Skewness Seeking in a Dynamic Portfolio Choice Experiment

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Abstract

We conduct a controlled laboratory experiment in which subjects dynamically choose to allocate their portfolio between (i) a safe asset, (ii) a risky asset, and (iii) a skewed asset with a negative expected value (a "bet"). Additionally, subjects can sometimes acquire information about the performance of their peers. We find three distinct groups of individuals: 16% of subjects never buy the bet, 29% of subjects learn not to buy the bet, and 55% of subjects persist buying the bet throughout the experiment. Among the latter group, purchases are most frequent when subjects are rich and when it is their last opportunity. Our subjects are also interested in the wealth of others, especially relative to theirs. Indeed, a subject with low, medium and high wealth has a preference for finding out what is the minimum, average and maximum wealth in the session, respectively. Finally, we also find that subjects buy more bets when they are richer and unexpectedly learn that their peers are outperforming them.

Keywords: laboratory experiment, portfolio allocation, skewed asset, relative performance.
JEL Classification: C91, D03, D81, G02, G11.

1 Introduction

The behavior of economic agents under risk is known to often depart from the predictions of the classical expected utility theory. In particular, the tendency to invest in skewed assets with negative expected value is a pervasive behavioral anomaly. Lotteries, race-tracks, and financial markets, provide evidence of skewness seeking behavior.[1] However, little is known as to why this occurs, whether preferences for skewness are an intrinsic trait of some individuals, whether subjects learn to avoid unfavorable bets, whether there are more likely to show in conjunction with specific circumstances, and/or whether they are driven by social concerns. For instance, it has been evidenced that the demand for lotteries increases at the last minute in race-track betting (McGlothlin (1956); Ali (1977); Asch et al. (1982)) suggesting that observed preferences for skewness might be triggered by certain events. It is also known that subjects in experiments sometimes react to relative wealth concerns and may buy more lottery tickets when they feel poorer than their peers (Haisley et al. (2008); Dijk et al. (2014)). This indicates that observed preferences for skewness may not be intrinsic, but rather tied to social comparisons. The objective of this study is to design a controlled laboratory experiment that generates two potential triggers of skewness seeking behavior: an option to act at different dates including a final date and the possibility of social comparisons. We then analyze how these options affect investment decisions. More precisely, we want to answer the following questions. How pervasive are preferences for skewness in the population and can frequent exposure help individuals realize the low (in our design, negative) expected value of such investment? Are social concerns driving to some extent preferences for skewness? Is the "last hour" effect an anomaly specific to race betting or do we observe a last period effect irrespective of the unit of time?

To address these questions, we design a dynamic portfolio allocation experiment in which each subject (she) allocates money at each date between different types of assets. We consider a within-subject design with three treatments. In the first (**NoBet**) treatment, the subject allocates wealth between a safe asset and a risky asset with higher expected payoff. It is a control treatment designed to elicit and structurally estimate the risk attitude of subjects. The results of this treatment are analyzed in Brocas et al. (2019)

[1] For evidence of skewness seeking in lotteries and race-track betting see Garrett and Sobel (1999) and Golec and Tamarkin (1998), respectively. For proposed evidence in the financial markets, see Mitton and Vorkink (2007), Kumar (2009), Boyer et al. (2009), Bali et al. (2011), Green and Hwang (2012), Conrad et al., (2013), and Boyer and Vorkink (2014).

and used for comparison in this paper whenever relevant.[2] In the second (**Bet**) treatment subjects can also buy "a bet" (a third, skewed asset with negative expected payoff) in each period. In the third (**Bet&Box**) treatment, subjects are given the option to obtain feedback about the wealth level of other participants in the session at specific points in time. More precisely, they can choose to learn the minimum, average or maximum current wealth. They can also choose to remain ignorant. In all treatments, feedback regarding the returns of all assets is provided at the end of each period. We address our three questions of interest and we obtain three main results.

First, we find that a small subset of our subjects (16%) never purchase the bet perhaps because they understand that it has negative expected value. Some others (29%) buy the bet at first but stop purchasing it half-way through the experiment. Finally, about half of the subjects (55%) purchase bets throughout the entire experiment. This echoes the results from other experiments in the literature that evidence preference for skewness. Testing higher order-risk preferences (prudence and temperance), Deck and Shlesinger (2010), Brünner et al. (2011), Ebert and Wiesen (2011) and Ebert (2015) find preference for skewness. In these studies, subjects are offered pairs of lotteries with the same mean and variance but different degrees of skewness. Many subjects choose options with higher skewness. Grossman and Eckel (2015) and Astebro et al. (2014) also find skewness seeking behavior in experiments with modified multiple price list paradigms. Lastly, in the asset market experiments of Ackert et al. (2006) and Huber et al. (2014), subjects exhibit stronger initial overpricing of skewed assets. However, none of theses studies have scope for learning about one's own reaction to the outcome of the lottery. The dynamic aspect of our experiment allows us to investigate the robustness of the preference for skewness, and it shows that such preferences are indeed quite robust. At the same, it also suggests that a non-negligible fraction of subjects learn to avoid these gambles, so that estimates of the preference for skewness based on one or a limited number of gamble opportunities may be biased upwards.

Second, subjects who buy the skewed asset during the entire experiment exhibit a strong last period effect, with purchases two to four times higher in the last opportunity they have (period 10 of their investment paths) than in any other one (periods 1 to 9 of their investment paths). As reviewed earlier, an increase in betting on long-shots in the

[2] For overviews regarding static empirical and experimental risk elicitation procedures, see Harrison and Rutström (2008), Charness et al. (2013), and Friedman et al. (2014). Dynamic experimental frameworks have been used in Kroll et al. (1988), Kroll and Levy (1992), Levy (1994), Sundali and Guerrero (2009), and in game show replications summarized by Andersen et al. (2008)

last race of the day has been observed in the field (McGlothlin (1956); Ali (1977); Asch et al. (1982)) and our study shows that the effect can also be generated in a controlled laboratory setting.[3] This suggests that a behavioral bias might be at play in dynamic situations, where a preference for skewness is developed over time. Furthermore, we find that the effect is strongest when subjects accumulate highest levels of wealth but it is also present in the mirror image case of lowest levels of wealth. The results are consistent with loss aversion, characterized by Kahneman and Tversky (1979) and Thaler and Johnson (1990), whereby bettors who have lost or not accumulated much wealth may try to catch up at the end of the day. It also supports the intuitive idea that subjects who accumulate large amounts of cash are more willing to bet with house money.

Third, our subjects are very curious about the wealth of others. They mostly choose to learn what is the highest wealth in the session. However, this choice is strongly affected by their own performance. Indeed, when a subject accumulates low, medium and high wealth, she typically looks for feedback regarding the minimum, average and maximum wealth in the session, respectively. Interestingly, subjects tend to buy more bets when they discover that they are lagging, in particular if this information is unexpected - an individual with relatively high wealth who discovers that her wealth is below the average in the session. This result is consistent with the existing literature. For example, Haisley et al. (2008) find that participants buy more lottery tickets when they are primed to feel they have relatively low income. Dijk et al. (2014) show that lower ranked individuals in an asset allocation game invest relatively more in skewed assets while the reverse holds for higher ranked individuals. Finally, Schwerter (2024) shows that subjects take more risk when they lag against the earnings of assigned peers.[4]

The paper is organized as follows. In section 2, we describe the experimental setting. In section 3 we present the basic results on portfolio allocation between the safe and risky asset. In section 4, we discuss the general propensity to purchase the skewed asset and the effects of wealth and end of period. In section 5, we study the willingness to obtain information on the performance of others. In section 6, we offer some concluding remarks.

[3]It is worth noting that in a much larger sample size of horse races, Snowberg and Wolfers (2010) show that this effect, albeit present, is statistically insignificant. However, drawing stimuli from a real day of racing, one experimental study by McKenzie et al. (2016) still finds a significant last race effect.

[4]See also Kuziemko et al. (2014) who show more risk taking by the subject in the last place and Schoenberg and Haruvy (2012) who show that in market experiments the price of the asset is higher when the traders are informed about the best performer than when they are informed about the worst performer (however and despite the effect on market prices, they could not find a significant difference in risk taking between leaders and laggards).

2 Experimental Design

We study the dynamic portfolio choice of agents when a skewed asset is present and how their investment decisions among the different assets is affected by relative concerns. The experiment consists of 13 sessions run in the Los Angeles Behavioral Economics Laboratory (LABEL) at the University of Southern California. Each session has between 7 and 10 subjects for a total of 120 recruited subjects, of which 3 are omitted from the analysis due to software malfunction. All subjects participate in three treatments presented always in the same order. In the first treatment (hereafter **NoBet**), subjects allocate wealth between two assets, a 'safe' and a 'risky', during 15 investment *paths* consisting of 10 *periods* each. The results of this treatment are reported in Brocas et al. (2019). The second treatment (hereafter **Bet**) is similar except that, in each period, subjects can also invest in a third asset, the bet, which costs \$1 and gives a return of \$20 with probability 0.04. The third and last treatment (hereafter **Bet&Box**) is identical to the **Bet** treatment, except that subjects can obtain feedback in designated periods. More precisely, they are given the option to check either the minimum wealth ('Min'), the average wealth ('Ave'), or the maximum wealth ('Max') among all participants in the session. We report here the results of treatments **Bet** and **Bet&Box** and compare them with the results obtained in the **NoBet** treatment whenever relevant.[5]

2.1 Treatment 1: benchmark portfolio allocation (NoBet)

In the **NoBet** treatment, each subject (she) starts each path in period 1 with an endowment of \$3, which she allocates between two assets, a risky asset A and a safe asset B. After period 1 ends, each subject earns a return on her portfolio and moves to period 2. She then reallocates her portfolio and earns new returns. This process continues for a total of 10 periods. After period 10, the investment path ends and the subject's final payoff in that path is recorded. Each subject then moves to the next investment path, where her endowment is reset to \$3. Subjects have 10 seconds to make their decision in period 1 of each path and 6 seconds in periods 2 to 10 of each path. They all begin and end investment paths at the same time. Finally, all subjects go through 15 investment paths for a total of 150 choices. Subjects know at the beginning of the treatment the number of paths and periods ahead.

[5]Fixing the order of treatments may have an effect on choices (Charness et al., 2012). However, in our setting there was a natural order for an already reasonably difficult problem: start with a two-asset portfolio allocation, add the third asset, and finally add the social comparison.

The return of the safe asset B is 3% while the return of asset A is drawn from a Normal distribution with mean 6% and standard deviation 55%.[6] The parameters do not change throughout the experiment. The draw of the return is presented in the form of a multiplier, that is, the number that multiplies the allocation to that asset (so the multiplier of asset B is always 1.03 whereas the mean multiplier of asset A is 1.06). All participants in a session are subject to the same draws but we make clear to each subject that the draw of the return of the risky asset is in no way affected by her past allocation decision or by the allocation decision of the other subjects.

Figure 1 provides a screenshot that describes what a subject sees in a given period of a path. Current wealth is represented by the vertical bar positioned above the current period number (period 4 in this example). When gray, the bar is not active and the wealth is not allocated to either asset. Subjects need to click on the bar to activate it and move a horizontal slider to divide their current wealth between assets A and B. The upper portion of the bar represents the money invested in A and the lower portion represents the money invested in B. The figures on the right side of the bar show the current allocation. To facilitate their reasoning, subjects may change the display of the allocation at any time between percentage in each asset (box labeled " % " as in this screenshot) and total amount in each asset (box labeled " $ "). After the period expires, returns are applied and subjects move to the next period. A new bar with a height corresponding to the new wealth appears to the right of the previous one for the new period and becomes inactive again. Subjects need to reactivate the bar in order to choose a new allocation, otherwise they earn no extra earnings in that period and their account just carries over.

[6]This (unrealistically high) mean and standard deviation ensure enough volatility in returns for generating interesting wealth effects and comparative statics. In the discrete version of the experiment, the evolution of wealth is:

$$X(t+1) = X_B(t)(1+r) + X_A(t)\, e^R$$

where $X_i(t)$ is the dollar amount invested in asset $i \in \{A, B\}$ and R normally distributed with a mean of 0.06 and standard deviation of 0.55. Note that the return of the risky asset, e^R, is log-normally distributed, so the worst case for the subject is to lose her investment in A. In a part of the instructions and on the upper left corner of the screen, we described in words the parameters of the return on asset A as being normally distributed with a mean of 6% and standard deviation of 55%, when it should have read log normally distributed with a mean of 23.5% and a standard deviation of 73.4%. In other words, we accidentally described R instead of e^R. Nevertheless, we are confident that this did not impact the results, as the rest of the instructions and accompanying slides vividly and correctly describe the entire distribution of Asset A through graphical and video examples. Moreover, students are shown a correctly specified interactive projection bar at the end of the screen that informs them of the possible distribution of payoffs at the end of the path as they change their current allocation. Previous research shows the importance of visual and interactive tools for financial literacy (Lusardi et al. (2017)). Lastly, students had five practice paths and a quiz before starting their paid trials, which was enough to experiment with the bar and the payoffs.

This helps prevent subjects' inertia and a bias towards a status quo allocation. Level of inactivity in our experiment was negligible. Subjects observe bars to the left of the current one (periods 1 to 3 in this screenshot) that reminds them of their past allocations and returns. These bars accumulate up to period 10, at which point earnings are recorded and a new investment path is started in period 1 with the endowment reset to \$3. Finally, the left hand side of the screen has a summary information of the main ingredients of the experiment: (i) the current path and period; (ii) a reminder of the mean and standard deviation of returns of assets A and B; (iii) the time left to make a choice in the current period; (iv) the accumulated wealth in the current path; and (v) the multiplier of assets A and B in the last period of the current path.

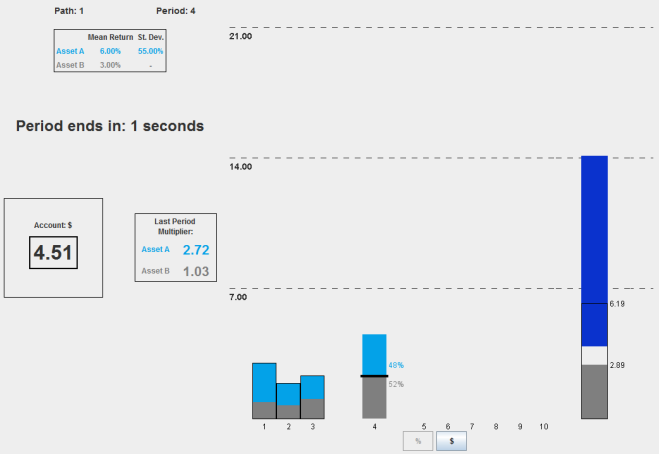


Figure 1. Screenshot of path 1 / period 4 in **NoBet** treatment

This dynamic wealth allocation problem is challenging and may require substantial learning. To deal with this issue, we employ a highly illustrative 40 minute instructions period using a neutral language with numerical examples, videos, 5 practice paths and a quiz to test the subjects' understanding (instructions can be found in the appendix). In addition, to help with the cognitive strain, we add a projection bar placed on the right end of the screen (see Figure 1). The projection bar tells the subject what she would expect if she were to keep her current investment strategy until the last period. The bar shows the potential accumulated earnings from asset B and identifies the 20th, 50th and 80th percentile of the earning distribution from asset A. As the participant changes her allocation the projection bar automatically adjusts.[7]

[7]We carefully explain the function of the bar by simulating potential period-by-period trajectories of

As stated above, the results of the **NoBet** treatment are extensively analyzed in Brocas et al. (2019). In particular, we structurally estimate the risk attitude of the subjects assuming they are expected utility maximizers and discuss the frequency and severity of behavioral biases. These findings form a benchmark for comparison when we add a skewed asset (**Bet** treatment) and the possibility of observing the earnings of other subjects (**Bet&Box** treatment).

2.2 Treatment 2: allocation in the presence of a skewed asset (Bet)

After completing the **NoBet** treatment, subjects move to the **Bet** treatment, which introduces two changes to the environment described in section 2.1. First, subjects go through 10 (rather than 15) investment paths of 10 periods each, for a total of 100 new choices. Second and most importantly, we add a new asset C, the "bet", which costs \$1 and yields \$20 with probability 0.04 (naturally, in the experiment we never refer to this asset as a bet). Figure 2 presents the screenshot from the **Bet** treatment, which is identical to Figure 1 except for the lower left corner where asset C is introduced.

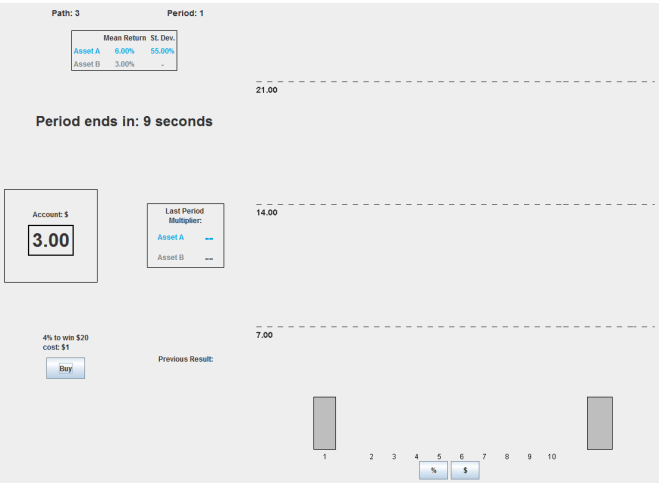


Figure 2. Screenshot of path 3 / period 1 in **Bet** treatment

Asset C is purchased by clicking on the button below the description of its cost and potential return. Subjects can buy at most one bet per period. If they have less than \$1 in their account, they cannot afford the bet and the box button is grayed out and inactive. If they buy a bet, the cost is withdrawn from the other two assets keeping constant the

wealth coming from a given allocation strategy.

proportion invested in assets A and B. Overall, subjects make two decisions per period: whether to buy a bet (asset C) and how to allocate the rest of the money between assets A and B. Subjects learn the outcome of the bet at the same time as the returns of assets A and B, that is, at the end of the period. Importantly, subjects are informed that bets are independent across individuals and across periods, in contrast with the return on asset A which is the same for all subjects in a given a period. They go through one practice path before commencing the **Bet** treatment.

2.3 Treatment 3: skewed asset with feedback (Bet&Box)

Feedback is provided in the **Bet&Box** treatment. More specifically, the environment is identical to the **Bet** treatment, with one exception. In periods 5 and 9 of each path, 3 boxes labeled 'Lowest', 'Average' and 'Highest' appear on the lower left corner of the subjects' screens (see Figure 3). These boxes contain information about the minimum, the average, and the maximum amount held currently by the subjects in the session. They do not disclose the identity of those subjects. Subjects may open only one box at the time it is offered and may decide to not open any.

Figure 3. Screenshot of path 4 / period 5 in **Bet&Box** treatment

Overall, in periods 5 and 9, subjects make three decisions: whether to obtain feedback about earnings of subjects in the session, whether to purchase the bet, and how to allocate the rest of the money between assets A and B. In the other periods, subjects make only the second and the third decision, just like in the **Bet** treatment.

2.4 Payments

At the end of the experiment we collect answers to education, demographics and income related questions as well as their own description of the strategies employed. Each participant receives a $5 show-up fee and her final earnings in the final period of two paths, *one* path randomly selected from the **NoBet** treatment and *one* path randomly selected from the **Bet** and **Bet&Box** treatments. Sessions last for 2 hours and the average payoff is $23, with a maximum payoff of $244.

3 Risk attitudes

As mentioned in the introduction, the main purpose of the paper is to analyze how the presence of a skewed asset and information regarding the wealth of other subjects affects risk taking behavior in a controlled environment. However, it is instructive to start the analysis of the data by studying the subjects' allocation of wealth between the risky and safe assets (A and B) in the **Bet** and **Bet&Box** treatments, and to compare their choices with those obtained in the **NoBet** treatment. There are at least two reasons why the results of such comparison must be taken with a grain of salt. First, the investment environment is complex, so we expect some learning over the course of the experiment about the implications of the different choice allocations as well as the subject's own risk tolerance. Differences in choices across treatments may simply reflect such knowledge acquisition (remember that treatment orders are not randomized). Second, even though a risk-neutral or risk-averse individual should never buy the skewed asset C in the **Bet** and **Bet&Box** treatments, we do observe purchases of the bet. Buying a bet (or simply being offered a bet) is likely to affect the allocation of wealth between the other two assets. Naturally, this is not to say that we expect choices across treatments to be uncorrelated.

Figure 4 presents a histogram with the average proportion of wealth allocated by each subject to the risky asset A in the **Bet** and **Bet&Box** treatments. Half the individuals put between 40% and 60% of their wealth in the risky asset and very few choose to put all their wealth in one asset. On average we observe more investments in the safe than in the risky asset, consistent with reasonable levels of risk aversion (Brocas et al., 2019). We only observe 2 participants who put all (or almost all) their wealth in asset A and therefore could potentially be labeled as risk-loving.

Next, we compare wealth allocation across treatments. Figure 5 presents for each subject the average proportion of wealth allocated to the risky asset in treatment 1 and

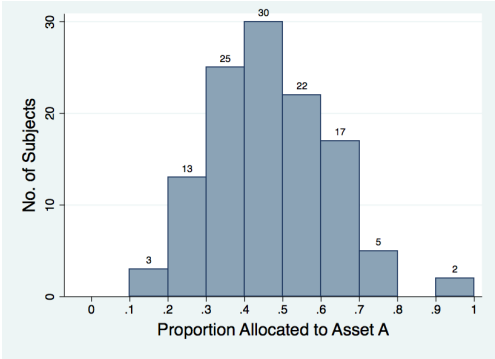


Figure 4. Average proportion of wealth in asset A (**Bet** and **Bet&Box** treatments)

in treatments 2 and 3 pooled together (left). It also presents the standard deviations of the portfolios (right).[8]

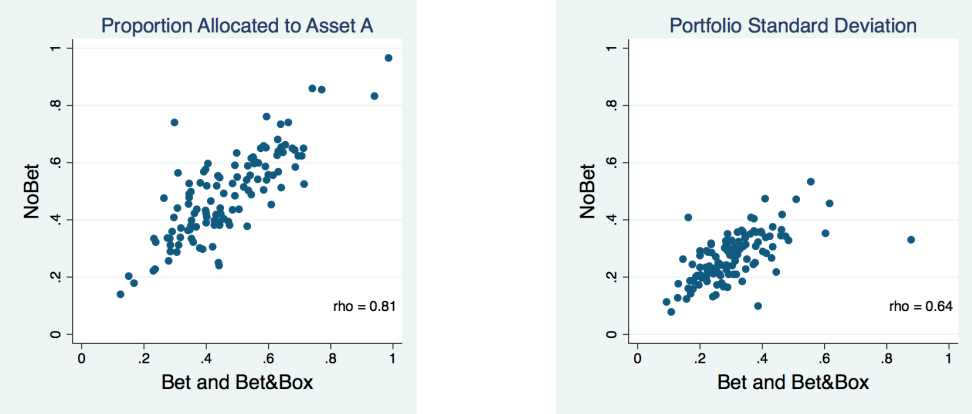


Figure 5. Comparison of subjects' allocation of risk across treatments

We note a large correlation across treatments both in the average proportion of wealth allocated to each asset and in the standard deviation of the allocations.[9] It suggests that subjects behave consistently over the course of the experiment and that the levels of risk identified in the analysis of the **NoBet** treatment (Brocas et al., 2019), apply reasonably well also to the **Bet** and **Bet&Box** treatments.

There are two final remarks regarding the relationship between risk allocation across

[8]The standard deviation is calculated using the ex-ante variances of all the assets and their respective weights in the portfolio.

[9]The correlations between the **Bet** and **Bet&Box** treatments are also high (0.86 for the average allocation to the risky asset and 0.79 for the standard deviation).

treatments. First and as depicted in Figure 6, the subjects' risk attitude in the **No-Bet** treatment is largely uncorrelated with their propensity to buy bets in the **Bet** and **Bet&Box** treatments. As we will see in section 4, subjects who invest in the skewed asset do not exhibit eccentric risk attitudes with their remaining wealth. Second, the average standard deviation of the portfolio choice of all subjects in the experiment is 0.27, 0.32 and 0.30 for the **NoBet**, **Bet** and **Bet&Box** treatments, respectively. As explained below, the differences in standard deviations across treatment are, to a large extent, a consequence of the differences in bet purchases.

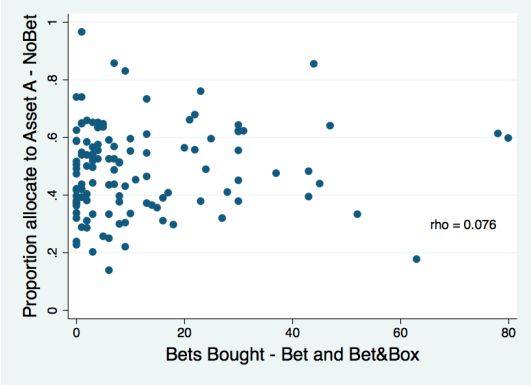


Figure 6. Risk allocation and bet purchases

4 Betting

We shall note to begin with that asset C has negative expected value so a risk-neutral or risk-averse expected utility maximizer should never buy a bet.[10] From the behavior in the **NoBet** treatment (and in accordance with previous research) we found that no subject exhibits risk-loving attitudes (Brocas et al., 2019). We should therefore expect zero or minimal levels of bet purchases. Furthermore, since a risk-loving attitude is necessary for the willingness to buy asset C, any expected utility maximizer subject who purchases that asset should invest the remaining of her wealth in the risky asset A. Indeed, that asset has higher expected return and higher variance than the safe asset B.

[10]Note that asset C return is independent from other assets' returns, thereby bringing no offsetting diversification benefits

4.1 General betting behavior

Figure 7 depicts the aggregate frequency of bet purchases over time conditional on subjects having the option to buy them (in 3.9% of the observations, subjects have less than $1 and therefore could not afford the bet). Contrary to the theoretical predictions, we find that 6.3% of the available bets are purchased. We notice, however, a significant decline in the number of bets purchased over time: 8.1% in the **Bet** treatment against 4.5% in the **Bet&Box** treatment. The trend is decreasing over the course of the **Bet** treatment and stabilizes afterwards, suggesting that in aggregate terms subjects realize that the bet is not profitable.

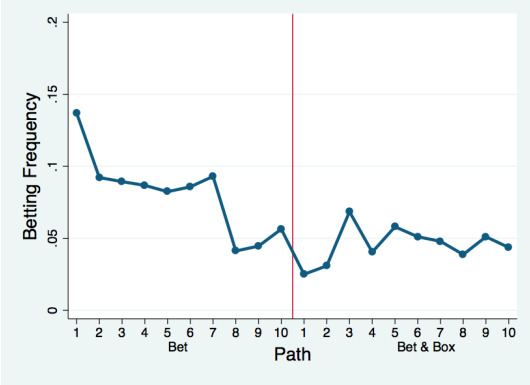


Figure 7. Frequency of bet purchase over time

Interestingly, out of the 1416 bets purchased over the two treatments, subjects put more than 98% of the remaining wealth in the risky asset only in 96 occasions (6.8%). This indicates that subjects do not behave as risk loving expected utility maximizers.[11]

There is a large heterogeneity in betting behavior among our subjects. We can informally classify subjects into three groups. There are 19 subjects who never bet (group 1 or G1), 34 subjects who bet a few times and stop purchasing bets before the end of the **Bet** treatment (group 2 or G2), and 64 subjects who bet in both parts (group 3 or G3). Figure 8 shows the distribution of stopping times, that is, the last path where a subject chooses to bet (histogram, axis on the left) and, for each subject, the total number of bets bought before stopping (filled circle, axis on the right). The majority of subjects in G2 bet only a few times before stopping (4.7 on average per subject). By contrast,

[11] Also, only two subjects exhibit this behavior more or less consistently: one purchases a total of 9 bets and in 8 of these instances puts all the remaining wealth in the risky asset whereas the other purchases 6 bets and in 4 of these instances puts all the remaining wealth in the risky asset.

many subjects in G3 bet often (19.6 on average) and keep betting throughout the entire experiment. These subjects also purchase more bets in the **Bet** treatment than subjects in G2 (11.6 on average).

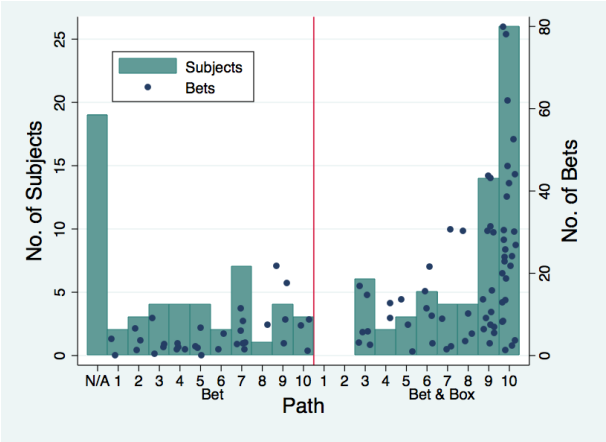


Figure 8. Distribution of stopping times

We explore gender effects as well. In line with the existing literature (see Charness and Gneezy (2012)), men tend to take more risks than women. In particular, among the participants that bought at least one bet, males tend to buy lotteries more frequently than females. They also lower the frequency of betting less than females as they transition from **Bet** to **Bet & Box** treatment. In the **Bet** treatment, males bought 10.7% of the available bets, and females bought 8.8%. In the **Bet & Box** treatment, males bought the bet 7.3% of the time and females bought it 3.9% of the time.

To better understand the differences in behavior, we compute the standard deviation of the portfolio of each subject in each treatment. Figure 9 reports the average results by group. Although the differences in variance across groups in the **NoBet** treatment are statistically significant, the levels are very similar (0.24, 0.28 and 0.27). When comparing across treatments, we notice that for G1 the variance is constant for the entire experiment, for G2 it increases between **NoBet** and **Bet** and then levels down in **Bet&Box**, and for G3 it increases and then stays up. Overall, variance mimics the evolution of bet purchasing behavior in the groups, which suggests that when subjects invest in asset C they do not change significantly the allocation of their remaining wealth between assets A and B.

We also investigate whether the outcome of the bet (win vs. loss) has an impact on the behavior immediately after and, to our surprise, find no effect. One possible reason is that very few bets are won (only 2.9% over all purchased) and only 27 subjects experience at

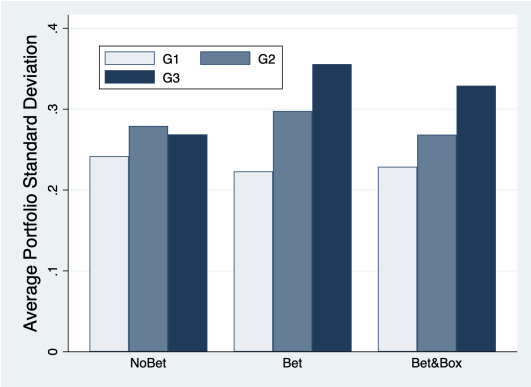


Figure 9. Standard deviation of portfolio

least one win. In particular, no subject in group 2 ever won, which also possibly accounts for their behavior in the treatment 3. However, even in group 3 where bets are sometimes won, the percentage of bet purchases at $t+1$ following a win at t and a loss at t are high and remarkably similar (35% vs. 37%). By contrast, the percentage of bet purchases at $t+1$ after no bet at t is very low (4%). Overall, there is persistence in behavior (bet is followed by bet and no bet is followed by no bet) and it does not seem to depend on the outcome of the bet.

4.2 Effects of wealth and end of period

Subjects in our experiment buy more bets when they are richer. To see this, we study within-subject heterogeneity in bet purchases as a function of wealth. More precisely, for each individual we remove the observations where she has less than \$1 (and therefore cannot buy a bet) and group all her other observations in wealth quintiles. We then determine the frequency of bet purchases when her wealth falls in each of these quintiles.[12] Figure 10 depicts this information separately for the **Bet** and **Bet&Box** treatments. In both treatments, the frequency of bet purchases is significantly higher when subjects are in their top wealth quintile (p-value < 0.001 for all pairwise comparisons between the top quintile and the other quintiles). Interestingly, it is also significantly higher in the bottom quintile compared to the second and third in the **Bet** treatment (p-value < 0.001 and p-value $= 0.003$, respectively), indicating a tendency in that treatment to invest in the

[12] We opt for a within-subject quintile analysis to avoid confounding wealth heterogeneity with subject heterogeneity.

skewed asset when wealth is "extreme."[13] However, the fact that this happens only in the **Bet** treatment prevents us from drawing further conclusions.

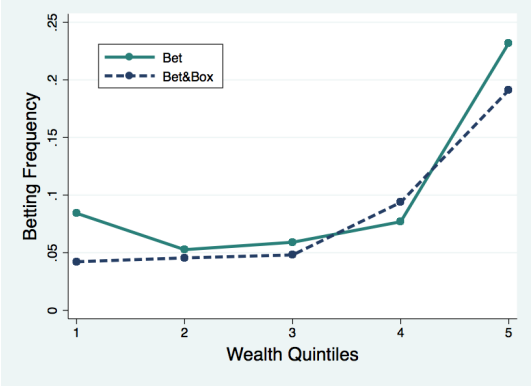


Figure 10. Frequency of bet purchase by wealth level

One striking result is the tendency of subjects to buy bets in the last period of every path, a feature that persists throughout the experiment. This is illustrated in Figure 11 which shows that the bet frequency is significantly higher in period 10 than in any other period (p-value < 0.001 for a test of comparison between bet frequency in period 10 and any of the earlier periods, overall and by treatment).

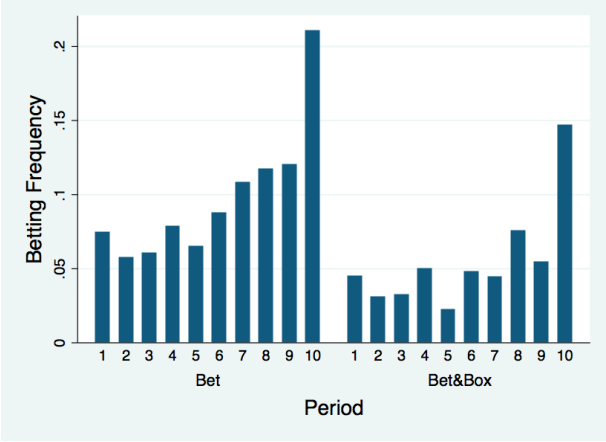


Figure 11. Frequency of bet purchase by period and treatment

[13]Further analysis suggests that the G3 group, subjects who bet in the Bet&Box treatment, reduces bet purchases in low wealth cases. This is why we do not observe higher betting propensity for the lowest wealth quintile in the Bet&Box treatment.

A possible explanation for this trend is that subjects bet more at the last minute simply because they are richer at that point. After all, wealth substantially accumulates over the periods of a path. However, we find that the last period effect is independent of wealth. Figure 12 depicts the frequency of bet purchases in periods 8, 9 and 10 by wealth quintile, as defined previously. A test of differences reveals that the last period effect is present in all wealth quintiles, although the effect is smaller in the highest one (p-values < 0.005 for tests of comparisons between periods 9 and 10 in all quintiles and between 8 and 10 in quintiles 1 to 4).

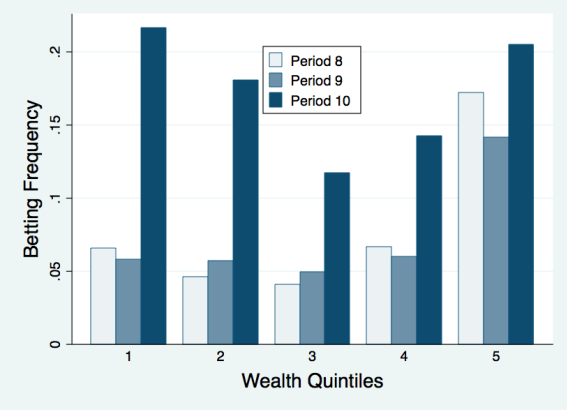


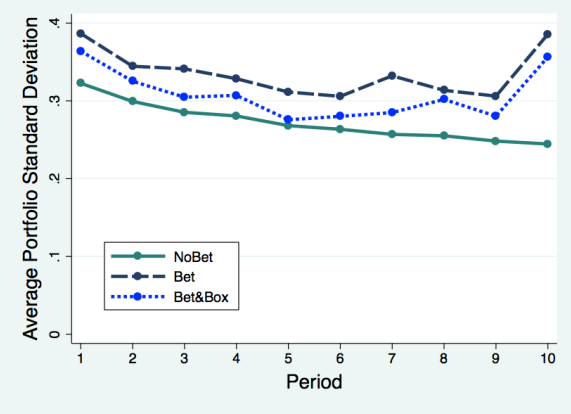
Figure 12. Last period effect and wealth

This effect is largely responsible for the increase in the standard deviation of portfolios we discussed earlier in treatments **Bet** and **Bet&Box** compared to **NoBet**. The left graph of Figure 13 shows that for the last two treatments subjects increase significantly the volatility of their portfolio in the last period. The right graph of Figure 13 describes portfolio volatility by wealth quintile and treatment. Consistent with the previous result, the increase in volatility is mostly due to last minute betting among the poorest subjects (quintiles 1 and 2).

To investigate this effect further, we run the following linear probability model for each of the 79 individual who purchase 3 or more bets:

$$Y_{it} = c + \beta_w W_{it} + \beta_x X_{it} + \epsilon_{it}$$

where Y_{it} is a dummy variable indicating whether subject i buys the bet at period t or not, W_{it} is her endowment at period t and X_{it} is a dummy variable for period 10. We find that about one-third of the subjects (28 out of 79) bet significantly more in the last period (at the 5% level). The majority of these subjects (23) belong to G3.



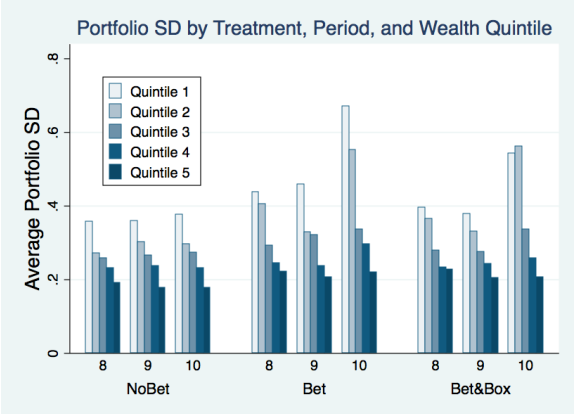


Figure 13. Frequency of bet purchase in the last period

4.3 Summary

There are three main results regarding investment in the skewed asset. First, there is a non-negligible amount of "betting" which decreases significantly over the course of the experiment: some subjects never try the gambling option, some like it all along, while others, likely realizing its low return, stop purchasing it. This suggests that studies based on one (or few) opportunities for skewed investments may provide an upward biased estimate of the willingness of individuals to undertake gambles. Second, bet purchases are higher when subjects are wealthy, consistent with the idea that the subject gambles when it constitutes only a small fraction of money, and wisely invests the rest. Third, betting increases significantly in the last period of each path in both the **Bet** and **Bet&Box** treatments and for all wealth levels. A possible explanation is that subjects realize that asset C has low expected value and want to avoid the compounding effect of buying it early in the path. Alternatively, the lognormality of Asset A may be used to build a skewed option dynamically. But, as the investment path comes to the 10th period that option is no longer viable; the subjects may then switch their strategy to the bet.

The dynamic skewness building through option A may underestimate the true preference for skewness. This is why our experimental design is not the most appropriate for structural estimation of utility functions that can account for lottery-seeking behavior. However, it is worth noting that the dynamic investment in asset A does not substitute for asset C, since we do not observe significant reallocation between the safe and the risky option with the introduction of the bet. Furthermore, as the left panel of Figure 13 shows, there is an increase in the overall riskiness of the portfolio with the introduction of the

bet, especially in the last period. This suggests that some particular attribute of the bet distinguishes it from the other option. For example, a single period $1 Asset A investment is virtually impossible to return $20. That salient payoff may be the driving force behind the demand for the skewed asset.

5 Feedback

We now analyze how the possibility of observing the payoffs of other subjects affects the portfolio allocation in the game. Recall that subjects make independent decisions, so they should not be affected by any information about the performance of their peers. Feedback collection depends on whether we think there is a (small) cost of opening boxes or a (small) benefit of satisfying curiosity. Either way, it should not affect subsequent choices.

We find that the vast majority of our subjects open a box whenever the option is available: 2158 out of the 2340 available times (92%). Subjects open boxes with equal frequency in periods 5 and 9 and in all investment paths. The distribution of the number of boxes open by subject is represented in Figure 14. Only 2 subjects never open a box and two-thirds of subjects open a box every single time.

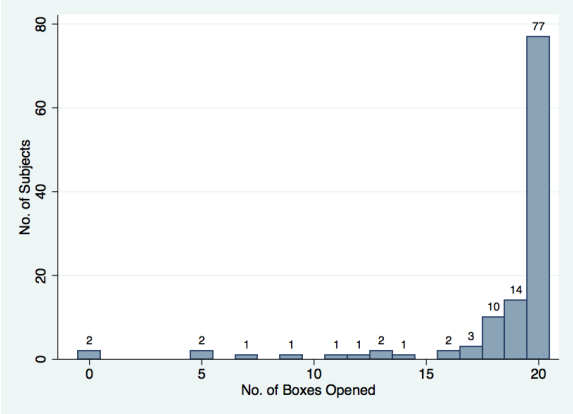


Figure 14. Distribution of lookups in the population

Remember that subjects can obtain information about the lowest (Min), Average (Ave) or highest (Max) payoff currently held by an individual in the session, although they never learn the identity of that subject. We are interested in assessing the reasons why subjects decide to collect feedback, why they choose a particular type of feedback, and how it affects their subsequent behavior.

5.1 Wealth and feedback

Only 17 subjects open always the same box while the remaining 98 switch between boxes. A natural possibility is that subjects care about their relative position within the population and try to figure out how far they are from a position of interest. Some subjects may be intrinsically more interested in checking some specific relative position (e.g., how far they are from Ave), while some others may be willing to track their relative position as a function of their performance (e.g., check that they are not the poorest when they fear it might be the case, and figure out if they are the wealthiest when they are likely to be). To test this hypothesis, we study lookup patterns of subjects by wealth quintile.[14] Figure 15 depicts the mean and 95% confidence interval for the fraction of lookups in each box.

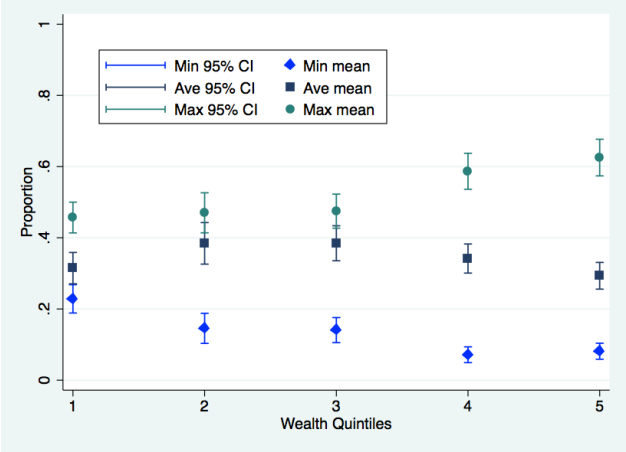


Figure 15. Lookups in Min, Ave and Max boxes by wealth quintile

Subjects are systematically more likely to open Max than Ave and Ave than Min. This trend holds independently of wealth levels. However, the likelihood of opening Min decreases with wealth, the likelihood of opening Ave is hump-shaped in wealth, and the likelihood of opening Max increases with wealth. This suggests that wealth levels drive lookups and that the two hypotheses previously mentioned have some support: (i) subjects are intrinsically more interested in finding out what is the maximum wealth currently held in the session and (ii) subjects are more likely to look at the box they believe is closest to their own wealth. These results hold in both periods in which feedback is possible and

[14] Contrary to the previous quintile analysis, we now keep all observations of the individuals in the **Bet&Box** treatment, including those in which wealth is smaller than $1.

across groups.[15]

5.2 Effect of feedback on bet purchases

The first noticeable result is that feedback has the immediate effect of reducing the overall betting activity. Indeed, the percentage of bets purchased in **Bet&Box** is significantly higher in period 4 compared to period 5 (0.041 vs. 0.018, p-value = 0.001) and marginally higher in period 8 compared to period 9 (0.059 vs. 0.043, p-value = 0.074).

We next study whether feedback obtained as a result of opening a box has an impact on the subsequent decision to purchase a bet. To this purpose we consider a very simple binary partition of feedback. For subjects who open the Min, Ave and Max boxes, we say they "lead", if they learn that they are above minimum, above average and at maximum, respectively. By contrast, we say they "lag" if they learn that they are at minimum, below average and below maximum, respectively.[16] Figure 16 reports the percentage of times subjects bet when they lead vs. lag as a function of the box they open.

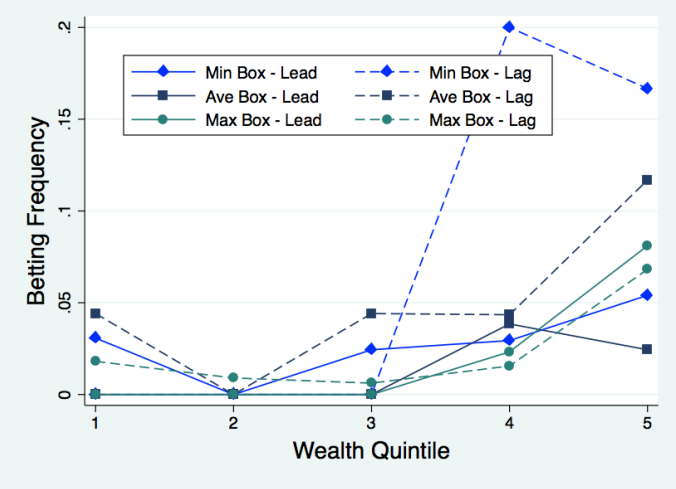


Figure 16. Betting frequency by wealth quintiles and lookup when lead vs. lag

[15]To investigate more formally this effect we create three dummy variables (Min, Ave, Max) and regress each of them separately on wealth and a number of control variables. We find that wealth has a significant positive effect on Max lookup, no significant effect on Ave lookup, and a significant negative effect on Min lookup (results omitted for brevity but available upon request).

[16]Obviously, a subject who opens Max is likely to be coded as "lag" even when she has high wealth a subject who opens Min is likely to be coded as "lead" even when she has low wealth. In that respect, this is just one simple (and imperfect) cut of the data. We have performed a similar analysis where we look at distance between wealth and information and obtained similar conclusions.

Consistent with the results in section 4, subjects rarely bet when their wealth is low (first and second quintile) independently of the information obtained. Subjects with average wealth (third quintile) who learn that they are below average increase moderately their betting activity. Most of the increase, however, occurs for high levels of wealth and unexpected news. In particular, a subject in the top quintile bets five times more when she discovers that her wealth is below average.[17]

Finally, we present a Probit regression of the probability of purchasing a bet on the type of feedback obtained (lead or lag) controlling for the level of wealth, the box opened (Min, Ave, Max) and the different sources of heterogeneity. We capture the intrinsic risk attitude with the average fraction of wealth invested in the risky asset in the **NoBet** treatment, and we control for the period where the box is open (5 or 9). The results are presented in Table 1.

	Prob. of bet purchase	
Lead	-0.324 **	-0.304*
Wealth	0.043 ***	0.039 ***
Ave (dummy)	-0.048	-0.038
Max (dummy)	-0.336	-0.332
Period 9 (dummy)	—	0.405***
% asset A in **NoBet**	—	-0.141
Constant	-1.552***	-1.707 ***

*, **, ***: significant at the 10%, 5% and 1% level.

Table 1. Behavior following feedback

Consistent with the evidence presented before, subjects are more likely to purchase bets when their wealth is high and when they learn they are lagging behind. They also purchase more bets in period 9 than in period 5. Once we control for these variables, the type of box open is not predictive of bet purchases. Similar results (not reported here) hold when, instead of using the lead/lag binary variable, we consider the actual difference between own wealth and wealth revealed in the box.

5.3 Summary

Our subjects are very curious about the performance of others. They have a preference to learn the highest payoff of the population but they often decide as a function of their

[17]There is also a large increase when she discovers that her wealth is at minimum as opposed to above minimum but it is based on few observations and therefore not statistically significant.

current performance: low wealth, medium wealth and high wealth subjects look relatively more at Min, Ave, and Max, respectively.

On aggregate, opening boxes decreases the likelihood of betting. However, subjects who are in an investment path where they accumulate equal or more wealth than they typically do and nevertheless learn that they are below average significantly increase their tendency to buy the bet. As a reminder, while Asset A period returns are exactly the same across subjects in the same session, the outcomes of lotteries purchased by two different subjects in the same period are independent. This allows subjects to use the lottery asset as a tool to outstrip their peers. Our results are in line with the predictions that portfolio choices may be driven by the quest to attain status or higher aspiration levels (Roussanov (2010), Krasny (2011), Aristidou et al. (forthcoming)).

Alternatively, the theory of inequality aversion may offer an explanation, plausibly, in the narrow range of wealth only. Coibion et al. (2020) has shown that low income households accumulated more debt in low income neighborhoods compared to high-inequality neighborhoods before the financial crisis. This suggests that low income households may have cared about their relative performance with respect to households with similar income levels rather than inequality itself. This is reminiscent of our finding, suggesting that a novel form of inequality aversion may impact behavior in both real life and controlled settings.

6 Conclusion

We design a controlled laboratory experiment where subjects dynamically choose to allocate their portfolio between a risky asset A, a safe asset B, and a skewed asset C. Many subjects purchase the skewed asset over the course of the experiment despite its negative expected payoff. However, we note substantial heterogeneity in bet purchases with the existence of three distinct groups: subjects who never buy asset C (16%), subjects who learn not to buy asset C (29%) and subjects who persist buying asset C (55%). Among the latter, purchases are more frequent when the subject is richest (possibly because they can afford a cheap lottery) and, to a lesser extent, when she is poorest (possibly as a chance to catch up). Purchases are also more frequent in the last period of the path, when it is the last occasion to make a big impact.

We also analyze the effect of feedback and notice that subjects care about the performance of others, especially in relation to their own wealth: subjects who accumulate little wealth are relatively more interested to check whether they are the poorest while

those who accumulate a large wealth are more inclined to check whether they are the richest. Finally, subjects tend to take riskier positions when they accumulate a high wealth and find out they are among the poorest subjects in the population. Overall, our results suggest that skewed assets are valuable for some individuals but purchased with caution. Also, subjects care about their relative performance and sometimes act upon it.

While our design is not intended to (nor suitable for) a structural estimation of existing non expected utility models that generate a preference for skewness (such as, for example, Epstein and Zin (1989), Chew and Tan (2005) or Koszegi and Rabin (2009)), we think that some of our findings may open avenues for future research. First, in our experiment the initial demand for a skewed asset drops, suggesting that the experience of lottery outcomes affects its subsequent demand. This result should be instructive for future experiments assessing preference for skewness. More broadly, it should be informative when estimating the demand for financial products incorporating lottery-like features such as prize-linked savings (PLS) accounts. These bank accounts offer savers to partially or entirely replace the interest payment on their principal with a lottery ticket.[18] In a lab experiment, Filiz-Ozbay et al. (2015) find that PLS offers increase subjects propensity to save. According to our results, it would be interesting and beneficial to investigate the long-term effects of PLS programs.

Second, the substantially higher purchases in the last period raise the question of what is deemed to be the "last period," especially in the cases where the end point may not be a salient feature of the investment cycle.[19]

Next, we found that subjects sometimes (namely in the **Bet** treatment) tend to bet more often when they are poor. Our design however does not allow to collect enough data at the individual level to further investigate this result. It would be interesting to design an experiment in which subjects would have to face different levels of wealth exogenously to better measure the relationship between wealth and betting attitude.

Lastly, we have found that subjects are mostly interested in checking their expected relative position and that they resort to bets to catch up with this belief. Whether this behavior is driven by aspirations and status or by the desire to reduce inequality needs to be understood further.

[18] For an overview of prize-linked savings products, see Kearney et al. (2011)

[19] For example, Thaler and Ziemba (1988) suggested that underperforming portfolio managers may take more long-shot investments as the year draws to a close. For the analysis of investment funds on this topic, see Brown et al. (1996) and Lin (2011).

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Appendix. Instructions

Note: The following instructions are accompanied by a slideshow presentation. Slides available upon request.

We are about to begin. Please put your cell phones and other electronic devices in your bag and do not use them until the end of the experiment.

Dear Participants,

Welcome and thank you for coming to this experiment. You will be paid for your participation, in cash, at the end of the experiment. You will remain anonymous to me and to all the other participants during the entire experiment; the only person who will know your identity is the person in the other room who is responsible for paying you at the end. Everyone will be paid in private and you are under no obligation to tell others how much you earned. The entire experiment will take place through the computer terminals.

Let us begin with a brief instruction where you will be given the complete description of the experiment and shown how to use the software. Please, pay attention to the instructions, as it is important for you to understand the details of the experiment. There will be a quiz at the end of the instructions that everyone needs to answer correctly before we can proceed to the actual experiment. Participants who are unable to answer the quiz will not be allowed to participate in the experiment. If you have any questions during the instruction period, raise your hand and your question will be answered so everyone can hear. If any difficulties arise after the experiment has begun, raise your hand, and an experimenter will come and assist you. If you cannot see the entire projection screen, please come forward as it is important for you to see the entire screen.

Today, we will ask you to make investment decisions. Your final payment consists of a $5 show-up fee plus your investment earnings. Those earnings depend both on the choices you make and on luck. The choices of other participants do not affect your payoff in ANY way, at ANY point in the experiment and your choices do not affect their payoff. The entire experiment is split in 3 parts. I will now give you instructions for Part 1. You will get additional instructions before Part 2 and Part 3.

PART 1

Let me first summarize the investment process and then we will go through each step in more detail. You will start with an initial amount of money that you will be able to invest in two assets, A and B. You will have 10 periods to invest. At each period you will decide how to allocate your money between the two assets. At the end of each period, you will earn returns from that period's investment in each asset. The two assets will pay differently, and later in the instructions I will explain what to expect from each asset. After period 10, the process ends and the computer will record your final money amount. This process of 10 investment periods is called an investment path. At the start of each path, your money will be reset to the initial amount.

In Part 1 you will complete 15 of these paths. Consequently, there will be 15 final amounts of money, one for each path. The computer will randomly select one of these 15 final amounts. The selected amount will be your payoff for Part 1. Are there any questions? Let me now walk you through the procedure step by step.

The Initial Endowment: This is a screenshot of what you will see on your computer at the beginning of each path, that is, in period 1 of each path. In each path you start with $3, this is your initial endowment. This amount is displayed on the left side of the screen in the box labeled "Account". It is also represented by the height of the bar in the middle of the screen. There is a grid in the background to help you get a sense of the bar's height.

Periods and Timing: As mentioned earlier a path is made of 10 periods, starting at 1 and ending at 10. The sequence is displayed on the bottom of the screen and your current period is displayed in the upper left corner. Each period is an opportunity for you to invest. A period ends when the time runs out. You can see the timer on the left hand side. For the first period in each path you will have 10 seconds to make your investment decision. For the other periods in the path, that is, periods 2 to 10, you will have 6 seconds to make your investment decision.

Investing: Let me show you with a short video how to make your investment.

Step 1. Choose display. To start your investment, you first need to click on one of the two boxes at the bottom, the ones labeled with percentage and dollar signs. These boxes control how your allocation between assets A and B is displayed: in percentages or dollar terms. You have to click one of the boxes in period 1 of each path. You can also change the display anytime simply by clicking on the other box. Select whichever box you find convenient and change it anytime you want.

Step 2. Activate the bar. Now you can activate the investment bar. Click anywhere on the light gray bar to activate it. Notice when the bar is light gray it means that your money is not invested in either asset. If the bar stays that way after the period ends, you will earn zero interest on your money: the same amount will just be transferred to the next period.

Step 3. Choose the allocation. Once you activate the bar you will notice that it is split between two colors: the top is light blue, and the bottom is gray. The top represents the amount of money allocated to Asset A, and the bottom represents the amount of money allocated to Asset B. Now you can see the display I previously mentioned. It shows how much money you have allocated to A and B either in dollar or in percentage terms. This example shows the dollar display. You can change the allocation between A and B in two ways: by holding the horizontal bar and moving it up or down or by clicking on the bar, as you can see in the video. Once you are satisfied with the allocation wait until the period ends.

Step 4. Proceed to the next period. When the period ends, a new gray bar will appear showing you the new amount. Here is the transition from period 1 to period 2. Your new amount will be the sum of the money you earned on both assets A and B and it will be shown on the left where your initial money amount was displayed. The new height of the bar will also represent this amount. Be aware that the background grid can be re-scaled to accommodate changes in the bar, so pay attention to the figures written on the grid. The last period's bar will become inactive but you will still be able to see your past allocation between assets A and B. Remember that you need to activate the bar and choose an allocation between A and B at every period, otherwise you earn no interest. Here is a period 2 allocation process and the transition to period 3. Notice how I changed the display from dollars to percentages. This process continues until period 10. After period 10, the path ends. Here is a screenshot of one path end. Your final amount will be shown in the box on the left and by the height of a green bar on the right. A message will appear informing you that the path ended. You need to click the "OK" button to continue. A new path will start shortly thereafter.

Assets A and B: Let me show you what to expect from the investment in each asset. In the upper left corner of your screen there is a box that reads "Asset A: mean return 6%, standard deviation 55%"; "Asset B mean return 3%". These numbers show how your investment in each asset grows and they will not change during the entire experiment.

Asset B: The 3% next to Asset B in the box means that, once the period ends, the amount allocated to Asset B will grow by 3% for sure. The interest rate of 3% will not change throughout the duration of the experiment. A reminder: money in Asset B is represented by the bottom,

GRAY portion of your active bar. Here is an example: if you have 2 dollars invested in B you will have 2 dollars and 6 cents in the next period. If you keep that money in B you will then have 2 dollars and 12.2 cents the period after. You can think of your money in Asset B being multiplied by 1.03. Note that 2 dollars is just an example. In the experiment you can choose any allocation you want provided it does not exceed your total amount.

Asset A: Contrary to asset B, your return on asset A is uncertain. Technically, the return on asset A has a Normal distribution with mean 6% and standard deviation 55%, as shown in the upper left box. This means that asset A grows by 6% on average. However, it may be more or it may be less. In particular, the growth rate could be negative. In this case the money you invested in Asset A will shrink. Although the return can be negative, the amount of money you hold on asset A can never go below zero. A reminder: money in Asset A is represented by the top, LIGHT BLUE portion of your active bar.

Another way to think about the return on this asset is that the amount you put in asset A will be multiplied by some positive number. On average, this number will be 1.06 which corresponds to a 6% growth. Let us call this number a multiplier. If the multiplier is less than 1, it means that your investment in Asset A shrinks. For example, if you allocate $2 to asset A and the multiplier turns out to be 0.8, you will have $1.6 in the next period. If the multiplier turns out to be 1.5, you will have $3 the next period. Here is a chart showing the probability of your multiplier being in a given range. With 20% chance it will be somewhere between 0 and 0.67. With 30% chance it will be somewhere between 0.67 and 1.06. With another 30% chance it will be somewhere between 1.06 and 1.7. Finally, with 20% chance it will be above 1.7. Once the period ends and you receive the returns on your assets, the box on the left marked "Last Period Multiplier" will show what turned out to be the multiplier for asset A in that period. The box will show always 1.03 as the multiplier for asset B.

Projection Bar: The returns from asset A obtained after several periods depend on many factors. In order to help you get an idea of the range of outcomes, we placed a projection bar at the end of the screen. Let me explain how the projection bar works. Suppose for example that in the first period you invest $2 in Asset A. If you keep the returns on that same asset, how much money will you have at the end of the 10th period? Observe what happens on the left hand side of the graph. It is a simulation of your return. The vertical axis represents dollars and the horizontal axis the periods. It begins with 2 dollars in the first period and it ends after 10 periods. Here is one potential final amount of money. But it can also be this. Or this. Or this. Notice that each time a path ends, we keep track where it lands by adding a dot on the right graph. Each dot represents a possible final amount of money. If we run enough paths, all with $2 invested in asset A, we will get a bunch of dots on the right end. The more dots each dollar region has, the more likely your amount of money will end up there. And that's exactly what the bar represents: the likelihood of your earnings ending up in a certain amount.

Now look at the example in the picture. It is period 4. Look at the projection bar. For the current investment strategy, the lower gray part is the projection of how much you will earn on asset B if you don't change the allocation between assets until the end of the path. In this case, you will earn 1.89 dollars on asset B. This amount is for sure since there is no uncertainty on this asset. The upper part shows the projected earnings on asset A if you don't change the allocation between assets until the end of the path. They correspond to the dots shown in the video. There is a 20% chance that the final amount lands in the white area above the gray one, a 60% chance that it lands in the dark blue area and another 20% chance that it lands above the dark blue area. Finally, there is a thick line showing the median, in this example, 16 dollars and 64 cents. This

means that with a 50% chance your final amount will be somewhere below that number and with a 50% chance it will be somewhere above that number.

Notice also from our demonstration that probabilities are different within a segment. For example, receiving an amount above the dark blue area has a 20% chance, but within this 20% it is more likely to be close to the dark blue area than further away. In other words, it is more likely to get this payoff [point to the slide] than this payoff [point to the slide], although both are possible. You can see this point more clearly on the frequency table. Based on the number of circles, it is more likely that your payoff will end up here [point to the slide] rather than [point to the slide] here, even though both of these areas correspond to the 20% region above the projection bar.

Important Points:

1. The projection bar shows the likelihood of different final earnings at the end of the path ASSUMING the amount you receive from each asset is reinvested in the same asset in all the following periods. However, you can change the allocation between assets at every period.
2. At each period, the projection bar recalculates the probabilities. If you move the cursor up and down within a period, the bar shows instantly the new projection.
3. The multipliers on asset A are independent across periods. In other words, the multipliers of previous periods will in no way impact the multiplier in the current period. For example, if the multiplier in a previous period was very high, it does not mean it will be high again. The new multiplier will simply follow the rules of uncertainty described before.
4. All the participants start and end the paths at the same time. The clock starts as soon as the screen appears, so pay attention.
5. The multiplier for asset A in each period is the same for all participants. So, for example if the computer chooses 2 as a multiplier in period 4, it means that all participants will have their investment in asset A doubled.

Are there any questions? If not, let us proceed to 5 practice paths. What you earn on these paths will not count towards your payment; these are meant only for you to familiarize yourself with the entire process of allocating money between assets A and B. Feel free to explore as many investment strategies as possible to better understand the different options.

Please double click on the icon on your desktop that says ABC STUDY. When the computer prompts you for your name, type a 4 digit number that you can easily remember. Please do not forget the number you typed. Then click SUBMIT and wait for further instructions.

Pay attention to the screen. The first practice path will be starting soon. Focus on understanding how to choose the display between percentage and dollars, how to activate the bar, and how to change the allocation between assets. Reminder: Once a path ends, you need to click the OK button in order to proceed to the next path.

[START game] [Complete practice path 1]

You have now completed practice path 1. Are there any questions? Let's proceed to practice paths 2 and 3. Now try to explore different investment strategies to get a good understanding of the investment process.

[Complete practice paths 2 and 3]

You have now completed 3 practice paths. Are there any questions? If not, we will proceed to a short quiz. Please pay close attention to answering the questions, as you will not be permitted

to continue with the experiment if you do not answer the questions correctly. Raise your hand if you have any question during the quiz.

[Complete quiz]

You have now completed the quiz. Let us proceed to the last 2 practice paths.

[Complete practice path 4 and 5]

You have now completed practice paths 4 and 5. Are there any questions? Before we start please write down your ID on your record sheet in front of you. You will locate your ID on the left side of your window bar. You will have to present the record sheet to get paid at the end of the experiment. Did everyone right their IDs down?

Let me remind you how you will be paid for Part 1. At the end of the experiment, the computer will randomly select one of the 15 paths and you'll be paid the final amount you earned in that path. Are there any questions? If there are any problems or questions from this point on, raise your hand and an experimenter will come and assist you. We are ready to start the experiment. Please pull out your dividers.

PART 2

You have now completed Part 1 of the experiment. Please push in the dividers.

You will now undertake 10 paths in Part 2 and another 10 paths in Part 3 of the experiment. At the end of Part 3, the computer will randomly select one of these 20 paths and you'll be paid the final amount in that path. This amount will be added to your show-up fee and to the final amount in the randomly selected path from part 1.

The rules in part 2 are similar to the rules in part 1. You start each path with \$3, there are 10 periods in each path, and you allocate your money between the same assets A and B as before. There are however two differences. First and as already mentioned, there will be 10 paths rather than 15. Second, besides investing in assets A and B, you can now use part of your money to invest in a third asset, asset C, located on the lower left side of the screen. You can buy at most one unit of asset C in each period. You can make this investment by clicking the 'buy' button [S 18c]. Asset C costs \$1. So, if you decide to invest in it, \$1 will be deducted automatically from your current amount of money, and the bar will shrink accordingly. In case you had already made your allocation between A and B prior to purchasing the asset, the money will be taken out of your two investments proportionally. For example, if you had 60% in Asset A and 40% in Asset B, 60 cents will be deducted from Asset A and 40 cents will be deducted from Asset B. Once the asset is purchased the button is disabled. The button is also disabled if you do not have enough funds to buy the asset, that is, if the amount of money you currently have is less than \$1.

If you purchase asset C, you will have a 4% chance of receiving \$20 and a 96% chance of not receiving anything. This information together with the cost of the asset is displayed above the 'buy' button and will remain constant for the rest of the experiment. At the end of the period, you will find out if you received the \$20. The result will be displayed under the label 'previous result'. If you receive the \$20, that amount is automatically added to your next periodÕs amount of money. You can then re-invest that money between assets A, B and C under the same set of rules.

Important point. Suppose several participants purchase asset C in the same period. Then, whether one participant receives \$20 or not is independent of whether the other participants receives the \$20. In other words, knowing the outcome of your asset C does not tell you anything about the outcome of asset C for the other participants. It does not tell you either about the likelihood of receiving \$20 in a future period: this chance is always 4% independently of past realizations.

Are there any questions? If not, please pull out the dividers and let us proceed to 1 practice

path. What you earn on this path will not count towards your payment. Please use this practice path to familiarize yourself with the new asset, asset C.

We have now completed the practice path. Are there any questions? If not, let us proceed to 10 paths in Part 2.

PART 3

You have now completed part 2 of the experiment. Please push in the dividers.

This is the last part of the experiment. It consists of 10 paths. It has the same rules as Part 2, with one addition. In Part 3, you can learn about the performance of other participants in the experiment. More precisely, in the lower left corner of the screen, there are 3 boxes labeled, 'Lowest', 'Average', 'Highest'. They hold the information as to how much is the lowest, the average, and the highest current amount of money among the participants in this session. The boxes, however, do not reveal the identity of the participants with those amounts. If you wish, you can open one of these boxes by clicking on it. You will be able to open one of the boxes only in periods 5 and 9. In those periods, you can open always the same box or you can open different boxes each time. You can open at most one box but you can also decide not to open any box. Opening boxes is for information only. They do not affect the returns on your assets in any way or the returns on the assets of any other participant. When available, the boxes will appear in the lower left corner of the screen just as shown here.

Remember that you can only open a box in periods 5 and 9. In periods 1, 2, 3, 4, 6, 7, 8 and 10 the boxes will not appear on the screen.

Are there any questions? If not, pull out the dividers and let us proceed to 10 paths in Part 3.

The experiment is now over. Your payoff is displayed on the screen. Please write down the payoff from both Part 1, displayed as subset 1, and Parts 2 & 3, displayed as subset 2, onto your record sheet. Write down the total by adding the $5 show-up fee to the sum. We will round up to the nearest quarter.

Lastly, please fill out the questionnaire you see on the screen. Reminder: You remain anonymous to the experimenter. Please submit your answers once you are finished. Once you submit your answers, please put the mouse on the side of the computer and do not use either the mouse or the keyboard.

QUIZ (accompanied by a display print-out):

1. Look at the display on the paper in front of you. What is the current period?

   (a) 1
   (b) 2
   (c) 6 (correct)
   (d) 8

2. Had the person not chosen any allocation between assets A and B, how much would she have in the next period?

   (a) $1.44
   (b) $4.16
   (c) $5.60 (correct)
   (d) $7.29

3. In this period, how much has the person invested in Asset A?

   (a) $5.60
   (b) $4.16 (correct)
   (c) $1.44
   (d) $0.81

4. Assume this person keeps reinvesting the returns of asset A in A and the returns of asset B in B until the end of the path. Given the current allocation, how much money will this person have in asset B after the path ends?

   (a) $1.67 (correct)
   (b) $1.44
   (c) $1.03
   (d) $7.29

5. Assume this person keeps reinvesting the returns of asset A on A and the returns of asset B on B until the end of the path. Given the current allocation, how much money will this person have in asset A after the path ends?

   (a) $7.29
   (b) $5.60
   (c) $18.00
   (d) Cannot be determined with certainty (correct)

6. Forget about the display. Imagine you invest $1 in Asset A and $1 in Asset B and suppose the multiplier on Assets A and B are 2.00 and 1.03 respectively. How much money will you have in the next period?

   (a) $3.03 (correct)
   (b) $4.00
   (c) $5.03
   (d) Cannot be determined from the information given.