The joint dynamics of investor beliefs and trading during the COVID-19 crash

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We analyze how investor expectations about economic growth and stock returns changed during the February–March 2020 stock market crash induced by the COVID-19 pandemic, as well as during the subsequent partial stock market recovery. We surveyed retail investors who are clients of Vanguard at three points in time: 1) on February 11–12, around the all-time stock market high, 2) on March 11–12, after the stock market had collapsed by over 20%, and 3) on April 16–17, after the market had rallied 25% from its lowest point. Following the crash, the average investor turned more pessimistic about the short-run performance of both the stock market and the real economy. Investors also perceived higher probabilities of both further extreme stock market declines and large declines in short-run real economic activity. In contrast, investor expectations about long-run (10-y) economic and stock market outcomes remained largely unchanged, and, if anything, improved. Disagreement among investors about economic and stock market outcomes also increased substantially following the stock market crash, with the disagreement persisting through the partial market recovery. Those respondents who were the most optimistic in February saw the largest decline in expectations and sold the most equity. Those respondents who were the most pessimistic in February largely left their portfolios unchanged during and after the crash.

beliefs | trading | COVID-19 | surveys

The dynamics of beliefs play a central role in macroeconomics and finance. As a result, analyzing how beliefs vary with changes in the economic environment and how they affect investment choices is important for understanding asset markets and real economic activity. This paper offers a unique picture of the joint dynamics of beliefs and trading during a time of severe market distress, for a relevant set of market participants: retail investors who are clients of Vanguard, one of the world's largest asset managers. To conduct this analysis, we field a large-scale survey to elicit Vanguard investors' beliefs about future economic growth and stock market returns before, during, and after the stock market crash of March 2020, which was triggered by the COVID-19 pandemic. We then describe the evolution of beliefs and disagreement, as well as the relationship between beliefs and investors' trading activity during this period.

This paper is part of an ongoing project that we launched in 2017 in collaboration with Vanguard, with the aim of deepening our understanding of expectations in macroeconomics and finance, and to provide insight into the relationship between beliefs and portfolio decisions (see ref. 1 for details).* The heart of this project is a newly designed survey, the Giglio, Maggiori, Stroebel, Utkus, and Vanguard (GMSU-Vanguard) survey, that elicits beliefs central to macrofinance. These beliefs include expected stock returns and expected GDP growth in both the short run and the long run, as well as respondents' perceived probabilities of economic and stock market disasters. In this paper, we explore three waves of the survey from early 2020. The first wave was administered in mid-February, near the peak of the US stock market; the second wave was in mid-March, after the US stock market had declined by about 20% from its peak; and the third wave was administered in mid-April, after the stock market had rallied by 25% from its low point (although it was still about 17% below its peak).

We find that average beliefs about stock returns over the next year turned substantially more pessimistic following the stock market crash; average expectations of GDP growth over the short term (the next 3 y) also declined, although only moderately. Average expectations of short-run disaster probabilities in stock returns and GDP growth, defined, respectively, as a stock market drop of 30% or more in the next year and annual real GDP growth of less than −3% over the next 3 y, both spiked during this episode. On the other hand, long-term expectations of GDP growth and stock returns over the next 10 y remained stable or even increased somewhat.

The dispersion of beliefs across investors, often referred to as disagreement, increased substantially during the crash. Interestingly, the beliefs of optimists and pessimists, classified according to their precrash beliefs, moved in substantially different ways during this period. Overall, the vast majority of investors became more pessimistic about the short-run outlook of the stock market. However, among those investors who were relatively pessimistic before the crash (i.e., those who, in February, were expecting negative 1-y stock market returns), about half actually revised their expectations upward in the March and April survey waves.

An important feature of our study is the ability to match survey responses to the respondents' portfolios and daily trading activity at Vanguard. This allows us to conduct a "high-frequency" study of the relationship between beliefs and investment decisions at the individual level. February and March 2020

Significance

We analyze how investor expectations about economic growth and stock returns changed during the February–March 2020 stock market crash induced by the COVID-19 pandemic, as well as during the subsequent partial stock market recovery. Our results provide guidance for the design of macro and finance models and related economic policies.

Author contributions: S.G., M.M., J.S., and S.U. designed research, performed research, analyzed data, and wrote the paper.

Competing interest statement: S.U. is employed at Vanguard in a research capacity. S.G., M.M., and J.S. are unpaid consultants at Vanguard in order to access the anonymized data. Vanguard provided anonymized portfolio and survey data and survey research services for this project.

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*Vanguard administers the survey and owns the resulting data. The academic researchers are allowed to analyze the data for research purposes under a nondisclosure agreement. The research was deemed not human subjects research (Harvard IRB15-1792).

were periods of elevated trading activity both at Vanguard and more generally in the markets. Consistent with the findings of ref. 1, we show that, before the crash, respondents who were more optimistic about stock market returns had a higher fraction of their portfolio invested in equity, although the differences were smaller in magnitude than those predicted by benchmark frictionless asset pricing models. We document that, when the crash occurs at the end of February, Vanguard clients in our sample rebalance their portfolios away from equities. Those investors who were ex ante more optimistic sell more equity immediately after the crash. Those investors who were initially more pessimistic keep their portfolios largely unchanged. The trading decisions, therefore, align closely with the differential belief dynamics for initial optimists and pessimists. From a quantitative perspective, the magnitude of trading was smaller than predicted by frictionless asset pricing models, again confirming the results in ref. 1 over this particular period.

The aim of this paper is to document these patterns in the data. We take no stance on whether the expectations measured by our survey are rational or include behavioral elements, or whether the trading decisions that we document were optimal. In *Implications for Economic Theory*, we review the main qualitative implications of our findings for asset pricing models; we conclude that the joint dynamics of prices, trading, and beliefs are hard to reconcile with a number of leading asset pricing models. While it is important to acknowledge that each stock market crash has a number of idiosyncratic elements, we believe that focusing on even just one large shock, such as the one studied in this paper, can be informative for asset pricing theories. Indeed, the dynamics of individual and aggregate expectations after large shocks are a central element of many models of macroeconomics and finance. (In the wake of the COVID-19 crisis, there is a wave of interesting work measuring expectations with different approaches; see, e.g., refs. 2 and 3.) This makes it imperative to study these shocks, in detail, when they occur, in particular, because they are so rare. For example, both the Great Depression and the Global Financial Crisis—each of them a specific event with its idiosyncratic components—have spurred large literatures that have advanced our understanding of economics and finance. As a result, we believe that our findings, which rely on newly available panel data on beliefs and portfolios, have the potential to contribute an important moment that can be used to develop, calibrate, and evaluate different models, especially models that feature rare disasters or belief heterogeneity.

Brief Survey Description

We explore responses to three waves of the GMSU-Vanguard survey. This survey elicits the beliefs of Vanguard investors about expected stock returns and expected GDP growth in both the short run and the long run, as well as investors' perceived probabilities of economic and stock market disasters. *SI Appendix* presents the full survey flow and the exact wording of the various questions. The survey has been administered to retail and retirement clients of Vanguard every 2 mo since February 2017.[†] The surveyed population is one that is relevant for understanding financial markets: retail investors with substantial investments in both equity and fixed income products. The median respondent has 225,000 USD invested with Vanguard—70% in equity instruments and 15% in fixed income instruments—and is ∼60 y of age. Ref. 1 provides more detailed summary statistics on the investor population sampled by this survey.

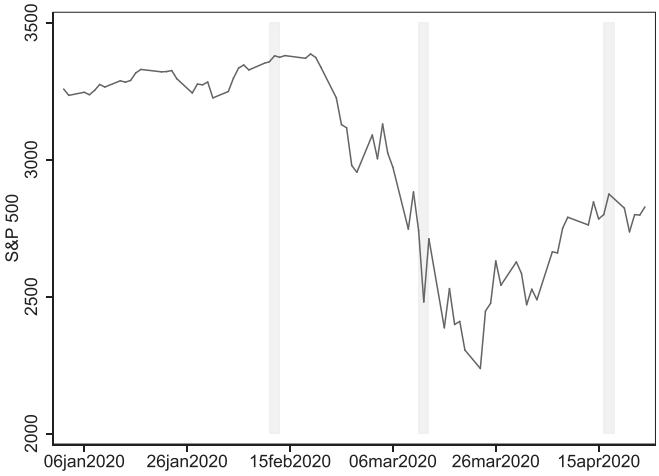

Fig. 1. S&P 500 and dates of GMSU-Vanguard survey. Figure shows the development of the S&P 500 index between January 2, 2020 and April 24, 2020. The three shaded regions correspond to the dates of the February, March, and April waves of the GMSU-Vanguard survey.

As part of our ongoing project, a regular survey was administered on February 11, 2020, which turned out to be almost exactly the precrisis all-time high in the US stock market. At this time, the COVID-19 outbreak in China had already occurred, but its implications had not yet been widely reported or understood. This survey wave therefore offers us a measure of investor beliefs before the subsequent crash. After one of the longest and most pronounced stock market booms on record during 2009–2019, the US stock market then experienced a sudden crash starting on Monday, February 24. By March 11, the S&P 500 index had dropped 19.2% from its previous high. On that day, the financial press announced that US stock markets had entered "bear market territory," commonly defined as a drop in value of 20% or more from the high point. Following these dramatic market events, we fielded an unscheduled flash survey on March 11, 2020, at 6 PM EDT, after the close of the market.[‡] After this survey wave, the market fell further, bottoming out on March 23, 2020 at 34% below its peak. On April 16, we fielded another one of the project's regular bimonthly survey waves. By that date, the stock market had rallied by 25% from its lowest point, although it was still about 17% below its February peak. By this time, newspapers had devoted substantial coverage to the impacts of COVID-19 on the real economy. Fig. 1 shows the dynamics of the S&P 500 index during this period, as well as the exact timing of our surveys.

Our regular survey obtains ∼2,000 responses per wave, with the majority of responses coming from people who responded to previous waves. The February wave obtained 2,374 responses. The March wave obtained 1,864 responses, and 484 of those responses came from individuals who had also responded to the February wave.[§] The April wave obtained 2,516 responses, and

[†]The sample selection rules are described in ref. 1, and we encourage the reader to refer to that paper for more background information on the survey. The only difference between the sample selection approach described in ref. 1 and the one used for the present study is that the flash survey in March 2020 did not add newly selected clients that had never been contacted before by our study. This is consistent with the focus in this article on within-individual changes in beliefs between February and April 2020.

[‡]When we started the GMSU-Vanguard survey, we had anticipated that one of the most interesting questions was how beliefs would change during an economic crisis or a large stock market crash. We had therefore designed the administration of the survey to be able to launch additional flash surveys at short notice following such events. This paper is the outcome of this preplanned contingent survey administration.

[§]Response rates vary, on average, between 4% for newly contacted people to above 10% for those who have already responded once. Ref. 1 discusses various dimensions of selection bias in who answers the survey.

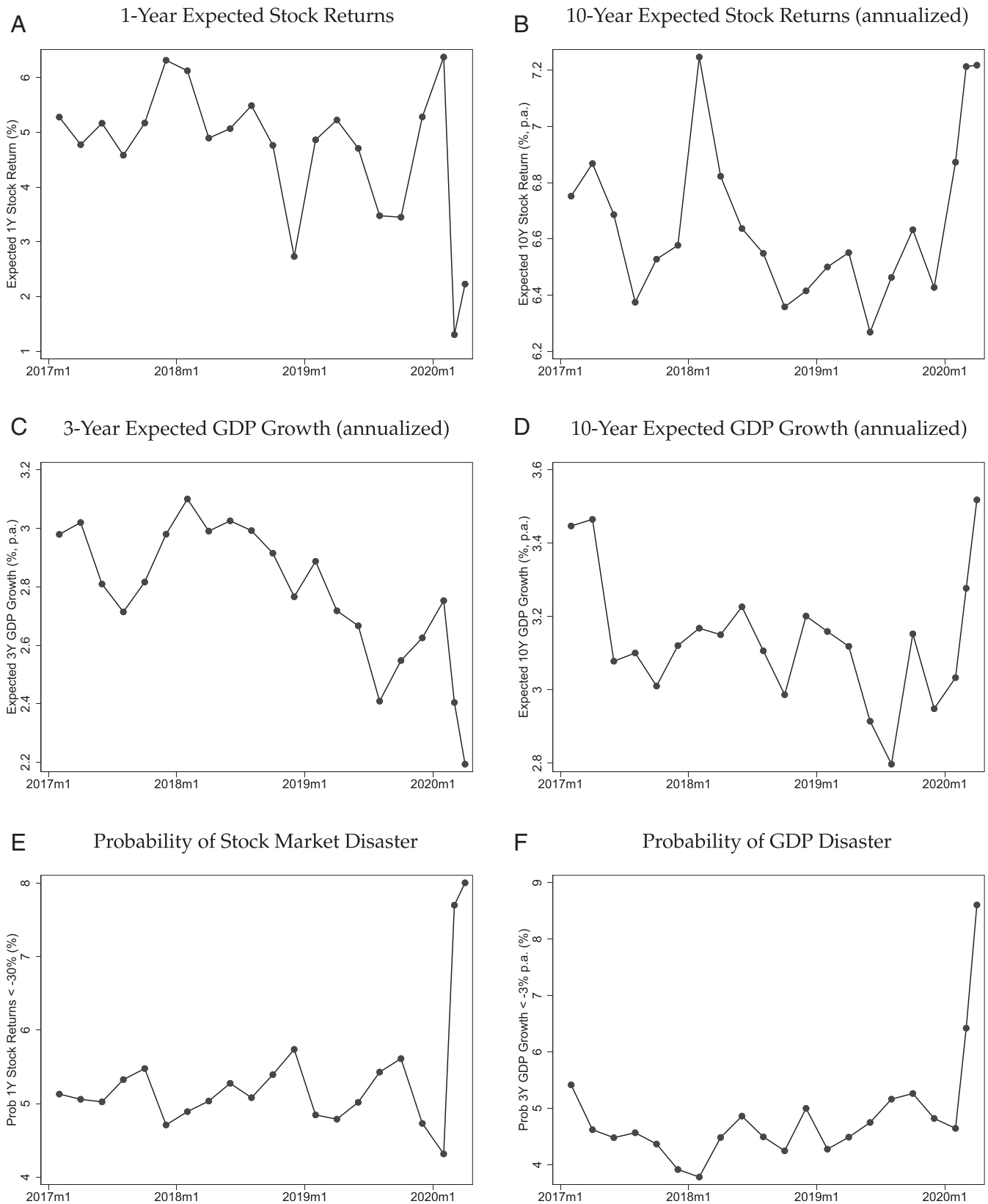

Fig. 2. Average responses to GMSU-Vanguard survey. Figure shows average beliefs across all respondents in each wave of the GMSU-Vanguard survey. (*A*) The 1-y expected stock market return, (*B*) the 10-y expected stock market return (annualized), (*C*) the expected real GDP annual growth over the next 3 y, (*D*) the expected real GDP annual growth over the next 10 y, (*E*) the probability of stock market returns being lower than −30% over the next year, and (*F*) the probability of GDP growth being less than −3% on average over the next 3 y.

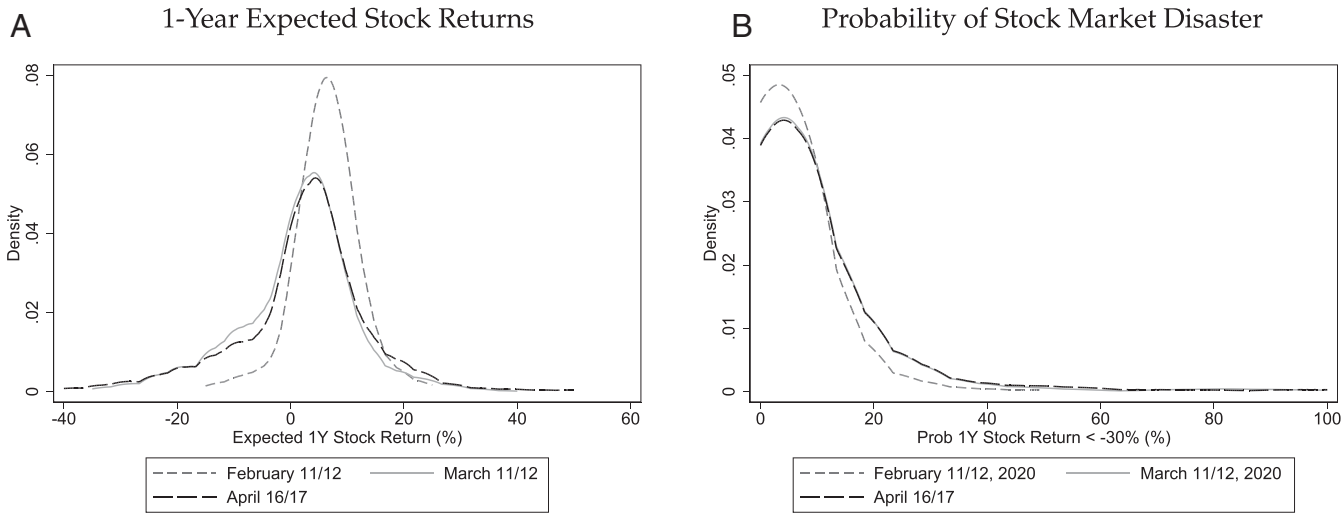

Fig. 3. Distribution of responses to the GMSU-Vanguard survey. Figure shows kernel density distributions over responses on the February 11–12, 2020, the March 11–12, 2020, and the April 16–17, 2020 waves of the GMSU-Vanguard survey. (*A*) The distribution of beliefs about 1-y expected stock returns, and (*B*) the distribution of beliefs about the probability of a stock market decline of more than 30% over the coming 12 mo.

715 of those responses came from investors who responded to the February wave.

Belief Dynamics and Trading over the COVID-19 Crash

Dynamics of Average Beliefs. We begin by documenting the patterns of average beliefs in the data. Fig. 2 shows the time series of average beliefs across all our respondents for the entire period covered by our survey.[¶] Fig. 2*A* shows the 1-y expected stock market return, Fig. 2*B* shows the 10-y expected annual stock market return, Fig. 2*C* shows the expected annual real GDP growth over the next 3 y, Fig. 2*D* shows the expected annual real GDP growth over the next 10 y, Fig. 2*E* shows the probability of stock market disaster (defined as a decline of more than 30% within the next year), and Fig. 2*F* shows the probability of a GDP disaster (defined as average annual GDP growth of less than −3% over the next 3 y).

Many of the panels in Fig. 2 show large changes in beliefs in the two survey waves following the stock market crash, changes of a magnitude not observed in the previous 2 y. Specifically, in the 2 y before the crash, expectations about 1-y stock market returns had ranged between 3% and 6%, and were at the high end of that range in February 2020. The crash brought them down to the 1 to 2% range. This pessimism about short-run market returns was not accompanied by pessimism about long-run returns of the stock market. Indeed, expected annual stock market returns over the next 10 y actually increased modestly after the crash, from 6.9% per y to 7.2% per y.

Fig. 2*C* shows that average expectations of real GDP growth over the next 3 y moved from 2.8 to 2.2% following the crash. (The median expectation also moves down from 2.3% in February to 2% in April, so that the change in the average is not driven by changes in outliers over time.) Similar to the expectations for stock returns, a fall in short-run expectations is associated with an increase in long-run expectations: Annual 10-y growth expectations increased from 3.0 to 3.5% per y. To provide a sense of the magnitude of expected GDP losses, it is illustrative to compare the expectations to what actually happened during the Global Financial Crisis. Starting at the end of June 2008, real GDP growth in the United States over the next 3 y was 0.3%, with a v-shaped pattern of growth over that period. At least by April 2020, the investors surveyed here were not expecting that the COVID-19 shock would lead to GDP losses as large as those experienced during the financial crisis.[#]

One interesting question is how this relatively moderate drop in GDP expectations can be reconciled with the large movement in stock prices observed during the COVID-19 crash. One possible explanation is related to the fact that our survey does not directly elicit expected dividend growth, but only GDP growth as a plausible proxy for dividend growth. However, refs. 2 and 3 use data on dividend futures and earnings forecasts, respectively, to show that variation in dividend growth expectations also cannot explain the large movement in prices. This is consistent with our findings that expectations of real economic activity had not declined dramatically between February 2020 and April 2020. Based on these results, one might conclude that the decline and subsequent recovery in the stock market must have been caused by an increase and subsequent decline in discount rates. In contrast with this, our survey shows that average expected returns of our respondents actually decreased in March 2020, before recovering somewhat by the April 2020 wave. This is consistent with findings from related work in the behavioral finance literature that has explored the conflict between observed subjective expectations and expectations of a rational observer (4), and presents a challenge to a large class of consumption-based asset pricing models.

Similarly, one can further decompose the variation in discount rates between risk premia and risk-free rates. During the

[¶]Similar to ref. 1, we set extreme outlier answers (i.e., responses below the bottom percentile or above the top percentile) for each unbounded expectation question equal to missing. Naturally, there are some critical judgment calls involved in selecting these cutoffs, which involve trading off retaining true extreme beliefs with excluding answers from individuals who probably misunderstood the question or the units of measurement. Ref. 1 conducted extensive sensitivity analysis to confirm that results are robust to a wide range of choices for the cutoff values. We also confirmed that the results are robust to winsorizing extreme answers rather than setting them equal to missing, and to dropping all answers of individuals who report extreme answers to at least one question.

[#]The short-run economic growth expectations elicited in this survey are also considerably higher than those of professional forecasters. In their World Economic Outlook released in April 2020, the International Monetary Fund forecast US GDP growth of −5.9% in 2020 and 4.7% in 2021. The *Wall Street Journal* survey of professional forecasters in April 2020 reported average expected annual growth for the period 2020–2022 at 0.88%.

Table 1. Changes in beliefs about expected 1-y stock returns, by initial beliefs

Expected 1-y stock returns (%, Feb)	Change in expected 1-y stock returns, %					
	Less than −20 ppt	Between −20 and −10 ppt	Between −10 and −5 ppt	Between −5 and 0 ppt	Between 0 and 5 ppt	Greater than 5 ppt
For Feb–Mar						
Less than 0	0.0	3.1	9.4	25.0	18.8	43.8
Between 0 and 5	8.8	17.6	10.8	35.3	17.6	9.8
Between 5 and 10	10.0	13.1	12.4	41.3	13.9	9.3
Greater than 10	3.8	29.5	29.5	24.4	5.1	7.7
For Feb–April						
Less than 0	0.0	5.8	15.4	5.8	19.2	53.8
Between 0 and 5	7.3	14.5	8.5	29.1	27.3	13.3
Between 5 and 10	6.1	12.2	15.0	36.3	17.2	13.3
Greater than 10	10.3	18.3	18.3	30.2	10.3	12.7

The table shows the transition density between the level of ex ante expectations about 1-y stock market returns (rows) and ex post changes in these expectations (columns), focusing on the transition between February 2020 and March 2020 and the transition between February 2020 and April 2020. "Expected probability of crash" shows an analogous analysis for the perceived probability of the stock market return over the coming year being lower than −30%. The interior buckets in both rows and columns are closed on the left and open on the right; ppt, percentage points. Darker shaded areas are those containing more of the transition mass.

COVID-19 crash, the yield curve decreased by about 1% at the short end and 0.5% at the long end. *SI Appendix*, Fig. S1 also reports the dynamics of average bond return expectations in our survey during this episode, showing that they decreased by about 0.5 to 0.8%. Given these magnitudes, variation in the risk-free rate alone can also not reconcile the observed changes in expected returns (implying expected risk premia decreased) and the drastic market movements observed during this period.||

Fig. 2 *E* and *F* shows large increases in the perceived probabilities of short-run disasters in stock market returns and GDP growth. The probabilities of such disasters increase from 4.3 to 7.9% for the stock market, and from 4.6 to 8.5% for GDP growth. It is these extreme outcomes that the economic policy response is trying to minimize, but our respondents still find their probability to have increased substantially. We discuss the implications of these movements for asset pricing theory in *Implications for Economic Theory*.

Dynamics of Belief Disagreement. Beyond studying the dynamics of average beliefs across investors, our data also allow us to understand the evolution of disagreement among investors. Fig. 3 shows smoothed kernel densities of the cross-section of beliefs, both for the 1-y expected return (Fig. 3*A*) and for the probability of a stock market disaster (Fig. 3*B*). In each panel, we plot three densities, each corresponding to a different survey wave (February, March, and April).

The dispersion in beliefs across individuals—the level of disagreement—increased substantially after the market crash, as visible from the fattening of densities. The cross-sectional SD (across respondents) of reported 1-y expected stock returns almost doubled from 5.3 to 10.1% between the February and March waves. The April survey shows a level of disagreement very similar to the March one, despite the fact that the stock market had rallied substantially in the meantime. The response of disagreement is asymmetric, with pessimism—the left tail of Fig. 3*A*—becoming substantially more pronounced in the investor population. Quantitatively, the cross-sectional skewness of beliefs increases in magnitude from −0.32 to −0.47 from February to March. Consistent with this finding, the 10th percentile of the belief distribution moves from 2 to −10%, whereas the 90th percentile remains essentially stable, falling from 12 to 10%. Finally, the 90th percentile of the distribution of perceived disaster probabilities, captured by the right tail of Fig. 3*B*, doubles from 10 to 20% between the February and March waves of the GMSU-Vanguard survey.

We next refine our understanding of the dynamics of disagreement by studying which people changed their beliefs, and how: Did pessimists become more pessimistic, or was the change in disagreement driven largely by investors who were previously optimistic? Our survey is well suited to answering these questions, because we observe a significant number of investors who respond to multiple waves of the survey.

In Tables 1 and 2, we study the subset of investors that responded to the February wave as well as to at least one of the March or April waves of the GMSU-Vanguard survey. Table 1 focuses on 1-y expected returns, and Table 2 focuses on the probability of a stock market disaster. In Table 1, we group respondents into four buckets based on their beliefs about 1-y stock returns before the crash in the February wave; each row corresponds to a different group. Those investors that, in the February wave, were most pessimistic are shown in the top row; this group expected negative returns going forward. The bottom row, instead, includes the most optimistic investors, those that, in February, expected 1-y stock returns above 10%. The columns report the change in beliefs (equally weighted) in percentage points between February and March and between February and April. Each entry reports the fraction of investors within each row that experienced a changed in belief in the range expressed in the corresponding column. For example, the first row shows that, of those investors that expected negative returns in February, 3% lowered their expectations by 10 to 20 percentage points, 9% lowered their expectations by 5 to 10 percentage

||While it is beyond the scope of this paper to propose alternative asset pricing models that can reconcile our findings, promising directions include exploring the potential role of changing disagreement, of changes in the identity of the marginal investor, and of intermediation frictions in these markets.

Table 2. Changes in beliefs about expected probability of a crash, by initial beliefs

Expected probability of crash (%, Feb)	Change in probability of crash, %					
	Less than −5 ppt	Between −5 and 0 ppt	Between 0 and 5 ppt	Between 5 and 10 ppt	Between 10 and 20 ppt	Greater than 20 ppt
Feb–Mar						
Between 0 and 2.5	0.0	4.9	64.8	14.8	9.8	5.7
Between 2.5 and 5	0.0	50.0	21.4	14.3	14.3	0.0
Between 5 and 10	1.8	23.6	42.7	19.1	9.1	3.6
Greater than 10	35.9	18.5	18.5	5.4	14.1	7.6
Feb–Apr						
Between 0 and 2.5	0.0	6.1	65.6	12.9	10.9	4.6
Between 2.5 and 5	0.0	28.1	37.5	15.6	12.5	6.3
Between 5 and 10	0.7	24.7	34.2	22.6	12.3	5.5
Greater than 10	40.1	20.4	16.1	6.6	10.2	6.6

The table shows the transition density between the level of ex ante expectations about perceived probability of the stock market return over the coming year being lower than −30% (rows) and ex post changes in these expectations (columns), focusing on the transition between February 2020 and March 2020 and the transition between February 2020 and April 2020. The interior buckets in both rows and columns are closed on the left and open on the right; ppt, percentage points. Darker shaded areas are those containing more of the transition mass.

points, and 44% increased their expected stock returns by more than 5 percentage points.

Table 1 shows a widespread transition toward more negative beliefs across most investors.** For example, 87% of the previously most-optimistic group became more pessimistic in March. One exception is the group that includes the most-pessimistic respondents in February; for this group, 63% of the respondents increased their expectations between February and March, and 73% of that group became more optimistic between February and April. One interpretation of these results is that, in February, after the spread of the coronavirus had already started, a set of individuals (the pessimists) thought a stock market crash was likely to occur over the next year. As this scenario actually unfolded, about half of these individuals thought that stock prices had fallen far enough to increase their expected returns going forward; the other half expected further stock market declines. On the other hand, the vast majority of optimists revised their expectations downward in light of the market crash that they did not anticipate in February.

This view is also supported by Table 2, which presents an analogous analysis for the perceived probability of a stock market disaster (initial pessimists are in the last row). Those who ex ante reported the highest probabilities of a large stock market decline are also those who decreased their perceived probability the most following the actual realization of such a decline: Just over half of the pessimists become more optimistic.

Trading Behavior. We find that both the levels and dynamics of beliefs are reflected in portfolio choice and trading activity. Fig. 4 shows the dynamics of portfolios over February and March for the respondents to the February wave of the GMSU-Vanguard survey, grouped by the level of their expected 1-y stock returns in February. We label those respondents who are in the top tercile of the February belief distribution as "optimists," those in the middle tercile as "neutrals," and those in the bottom tercile as "pessimists."[††] The percentage of each individual's portfolio that is invested in equity is associated with her expected stock returns. On January 31, 2020, the date at which we measure the portfolios using market values, optimists had, on average, 73% of their portfolio invested in equity. The average equity percentage is 66% for neutrals and 62% for pessimists. This result is consistent with the findings in ref. 1, who documented that individual beliefs are associated with portfolio choice, but also that the relationship is quantitatively more muted than in frictionless benchmark models; ref. 2 identifies a number of frictions—such as inattention and capital gains taxes—that help explain this discrepancy.

For February and March, we construct portfolios for each respondent, keeping prices constant at their January 31 levels. As a result, the portfolio dynamics in Fig. 4 reflect active trading, as opposed to changes in market values.[‡‡] Fig. 4*A* focuses on all respondents and shows that, in accordance with the differential belief dynamics by group described above, the optimists sell the most equity (on average, they actively decrease their equity share by 1.05%), followed by the neutrals (active decrease of 0.98%). Initial pessimists had the lowest active change in the equity share, with an active decrease of 0.63%. To inspect this mechanism further, Fig. 4*B* focuses exclusively on those respondents

**Despite this large time series decline in expected returns, Fact 3 from ref. 1—which emphasized that the panel variation in beliefs is best explained by individual fixed effects and not time fixed effects—continues to hold. Focusing on individuals who have responded to at least three survey waves since February 2017, the R-squared of a regression of panel beliefs on individual fixed effects is 50.8%, while it is 5.7% for a regression of the panel beliefs on time fixed effects. Similar patterns hold for all beliefs elicited in the GMSU-Vanguard survey.

††We group in terciles, rather than the finer groups in Tables 1 and 2, to maintain equal-sized groups and sufficient statistical power, given that most people do not trade. The average expected stock market returns over the next year (February wave) for the three groups are 12.2% for the optimists, 7% for the neutrals, and 2.1% for the pessimists. Thus the "pessimists" in this analysis are not as pessimistic as the lowest group in Table 1.

‡‡One exception is that, when respondents trade, we value the trade at the actual transaction price. In the context of our study, this is likely to be conservative in the sense that it underestimates the change in portfolio allocation. This occurs because, when agents sell equity after the crash, they do so at lower prices. Similarly, the share of portfolio equity at market value is falling during this period also for those who do not trade. While we focus on active trading, we also stress that "not trading" to rebalance a portfolio after market changes is also an endogenous decision and might reflect respondents' assessments that a lower equity share in their portfolio is consistent with their belief changes.

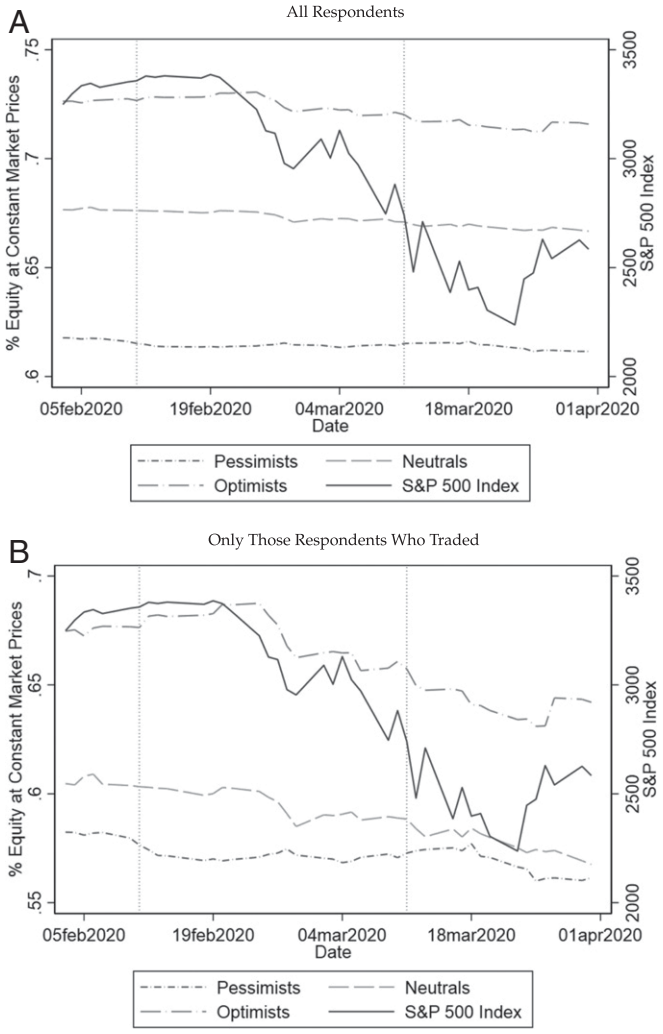

Fig. 4. Portfolio and trading activity. Figure shows portfolio dynamics at constant market prices (from January 31, 2020). We group respondents to the February survey by their level of expected 1-y stock market returns, with the optimists being the top tercile, and trace their portfolio activity daily over February and March. (*A*) All February respondents. (*B*) Only those who actively change their portfolio equity share by at least 1% between January 31 and March 31. Both panels include, for reference, the dynamics of the S&P 500 index (right axis).

who actively change their portfolios during the period.[§§] Similar patterns appear, but they are now more pronounced, reflecting the fact that a substantial portion of respondents (67% of optimists, 73% of neutrals, and 70% of pessimists) did not change their portfolios during this period. The optimists who trade move their equity percentage from a high of 68% to a low of 64% by the end of March; initial neutrals with active trading move their equity share from 60 to 57%; and initial pessimists move theirs from 58 to 56%. There is also an interesting higher-frequency dynamic: The optimists sell their equity during the crash between the end of February and early March, and, by the end of March, after the market rebounds, they buy back part of that equity.

Correlations across Belief Changes. Our final analysis uses our panel data to investigate the joint dynamics of changes in expectations about economic growth and stock market returns across individuals. Table 3 reports the correlation of individual-level changes in beliefs between the February and March and February and April waves of the GMSU-Vanguard survey. For example, the table shows (row 6, column 3) that investors who increased their perceived probability of a stock market disaster also increased their perceived probability of GDP growth disaster.

The first column also highlights that, on average, those investors who became more pessimistic about average stock returns also became more pessimistic about the probability of a stock market crash and a GDP disaster (rows 3 and 6), as well as about the short-run outlook for GDP growth (row 4). However, changes in beliefs about long-run GDP growth and long-run stock market returns (rows 2 and 5) are essentially uncorrelated with changes in short-run expected returns.

Limitations. Before concluding, we point out a number of possible limitations of the current study. First, like all survey-based studies, the presence of measurement error is a potential concern, especially for the quantitative interpretation of the results. Second, the population of investors we survey is selected both in terms of being Vanguard clients and in terms of choosing to answer the survey. Both of these concerns are extensively discussed in our previous work (1), and we limit ourselves here to pointing out that 1) Vanguard is one of the world's largest asset managers, with assets of $6 trillion and over 30 million investors globally (our study draws from the US population of individual retail investors and retirement plan participants, ∼10 million investors), thus making it an interesting population to study, and 2) while measurement error and selection are present, we have found our surveys to reveal beliefs that are actually reflected in investors' trading decisions. A final concern, more specific to this paper, is that the COVID-19 crisis is a particular shock with a number of idiosyncratic components. It is therefore unclear how many of the patterns here might generalize to other large economic shocks. However, as we have already discussed, shocks of this magnitude are so rare that some advancement in our understanding can be achieved by their study even after considering their idiosyncratic limitations.

Implications for Economic Theory

Our purpose in this paper is to document novel patterns of belief dynamics and trading activity during a substantial market crash. These patterns represent data moments that can be useful in designing, calibrating, and evaluating economic models. In this section, we briefly highlight the main qualitative implications for various models, while leaving a quantitative exploration that requires more theoretical structure to future research.

Our data are perhaps most directly suited to evaluating a rare-disaster model of macrofinance (5, 6). Our data support a central feature of versions of these models with time-varying disaster probabilities (7, 8): The prediction that the occurrence of a crash is associated with higher (perceived) probability of future disasters closely aligns with our survey evidence. However, these models also imply that, precisely because the probability of disasters increases, expected returns should also increase following a stock market crash.[¶¶] This latter prediction is not supported by

[§§]We include only those respondents to the February survey who actively change their portfolio equity share by at least 1% between January 31 and March 31.

[¶¶]More precisely, risk premia should increase. In these models, like in the data, the risk-free rate decreases with the crash. In our data, expected returns decreased from 6.37 to 1.3%, while short-term rates (1-y treasury bills) decreased from 1.44% (February 11) to 0.39% (March 11). We conclude that expected excess returns (a form of risk premium) decreased in the data with the crash.

Table 3. Correlation across belief changes

	Δ Expected 1-y stock return (%)	Δ Expected 10-y stock return (% p.a.)	Δ Prob 1-y stock return < −30% (%)	Δ Expected 3-y GDP growth (% p.a.)	Δ Expected 10-y GDP growth (% p.a.)	Δ Prob 3-y GDP growth < −3% (% p.a.)
Feb–Mar						
Δ Expected 1-y stock return (%)	1					
Δ Expected 10-y stock return (% p.a.)	0.061	1				
Δ Prob 1-y stock return < −30% (%)	−0.363	0.094	1			
Δ Expected 3-y GDP growth (% p.a.)	0.155	0.140	−0.063	1		
Δ Expected 10-y GDP growth (% p.a.)	0.010	0.276	−0.048	0.446	1	
Δ Prob 3-y GDP growth < −3% p.a. (%)	−0.188	0.004	0.230	−0.184	−0.037	1
Feb–Apr						
Δ Expected 1-y stock return (%)	1					
Δ Expected 10-y stock return (% p.a.)	0.113	1				
Δ Prob 1-y stock return < −30% (%)	−0.332	0.017	1			
Δ Expected 3-y GDP growth (% p.a.)	0.234	0.112	−0.159	1		
Δ Expected 10-y GDP growth (% p.a.)	0.074	0.254	−0.019	0.403	1	
Δ Prob 3-y GDP growth < −3% p.a. (%)	−0.155	0.025	0.362	−0.243	−0.006	1

Table shows cross-sectional correlation of changes in individual beliefs between the February 2020 and March 2020 waves of the GMSU-Vanguard survey, and between the February 2020 and April 2020 waves. Prob, probability; p.a., per annum.

our data. The prediction of higher expected excess returns following a stock market crash is a shared feature of many rational expectation asset pricing models, and, in this sense, the empirical failure is common across this class of models.[##] Our paper offers a useful testing ground and guidance for future evolution of these theories.

Our data also highlight the importance of mechanisms that are at the core of the theoretical literature on heterogeneous beliefs and trading (10–12). Ex ante optimists have more exposure to equity than ex ante pessimists and, as a result, they lose more wealth when the crash occurs. In those models, changes of beliefs play a crucial role in generating trading activity when investor beliefs "cross" each other. Consistent with such mechanisms, we find that ex ante optimists lower their beliefs the most after the crash, and, correspondingly, sell the most equity. While a full quantitative evaluation of the correspondence between these models and our data is outside the scope of this paper, our analysis suggests that this class of models can be a promising direction to explain the patterns of beliefs and trading that we document. In addition, in much of the existing literature, belief changes for different agents are idiosyncratic. We show, in Tables 1 and 2, that, in addition to such idiosyncratic belief changes, the COVID-19 crisis induced correlated belief changes among all of our agents. Furthermore, different individuals' exposures to these correlated belief changes varied with the level of their initial beliefs. These patterns provide directions for future iterations of models with heterogeneous beliefs.

Finally, we confirm, in this paper, the low sensitivity of portfolios to beliefs documented originally in ref. 1. Strikingly, this low sensitivity holds even during a major market crash, when beliefs are changing significantly and many retail investors were paying substantial attention to developments in the stock market. This pattern has important implications for both rational and behavioral models, since it informs us about the way changes in expectations affect individual actions. For example, simple behavioral models, like those reviewed by ref. 13, imply a strong pass-through of belief changes to portfolios of behavioral agents. These models would explain a large drop in asset prices via a

[##]The literature's focus on representative agent models makes the mapping with our data difficult in the absence of an explicit aggregation theorem. Nonetheless, the literature that documented the negative correlation between expected rational returns and those elicited via surveys routinely equates average beliefs obtained from survey to those of representative agents (4). One exception is ref. 9, who explicitly model heterogeneous beliefs about time-varying rare disasters. In that model, the optimists underestimate the probability of a disaster and, therefore, expect higher returns than the pessimists. When the probability of a disaster increases, expected returns for both types of agents increase. In the data, with the exception of a portion of the most pessimistic investors, all investors lower their expected returns after the crash.

turn to pessimism in expectations and an attempt to sell large parts of the equity portfolio. Our work cautions against this simple modeling, which implies too strong a link between beliefs and portfolios. Ongoing research by ref. 14 shows possible avenues to match our evidence by adding additional elements, like inelastic demand by institutional investors, which can amplify the price effects of small portfolio changes.

To conclude, our study provides a unique real-time look inside the mind of stock market participants during the COVID-19 crisis, and the associated stock market crash. It shows that investors turned more pessimistic and increased their perceived probabilities of catastrophic events in terms of real economic outcomes and further stock market declines. We also find that investors reduced their equity exposures according to changes in their expectations. At the same time, we find that investors also formed a nuanced view of long-term prospects. Short-term pessimism was matched with unchanged or even improved long-run expectations. By documenting these dynamics of beliefs and trading during a large market crash, and by characterizing their heterogeneity across investors, we hope to bring useful additional moments that can help test and calibrate macrofinance theories.

Data Availability. All code and aggregated data are deposited at openICPSR (https://doi.org/10.3886/E128681V1). Individual-level data and other disaggregated data cannot be shared due to a nondisclosure agreement.

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