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Hidden skewness*

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Abstract

We provide laboratory evidence that people neglect skewness resulting from compound shocks.

JEL-Classification: C91, D03
Keywords: skewness, belief biases, binomial tree

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1 Introduction

In a controlled experiment, participants consider a security that has a seemingly simple price transition. They are told that the security, if bought, has to be held for exactly 12 months and is then to be sold.

> You can buy the security at a price of 10,000 Euros. During each month, the security's price either increases by 70% or decreases by 60%. The two possible price changes in each month occur with equal probabilities ("fifty-fifty").

The instructions also explain that all random draws are independent. They are written for maximal clarity, with the important exception that they do not show the values of any compound price changes that accumulate over time. The participants may thus misperceive the random price process, given its compound nature.

The actual distribution of the security's selling price is, as the reader can verify, extremely skewed. A decrease by 60% cannot be undone by a single increase by 70% and the typical price path therefore tends downward. If the security was held infinitely long rather than 12 months, the price would converge to zero in probability. But already with a fixed maturity after 12 months, the *median* selling price is as low as 989 Euros. Skewness shows in the observation that the *mean* selling price after 12 months is much higher, at 17,959 Euros — the fact that 70% exceeds 60% implies that, in expectation, increases dominate decreases.

Our laboratory experiment tests whether the participants correctly locate the median. Through a sequence of simple choice problems we identify bounds on the median of each participant's subjectively expected distribution and find that it is typically far too high: 98% of the participants reveal that they have a subjective median above 2,000 Euros, and 84% above 9,000 Euros. We conclude that the participants have an incomplete understanding of the compound effects of multiplicative shocks in our example. A further result is that the effect is fairly robust to learning from feedback.[1]

We did not select this illustrative example for the sake of realism, of course. Yet we note that many investments are subject to a multiplicative compounding of shocks. In the option pricing literature, several leading models are based on a multiplicative random process,[2] as are many other decision problems in economics and finance. Geometric growth of random variables arises naturally in many models, like in our example. While an artificial experiment cannot generate quantitative statements that are portable to the 'real world', it can generate novel and clean qualitative evidence — to our knowledge, this is the first study asking whether people understand distributions arising from multiplicative random processes.

Our experiment is reminiscent of additive random processes that have been studied experimentally, see e.g. Redelmeier and Tversky (1992) Benartzi and Thaler (1999) and Klos, Weber and Weber (2005), all of whom follow up on Samuleson's (1963) hypothetical offer of a sum of gambles to his colleague. While a formal connection to our security appears to be immediate by taking the logarithm, a key discrepancy is that taking the logarithm of our security leads to a sum of less-than-fair gambles, not more-than-fair gambles like those studied in previous experiments. This feature of our security is equivalent to the property that a 60% decrease weighs proportionally stronger than a 70% increase, creating the extreme skewness that we examine.[3]

The next section gives the essential details on the experiment, while the appendix contains the full instructions. Section 3 shows the results.

[1] In the fifth repetition of our experiment, with feedback about the realized selling prices (detailed in Section 2), 86% of subjective medians are still above 2,000 Euros and 55% above 9,000 Euros.

[2] Our security matches exactly the underlying asset in Cox, Ross and Rubinstein (1979).

[3] Other related literatures show that decision-makers misperceive exponential growth (see Stango and Zinman, 2009, and the literature cited therein) and the return distributions of different financial options (e.g. Gneezy, 1996, Abbink and Rockenbach, 2006). None of these studies focus on skewness.

2 Experimental design

Choice problems: The experiment is designed to elicit the participants' expectations, irrespective of their risk preferences. The monetary incentives in each choice problem therefore involve only two possible payments — "receive a bonus" versus not — making it optimal for any decision-maker with monotonic preferences to maximize the subjectively perceived probability of receiving the bonus.

The choice problems are framed in a financial investment context: two risky securities are offered and the selling price of the chosen security determines whether the bonus is paid.[4] Security A is the security described in the introduction. A participant who chooses this security receives the bonus if the selling price at maturity exceeds a given threshold t_A. The alternative choice is Security B, which yields the bonus with probability one half. One can immediately see that it is subjectively optimal for a participant to choose Security A if and only if she believes that Security A yields the bonus with probability more than one half. A choice for Security A thus reveals that the median of her subjective probability distribution of Security A's selling price is below t_A.

For a balanced description of the two choice options, Security B is phrased analogously to Security A, with the difference that only a single price change of +70% or -60% (equiprobably) occurs during the 12 months. A participant who chooses Security B receives the bonus if the selling price of B exceeds a separate threshold t_B. This threshold is fixed at the initial price of 10,000 Euros throughout the experiment whereas the threshold t_A varies between 10 different values (ranging from 100 to 250,000 Euros). Each experimental participant makes a choice between A and B for each of the 10 possible values of t_A, allowing us to infer bounds on her subjective median of the selling price of Security A. Table 1 shows the 10 choice problems as seen by the participants.

Treatment conditions: Participants are randomly assigned to one of

[4] The descriptions begins with the wording: "You are a manager and have to make a decision between two risky investments".

Table 1: The 10 binary choices

	Threshold for Security A	Threshold for Security B	Your decision (A or B)
Task 1	100	10,000	___
Task 2	500	10,000	___
Task 3	2,000	10,000	___
Task 4	6,000	10,000	___
Task 5	9,000	10,000	___
Task 6	12,000	10,000	___
Task 7	20,000	10,000	___
Task 8	35,000	10,000	___
Task 9	90,000	10,000	___
Task 10	250,000	10,000	___

two conditions that differ in the extent to which the experimental instructions explain the implied distributions. The CONTROL condition presents the basic explanation. To introduce Security A, the instructions use the above formulation "You can buy...". This is followed by a statement about the independence of random draws and by the paraphrase that after month 1, the security's price is either at 17,000 Euros or at 4,000 Euros. The instructions then repeat the random price transition, but without calculating compound effects explicitly: "At the end of month 2, the price is either 70% higher or 60% lower than at the end of month 1. At the end of month 3, the price is either 70% higher or 60% lower than at the end of month 2. And so on, ..." The Security B is introduced with identical wording to that of Security A (where applicable). Next, the thresholds t_A and t_B are explained and two examples are given. Finally, participants face an understanding test of four questions which they have to answer correctly before they may proceed. The examples and understanding test are carefully chosen so to not suggest any responses to the participants.

There remains the possibility that results in the CONTROL condition are driven by the choice format, the context frame or other cues. In particular, the set of 10 threshold values can conceivably influence the responses.[5] We

[5]We deliberately fixed the 10 values of t_A so that half of them exceed Security A's starting price of 10,000 Euros, in order to not suggest a direction of price change. However,

address these concerns by including the Treatment condition where we provide the participants with an additional explanation, leaving the remainder of the instructions unchanged. The additional text (about one written page) gives an explicit calculation of the distribution of compound price changes after two periods. It also points out the asymmetry in the selling price distribution and lists the implicit probabilities of receiving the bonus from choosing Security A for each value of t_A. Any difference in responses under the two conditions must stem from differences in the understanding of these implied truths.

Feedback and repetitions: After the participants make their 10 choices, each participant receives individual feedback in the form of a sample pair of selling prices of Securities A and B. This concludes the first round of the experiment. The experiment is then repeated for four additional rounds of the same nature, each including 10 choices and feedback. The feedback procedure and the choice format are identical for both treatment conditions.[6]

Procedures and payments: All 128 participants (68 in Control and 60 in Treatment) are students at Technical University Berlin. Six sessions, three in each treatment condition, are conducted in a paper-and-pencil format. The protocol is fixed across all sessions. The instructions are read aloud to the participants, up to the beginning of the understanding test. Participants receive a participation fee of 5 Euros and a possible bonus of 5 Euros per round. That is, participants can earn up to five bonuses of 5 Euros each, one per round of the experiment. After completing all choices, each participant receives five random draws of integers between 1 and 10 to determine which of the 10 choice problems in each round is payoff relevant for her. She receives the bonus for a given round if the selling price of the chosen security in the payoff-relevant problem exceeds its threshold.

this property may conceivably induce a midpoint effect, leading the participants to switch from A to B towards the middle of the list.

[6]Each additional round comes with the chance to earn a new bonus (see the next paragraph in the main text), but this does not affect the simple optimality conditions for choice. Independent of other choices it remains optimal to choose A iff the subjective median is below t_A.

3 Results

The data analysis is simplified by the observation that a participant with any subjective belief about selling prices maximizes her preference by choosing Security A for low values of t_A and switching to B for all values higher than her subjective median, i.e. she switches between the securities no more than once. We observe such unique switching points in the large majority of responses (93%) and restrict attention to these data.[7] The benchmark prediction is for all participants to choose A in the first two tasks and then switch to B. This is optimal as the true median of A's selling price is between the second and third threshold values.

Figure 1 shows the mean switching point for each round of the experiment, separately for Control (solid line) and Treatment (dashed line). More precisely, it shows the mean of task numbers at which participants start choosing Security B.[8] The dotted lines show the 95% confidence intervals, taken pointwise around the means at each round of the experiment. As shown in the figure, the mean switching point in Control is 6.5 in the first round of the experiment and decreases to 5.1 in the fifth round of the experiment. In Treatment, the mean switching point is 3.8 in round one and decreases to 3.3 in round five. Figure 2 shows histograms of the distributions of switching points, again separately for each round of the experiment and for the two conditions Control and Treatment. Both figures show strong differences between the two conditions, and parametric t-tests as well as non-parametric Wilcoxon rank-sum tests confirm that all round-by-round comparisons between the two conditions are statistically significant at $p < 0.001$. In particular, the treatment effects are still highly significant in the last round of the experiment.

Table 3 reports the distributions of switching points that underlie Figure 2 and lists the implied ranges for the median of the participants' subjective

[7] If a participant has multiple switching points in one round, her answers in the remaining rounds are still considered. None of our conclusions would change if we dropped all responses by subjects who switch strictly more than once in at least one round (12% of participants), or if we included all data and considered each of the 10 tasks separately.

[8] We assign the value 11 if a participant always chooses A.

Figure 1: Means of switching points, separated by round and CONTROL/TREATMENT.

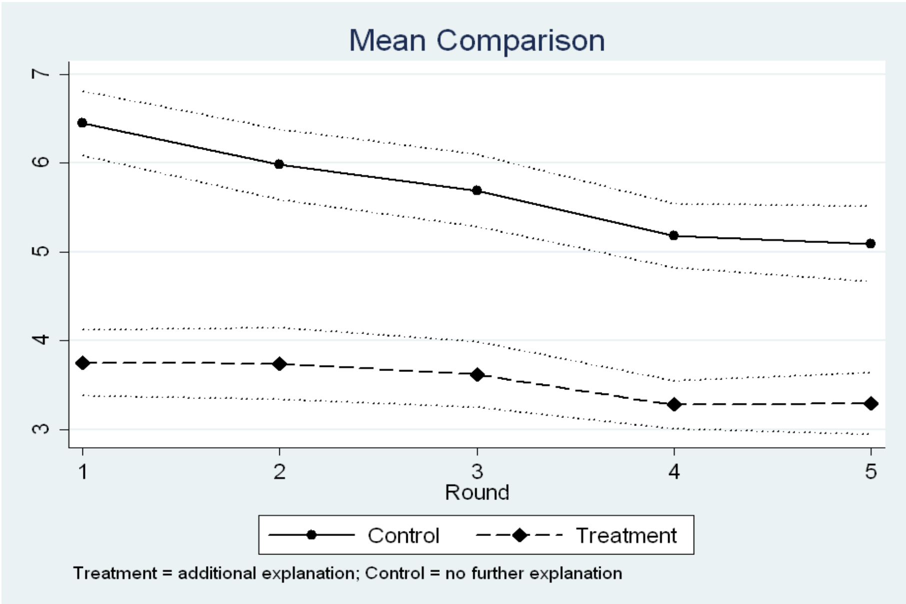
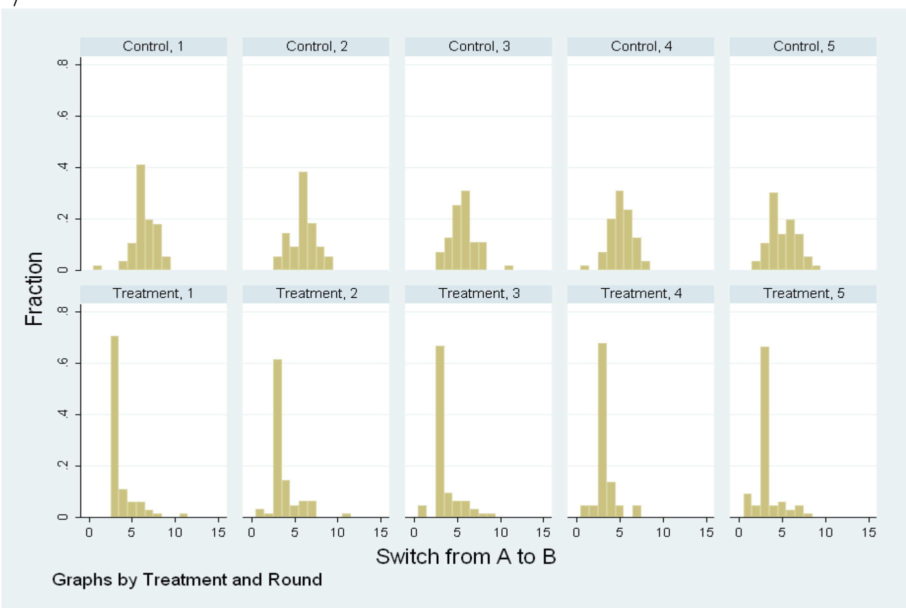


Figure 2: Distribution of switching points, separated by round and CONTROL/TREATMENT.



distributions of Security A's selling price. The modal choice in round 1 in CONTROL is a switching point of 6 indicating a subjective median between 9,000 and 12,000 Euros. Not a single CONTROL participant in round 1 reveals a subjective median between 500 and 2,000 Euros (switching point of 3). Instead, 98% of CONTROL participants reveal that their subjective medians are above 2,000 Euros in round 1, and still 86% in round 5. Under the TREATMENT condition, 70% of responses are at the optimal switching point of 3 already in round 1. Altogether, the data show a consistent pattern that the performance is poor under the CONTROL condition, and much better in TREATMENT. Since the only difference between the two conditions lies in the additional explanation, we conclude that CONTROL participants have an incomplete understanding of the implied distribution of Security A's selling price.

We run random effects regressions to obtain a better description of responses over time, exploiting the panel structure of the data. This allows accounting for individual heterogeneity as well as describing the reaction of participants to their individually different feedback information.[9] The dependent variable is a participant's observed switching point in a given round,[10] and the explanatory variables are $Treatment$ (1 if in condition TREATMENT, 0 if in CONTROL), *Round* and $Feedback$. The latter is a dummy variable that is 1 if the participant's sample feedback in the previous round has the property that Security B's selling price exceeds that of Security A. In this case, participants get the 'correct' feedback that returns to investment in Security A are likely to be small.

The estimation of model (1) in Table 2 repeats the main result that the additional explanation in TREATMENT has a significant effect. Comparisons with the richer models show that the coefficient is fairly robust to changes in the specification. The coefficient of *Round* is negative and significant (model

[9]The appropriateness of random effect regressions is confirmed by applying a Hausman-test that does not reject the statistical independence between unobserved factors and the explanatory variables used. A comparison to pooled OLS regressions shows no substantial differences across comparable coefficients.

[10]Translating the task number into the corresponding subjective median would not change the main conclusions. But the subjective medians have some extreme outliers, complicating the analysis.

Table 2: Results from Random Effects Regressions

Dep. Var: Switch	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	-2.129***	-2.123***	-2.791***	-2.136***	-2.095***	-2.135***	-2.755***
	(0.19)	(0.19)	(0.33)	(0.19)	(0.20)	(0.19)	(0.33)
Round		-0.237***	-0.356***			-0.265***	-0.385***
		(0.04)	(0.06)			(0.04)	(0.06)
Treatment × *Round*			0.223**				0.229**
			(0.08)				(0.08)
Feedback				-0.248*	-0.355*	-0.462***	-0.610***
				(0.12)	(0.14)	(0.12)	(0.15)
Treatment × *Feedback*					-0.187		-0.299
					(0.24)		(0.23)
Constant	5.683***	6.393***	6.748***	5.879***	5.963***	6.840***	7.316***
	(0.14)	(0.19)	(0.23)	(0.17)	(0.18)	(0.22)	(0.28)
N	596	596	596	596	596	596	596

(2)) indicating that participants adjust their decision over time. Moreover, participants in CONTROL make greater progress across rounds, as shown in model (3). There, a test for sums of coefficients shows that participants in condition TREATMENT do not significantly change their response over time.

Regarding the participant's reaction to feedback, the coefficient of the *Feedback* dummy variable has the expected negative sign, i.e. participants switch from A to B at a lower threshold if their feedback shows a relatively low selling price for Security *A*. The effect is less significant, however, if *Round* is not included (models (4) and (5)).[11] Models (6) and (7) include both *Round* and *Feedback*. The results remain essentially the same, except that the coefficient on *Feedback* is now significant at lower levels. Overall, the regression analysis confirms that participants in CONTROL have a poor understanding of the median selling price of Security *A*, whereas in TREATMENT their responses are significantly closer to the optimal response.

[11] In an alternative specification of the *Feedback* dummy we assign the value 1 if the participant's selling price of Security A lies above their subjective median in the previous round. (To generate this variable, we lineraly interpolate each participant's subjective median to be the arithmetic average of the revealed bounds.) However, the corresponding coefficient estimates are mostly insignificant.

Table 3: Subjective Medians

Switching point from A to B	**Range of subjective Median for A**	**Share of people switching from A to B**									
		Round 1		**Round 2**		**Round 3**		**Round 4**		**Round 5**	
		Control	**Treatment**	**Control**	**Treatment**	**Control**	**Treatment**	**Control**	**Treatment**	**Control**	**Treatment**
1	[0 - 100]	1.79	0.00	0.00	3.23	0.00	4.76	1.82	4.62	0.00	9.23
2	[100 - 500]	0.00	0.00	0.00	1.61	0.00	0.00	0.00	4.62	3.57	4.62
3	[500 - 2,000]	0.00	70.31	5.45	61.29	7.27	66.67	7.27	67.69	10.71	66.15
4	[2,000 -6,000]	3.57	10.94	14.55	14.52	12.73	9.52	20.00	13.85	30.36	4.62
5	[6,000 - 9,000]	10.71	6.25	9.09	4.84	25.45	6.35	30.91	4.62	14.29	6.15
6	[9,000 - 12,000]	41.07	6.25	38.18	6.45	30.91	6.35	23.64	0.00	19.64	3.08
7	[12,000 - 20,000]	19.64	3.13	18.18	6.45	10.91	3.17	12.73	4.62	14.29	4.62
8	[20,000 - 35,000]	17.86	1.56	9.09	0.00	10.91	1.59	3.64	0.00	5.36	1.54
9	[35,000 - 90,000]	5.36	0.00	5.45	0.00	0.00	1.59	0.00	0.00	1.79	0.00
10	[90,000 - 250,000]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	[250,000 - ∞]	0.00	1.56	0.00	1.61	1.82	0.00	0.00	0.00	0.00	0.00

References

Abbink, K., and B. Rockenbach, 2006, Option pricing by students and professional traders: a behavioural investigation, *Managerial and Decision Economics* 27 (6), 497-510.

Benartzi, S., and R.H. Thaler, 1999, Risk aversion or myopia? Choices in repeated gambles and retirement investments, *Management Science* 45, 364-381.

Cox, J.C., S.A. Ross, and M. Rubinstein, 1979, Option pricing: a simplified approach, *Journal of Financial Economics* 7, 229-263.

Gneezy, U., 1996, Probability judgments in multi-stage problems: experimental evidence of systematic biases, *Acta Psychologica* 93, 59-68.

Klos, A., Weber, E.U., and M. Weber, 2005, Investment decisions and time horizon: risk perception and risk behavior in repeated gambles, *Management Science* 51, 1777-1790.

Redelmeier, D.A. and A. Tversky, 1992, On the framing of multiple prospects, *Psychological Science* 3(3), 191-93.

Samuelson, P. A., 1963, Risk and uncertainty: a fallacy of large numbers, *Scientia* 98, 108-113.

Stango, V., and J. Zinman, 2009, Exponential growth bias and household finance, *Journal of Finance* 64 (6), 2807-2849.

Appendix (not intended for publication): Instructions

Welcome!

You are about to participate in an experiment in decision making. Universities and research agencies have provided the funds for this experiment.

In this experiment we will first ask you to read instructions that explain the decision scenarios you will be faced with. We will also ask you to answer questions that test your understanding of what you read. Finally, you will be asked to make decisions that will allow you to earn money. Your monetary earnings will be determined by your decisions and by chance. All that you earn is yours to keep and will be paid to you in private, in cash, after today's session.

Only for coming here and completing the experiment, you will also receive a fixed participation fee of EUR 5.00. The earnings that you make during the experiment will be added to this amount.

It is important to us that you remain silent and do not look at other people's work. If you have any questions or need assistance of any kind, please raise your hand, and an experimenter will come to you. If you talk, exclaim out loud, etc., you will be asked to leave and will forfeit your earnings. Thank you.

[page break]

Procedure and payment structure

You are asked to make a sequence of decisions. There are five rounds in this experiment. In each round, you have the opportunity to earn a bonus of EUR 5.00. In what follows, the term “bonus” will always refer to these EUR 5.00. All bonuses that you earn in any of the five rounds will be paid to you in cash after the experiment.

Each round consists of a list of ten tasks. One of the ten tasks will be chosen by a random draw made on the computer. This task will be paid out for real. That is, if you were successful in the task that the computer picked, you will earn the bonus of EUR 5.00. If you were unsuccessful in the task that the computer picked, you will not receive a bonus in this round.

The tasks are described on the next pages.

[page break]

INVESTMENT TASK

Setting

You are a manager and have to make a decision between two risky investments, either to buy security A or to buy security B. Either security, if bought, has to be held for 12 months. After the 12 months you sell the security. Depending on your investment success, you have the chance to earn a bonus.

Security A:

You can buy the security at a price of 10,000 Euros. During each month, the security's price either increases by 70% or decreases by 60%. The two possible price changes in each month occur with equal probabilities ("fifty-fifty"). The direction of price change (increase/decrease) is not influenced by the direction of price changes in previous months.
Thus, at the end of month 1, the price is either 70% higher or 60% lower than at the beginning of month 1. That is, the price is either 17,000 Euros or 4,000 Euros. At the end of month 2, the price is either 70% higher or 60% lower than at the end of month 1. At the end of month 3, the price is either 70% higher or 60% lower than at the end of month 2. And so on, until you sell the security at its price at the end of month 12.

Security B:

You can buy the security at a price of 10,000 Euros. During month 1, the price of security B moves identically to the price of security A. After the end of month 1, the price stays constant until the end of month 12.
Thus, at the end of month 1, the price is either 70% higher or 60% lower than at the beginning of month 1, with equal probability. That is, the price is either 17,000 Euros or 4,000 Euros. The price then stays constant until you sell the security at the end of month 12.

The following rule determines your payment: If the selling price of the security that you bought is higher than a certain threshold, you receive the bonus.

[page break]

Thresholds

The thresholds differ between security A and security B. Security B's threshold always equals its initial price of 10,000 Euros. Security A's threshold varies between 100 and 250,000 Euros.

For each of the possible thresholds of security A and security B that are presented in the table below, you will be asked to make a decision between A and B. These are the 10 tasks for one round of this experiment.

	Threshold for security A:	Threshold for security B:	Your decision (A or B):
Task 1	100	10,000	
Task 2	500	10,000	
Task 3	2,000	10,000	
Task 4	6,000	10,000	
Task 5	9,000	10,000	
Task 6	12,000	10,000	
Task 7	20,000	10,000	
Task 8	35,000	10,000	
Task 9	90,000	10,000	
Task 10	250,000	10,000	

Example 1
Consider *Task 1*, where the threshold for security A is 100 Euros, and the threshold for security B is 10,000 Euros.
Suppose that you decide to buy *security A*. If the selling price of security A is higher than 100 Euros, you receive the bonus. If the selling price is less than or equal to 100 Euros, you do not receive the bonus.
Now, suppose instead that you decide to buy *security B*. If the selling price of security B is higher than 10,000 Euros, you receive the bonus. If the selling price of security B is less than or equal to 10,000 Euros, you do not receive the bonus.

Example 2
Consider *Task 2*, where the threshold of security A is higher than in the previous example, at 500 Euros, and the threshold for security B is again 10,000 Euros.
First, suppose that you decide to buy *security A*. In this case, if security A's selling price is higher than 500 Euros, you receive the bonus. Otherwise, you do not receive the bonus.
If, instead, you decide to buy *security B*, you receive the bonus if the selling price of security B is higher than 10,000. Otherwise, you do not receive the bonus.

And so on, analogously for *Task 3, Task 4, etc., until Task 10*.

[page break]

[The following page is for participants in condition TREATMENT only.]

How likely does security A's selling price exceed its threshold?

As security A's selling price is determined by 12 price changes, there are 13 possible selling prices for security A altogether: the lowest price results if security A's price decreases in each of the 12 months; the second-to-lowest price results if 11 price changes are decreases and 1 is an increase; and so on.

An important property of security A is that if the price decreases *once* it requires *multiple* price increases to compensate for the decrease. A single price increase by 70% cannot make up for a single decrease by 60%.

For example, consider the price at the end of month 2. If the price change in month 1 is downward, i.e. a decrease from 10,000 Euros to 4,000 Euros, then an increase in month 2 would only yield a price of 6,800 Euros, well below the starting price of 10,000 Euros. Likewise, if the first price change is an increase from 10,000 Euros to 17,000 Euros but the second price change is a decrease, then the price at the end of month 2 would again be only 6,800 Euros (which is 40% of 17,000 Euros). For the price to exceed 10,000 Euros at the end of month 2, the price would therefore have to increase twice in a row – from 10,000 Euros to 17,000 Euros in month 1, and from 17,000 Euros to 28,900 Euros in month 2.

The example illustrates a general feature of security A: it has a small probability of ending up at an extremely high price, and a large probability of ending up at low prices.

The following table shows how many price increases are required for security A's selling price to exceed the threshold, in each of the 10 investment tasks. The table's final column shows exactly how likely the selling price exceeds the threshold.

	Threshold for security A:	Required # of increases, to exceed threshold	Probability of exceeding threshold
Task 1	100	5 or more	80.6 %
Task 2	500	6 or more	61.3 %
Task 3	2,000	7 or more	38.7 %
Task 4	6,000	8 or more	19.4 %
Task 5	9,000	8 or more	19.4 %
Task 6	12,000	8 or more	19.4 %
Task 7	20,000	9 or more	7.3 %
Task 8	35,000	9 or more	7.3 %
Task 9	90,000	10 or more	1.9 %
Task 10	250,000	11 or more	0.3 %

For example, in Task 1, the selling price of security A exceeds the threshold if the price increases during 5 or more of the 12 months. This happens with probability 80.6%. The higher the threshold, the higher the number of required price increases. For example, in Task 2, the selling price exceeds the threshold if the price increases in 6 or more months. This happens only with probability 61.3%. Similarly, you can read in the subsequent lines how likely the threshold is met in the other tasks.

For comparison, recall that security B has a selling price of 17,000 Euros or 4,000 Euros, with equal probability, and a threshold of 10,000 Euros. Therefore, in each task, security B's selling price exceeds its threshold with probability 50%.

[end of insert for condition TREATMENT]

[page break]

Payment

For each round, one of the 10 tasks is picked at random. Each task is picked with equal probability by a computerized random draw. Depending on your decision in the task that is picked by the computer, you will receive the bonus or not.

After each round, you will learn the selling prices of both securities. We obtain these prices by means of computer simulation, which is conducted individually for each participant. You will receive the price information on a separate sheet of paper after each round. The selling price of your chosen security determines whether you receive the bonus in this round.

We then continue with another round of 10 tasks. (Recall there are 5 rounds.)

Are there questions about the tasks or payment rules in this experiment? If so, please raise your hand and we will help you at your desk.

If there are no further questions at this point, you will now face a brief understanding test. Only if you answer all questions correctly, you will proceed to the actual tasks.

In the top right corner of the understanding test, please enter the code number that you were assigned when you entered the laboratory. Please also enter this number on all subsequent sheets during this experiment.

[page break]

Understanding test

Code number: _________

Please record your code number on this sheet, as well as on all subsequent sheets during the experiment

Consider questions (1) to (4) below. You will only be allowed to continue with the experiment after answering all questions correctly. If you have a question of any kind, please raise your hand.

Questions:

(1) Suppose you buy security B in the task that is picked by the computer. Suppose the selling price of security B is 17,000 Euros. Do you receive a bonus? ______

(2) Suppose you buy security A in Task 1. Suppose the selling price of security A is higher than 100 Euros. Do you receive a bonus if Task 1 is picked by the computer? ______

(3) Suppose you buy security A in Task 10. Suppose the selling price of security A is less than 250,000 Euros. Do you receive a bonus if Task 10 is picked by the computer? ______

(4) Suppose you buy security A in both Task 1 and Task 10. Which of the two tasks has the higher chance that the selling price exceeds the threshold? _________

Once you finish the understanding test, please wait for instructions for the decisions. If you have a question, please raise your hand. Please make sure that the code number is recorded on the understanding test.

[page break]

[decision form]

Code number: _________

Round 1

	Threshold for security A:	Threshold for security B:	Your decision (A or B):
Task 1	100	10,000	
Task 2	500	10,000	
Task 3	2,000	10,000	
Task 4	6,000	10,000	
Task 5	9,000	10,000	
Task 6	12,000	10,000	
Task 7	20,000	10,000	
Task 8	35,000	10,000	
Task 9	90,000	10,000	
Task 10	250,000	10,000	

Once you finish making the decisions, please wait until the experimenter collects the decision sheets. If you have a question, please raise your hand. Please make sure that the code number is recorded on the first decision sheet.

[page break]

[feedback form]

Code number: _________

Selling prices in round 1:

Security A: ____________

Security B: ____________

[round 2 to 5 identically]

[page break]

SURVEY

Please provide the information requested below, but do **not** write your name. (Please respond truthfully to aid us in our research. You can be assured that all information will be stored in a 100% anonymous way, ensuring your privacy.)

CODE NUMBER_________ Date _________.

Age:___ Sex:______ Nationality: _______________

Undergraduate___ Graduate___ Year of study _____.

Main Subject of Study _______________

Your average monthly budget, including all expenses for food and lodging: _____________

Do you currently work for money? ____________

Please indicate your main source of income: _________________________

In your household, do you live (check all that apply): ____with parents _____alone _____with partner _____with children ______none of the aforementioned, but sharing an apartment with someone else.

Did you take a mathematics course as an undergraduate? ____yes ____no

Indicate the duration of schooling that your mother received, including any higher education, by checking the number of years that comes closest: ____4 ___8 ____12 ____16 _____20

Indicate your father's years of schooling: ____4 ____8 ____12 ____16 _____20

THE FOLLOWING ARE SOME NUMERICAL PROBLEMS. PLEASE ANSWER THEM AS BEST YOU CAN.

First problem: What is 15% of 1,000? ______

Second problem: A car rental agency charges $35 a day plus $0.14 per mile for its rental cars. If these charges include tax, what is the total cost of travelling 300 miles over 3 days in a car rented from this agency?
_____$42 _____$105 ______$125 _____$147 _____$300

Third problem: Which of the following is larger than 3/5?
_____19/35 ______13/20 ______4/7 ______7/13 _____None of the above

Fourth problem: If it takes 5 people 5 months to save a total of $5,000, how many months would it take 100 people to save a total of $100,000? _______

Fifth problem: A TV and a radio cost $110 in total. The TV costs $100 more than the radio. How much does the radio cost? _________

Sixth problem: In a lake, there is a patch of lily pads. Each day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? __________