Higher-Order Beliefs and Risky Asset Holdings*

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Abstract

We implement a survey of stock market investors, focusing on their higher-order beliefs about the future stock market payoffs. The survey provides novel evidence on the relationship between first-order and higher-order beliefs, including how investors' characteristics are associated with first-order and higher-order beliefs differentially. Through an information provision experiment, we show that while higher first-order beliefs significantly increase the holding of risky assets, higher higher-order beliefs significantly decrease the holding of risky assets. The findings provide important guidance for the design of macro-finance models.

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A. Introduction

Analyzing higher-order beliefs is crucial for navigating the dynamics of the financial market. As illuminated by Keynes' analogy of the stock market to a beauty contest, successful investment decisions emphasize on predicting not just the fundamental values of stocks but also, and perhaps more critically, how others perceive these values and will act upon them. Nonetheless, in which direction investors should act against other's belief is ambiguous. In forming their optimal strategies, traders must adeptly read the collective sentiment, and deciding whether to ride the wave of rising prices (de Long et al., 1990; Brunnermeier and Nagel, 2004) or behave contrarian when over-optimistic valuation would soon rewind before the traders outsmart the market. In this study, we causally study the effects of higher order beliefs (HOB) on investors' risky-asset holdings.

The empirical challenge about studying HOB usually lies in how to sufficiently control for confounding factors. Especially, growing empirical evidence rejects the benchmark of full information rational expectations in asset pricing (Adam and Nagel, 2023). Therefore, investors with incomplete information constantly seek signals to update beliefs about future asset payoffs. As a results, signals that affect HOB, which contains the market's sentiment about current valuation, also provide relevant information about future payoffs. This changes investors' first-order beliefs (FOB) at the same time, and casts issues for identifying the effects of HOB.

To tackle this identification challenge, we design a randomize control trail (RCT) in a survey with information provisions, focusing on a representative sample of investors that are either full-time or part-time employed in the US. The survey asks not only what investors think about the future payoffs of the stock market, but also how they think other investors think about the future stock market payoffs, that is, their higher order beliefs, in a similar spirit of Coibion et al. (2021). The survey thus allows us to provide a unit set of evidence relating FOB and HOB, as well as investor characteristics with relative sentiment, defined as the difference between the first moments of HOB and FOB. Besides, in the survey, randomly selected groups of investors were provided different pieces of information about the outlooks of the financial market. The information, including either

past earnings growth or other investors' beliefs about the future payoff of S&P 500 index, lead to different relative changes in investors first-order and second-order beliefs about the future stock market returns. The information treatments consequently provide a powerful tool to quantify the effects of HOB on trading decisions conditional on FOB.

We measure investors' expectations and decisions using two waves of surveys. The first survey, run in November 2023, focused on measuring a set of investors' demographics, trading behaviors, and prior expectations. In addition, we implement the information treatments in the first wave of surveys as well and elicit posterior expectations after the treatment. We then ran the second wave of surveys three months later in February 2024 to the same set of participants. The second survey primarily asked the investors to report their current allocation of financial wealth. Given randomization among the control and treatment groups at receiving the first survey, difference in portfolio allocation between different groups in the second wave suggests the effects of information treatments on portfolio choices. Jointly, these surveys provide us with a clear strategy to study the effects of FOB and HOB on risky asset holdings.

We first provide a set of stylized facts of investor beliefs and trading patterns using data from the first-wave surveys. Among the survey participants, a fair amount, about 50%, of financial wealth is allocated to risky assets including single-company stocks, ETF, index funds, and financial derivatives. Our surveys also allow us to study the frequency investors check their stock market wealth and change the portfolio allocations. We find that investors check and adjust their stock-market wealth infrequently: they check their stock-market wealth every five days and change allocation every 21 days on average. In addition, they are relatively experienced in trading in the stock markets. Most participants have at least one year of experience in investing stocks, and around 50% of the investors have at least 5 years of experience.

We also provide a set of evidence about HOB and FOB. First, we show that the first moment of HOB and FOB are highly positively, but imperfectly, correlated. A regression between HOB and FOB yields an R^2 of 0.30. To study how HOB and FOB are differentially related to investor characteristics, we construct a measure of relative

sentiment defined as the difference between HOB and FOB. When relative sentiment is high, investors believe that other investors are more optimistic about the stock market than themselves. We find that relative sentiment is not random. Rather, it is correlated with a set of investor characteristics. Specifically, relative sentiment tends to be high when investors have experienced worse portfolio performance in the near past, and when subjective uncertainty about future stock market outlook is high. In addition, younger investors are more likely to believe that others are too pessimistic. To this end, the stylized facts suggest that HOB and FOB are highly positively correlated. but there is clearly independent variation between the subjective distribution of FOB and HOB.

We find clear causal evidence that exogenous changes in FOB and HOB both affect risky-asset holdings. In particular, we document that FOB and HOB have opposite effects on trading behaviors: higher FOB increases the holding of risky assets, whereas higher HOB reduces the holding of risky assets. The sensitivity of risky asset allocation to FOB and HOB depends crucially on if one of the two is controlled. We find that, when only one of FOB and HOB is included, each 10% higher FOB increases the holding of risky assets by 8.9 percentage points and each 10% higher HOB reduces the holding of risky assets by 7.4 percentage points. When both are included, the effects more than doubled: each 10% higher FOB increases the holding of risky assets by 25.1 percentage points, whereas each 10% higher HOB reduces the holding of risky assets by 19.8 percentage points. This indicates that information about the stock market affect both FOB and HOB. Without conditioning on both, risky share sensitivity to belief bias towards zero. The findings therefore also help explain the weak sensitivities of beliefs to trading decisions as documented in recent studies (Giglio et al., 2021; Charles, Frydman, and Kilic, 2023).

The findings about how HOB affects risky asset holdings provide novel insights about whether investors ride on the winds or act contrarian. When investors are uncertain in evaluating future payoffs but are otherwise identical and rational in updating expectations, HOB reduces return expectations by implying higher current valuation but not higher subjectively expected future payoffs. Conversely, existing studies suggest that many investors may believe they can outwit the market by acting on information faster

(Brunnermeier and Nagel, 2004). In this case, HOB would positively affect risky asset holdings by increasing anticipated payoffs. To further explore the mechanism behind, we study investor's perception about how fast they can react to significant news pertaining to the financial market, and how faster the investors believe that other can react to significant news pertaining to the financial market. We show that only slightly more than 20% of the investors consider themselves capable of acting on financial news faster than others. This result is evident that most investors believe that they cannot beat the gun by trading on news faster than others, therefore acting contrarian according to HOB.

This study contributes to the literature that delves into how various economic agent form their expectations, especially regarding overall conditions. Some studies, like those by Coibion and Gorodnichenko (2012, 2015), highlight an often observed underreaction to economic shocks, which aligns with models of imperfect information handling. Conversely, works by Bordalo, Gennaioli, and Shleifer (2018), and others point to an overreaction in certain aspects. Some research applies randomized information experiments to assess agents' responses to new data (e.g., Armantier et al. 2015; Cavallo, Cruces, and Perez-Truglia 2017). Others investigate the impact of macroeconomic expectations on economic decisions. For instance, Coibion, Gorodnichenko, and Ropele (2020) found a connection between firms' inflation expectations and their business choices, while studies like Roth and Wolfhart (2020) link households' macroeconomic views with spending. Recently, Coibion et al. (2021) study firms' HOB and relating them to their FOB and attributes of the firm and manager. Our study is pioneering in providing evidence on stock market investor's HOB and associating them to investors' characteristics. In addition, we provide the first set of causal evidence on the effects of HOB and FOB on economic agents' real decisions.

Our study also contributes to the expanding body of works that focuses on the role of subjective expectations on investor portfolio decisions. Among the literature, Malmendier and Nagel (2011) show that macroeconomic experience could affect risk taking significantly. Giglio et al. (2021), Beutel and Weber (2023), and Charles, Frydman, and Kilic (2023) analyze the relationship between subjective expectations on portfolio and

trading choices. In addition, Chinco, Hartzmark, and Sussman (2022) and Liu et al. (2022) show that subjective survey responses could help to regulate macro-finance models that better describe agents' trading motives. While most existing literature has focus on first-order expectations in asset pricing, this study advances by exploring how HOB causally affects trading behaviors. The analysis offers important insights on investors' strategic consideration in the stock market.

Our study also contributes to the discussion of higher order beliefs in asset pricing. Among the theoretical literature, Allen, Morris and Shin (2006), Bacchetta and van Wincoop (2006, 2008), Banerjee, Kaniel, and Kremer (2009), Makarov and Rytchkov (2012), Kasa, Walker and Whiteman (2014), Cespa and Vives (2015), and Nimark (2017) analyze models with rational investors facing frictions of acquiring other investors' beliefs and fundamental asset valuation. On the other hand, Harrison and Kreps (1978), Harris and Raviv (1993), Kandel and Pearson (1995), Scheinkman and Xiong (2003), and Banerjee and Kremer (2010) studies the differences-of-opinion models that focus on investors who are aware of and disagree with the private valuations of others. With survey data, Egan, Merkle, and Weber (2014) and Schmidt-Engelbertz and Vasudevan (2024) show that investors are likely engaging in price speculation. Our work is distinct in implementing an RCT with quantitative surveys to causally study how HOB about future payoffs affect risky asset holdings.

The reminder of the paper is organized as follows. Section B layouts a conceptual framework to guide the empirical methodologies. Section C describes the survey and the experimental design and provide a set of stylized facts about investors' characteristics and beliefs. Section D validates the first-stage results and study the effects of the experiment on expectations. Section E presents the effects of FOB and HOB on risky asset holdings. Section F concludes the paper.

B. Conceptual Framework

In this section, we lay out a simple model to illustrate the mechanisms of how HOB about future payoffs could affect trading decisions. There are three periods, $t \in \{0, 1, 2\}$, in the

model and a risky asset with a fixed supply of X shares. The asset has a total payoff of D_2 at t_2[1]. D_2 is assumed to follow a normal distribution with the expected value of $\overline{D}$. At time 1, a continuum of investors decides on the number of shares to hold, taking the equilibrium price at time 1, P_1^*, as given. All investors have CARA utility with a constant coefficient of risk aversion equal to γ. Finally, let the asset's price before all investors make their decisions at t_1 set at P_0.

1. Individual Beliefs

The investors do not know the value of D_2. At the beginning of t_1, each agent i has a prior of D_2 that follows $D_{i0} \sim N(\overline{D}, \sigma_0^2)$. In addition, i receives a signal s_i about D_2 that follows

$$s_i = \overline{D} + \upsilon_i,$$
$$\upsilon_i \sim N(0, \sigma_\upsilon^2).$$

The investors update beliefs based on Bayesian learning. After receiving the signal, i's posterior about D_2 follows

$$\widehat{D}_i \sim N(\overline{D} + \kappa_i \upsilon_i, \hat{\sigma}_i^2).$$

where $\kappa_i = \sigma_0^2/(\sigma_0^2 + \sigma_\upsilon^2)$ is the Kalman gain, and $\hat{\sigma}_i^2 = \kappa_i \sigma_\upsilon^2$ is the posterior uncertainty.

2. Higher-Order Beliefs

To formulate HOB, assume that from i's perspective, all other investors (the market) have the same signal-extraction process as investor i but different signal precision[2]. Therefore, the investors perceive belief disagreements with others. Specifically, assume that i believes that the market's prior D_{m0} has the same distribution with D_{i0}. However, the signal the markets receive is

$$s_m = \overline{D} + \upsilon_m,$$

[1] Analogously, for a model with an asset that pays out dividends D_t in each period t, and investors who only live for two periods, in any period t, D_2 can be thought as the total payoff, $P_{t+1} + D_{t+1}$, in $t+1$, which is the sum of the resale value plus the dividend payout.
[2] The different level of precisions could come from investors having over- or under-confidence.

$$\upsilon_m \sim N(0, \sigma_{\upsilon m}^2).$$

After learning, the market's posterior follows

$$\widehat{D}_m \sim N(\overline{D} + \kappa_m \upsilon_m, \hat{\sigma}_m^2).$$

where $\kappa_m = \sigma_0^2/(\sigma_0^2 + \sigma_{\upsilon m}^2)$ is the Kalman gain, and $\hat{\sigma}_i^2 = \kappa_i \sigma_{\upsilon m}^2$ is the posterior uncertainty.

Suppose *i* acquires information such that the market receives a signal $\upsilon_m = \upsilon_{im}$. In addition, assume that the market signal and the private signal are correlated with correlation ρ. Then the conditional distribution of *i*'s posterior given market posterior follows

$$N\left(\overline{D} + \kappa_i \upsilon_i + \rho \frac{\hat{\sigma}_i}{\hat{\sigma}_m} \kappa_m \upsilon_{im}, (1-\rho^2)\hat{\sigma}_i^2\right) \quad (1)$$

From (1), the posterior expectation follows a normal distribution. The expected value increases with private signals. At the same time, subjective beliefs about the market signals also affects FOB, and the direction depends on the correlation between the two signals.

Proposition 1: Signals about future payoffs increase FOB about future payoffs. When signals about HOB positively correlate with FOB, i.e., $\rho > 0$, a positive surprise to HOB also increases beliefs about future payoff.

3. Equilibrium Price

Given atomistic investors, equilibrium price is determined by the market portfolio. That is, from the perspective of *i*, the markets' problem is to

$$\max_{x_m} x_m \left(E_m\left[\widehat{D}_m\right] - P_i^*\right) - \frac{\gamma}{2} x_m^2 \hat{\sigma}_m^2,$$

where P_i^* is the equilibrium price perceived by *i*. The problem yields

$$x_m = \frac{\overline{D} + \kappa_m \upsilon_m - P_i^*}{\gamma \hat{\sigma}_m^2}.$$

Market clearing indicates the total share purchased equals *X*, which gives *i*'s perceived equilibrium price as

$$P_i^* = \overline{D} + \kappa_m \upsilon_m - X\gamma\hat{\sigma}_m^2 \quad (2)$$

A key aspect of (2) is that, since individual investors do not have price impact, price as perceived by each *i* is determined by the average investor (the market). Therefore, private signals do not affect price.

4. Portfolio Decisions

For investor *i*, the gross return of the asset is determined as the price differential between period 1 and 2, which is

$$\begin{aligned}\hat{R}_i &= P_2 - P_i^*, \\ &= E\left[\hat{D}_i \middle| \upsilon_{im}\right] - P_i^* \\ &= \kappa_i \upsilon_i + \left(\rho \frac{\hat{\sigma}_i}{\hat{\sigma}_m} - 1\right) \kappa_m \upsilon_{im} + X\gamma\hat{\sigma}_m^2.\end{aligned}$$

Given the subjective distribution of asset return, optimal asset holding of *i* is

$$x_i = \frac{\hat{R}_i}{\gamma(1-\rho^2)\hat{\sigma}_i^2}. \quad (3)$$

Proposition 2: An increase in FOB leads to more stock holding. The effect of increases in HOB on subjective return expectation and stock holding is ambiguous. When $\rho\hat{\sigma}_i/\hat{\sigma}_m > 1$*, subjective return expectation and stock holding increase with HOB.*

The intuition behind Proposition 1 is straightforward. Private signal directly increases subjective return expectations, which in turn increases stock holdings. On the other hand, there are two effects of HOB on asset holding. First, when υ_{im} is larger, *i* perceives that the market believes the future return is higher. Since the market signal is correlated with the private signal, when HOB increases, *i* also infers information from the signal and updates FOB as well. At the same time, market belief directly determines equilibrium asset price that *i* has to pay to acquire the assets. A higher payoff as perceived by the market increase current stock demand. This drives up equilibrium prices. Since all individual

investors act at the same time within each period, they are all price-takers, and cannot snipe a lower price before others acting. Therefore, HOB about payoffs decreases subjective return and asset holding through this price-setting channel.

Proposition 1 yields the principal difficulties about studying how HOB affect stock holdings in the data. Note that, the model predicts that holding FOB constant, HOB *decreases* current stock demand. However, since HOB also tells the investors some information about future payoffs, the unconditional effects of HOB on stock holding is ambiguous. In particular, when $\rho\widehat{\sigma}_i/\widehat{\sigma}_m > 1$, the market signal has much higher precision, and FOB moves more than one-to-one with the market's belief. In this case, after receiving a signal about HOB, investors adjust beliefs about future payoffs by much more than the adjustments about the equilibrium prices. Therefore, exploring the effects of HOB on stock holding requires distinguishing between HOB's direct effects and indirect effects through changing FOB.

5. Discussion

The framework delivers the basic idea behind how HOB affects subjective return and asset demand. The key effects of belief heterogeneity are through two channels: first, FOB affects investors' beliefs about future payoffs; and second, HOB affects investors' beliefs about whether the current price is too high. Note that given no price impact from each investor, the HOB is effective only at the second order. This is to say, the market does not take into consideration how other investors think about their beliefs.

A different setting is to consider several types of heterogeneous investors, each with a non-zero mass (Han and Kyle, 2018). In such models, each group of investors would need to care about how others believe what they think about the future payoffs, and so on. Nonetheless, the intuition is similar to the simple framework here. For example, when second-order beliefs are higher, investors believe that the current price is too high because there is over-optimism in others' beliefs. However, when third-order beliefs are higher, investors would believe the current price is too low because of others' conjecture that the current price is too high. Therefore, differences in odd-order (even-order) HOB tend to push up (down) subjective beliefs about future returns.

6. Empirical Specifications.

After rearranging, (3) can be expressed as

$$x_i = \alpha + \omega_i s_i + \omega_m s_m. \quad (4a)$$

In (4a), s_i is a signal that affects individual beliefs about future payoffs. s_m is a signal that affects individual beliefs about the future payoffs as perceived by others. ω_i is the marginal influence of the signal of future payoff on stock holding. It is expected to be a positive number. ω_m is the marginal influence of a signal of the market's belief about future payoffs (the future aggregate price level), holding individual beliefs about future payoff constant, on stock holding. As suggested by Proposition 1, the sign of ω_m is ambiguous and depends on if $\rho\hat{\sigma}_i/\hat{\sigma}_m > 1$. Since in general signals about HOB also affect FOB, identification of (4) needs two shocks that affect s_i and s_m differentially.

Alternatively, we can scale the signals by P_0, which is set before the start of the game. Then

(4a) can be written as

$$x_i = \alpha + \widetilde{\omega}_i \tilde{s}_i + \widetilde{\omega}_m \tilde{s}_m, \quad (4b)$$

where $\tilde{s}_i$ and $\tilde{s}_m$ are signals of about *returns* from t_0 to t_2. $\widetilde{\omega}_i = P_0\omega_i$ and $\widetilde{\omega}_m = P_0\omega_m$ respectively have the same signs with ω_i and ω_m. The scaling of the signals by the stock price before the trading period enables us to provide signals in terms of return instead of payoffs, as the former is in general easier for investors to digest.

C. Data and Survey Design

We collect a sample of 2151 subjects that is representative of US stock market investors. The survey data is from Prolific, an online panel provider with two waves of surveys covering the same set of participants. Prolific has a very high quality in filtering out bots during completing the surveys. The collected surveys have a perfect rate of passing the attention checking question. The panel structure allows us to track individual behaviors before and after treatments. The two waves were sent respectively in Nov 2023 and Feb 2024. The design of the experiment closely follows the conceptual framework in Section B.

1. Experimental Design

Figure 1 plots the timeline of the experiment. We focus on US stock market investors that are either full-time employed or part-time employed[3]. Data collection is comprised of two waves of surveys covering the same set of participants.

Our goal is to exogenously vary investors' FOB and HOB about future payoffs. Mapped to (4b), the experiment seeks to provide signal $\tilde{s}_i$ and $\tilde{s}_m$ to the investors. Since we cannot construct signals that are tailored to each individual's portfolio, we provide signals about the S&P 500 index. The implicit assumption is that subjective expectations about individual portfolio returns have positive factor loadings on the market portfolio. With the provided signals, we then study the effects of expectations on stock holding behaviors.

Mapped to the conceptual framework, we set Oct 2023 as t_0 and Sep 2024 as t_2. The signals about stock returns from t_0 to t_2 is therefore the expectation about the 12-month S&P 500 return from Oct 2023 to Sep 2024. The information treatments are provided at the beginning of November. We then follow the participants from three months and send out the second wave in Feb 2024 to retrieve investors' trading behaviors in the three months after the information treatment. In this case, the three months from Nov 2023 to Feb 2024 can be thought of as t_1, at which the trading actions occur. The specific process can be summarized as follows:

1. At the beginning of Nov 2023, before sending the surveys, we randomly split all participants on Prolific that satisfied the sampling criteria into three groups: control group (C), treatment group 1 (T1), and treatment group 2 (T2).

   We mainly use the first wave of surveys to provide information treatments about S&P 500 return from t_0 to t_2, and collect distributions about prior and posterior returns, and subjective distribution about *others'* return expectations.

[3] We only focus on employed individuals to avoid over recruiting those with lower time costs. Alternatively, Prolific allows researches to send surveys that are balanced according to the US census. However, doing so requires researchers to ask more questions to elicit demographics. Without balancing according to the census, demographic data directly comes with the data.

2. After collecting the survey responses from the control group, we send the surveys to the two treatment groups. For treatment group 1, we show them the following information:

> We would now like to show you some information on the S&P 500 index.
>
> **Over the past 12 months, the earnings of the companies represented in the S&P500 index have increased by approximately 2%. This is lower than the average of around 7.5% annually over the past 10 years.**
>
> Please proceed to the next page.

For treatment group 2, we show them the following information:

> We would now like to show you some information on the S&P 500 index.
>
> **Other investors participated in this survey on average believe that the 12-month return of S&P500 index from October 2023 to September 2024 would be 3.21%. This is lower than the average of an around 9% annual return on S&P500 over the past 10 years.**
>
> Please proceed to the next page.

3. In Feb 2024, we send the second wave to the same set of participants. The second survey mainly retrieves the participants trading histories between taking the two waves of surveys.

The purpose of the two treatments is to generate exogenous variation in investors FOB and HOB about S&P 500 return over the period of Oct 2023 and Sept 2024. The first information treatment, following Beutel and Weber (2023), seeks to generate a larger variation in FOB, while the second treatment, following Coibion et al. (2021), aims at generating a larger variation in HOB. Note that the two treatments are expected to change beliefs about FOB and HOB at the same time, given that signals about FOB and HOB are in general correlated. But for identification, we only need the two signals to change FOB and HOB to different degrees.

The 3.21% 12-months return as perceived by others shown in the second treatment is the average 12-month return expectation from the control group. Since the control group is a random sample of all participants, we can use this average return to represent the average return from all participants.

2. Summary Statistics and Stylized Facts

Table 1 provides the descriptive statistics of our data from the first wave of surveys. Panels A, B, and C respectively summarizes group C, group T1, and group T2. Columns (7) and (12) gives the *p*-values testing the differences in the averages of the characteristics. The *p*-values are all above 10%, which ascertains the success of the randomization.

Among all participants, the average age is around 40. About 40% of the participants are female. The average personal income of the participants is around 75000 dollars. The average total wealth is around 350 thousand dollars. Among those, about half is in the financial market, and a further half among the financial wealth is in the stock market in the form of individual companies, ETF, index funds, or derivatives. A calculation shows that the average wealth in the stock market, excluding pension, is around 80000 dollars.

To assess the representativeness of our sample, we compare the demographics with surveys from some recent reports[4]. Since we exclude retired individuals, our participants are slightly younger, but close to the population excluding older investors. The age in the sample is close to the average of around 42 years old in a recent survey by Gallup in 2023, conditional on individual younger or equal to 65[5]. The 40% female composition in the range of 40% - 45% estimated by Gallup and NerdWallet. As for education, about 15% have high-school or less education and 85% have some college educations. From Gallup, these numbers are respectively 16% and 84%. Therefore, the composition of our sample is broadly similar to the composition from other sources.

Figure 2 plots some characteristics about the investors trading behaviors. Most investors have invested in the stock market for more than one year. About 1.5% of the participants indicate no experience in the stock market. Voluntary comments after taking the survey indicating that these participants' stock market participation is not active and purely through retirement saving. The investors check their balance in the stock market relatively infrequently. The average is 71 times a year, which is about once every five days.

4 See here and here for the reports.
5 The average age of stock market investors from 2022 Survey of Consumer Finance is also 42 conditioning on those with positive income, and after adjusting for age coverage from Census.

Their trading frequency is much lower. The average number of trades the investors make a year is 17.5, which is equivalent to making a trade every 21 days. The 12-month portfolio returns from Nov 2022 to Oct 2023 are widespread, with a mean of 4% but an interquartile range of -5% to 12%.

We also assess participants' beliefs about how fast stock market investors incorporate significant news events to their trading decisions. The questions we rely on are follows:

> Based on your experience and observations as a stock market investor, how many days do you believe it typically takes for **you** to react to significant news events in the stock market? Consider news events such as earnings reports, geopolitical developments, and macroeconomic data releases, etc.
>
> Based on your experience and observations as a stock market investor, how many days do you believe it typically takes for **other investors** to react to significant news events in the stock market? Consider news events such as earnings reports, geopolitical developments, and macroeconomic data releases, etc.

The two questions respectively elicit the subjective beliefs about individuals own reaction speed to news and other investors' reaction speeding. The answers are plotted in Figure 4. The participants believe that it takes quite a long time for them to react to news. The average number of days to react to financial news is 15.5. At the same time, they believe that others react much faster than themselves. The average number of days the participants believe that others react to news is 8.7. In addition, only 22.5% of the participants that they are faster in reacting to significant news about the stock market.

3. First- and Higher-Order Expectations

The last six rows of Table 1 give the first and second moments of participants' *prior* subjective expectations about the return distribution of their own portfolios, the S&P 500 index (FOB), and that of other investors' beliefs (HOB) about the S&P 500 index. The question that elicits the distributions about FOB is

> Please assign probabilities (from 0-100) to the following ranges of possible overall stock price changes (%) for the **S&P500 index** over the 12 months from October 2023 to September 2024:
>
> Note: the sum of the answers has to be equal to 100%. Answers can range from 0% to 100%.

and the corresponding question eliciting prior distribution about HOB is

We would like to know what your opinion is about what **other investors** think will happen to the stock market price. Please assign probabilities (from 0-100) to the following ranges of beliefs that **other investors** might hold about overall price changes in the **S&P500 index** over the 12 months from October 2023 to September 2024:

Note: the sum of the answers has to be equal to 100%. Answers can range from 0% to 100%.

In general, the participants are pessimistic about the market performance from Oct 2023 to Sept 2024. The average expected return of S&P 500 is mildly above 3.2%. This is much lower than the average yearly return of around 9% over the past 10 years, and much lower than the around 16% return over the past 12 months of when taking the surveys. The first moment of FOB about S&P returns is slightly smaller but not starkly different than HOB about S&P returns. The difference between FOB and HOB about future S&P returns over the whole sample is -0.36% with a *t*-statistic of -3.34. This indicates that on average, the participants think that the market is slightly more optimistic than themselves at the time of taking the first survey. On the other hand, the implied standard deviations of the FOB about their own portfolio and the S&P 500 return and HOB are around 6%, implying that the investors are quite uncertain about their forecasts both about the FOB and HOB. They also display significant disagreements over FOB and HOB: the cross-sectional standard deviations in forecasts are all above 5.5%.

A novelty of our sample is that we can study the relationship between investors' own expectation and their expectations about how others believe about the return distribution. The first fact is that there is a strong positive but imperfect correlation between an investor's own market return expectations and higher-order return expectations. As shown by Panel A of Figure 3, investors who expect a higher market return also expect that other investors expect higher market returns. A regression between the two yields a coefficient of 0.54 and an R^2 of 0.30. Figure 3 Panel B plots the distribution of subjective sentiment, defined as the within-investor probability differences of HOB and FOB. For each of the possible return realization, there is a wide range of difference in FOB and HOB. In sum, information about HOB is also indicative about FOB, but there is clearly independent variation between the subjective distribution of FOB and HOB.

The second fact is that subjective sentiment is not random, it is rather associated with individual and portfolio characteristics. Table 2 studies the relationship between subjective

sentiment and different types of individual characteristics. We use jackknife resampling to control for outliers. In general, younger investors believe that the market is too pessimistic. Apart from age, relative sentiment does not seem to vary significantly with individual demographics. However, it is significantly correlated with the subjective uncertainty. From column (3), those who believe that the market is too optimistic also tend to have higher uncertainty about future index return. Subjective sentiment is also marginally negatively correlated with past return. Specifically, investors tend to believe that others are more pessimistic when their past portfolio return is high. This is indicative of investors forming beliefs based on recent experiences (Malmendier and Nagel, 2011). However, in contrast to the previous literature that documents that over-confident investors tend to trade more (Odean, 1999), we don't find that relative sentiment to be significantly correlated with the number of trades the investors make a year, or the number of times checking financial wealth.

To sum up, even if FOB and HOB are positively correlated, there are systematic patterns in the within-investor difference in FOB and HOB. At the same time, relative sentiments significantly vary with investors' age, past stock market performance, and subjective uncertainties.

D. The Effects of Information Treatments on Expectations

In addition to the stylized facts about respondents' expectations, we can use the experiment to assess how agents revise their FOB and HOB in response to new information. After displaying the information treatments, we elicit participants' posterior expectation distributions with the following questions:

> Q13: Now we'd like you to think about what you perceive as the most pessimistic and most optimistic outlooks for the **S&P500 return** over the 12 months from October 2023 to September 2024. What do you think the lowest 12-month return might be for this time period and what do you think the highest might be? (please provide an answer as % per year).
>
> Lowest return (%):
> Most likely return (%):
> Highest return (%):

Q14: Now we want to ask you to think about the chance of the **S&P500 return** you entered in the previous question. Please assign a percentage chance to each return to indicate how likely you think it is that this return will actually happen to S&P500 index over the 12 months from October 2023 to September 2024.

Note: your answers have to be greater than or equal to 1%, where 1% means nearly no chance that this growth rate will happen. The sum should total to 100%.

S&P500 return will be *X1*: ___ %
S&P500 return will be *X2*: ___ %
S&P500 return will be *X3*: ___ %

where *X1*, *X2*, and *X3* in Q14 are respectively the three answers from Q13. The questions eliciting posterior expectation distributions for individual portfolio returns and HOB about S&P 500 return have similar formats (See Appendix).

Measuring revisions in expectations after the treatment allows us to obtain the effect of the treatments on individuals' beliefs. Note that priors are measured as mean expected return implied by the reported distribution of future return while the posteriors are measured as point predictions. Different formulations of the return questions are deliberately used pre- and post- treatment to avoid antagonizing respondents by repeatedly asking them to answer identical distributional questions. Any difference in responses induced by the formulation of the questions will be captured in the control group's responses and will not affect the results of the information treatment.

Following Coibion et al. (2024), we use the following econometric specification to assess the influence of various information treatments on investors' beliefs

$$Posterior_i = a_0 + \sum_{k=1}^{2} a_k \times I_{\{Treat_i = k\}} + b_0 \times Prior_i + \sum_{k=1}^{2} b_k \times I_{\{Treat_i = k\}} \times Prior_i + error_i$$

where i denotes participants. $Prior_i$ is the participants' prior beliefs, $Posterior_i$ is the participants' posterior beliefs. $I_{\{Treat_i = k\}}$ is a dummy variable that is equal to one if the treatment status of i is equal to k. The omitted category is the control group, so that the coefficients a_k and b_k can be interpreted as being relative to the control group. Because we are interested in how investors respond to new information and to different kinds of information, we estimate the specification for each treatment separately.

The specification is consistent with Bayesian learning in which agents form beliefs as a combination of their priors and the signals they receive. As discussed in Coibion et al. (2018), the weight on their prior belief is an indication of how noisy they perceive the signals to be. The coefficient on the prior belief for treated investors, $b_0 + b_k$, should be between 0 and 1. If the sum is equal to 1, then no weight is being assigned to new information. On the other hand, a coefficient of zero on priors for treated investors indicates that agents are changing their beliefs fully to the provided signal. While allowing this slope coefficient to vary across treatment groups, we can assess the extent to which agents respond to different signals in updating their beliefs. Because we use different types of questions to elicit posterior and prior beliefs, the estimated slope may be biased up or down depending on how investors respond to probability distribution questions versus point forecasts (see Bruine de Bruin et al. 2000; Kleinjans and van Soest 2010; Coibion et al. 2021), but this will be observable in the estimated b_0 for the control group.

Table 3 presents the results of these regressions. Following Coibion et al. (2021) and Coibion et al. (2024), we use Huber-robust regressions to systematically control for outliers when studying expectations. Roughly speaking, robust regression is a form of weighted and reweighted least squares regression. It is used in the situation when the existence of outliers is likely. In most of our regressions, robust regressions assign a weight of zero to around 6% of the sample, indicating that there is a small portion of outliers in the sample.

Columns (1) and (2) are for FOB and columns (3) and (4) are for HOB. Focusing on the control group, the coefficients on prior beliefs are approximately 0.5 for FOB and 0.7 for HOB. Absent any informational intervention, a slope coefficient of unity might be anticipated. Nonetheless, the employment of disparate questions to elicit prior and posterior expectations introduces additional variance, yielding a baseline coefficient for priors that falls below the expected value of one.

In examining the efficacy of the treatments in engendering belief variation, it is evident that both interventions significantly affect beliefs in accordance with the imparted signals. Specifically, Treatment 1 produces a notably lower coefficient on prior beliefs ($b_0 + b_1$) in comparison to Treatment 2 ($b_0 + b_2$), suggesting a more substantial influence on FOB. This

implies that the provision of historical earnings growth data prompts a more profound adjustment in investors' beliefs about market fundamentals than does information about HOB. This pattern is mirrored in the case of HOB, where both treatments induce significant belief adjustments. However, for HOB, the coefficient on prior beliefs is much lower for Treatment 2 than for Treatment 1, indicating a stronger influence of Treatment 2 on HOB. That is, by informing participants about the beliefs of others, this treatment more substantially influences the beliefs regarding resale options. Note that providing information about HOB also affects prior beliefs about FOB greatly. Therefore, investors also use signals about HOB to form beliefs about their own expectations as well. This calls for the importance of isolating the effects of FOB and HOB on trading decisions in empirical exercises.

To summarize, the informational interventions are instrumental in altering investors' beliefs about FOB and HOB with respect to future index returns. Importantly, the treatments do not engender uniform belief revisions across FOB and HOB. Rather, Treatment 1, which provides statistic on past earnings growth, exerts a greater impact on FOB, whereas Treatment 2, which centers on the aggregate beliefs of other participants, has a more pronounced effect on HOB. The information treatments are thus successful in eliciting differential and exogenously driven shifts in both the first-order and second-order beliefs of investors about index returns, serving as robust instruments for exploring the impact of HOB and FOB on investor decision-making separately, as assessed in subsequent surveys.

These effects also shed light on the nature of expectation formation within the stock market. The marked response to publicly available information challenges the full-information rational expectation hypothesis. Furthermore, the reaction to signals about HOB indicates investors' uncertainty concerning the strategic behaviors of others in the marketplace. The efficacy of the information treatments in molding investor beliefs reflects a market environment where investors possess limited knowledge regarding earnings growth and lack full awareness of market sentiment disparities. Consequently, investors,

being aware of their informational limitations, exhibit pronounced responses to new information.

E. The Effects of Expectations on Risky Asset Holdings

We continue to study the effects of FOB and HOB on risky asset holdings as a share of total wealth.

1. Contemporaneous Relationship

Before exploring the causal relationship leveraging the experiments, we first provide some static relationship between beliefs and asset holdings. We measure investors' share of financial asset, *Financial%*, based on the following two questions.

> Approximately what percentage of your current wealth is financial wealth?
>
> Note: financial wealth includes stocks, ETFs, financial derivatives, bonds, pension funds, bank savings, and other wealth in the financial system.

In addition, we measure investors' holding of risky assets as a fraction of financial asset, *Risky_F%*, with the question

> We would now like to ask how your current financial assets (excluding real estate) are distributed across different asset classes. Please enter the approximate percentage you currently have invested in the following asset.
>
> Note: the sum of the answers has to be equal to 100%. Answers can range from 0% to 100%.
>
> Stocks (Individual Companies) ___ %
> ETFs or index fund ___ %
> Financial derivatives (option, future, forward, etc) ___ %
> Bonds ___ %
> Pension fund (401k, IRA etc) ___ %
> Other ___ %

Risky_F% is defined as the sum of shares of individual stocks, ETFs or index funds, and financial derivatives. In the end, the total share of risky asset holding, *Risky%*, is the product of *Risky_F%* and *Financial%*, which gives risky asset holdings as a share of total wealth. We also construct $Risky_{no\_der}\%$ that is equal to *Risky%* excluding the share of financial derivatives. In the second wave, we further elicit equity share from the pension

fund. Specifically, those who answered zero to the question Pension fund (401k, IRA etc) were asked the question

> What proportion of your pension fund is currently allocated to equity investments?
>
> Note: If you don't have any pension fund wealth, please select zero.

With this question, we also define $Risky_{w.pen}\%$ as the risky asset share inclusive of equity allocated through pension.

Table 4 presents the regression results of risky asset shares on beliefs. The analysis is based on all data in the first wave. In columns (4) and (5), we include a set of investor-level controls. There are two notable observations from Table 4. First, individuals' own beliefs about future market return are positively related with risky asset shares, a result that is also well documented in the previous literature. Second, the relationship between HOB and asset holding depends on if FOB is controlled or not. From column (2), when FOB is not controlled, HOB has a weakly negative relationship with risky asset holdings. An insignificant relationship between HOB and risky asset holding is often used as evidence that investors fail to incorporate the mechanism that market beliefs increases current valuation, and therefore decreases stock return. However, when FOB is controlled, the relationship between HOB and risky asset holdings becomes negative. A bootstrap with 500 replicates indicates that the difference in the coefficients of HOB between columns (3) and (2) is significant at 1% level.

Combined with the findings in Table 3, the results show that the total effects of HOB on stock holding is ambiguous as signals about HOB changes investors assessment of future fundamentals as well. Consistent with Proposition 1, without controlling for FOB, the effects of HOB on risky asset holding is upward biased.

2. The Identified Effects

The results in Table 4 suffer from endogeneity problems due to unobservable characteristics that affect both beliefs and asset holdings. In this section, we utilize the experiment to identify the effects of beliefs on share of holdings in risky assets. Our

methodology is two-stage least square estimations following Coibion et al. (2024) and Beutel and Weber (2023). The first-stage estimation is

$$Posterior_i = a_0 + \sum_{k=1}^{2} a_k \times I_{\{Treat_i = k\}} + \sum_{k=1}^{2} b_k \times I_{\{Treat_i = k\}} \times Prior_i^F + \sum_{k=1}^{2} c_k \times I_{\{Treat_i = k\}} \times Prior_i^H + Controls_i + error_i. \quad (5a)$$

In (5a), $Prior_i^F$ and $Prior_i^H$ are the prior expectations for FOB and HOB. (5a) is fitted for both the posterior expectations of FOB and HOB. The second-stage estimation is then

$$Risky\%_i = \alpha_0 + \beta_F E[\Delta S\&P - F] + \beta_H E[\Delta SP - H] + Controls_i + error_i, \quad (5b)$$

where $E[\Delta S\&P - F]$ and $E[\Delta S\&P - H]$ are respectively the predicted values of posterior expectations for FOB and HOB estimated with (5a). In both stages, we control for prior expectations such that the instruments only contain the exogenous information in the experiments. In addition, we also include a set of investor-level controls to increase the precisions. We also verify the effectiveness of the experiment by only controlling for prior beliefs. The control variables are all pre-experiment and include sex, age, indicator for full-time employees, indicator for having at least college degree, ethnic group fixed effects, reaction speeds, log income, and portfolio returns. Following Coibion et al. (2022) and Coibion et al. (2024), we estimate the first stages using Huber robust regressions and the second stages using Jackknife resampling to control for outliers.

The results of (5b) are in Table 5. The first-stage *F*-statistics for FOB and HOB are respectively 18.53 and 17.28. This indicates that the information treatments have generated large movement in beliefs, inducing a strong first-stage relevance. Columns (1) and (2) respectively exclude HOB and FOB. These results estimate the total effects of FOB or HOB unconditional of the other. Column (3) gives the benchmark result of (5b) that includes both of FOB and HOB. As suggested by Table 3, signals about FOB or HOB alone shifts beliefs about FOB and HOB simultaneously. As the main effects of FOB (HOB) on risky asset holdings are positive (negative), excluding any one would cause the estimates to be biased towards zero. From columns (1), each 10% increase in FOB increases risky asset holding by 8.9%, an estimate that is close to that in Giglio et al (2021). From columns

(2), each 10% increase in HOB decreases risky asset holding by 7.4%. Both estimates are statistically insignificant. When including both FOB and HOB, the effects of beliefs are much larger, with 10% higher FOB increasing risky asset holdings by 24.8% and 10% higher HOB decreasing risky asset holdings by 19.5%. At the same time, the estimates are statistically significant at 1% level. From the last three columns, the results hold if conditional only on financial assets, including equity holdings in pension, or excluding financial derivatives. Besides, Panel B of Table A.1 in the appendix excluding the investor-level controls, and the results are very close to those in Table 3.

The magnitudes of the estimates are much larger than the OLS estimates in Table 3, but the univariate estimate in front of FOB, which is 0.89, is very close to the estimates of around 1.2 in Giglio et al. (2021) with obviously related instrumental variable to take care of measurement errors. There are many reasons for the discrepancy between OLS estimates and 2SLS estimates. The first is the attenuation bias caused by measurement errors. In particular, survey data is expected to suffer from noises in measurement. Using IVs that are unrelated to such noises alleviates the attenuation bias (Gillen et al. 2019). Besides, 2SLS takes care of unobservable factors, e.g., transaction costs, that refrain optimistic investors to increase risk asset holdings. The estimates in front of FOB, after controlling for HOB, are much larger than the estimates in Giglio et al. (2021) without RCT.

A concern of our specification is that subjective uncertainty changes as well after receiving the signals. Through a Bayesian learning framework, posterior uncertainty is expected to be smaller than prior uncertainty as long as the investors are not in a learning steady state. If this is the case, risky asset holdings will increase due to lower perceived riskiness, and our estimates in front of both FOB and HOB might be biased upwards. While our experimental design does not exogenously vary subjective uncertainty, we cannot use 2SLS to control for changes in higher moments of expectations. To control for the changes in subjective uncertainty, we follow Coibion et al (2024) and add implied posterior standard deviations as exogenous controls. The results, which are shown in Panel A of Table A.1, hardly change.

3. Discussion

There are two notable implications from Table 5. First, consistent with Proposition 1, information about the stock market affect both FOB and HOB. Without conditioning on both, risky share sensitivity to belief bias towards zero. This helps explain the weak sensitivities of beliefs to trading decisions as documented in recent studies.

The second is on how HOB affects stock holdings. The stock market is often metaphorically described as a beauty contest, and investors seek to earn high returns based on predictions of other investors' beliefs rather than their own fundamental asset valuations. The debate centers on the direction in which these beliefs influence trading behavior. When investors are uncertain in evaluating future payoffs but are otherwise identical and are rational in updating expectations, HOB is likely to reduce return expectations, provided that signals about HOB do not increase FOB more than one-to-one. This stems from the premise that no individual can consistently outpace others in responding to news, aligning with the results presented in Figure 2. In this case, positive surprises regarding HOB tend to raise beliefs about trading prices at the moment of reacting to news, leading to lower expected returns in the future. Conversely, many studies suggest that many investors overlook the equilibrium price adjustments caused by others' actions (Eyster et al. 2019; Bastianello and Fontanier, 2022; Andrei et al., 2023) or believe they can outmaneuver the market by acting on information faster (DeLong et al., 1990; Brunnermeier and Nagel, 2004). In these scenarios, HOB is thought to elevate return expectations by boosting anticipated future payoffs, while maintaining trading price beliefs similar to those at the time the market assesses the payoffs. Our findings support the view that most investors do not consider themselves capable of acting on financial news faster than others. Consequently, the market's current price is seen as already reflecting others' beliefs, and HOB lowers return expectations.

4. Composition of Portfolio

We continue to study the effects of beliefs on different component of investors' financial assets. This analysis allows us to see whether HOB reallocates risky assets to less risky assets like bonds or reduces the holding of financial asset as a whole. Especially, the

correlation between bond and stock returns turns from positive to negative after the start of 2000 (Campbell et al., 2020). Therefore, positive shocks to HOB that reduces risky asset holdings are expected to increase the holdings of bonds.

The results are in Table 6. In general, beliefs affect different categories of risky assets in the same direction. FOB (HOB) increases (decreases) the holding of single-company stocks, ETFs and index funds, and financial derivatives. However, many of the estimates are not statistically significant, potentially because many investors hold zero share of the sub-categories of the risky assets. At the same time, we see opposite effects of beliefs on holdings of bond and pension. Each 10% higher FOB increases bond share by 17.8% and each 10% higher HOB decreases bond share by 16.8%.

5. Conclusion

This study unveils significant insights into the complex interplay between FOB and HOB on investors' decisions in the financial markets. Through a meticulously designed RCT, we empirically demonstrate the nuanced impacts of these beliefs on the allocation of risky assets. We first show that HOB and FOB are positively but imperfectly correlated, and the differences between HOB and FOB are significantly associated with investor subjective uncertainty and past stock portfolio performance. In addition, we observe that while higher FOB encourages the accumulation of risky assets, elevated HOB generally prompts a reduction in such holdings. This differential impact underscores the critical role of understanding both FOB and HOB for understanding the dynamics in the financial market. Our findings also illuminate the varied strategies investors adopt, influenced by their perceptions of market dynamics and their positions relative to others. Despite the inherent challenge in navigating the financial market with incomplete information, our research provides compelling evidence on regulating the existing asset pricing models to analyze investor’s trading behavior. Future research should continue to explore this intricate relationship and study the dynamics of FOB and HOB on price fluctuations.

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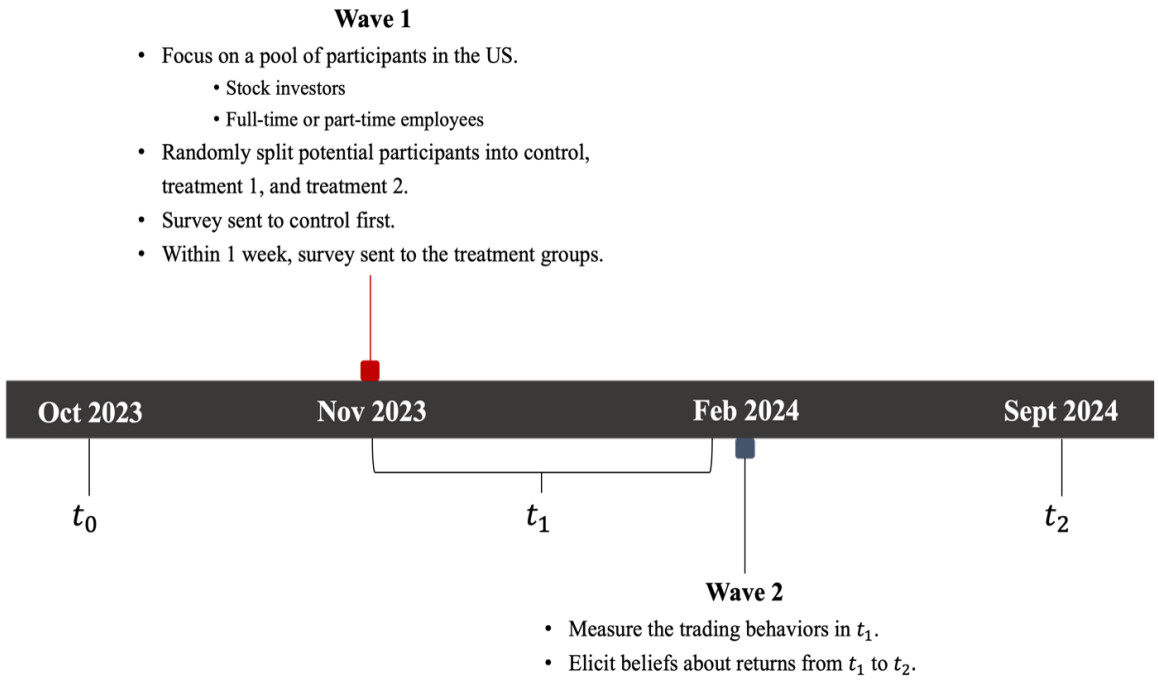
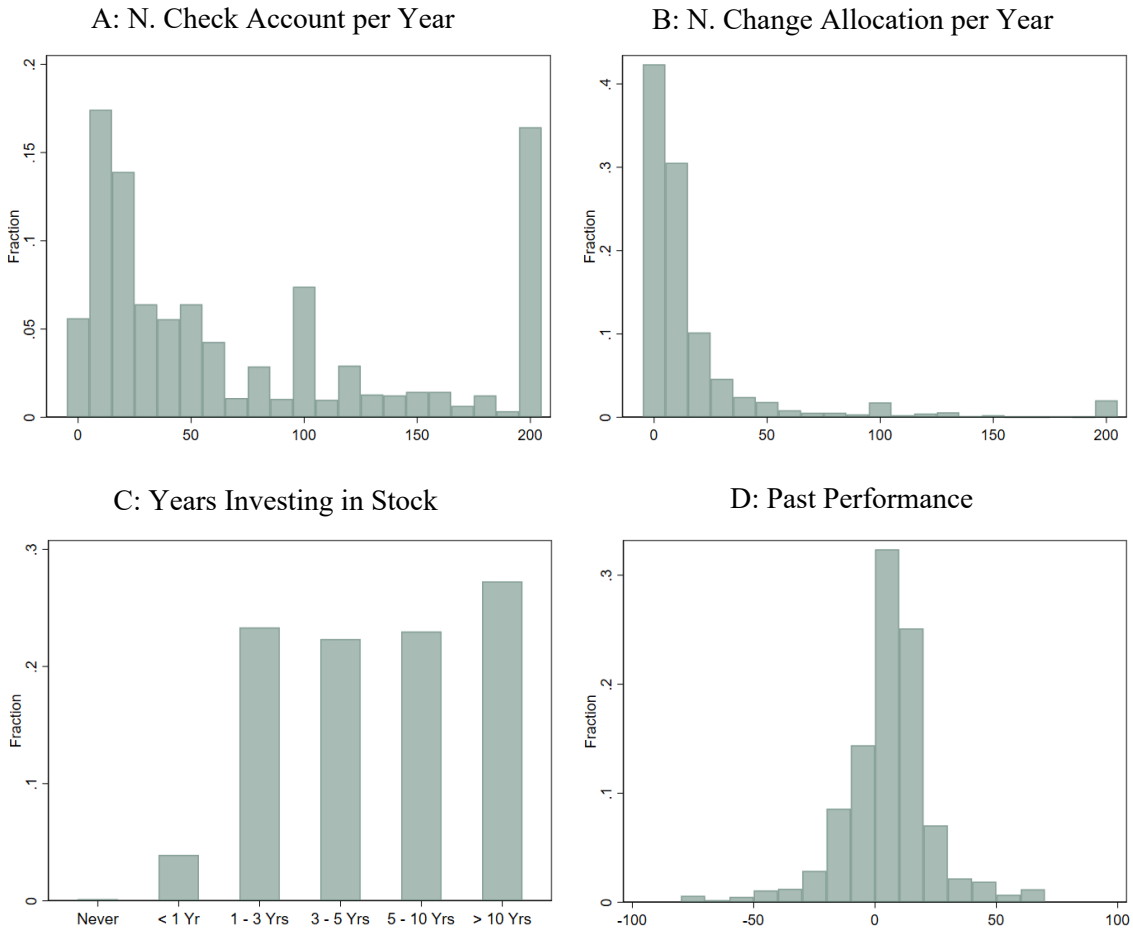
Figure 1: Timeline of the Experimental Design



Note: this figure plots the timeline of the experimental design. t_0, t_1, and t_2 are respectively set in accordance with the timeline inf Section B.

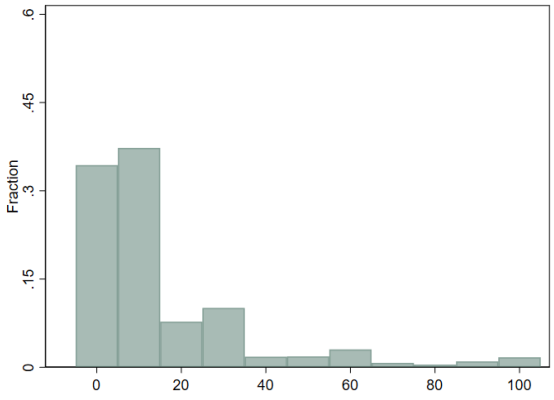
Figure 2: Trading Characteristics



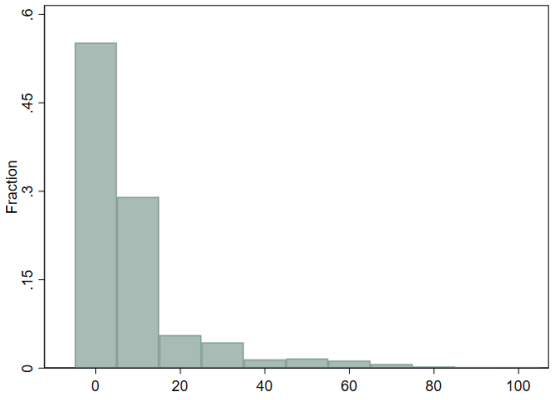
Note: Panel A gives the number of times the investors check their balances in the stock market every year. Panel B plots the number of times the investors change their allocations in the stock market. Panel C is the number of years the investors have been investing in the stock market. Panel D is the 12-month return of the investors' portfolio over the 12 months before taking the first wave of surveys.

Figure 3: Reaction Speed to Financial News

A: Reaction Speed -- Self



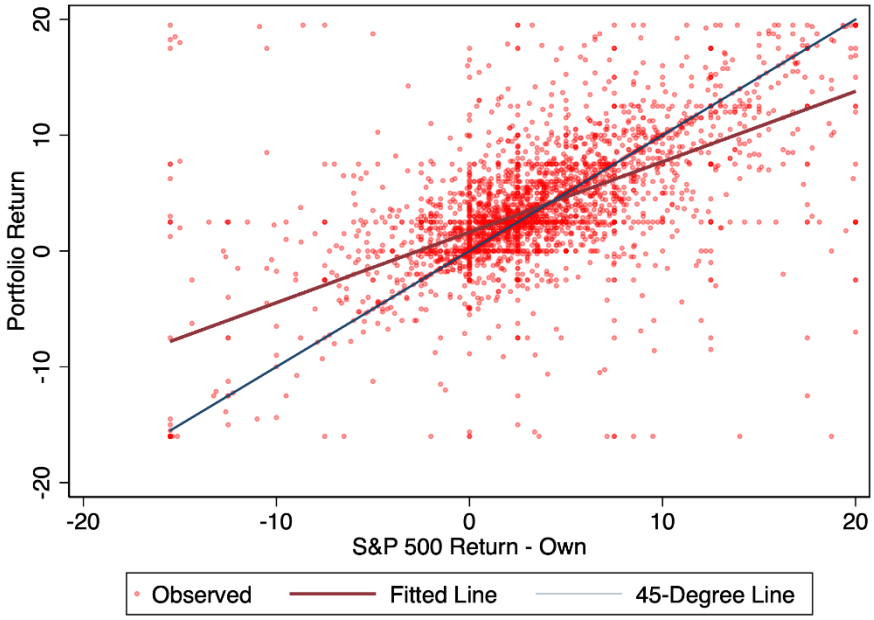
B: Reaction Speed -- Other



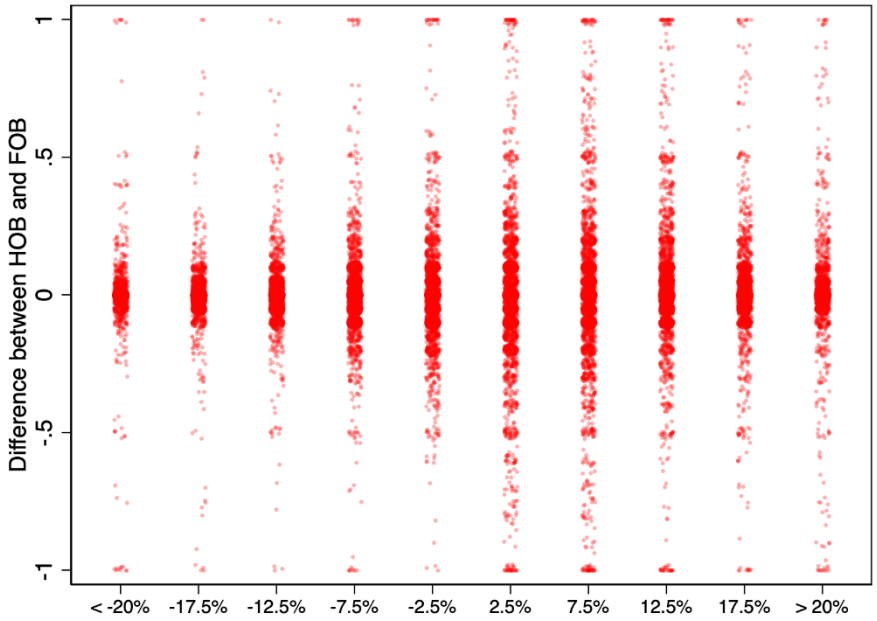
Note: Panel A is the number of days for the participants to incorporating news into trading decisions. Panel B is the number of days the participants believe that other investors need to incorporate news into trading decisions.

Figure 4: HOB and FOB

A: Relationship between HOB and FOB



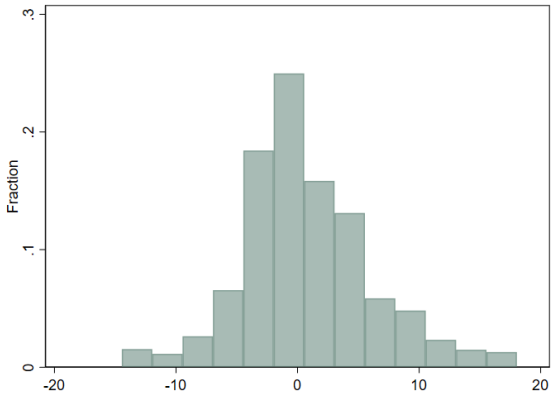
B: Distribution about Relative Sentiments



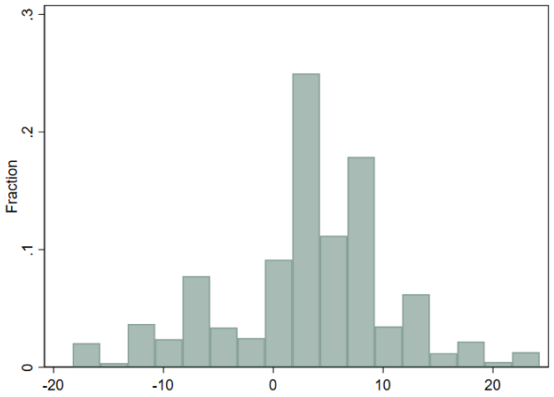
Note: Panel A gives the scatter plot of HOB on S&P 500 return on FOB on S&P 500 return. The red line is the fitted OLS line, and the blue line is the 45-degree line. Panel B is the distribution of relative sentiments, which is the difference beween HOB and FOB.

Figure 5: Perception Errors

A: Perception Errors – HOB



B: Perception Errors – Earnings Growth



Note: Panel A gives the differences between investors' prior HOB and the true value. Panel B gives the differences between investors' prior perception about the S&P 500 earnings growth over the past 12 month and the true value.

Table 1: Summary Statistics

	Mean	SD	N	Mean	SD	Diff	*p*-values	N	Mean	SD	Diff	*p*-values	N
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Panel A: Control			Panel B: Treatment 1					Panel C: Treatment 2				
Age	39.68	10.95	725	40.65	11.90	0.97	0.11	712	38.99	11.54	-0.70	0.25	714
Female	0.37	0.48	725	0.41	0.49	0.04	0.13	712	0.40	0.49	0.03	0.33	714
Wealth (K)	363.31	639.59	725	361.59	624.43	-1.73	0.96	712	341.37	584.81	-21.95	0.50	714
Income (K)	75.23	64.17	725	76.83	72.00	1.60	0.65	712	74.22	62.39	-1.02	0.77	714
Past Return	4.27	16.78	725	4.08	19.89	-0.19	0.85	712	3.17	19.28	-1.10	0.26	714
Financial%	0.51	0.32	725	0.49	0.32	-0.02	0.15	712	0.49	0.32	-0.02	0.23	714
Stock%	0.26	0.27	725	0.27	0.30	0.01	0.48	712	0.26	0.29	0.01	0.71	714
ETF%	0.19	0.25	725	0.17	0.24	-0.02	0.15	712	0.18	0.25	0.00	0.92	714
Derivative%	0.02	0.05	725	0.02	0.06	0.00	0.72	712	0.02	0.06	0.00	0.89	714
Bond%	0.36	0.32	725	0.37	0.33	0.01	0.61	712	0.36	0.33	0.00	0.85	714
Pension%	0.12	0.25	725	0.12	0.26	0.00	0.80	712	0.12	0.25	0.00	0.88	714
E[Return - F]	0.03	0.05	725	0.04	0.06	0.00	0.69	712	0.03	0.05	0.00	0.51	714
E[Δ S&P - F]	0.04	0.05	725	0.04	0.05	0.00	0.67	712	0.04	0.05	0.00	0.49	714
E[Δ S&P - H]	0.04	0.05	725	0.04	0.06	0.00	0.29	712	0.04	0.05	0.00	0.69	714
SD[Return - F]	6.56	3.15	725	6.44	3.47	-0.11	0.52	712	6.55	3.47	0.00	0.98	714
SD[Δ S&P - F]	5.70	3.38	725	5.60	3.73	-0.09	0.61	712	5.62	3.62	-0.07	0.69	714
SD[Δ S&P - H]	6.48	3.34	725	6.39	3.58	-0.09	0.62	712	6.58	3.70	0.10	0.59	714

Note: Wealth is the total level of current wealth (excluding debt). Financial% is the percent of total wealth in the financial market. Stock%, ETF%, Derivative%, Bond%, Pension% are respectively the percent of total financial wealth allocated in these types of assets. Return is the participants' financial portfolio returns over the 12 months before taking the first surveys. E[Return - F] (SD[Return - F]) and E[Δ S&P - F] (SD[Δ S&P500 - F]) are respectively the expected values (standard deviations) of individual subjective expectations about the returns on their own portfolios and the S&P 500 index. E[Δ S&P - H] (SD[Δ S&P - H]) is the expected values (standard deviations) of higher-order expectations about the returns on S&P 500 index.

Table 2: Determinants of Relative Sentiments

	HOB-FOB	HOB-FOB	HOB-FOB	HOB-FOB	HOB-FOB
	(1)	(2)	(3)	(4)	(4)
Young	-0.58***	-0.60***	-0.67***	-0.64***	-0.65***
	(0.21)	(0.22)	(0.21)	(0.21)	(0.21)
Female	0.12	0.12	0.14	0.14	0.16
	(0.21)	(0.21)	(0.21)	(0.21)	(0.21)
Full-time	0.03	0.11	0.00	0.03	0.04
	(0.27)	(0.29)	(0.29)	(0.29)	(0.29)
College	-0.01	0.04	0.06	0.06	0.07
	(0.24)	(0.25)	(0.25)	(0.25)	(0.25)
log Wealth		0.01	-0.02	-0.01	-0.01
		(0.07)	(0.06)	(0.07)	(0.07)
log Income		-0.09	-0.11	-0.10	-0.10
		(0.13)	(0.13)	(0.13)	(0.13)
SD[Δ S&P - F]			0.48***	0.48***	0.48***
			(0.06)	(0.06)	(0.06)
SD[Δ S&P - H]			-0.41***	-0.40***	-0.40***
			(0.05)	(0.06)	(0.06)
Past Return				-0.01*	-0.01*
				(0.01)	(0.01)
N. Trade					-0.00
					(0.00)
N. Check					0.00
					(0.00)
Intercept	0.64**	1.51	1.62	1.46	1.39
	(0.32)	(1.20)	(1.17)	(1.18)	(1.18)
N	2151	2151	2151	2151	2151
R^2	0.01	0.01	0.07	0.07	0.07

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Standard Errors in Parentheses

Note: The left-hand-side variable, relative sentiments, is defined as the difference between the HOB and FOB over future S&P 500 return. Young is an indicator for age below the sample median. Full-time is an indicator for full-time employees. Rel. React Speed is the difference between the number of days for the participants to incorporating news into trading decisions and that the participants believe that other investors need to incorporate news into trading decisions. Estimation is based on Jackknife resampling. All columns include ethnicity dummies,

Table 3: First-Stage: The Effects of Information Treatments on Expectations

	FOB	FOB	HOB	HOB
	(1)	(2)	(3)	(4)
Prior	0.61***	0.50***	0.71***	0.70***
	(0.03)	(0.03)	(0.04)	(0.04)
T1	-0.00	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
T2	0.01**	0.00*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
T1 x Prior	-0.33***	-0.32***	-0.34***	-0.35***
	(0.04)	(0.04)	(0.05)	(0.05)
T2 x Prior	-0.26***	-0.21***	-0.43***	-0.43***
	(0.04)	(0.04)	(0.05)	(0.05)
Controls	No	Yes	No	Yes
N	2151	2151	2151	2151
R^2	0.24	0.30	0.21	0.23

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$
Standard Errors in Parentheses

Note: The left-hand-side variables are the posterior expectations. Prior for columns (1) and (2) is investors' prior expectations about the FOB on S&P 500 index return; for columns (3) and (4), it is investors' prior expections about the HOB on S&P 500 index return. T1 is an indicator for receiving treatment 1, and T2 is an indicator for receiving treatment 2. Controls are all pre-experiment and include prior expectations, sex, age, indicator for full-time employees, indicator for having at least college degree, ethnic group fixed effects, implied prior return volatilities, reaction speeds, log income, and portfolio returns. Estimation is based on Huber robust regressions.

Table 4: Beliefs and Risky Asset Shares

	Risky%	Risky%	Risky%	Risky%	Risky%
	(1)	(2)	(3)	(4)	(5)
FOB	0.16*		0.27**	0.20*	0.18*
	(0.10)		(0.11)	(0.10)	(0.10)
HOB		-0.06	-0.21*	-0.23**	-0.22**
		(0.10)	(0.11)	(0.11)	(0.11)
Controls	No	No	No	Yes	Yes
N	2151	2151	2151	2151	2151
R^2	0.00	0.00	0.00	0.08	0.08

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$
Standard Errors in Parentheses

Note: Risky% is defined as the product of share of financial assets and share of financial assets invested in single stocks, ETF and index funds, and financial derivatives. Results are based on data in wave 1 and data from the control group in wave 2. Controls include sex, indicator for being younger than 40, indicator for full-time employees, indicator for having at least college degree, ethnic group fixed effects, log total wealth, number of times checking and changing stock market allocation, and wave fixed effects. Estimation is based on Jackknife resampling.

Table 5: The Effects of Beliefs on Risky Asset Holdings

	Risky%	Risky%	Risky%	Risky_F%	$Risky_{w.pen}$%	$Risky_{no\ der}$%
	(1)	(2)	(3)	(4)	(5)	(6)
FOB	0.89		2.51***	3.26**	2.43***	2.19**
	(0.70)		(0.92)	(1.31)	(0.92)	(0.88)
HOB		-0.74	-1.98***	-2.40**	-1.97***	-1.90***
		(0.51)	(0.71)	(1.04)	(0.71)	(0.68)
First-stage *F* -- FOB	18.53		18.53	18.53	18.53	18.53
First-stage *F* -- HOB		17.28	17.28	17.28	17.28	17.28
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	2151	2151	2151	2151	2151	2151

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Standard Errors in Parentheses

Note: Risky-F% is the share of financial assets invested in single stocks, ETF and index funds, and financial derivatives. Risky% is the product of Risky_F% and the share of financial assets. $Risky_{no.der}$% is Risky% excluding financial derivatives. $Risky_{w.pen}$% is Risky% including equity allocated through pension. Controls are all pre-experiment and include prior expectations, sex, age, indicator for full-time employees, indicator for having at least college degree, ethnic group fixed effects, implied prior return volatilities, reaction speeds, log income, and portfolio returns. First stages are based on Huber robust regressions, and second stages are based on Jackknife resampling.

Table 6: The Effects Beliefs on Financial Assets

	Stock%	ETF%	Der%	Bonds%	Pension%
	(1)	(2)	(3)	(4)	(5)
FOB	1.00	1.19*	0.32*	-1.78	-0.56
	(0.64)	(0.64)	(0.19)	(1.10)	(0.74)
HOB	-0.50	-1.40***	-0.08	1.68*	0.70
	(0.44)	(0.50)	(0.12)	(0.91)	(0.63)
First-stage *F* -- FOB	18.52	18.52	18.52	18.52	18.52
First-stage *F* -- HOB	17.27	17.27	17.27	17.27	17.27
Controls	Yes	Yes	Yes	Yes	Yes
N	2151	2151	2151	2151	2151

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$
Standard Errors in Parentheses

Note: Stock%, EFT%, Der%, Bonds%, and Pen% are respectively the share of total wealth invested in single companies, ETF and other index funds, financial derivatives, bonds, and pension. Controls are all pre-experiment and include prior expectations, sex, age, indicator for full-time employees, indicator for having at least college degree, ethnic group fixed effects, implied prior return volatilities, reaction speeds, log income, and portfolio returns. First-stages are based on Huber robust regressions, and second stages are based on Jackknife resampling.

Table A.1: The Effects of Beliefs on Risky Asset Holdings – Changing Controls

	Risky%	Risky F%	$Risky_{w.pen}$%	$Risky_{no.der}$%
	(1)	(2)	(3)	(4)
	Panel A: Controlling for Posterior Uncertainties			
FOB	2.51***	3.20**	2.45***	2.22**
	(0.92)	(1.32)	(0.92)	(0.89)
HOB	-2.12***	-2.50**	-2.12***	-2.05***
	(0.73)	(1.06)	(0.73)	(0.71)
First-stage *F* -- FOB	18.38	18.38	18.38	18.38
First-stage *F* -- HOB	16.78	16.78	16.78	16.78
Controls	Yes	Yes	Yes	Yes
	Panel B: No Controls			
FOB	2.64***	3.28**	2.57***	2.31**
	(0.99)	(1.36)	(0.99)	(0.94)
HOB	-1.87**	-2.11**	-1.87**	-1.82**
	(0.75)	(1.05)	(0.75)	(0.72)
First-stage *F* -- FOB	17.96	17.96	17.96	17.96
First-stage *F* -- HOB	16.73	16.73	16.73	16.73
Controls	No	No	No	No
N	2151	2151	2151	2151

Note: Risky% is the product of Risky-F% and the share of financial assets. $Risky_{w.pen}$% and $Risky_{no.der}$% are respectively Risky% including equity investment in pension and that excluding financial derivatives. In Panel A, controls include prior expectations, sex, age, indicator for full-time employees, indicator for having at least college degree, ethnic group fixed effects, implied prior return volatilities, reaction speeds, log income, portfolio returns, and posterior uncertainties. Panel B only controls for prior expectations. First stages are based on Huber robust regressions, and second stages are based on Jackknife resampling.