, and field experiments," *Journal of Behavioral and Experimental Finance*, 9, 88–97. Cited on page 7.

Cheng, I.-H., S. Raina, and W. Xiong (2014): "Wall Street and the housing bubble," *American Economic Review*, 104, 2797–2829. Cited on page 2.

Eil, D. and J. M. Rao (2011): "The good news-bad news effect: asymmetric processing of objective information about yourself," *American Economic Journal: Microeconomics*, 3, 114–38. Cited on pages 2 and 13.

Epley, N. and T. Gilovich (2016): "The mechanics of motivated reasoning," *Journal of Economic Perspectives*, 30, 133–40. Cited on page 2.

Festinger, L. (1962): *A theory of cognitive dissonance*, vol. 2, Stanford university press. Cited on pages 2 and 13.

Fréchette, G. (2015): "Laboratory Experiments: Professionals versus Students," in *Handbook of Experimental Economic Methodology*, ed. by G. Fréchette and A. Schotter, Oxford University Press, 360–390. Cited on page 14.

Frederick, S. (2005): "Cognitive Reflection and Decision Making," *Journal of Economic Perspectives*, 19, 25–42. Cited on page 7.

Gino, F., M. I. Norton, and R. A. Weber (2016): "Motivated Bayesians: Feeling Moral While Acting Egoistically," *Journal of Economic Perspectives*, 30. Cited on pages 2 and 3.

Goetzmann, W. N. and N. Peles (1997): "Cognitive dissonance and mutual fund investors," *Journal of Financial Research*, 20, 145–158. Cited on pages 2 and 5.

Greiner, B. (2004): "The online recruitment system orsee 2.0-a guide for the organization of experiments in economics," *University of Cologne, Working paper series in economics*, 10, 63–104. Cited on page 7.

Gropp, R., C. Gruendl, and A. Guettler (2013): "The impact of public guarantees on bank risk-taking: Evidence from a natural experiment," *Review of Finance*, 18, 457–488. Cited on page 14.

Haisley, E. C. and R. A. Weber (2010): "Self-serving interpretations of ambiguity in other-regarding behavior," *Games and Economic Behavior*, 68, 614–625. Cited on page 2.

Herbst, D. and A. Mas (2015): "Peer effects on worker output in the laboratory generalize to the field," *Science*, 350, 545–549. Cited on page 14.

Hossain, T. and R. Okui (2013): "The binarized scoring rule," *Review of Economic Studies*, 80, 984–1001. Cited on page 7.

Konow, J. (2000): "Fair shares: Accountability and cognitive dissonance in allocation decisions," *American economic review*, 90, 1072–1091. Cited on page 5.

Lusardi, A. and O. S. Mitchell (2011): "Financial literacy and planning: Implications for retirement wellbeing," Tech. rep., National Bureau of Economic Research. Cited on page 7.

Mayraz, G. (2017): "Wishful thinking," . Cited on pages 3 and 12.

McMaster, C. and C. Lee (1991): "Cognitive dissonance in tobacco smokers," *Addictive behaviors*, 16, 349–353. Cited on page 13.

Nosić, A. and M. Weber (2010): "How riskily do I invest? The role of risk attitudes, risk perceptions, and overconfidence," *Decision Analysis*, 7, 282–301. Cited on page 3.

Oxoby, R. J. (2004): "Cognitive dissonance, status and growth of the underclass*," *The Economic Journal*, 114, 727–749. Cited on page 5.

Rabin, M. (1994): "Cognitive dissonance and social change," *Journal of Economic Behavior & Organization*, 23, 177 – 194. Cited on page 5.

Rammstedt, B. and O. P. John (2007): "Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German," *Journal of Research in Personality*, 41, 203–212. Cited on page 7.

Rubin, J., A. Samek, and R. M. Sheremeta (2017): "Loss aversion and the quantity–quality tradeoff," *Experimental Economics*. Cited on page 7.

Sun, C. (2018): "Does Making a Choice Affect Subsequent Belief Formation? An Experimental Study," mimeo. Cited on page 12.

Thomson, K. S. and D. M. Oppenheimer (2016): "Investigating an alternate form of the cognitive reflection test," *Judgment and Decision Making*, 11, 99. Cited on page 7.

Toplak, M. E., R. F. West, and K. E. Stanovich (2014): "Assessing miserly information processing: An expansion of the Cognitive Reflection Test," *Thinking & Reasoning*, 20, 147–168. Cited on page 7.

Weber, M., J. Duffy, and A. Schram (2018): "An experimental study of bond market pricing," *The Journal of Finance*, 73, 1857–1892. Cited on page 3.

Zimmermann, F. (forthcoming): "The dynamics of motivated beliefs," *American Economic Review*. Cited on pages 2 and 13.

A Additional Tables

	1 = 2	1 = 3	2 = 3	4 = 5	4 = 6	5 = 6
Session type 1:	Control	Control	Control	Treatment	Treatment	Treatment
ExpPrice	<0.001	0.089	<0.001	0.442	0.308	0.851
ProbLoss	<0.001	0.009	<0.001	0.531	0.009	0.330
Investment	<0.001	0.007	0.005	0.894	<0.001	0.015
Session type 2:	Control	Control	Control	Treatment	Treatment	Treatment
ExpPrice	<0.001	0.007	<0.001	<0.001	0.020	0.263
ProbLoss	<0.001	<0.001	0.004	<0.001	<0.001	0.448
Investment	<0.001	0.036	<0.001	0.028	0.001	0.047
Session type 3:	Treatment	Treatment	Treatment	Control	Control	Control
ExpPrice	<0.001	0.030	0.021	0.018	<0.001	0.389
ProbLoss	0.021	0.143	0.039	0.203	<0.001	0.094
Investment	0.001	0.357	0.009	0.027	<0.001	0.228

Table 3: p-values of Wilcoxon matched-pairs signed-ranks test for pairwise comparisons across graphs (from Table 1).

Treatment = Control	Graph 1	Graph 2	Graph 3	Graph 4	Graph 5	Graph 6
ExpPrice	0.377	0.183	0.598	0.015	0.449	0.683
ProbLoss	0.486	0.220	0.556	0.247	0.498	0.243
Investment	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4: p-values resulting from Wilcoxon rank-sum tests comparing Treatment and Control decisions.

	Graph 1	Graph 2	Graph 3	Graph 4	Graph 5	Graph 6
ExpPrice	0.075	0.125	0.15	0.15	0.135	0.11
ProbLoss	0.3	0.175	0.255	0.25	0.2	0.2

Table 5: Interquartile range for the elicited beliefs (ExpPrice and ProbLoss) for each graph under treatment. Both measures have been normalized to 1.